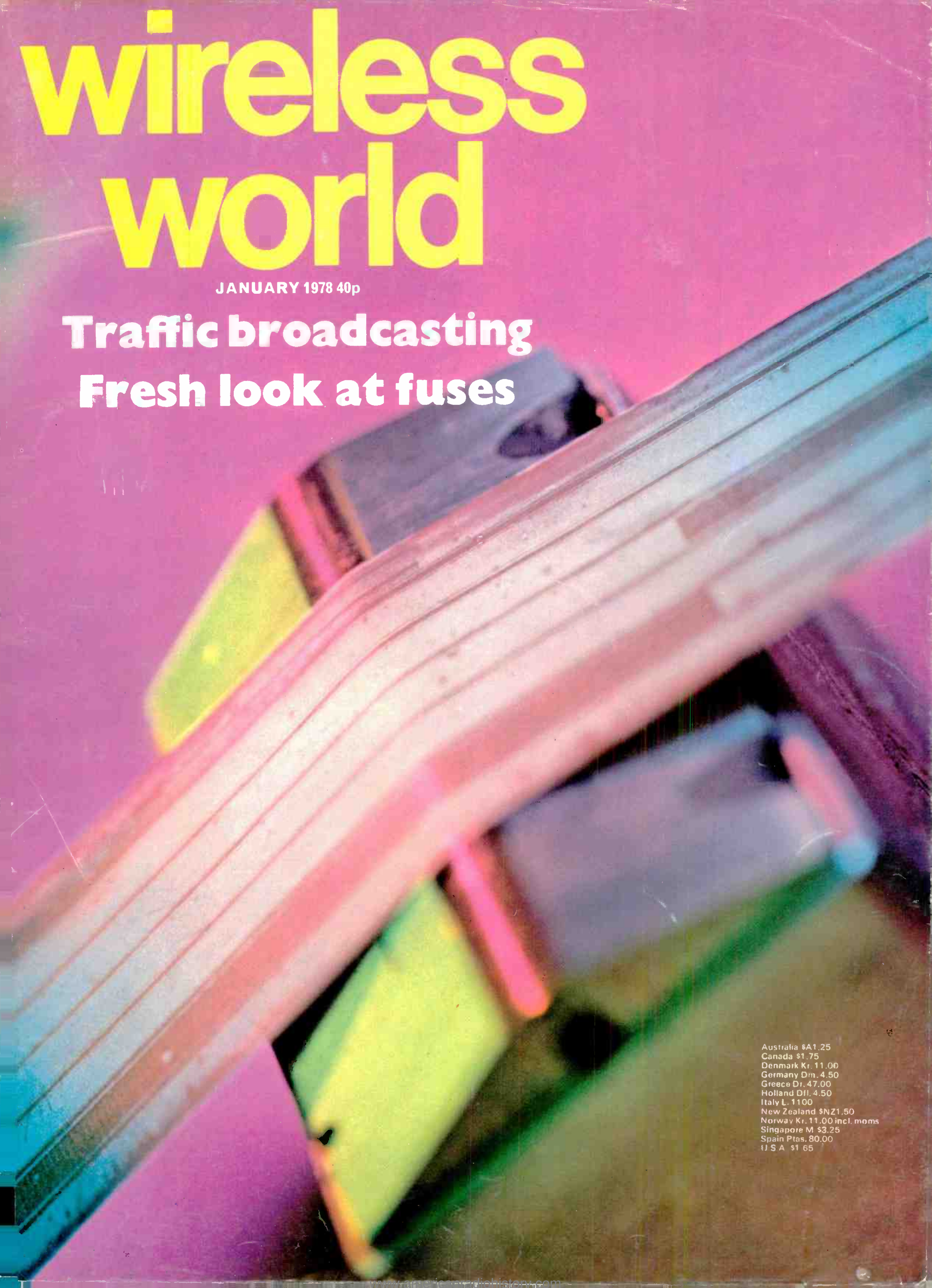
# wireless world

JANUARY 1978 40p

## Traffic broadcasting

## Fresh look at fuses



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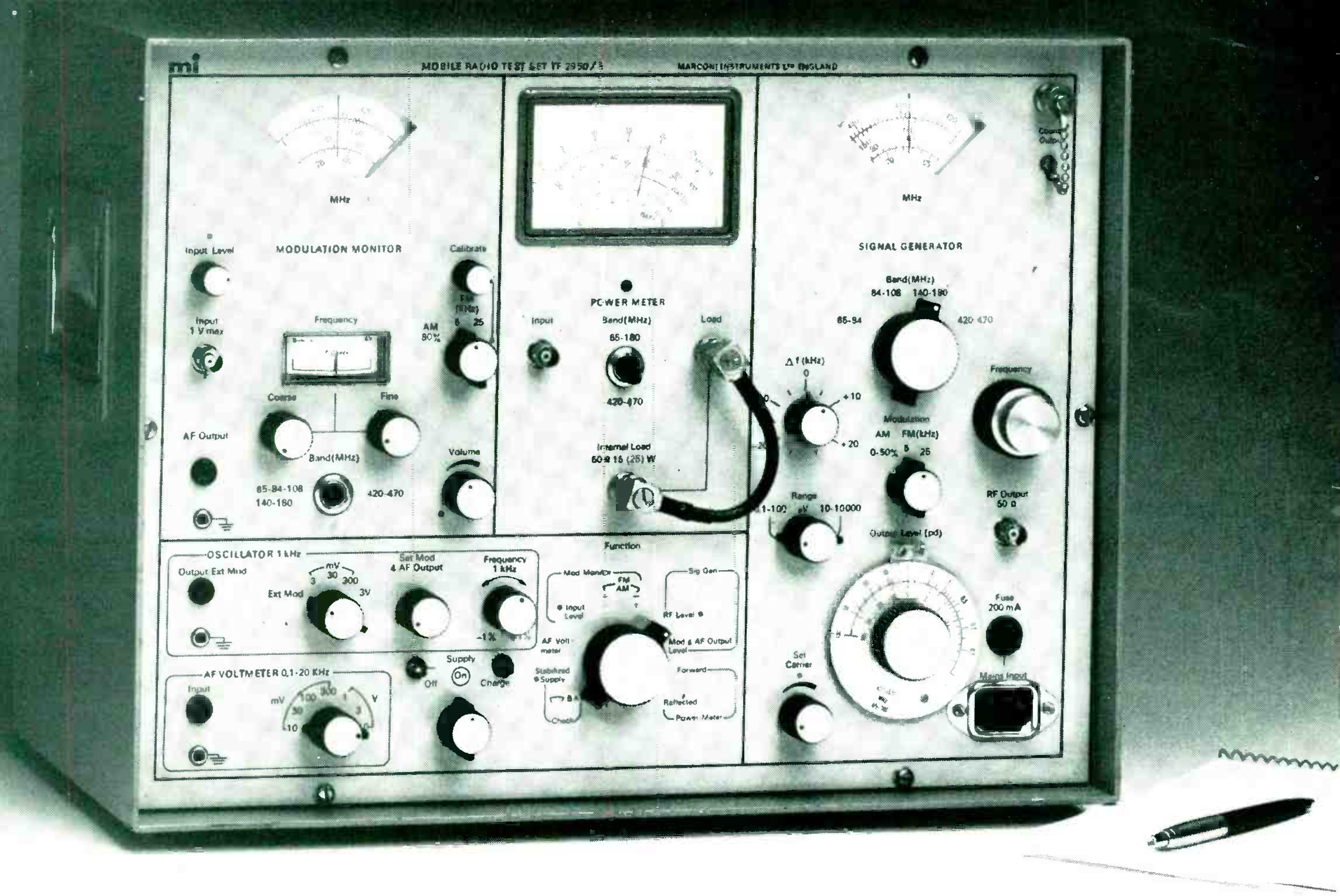
# The better value box for mobile radio servicing.




By combining all mobile radio servicing instruments in one portable unit, Marconi Instruments' Mobile Radio Test Set, TF 2950, streamlines your testing and servicing operation. And it is realistically priced.

Signal generator, a.f. voltmeter, modulation monitor, power meter (in-line and absorption) and a.f. oscillator are housed in a compact and robust cabinet – measuring only 315 mm high, 420 mm wide and 230 mm deep, and weighing only 16 kg.

TF 2950 is suitable for all a.m./f.m. mobile radio equipment and is available in a number of versions to cover a wide frequency range.

For maximum convenience, the equipment operates from internal, rechargeable batteries or mains. A battery state meter is incorporated.

Marconi Istruments' TF 2950 gives you single-handed portability to meet all your mobile test needs.

Put it to the test.

Write or telephone for a full technical description and, if this whets your appetite further, we will be happy to arrange a demonstration.

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A GEC-Marconi Electronics Company

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*Front cover shows magnetic pattern on tape in a Racal Thermionic instrumentation recorder. Photographer Paul Brierley*

IN OUR NEXT ISSUE

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***Linsley Hood cassette deck.*** **Postscript to the original 1976 articles: ways to improve the signal-to-noise ratio.**

***Microwave hybrid integrated circuit.*** **Processes and devices used and examples of m.i.c. sub-assemblies currently in use.**

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**Editorial & Advertising offices:** Dorset House, Stamford Street, London SE1 9LU.
**Telephones:** Editorial 01-261 8101 Advertising 01-261 8339
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# wireless world

ELECTRONICS/TELEVISION/RADIO/AUDIO

JANUARY 1978 VOL 84 NO 1505

# If you want your connectors to have a good innings specify Ferranti.

Ferranti circuit board edge connectors are known for their staying power. They're designed for a far higher number of insertions and withdrawals than you're likely to make. They need to be, so that you can rely on them throughout their working life.

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Telephone: 0382 89321 Telex: 76166
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**FERRANTI**
**Connector Capability**

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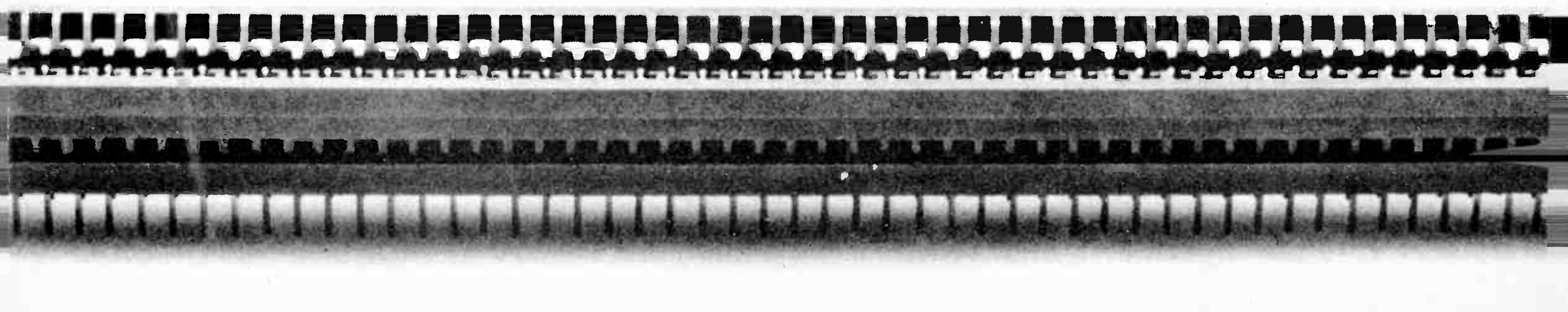

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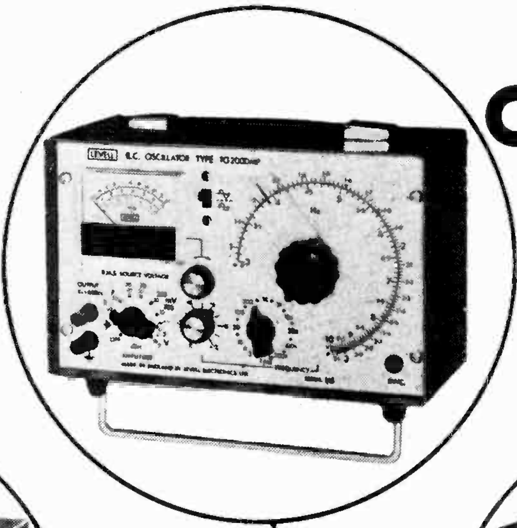

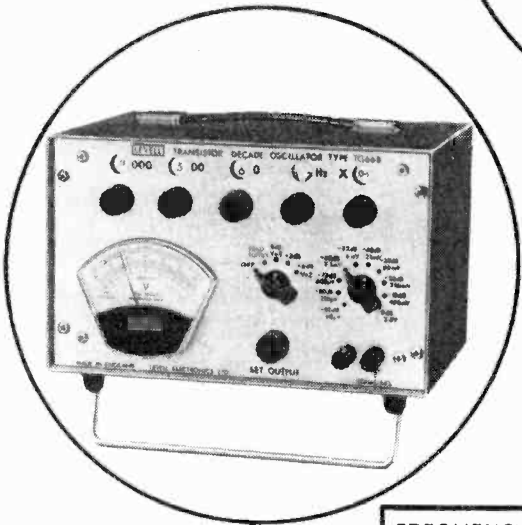

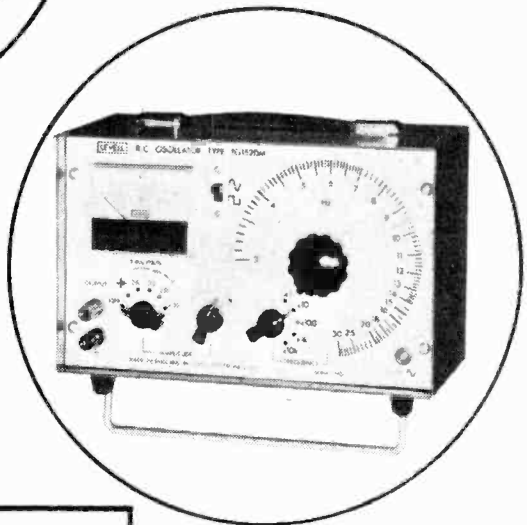

| | |
|---|---|
| FREQUENCY | 1Hz to 1MHz in 12 ranges. 0 to 1% fine control on TG200DMP. |
| ACCURACY | ±1.5% ±0.01Hz up to 100kHz. ±2% up to 1MHz. |
| SINE OUTPUT | 7V r.m.s. down to <200µV with Rs=600Ω. |
| DISTORTION | <0.05% from 50Hz to 15kHz, <0.1% from 10Hz to 50kHz, <0.2% from 5Hz to 150kHz, <1% at 1Hz and 1MHz. |
| SQUARE OUTPUT | TG200D, DM & DMP only. 7V peak down to <200µV. Rise time <150nS. |
| SYNC. OUTPUT | >1V r.m.s. sine in phase with output. |
| SYNC. INPUT | ±1% freq. lock range per volt r.m.s. |
| METER SCALES | TG200M, DM & DPM only. 0/2V, 0/7V & −14/+6dBm. |
| SIZE & WEIGHT | 260 x 130 x 180mm. 4.3kg with batteries. |

| TG200 | TG200D | TG200M | TG200DM | TG200DMP |
|---|---|---|---|---|
| **£75** | **£79** | **£91** | **£95** | **£99** |

| | |
|---|---|
| FREQUENCY | 0.2Hz to 1.22MHz on four decade controls. |
| ACCURACY | ±0.02Hz below 6Hz. ±0.3% from 6Hz to 100kHz. ±1% from 100kHz to 300 kHz. ±3% above 300 kHz. |
| SINE OUTPUT | 5V r.m.s. down to 30µV with Rs=600Ω. |
| DISTORTION | <0.15% from 15Hz to 15kHz. <0.5% at 1.5Hz and 150kHz. |
| METER SCALES | 2 Expanded voltage & −2/+4dBm. |
| SIZE & WEIGHT | 260mm x 190mm x 180mm. 5.6kg. |

**TG66B** Battery model **£195**

**TG66A** Mains & battery model **£210**

| | |
|---|---|
| FREQUENCY | 3Hz to 300kHz in 5 decade ranges. |
| ACCURACY | ±2% ±0.1 Hz up to 100kHz, increasing to ±3% at 300kHz. |
| SINE OUTPUT | 2.5V r.m.s. down to <200µV. |
| DISTORTION | <0.2% from 50 Hz to 50kHz. |
| SQUARE OUTPUT | 2.5V peak down to <200µV. |
| SYNC. OUTPUT | 2.5V r.m.s. sine. |
| METER SCALES | 0/2.5V & −10/+10dB on TG152DM. |
| SIZE & WEIGHT | 260mm x 130mm x 180mm. 3.4kg. |

**TG152D** Without meter **£59**

**TG152DM** With meter **£75**

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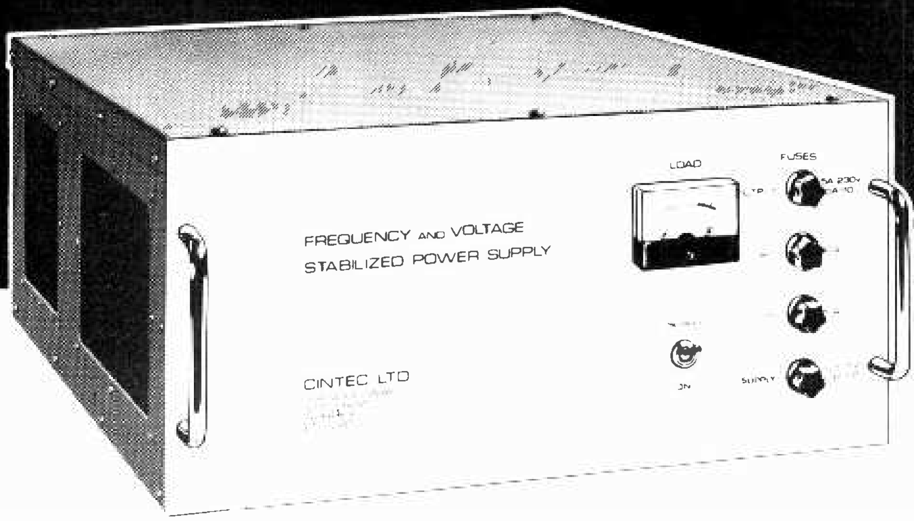
# THE CINTEC SINUSOIDAL FREQUENCY AND VOLTAGE STABILIZER




## APPLICATIONS

* SOUND RECORDING
* VIDEO RECORDING
* MEDICAL
* MARINE
* COMPUTERS
* NAVIGATIONAL SYSTEMS

Applications for the use of CINTEC FREQUENCY & VOLTAGE STABILIZER are more numerous than can be listed Therefore, if you have a supply problem, contact CINTEC LIMITED whose engineers will be only too pleased to assist

★ 500VA OR 250VA
★ SOLID STATE
★ HIGH STABILITY
★ ROBUST
★ VERSATILITY
★ RELIABILITY
★ SINUSOIDAL

**Reliable Frequency & Voltage Stabilization**

The efficent operation of sophisticated electrical and electronic equipment is, in many instances, dependent upon an electrical supply which is stable in both frequency and voltage.

In many countries and even in the United Kingdom during periods of heavy demand, the variation in the frequency and voltage is sufficient to introduce errors and the malfunction of such items as Recording equipment etc. Likewise, in certain areas, the only source of supply is from a Generator, the output of which can vary considerably when different loads are imposed. This has precluded the use of a wide range of equipment in many countries. Voltage Stabilizers are readily available but these do not stabilize the frequency of the supply which, in many instances, is essential.

**The CINTEC FREQUENCY & VOLTAGE STABILIZER provides the answer to both these problems**

When the supply frequency is fluctuating wildly, between 45Hz and 65Hz and the voltage by more than 10% the output from the Stabilizer will not vary more than .01% from 50Hz or 1% in voltage, even when different loads are imposed.

Used by Government establishments, oil rigs, hospitals, police, video and electronic industry, shipbuilders etc. for a wide range of applications including video systems, medical, frequency conversion, navigational aids and sound recording systems.

**The CINTEC FREQUENCY & VOLTAGE STABILIZER** is also available for supplies of 100-125 volts, 45-65Hz with an alternative output of 50Hz or 60Hz at 115 volts or 230 volts and as a dual frequency model with a switchable output of 50Hz or 60Hz

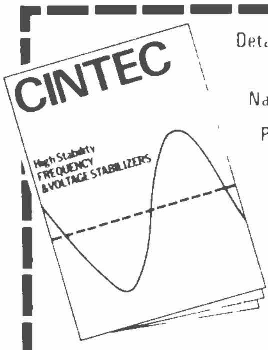
The Stabilizer may also be used as a frequency converter. For example, the supply to it can be any frequency between 45-65Hz and the output can be switched to either 50Hz or 60Hz

## SPECIFICATION

| | | |
|---|---|---|
| INPUT | | 100-125 volts or 200 250 volts at 45 65Hz |
| OUTPUT | | 115 volts or 230 volts |
| RATING | | 500A Or 250VA |
| STABILITY | Voltage | ± 1% No load to full load — |
| | Frequency | ± 0 01% No load to full load |
| FREQUENCY | | 50Hz or 60Hz Single or dual versions |
| WAVEFORM | | SINUSOIDAL |
| DISTORTION | | 2% |
| AMB TEMP | | −20 to + 40 C |
| DUTY | | Continuous |
| DIMENSIONS | | 432 (W) x 196 (H) x 508mm (D) (17" x 7¾" x 20") |
| WEIGHT | | 45 or 30Kg unpacked |
| CONSTRUCTION | | Cabinet or rack mounting |
| TERMINATION | | Cannon Connectors at rear of case (in catalogue) |

**24V DC Inverter**

In addition to the A C operated models, a 24v D C INVERTER Stabilizer is available which operates from a heavy duty 24 volt battery and has output ratings similar to the A C models. This type of Stabilizer is particularly suitable for mobile operation

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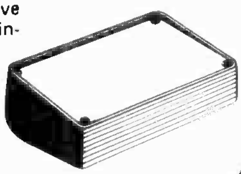
# BIMCONSOLES
# BIMBOXES
# BIMBOARDS
# BIMDRILLS
# BIMDICATORS

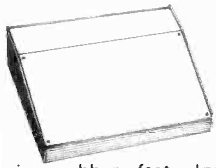
## MINI DESK BIMCONSOLES

Moulded in Orange, Blue, Black or Grey ABS and incorporating guides on all sides for holding 1.5mm thick pcb's. 1mm Grey Aluminium panel sits recessed into front of console and held by screws running into integral brass bushes. Stand-off bosses in base for supporting small sub-assemblies etc. 4 self adhesive rubber feet also included.

BIM1005 (161x96x58mm) £1.97*
BIM1006 (215x130x75mm) £2.70*



## LOW PROFILE BIMCONSOLES

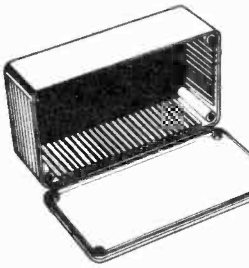


1mm Grey Aluminium panel sits recessed into front of console base, which is moulded in Orange, Blue, Black or Grey ABS and sits on 4 self adhesive rubber feet. Incorporating guides for holding 1.5mm thick pcb, the base also has stand-off bosses for supporting small sub-assemblies etc. and ventilation slots. Front panel is held by 4 screws which run into integral brass bushes.

BIM6005 (143x105x55.5[31.5] mm) £2.14*
BIM6006 (143x170x55.5[31.5] mm) £2.73*
BIM6007 (214x170x82[31.5] mm) £3.75*

## ABS & DIECAST BIMBOXES

5 sizes, in either ABS or Diecast Aluminium
ABS moulded in Orange, Blue, Grey or Black
Diecast Aluminium available in Grey Hammertone or Natural



All boxes incorporate guides on all sides for holding 1.5mm thick pcb's and stand-off bosses in base for supporting small sub-assemblies etc. Close fitting flanged lids held by screws running into integral brass bushes (ABS) or tapped holes (Diecast).

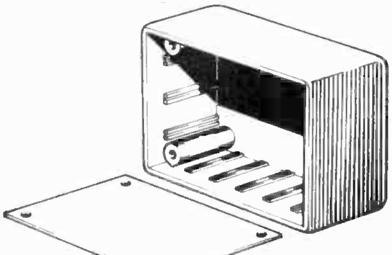
| | ABS | | Diecast | Hammertone | Natural |
|---|---|---|---|---|---|
| (100x50x25mm) | BIM2002/12 | £0.87* | BIM5002/12 | £1.20* | £0.97* |
| (112x62x31mm) | BIM2003/13 | £0.97* | BIM5003/13 | £1.50* | £1.20* |
| (120x65x40mm) | BIM2004/14 | £1.05* | BIM5004/14 | £1.86* | £1.49* |
| (150x80x50mm) | BIM2005/15 | £1.18* | BIM5005/15 | £2.38* | £1.91* |
| (190x110x60mm) | BIM2006/16 | £1.84* | BIM5006/16 | £3.41* | £2.85* |

Also available in Grey Polystyrene (112x61x31mm) with no slots and self tapping screws BIM2007/17 £0.82*

## MULTI-PURPOSE BIMBOXES

Moulded in Orange, Blue, Black or Grey ABS with 1mm thick Grey aluminium recessed front cover which is retained by 4 screws running into integral brass bushes. 1.5mm pcb guides are incorporated on all sides and as with all ABS boxes they are 85°C rated. 4 self adhesive rubber feet also included.

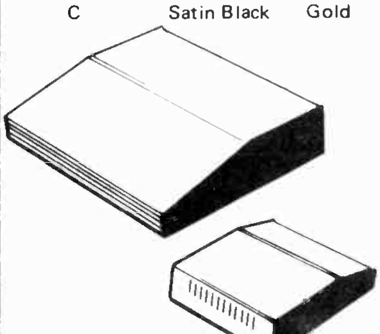
| | | |
|---|---|---|
| BIM 4003 | (85x56x28.5mm) | £1.13* |
| BIM 4004 | (111x71x41.5mm) | £1.42* |
| BIM 4005 | (161x96x52.5mm) | £1.87* |



## ALL METAL BIMCONSOLES

All aluminium, 2 piece desk consoles with either 15° or 30° sloping fronts, sit on 4 self-adhesive non slip rubber feet. Ventilation slots in base and rear panels permit efficient cooling.

| Colour Code | Top Panel | Base |
|---|---|---|
| A | Off White | Blue |
| B | Sand | Green |
| C | Satin Black | Gold |



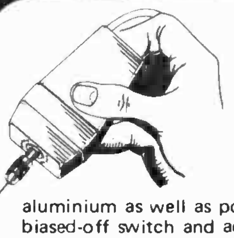
15° Sloping Panel

| | | |
|---|---|---|
| BIM7151 | (102x140x51[28] mm) | £ 9.43 |
| BIM7152 | (165x140x51[28] mm) | £10.43 |
| BIM7153 | (165x216x51[28] mm) | £11.42 |
| BIM7154 | (165x211x76[33] mm) | £12.39 |
| BIM7155 | (254x211x76[33] mm) | £13.66 |
| BIM7156 | (254x287x76[33] mm) | £14.65 |
| BIM7157 | (356x211x76[33] mm) | £15.80 |
| BIM7158 | (356x287x76[33] mm) | £16.78 |

30° Sloping Panel

| | | |
|---|---|---|
| BIM7301 | (102x140x76[28] mm) | £ 9.43 |
| BIM7302 | (165x140x76[28] mm) | £10.43 |
| BIM7303 | (165x183x102[28] mm) | £11.42 |
| BIM7304 | (254x140x76[28] mm) | £12.39 |
| BIM7305 | (254x183x102[28] mm) | £13.66 |
| BIM7306 | (254x259x102[28] mm) | £14.65 |
| BIM7307 | (356x183x102[28] mm) | £15.80 |
| BIM7308 | (356x259x102[28] mm) | £16.78 |

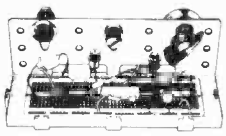
## MAINS BIMDRILL

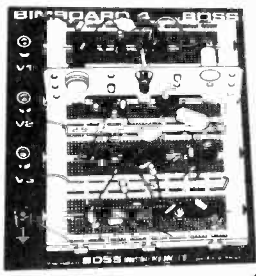


Operates directly from 220-240Vac and supplied with 2 metres long cable fitted with 2 pin DIN plug. Will drill brass, steel and aluminium as well as pcb's etc. Has integral biased-off switch and accepts tools with 1,2 and 3.2mm dia shanks £9.72*
Accessory Kit including 1mm, 2mm, .125" twist drills, 5 burrs and 2.4mm collet £2.20*

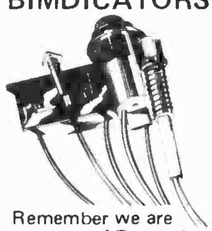
## DIL COMPATIBLE BIMBOARDS

Bimboards accept all sizes of DIL packages as well as resistors, diodes, capacitors and LED's etc. They have integral Bus Strips running up each side for carrying Vcc and ground as well as Component Support Brackets for holding lamps, fuses and switches etc. Available as either single or multiple units, the latter mounted on 1.5mm thick, matt black aluminium back plates which stand on non slip rubber feet and have 4 screw terminals for incoming power.
Bimboard 1 contains 500 individual sockets whereas the multiple units containing 2, 3 or 4 Bimboards incorporate 1,100, 1,650 or 2,200 individual sockets, all arranged on a 2.5mm(0.1") matrix.
Bimboard 1 £ 9.72* Bimboard 2 £22.68*
Bimboard 3 £32.40* Bimboard 4 £42.12*





## BIMDICATORS



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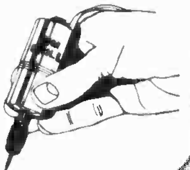
2 small but powerful 12V dc drills, easily held in hand or used with lathe/stand adaptor. Both drills have integral on/off switches and 1 metre long cable.
Mini Bimdrill with 2 collets up to 2.4mm capacity £7.56*
Major Bimdrill with 3 collets up to 3mm capacity £12.96*
Mains to 12 Volts adaptor, lathe, stand and accessory kits also available, details on request.



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Not a win on the pools, a trip to a Pacific paradise, or a reduction in income tax, but distortionless "current dumping".

Z's 1 to 4 are the four passive components which interconnect the current dumpers, (the output transistors which supply the power), to the small high quality amplifier which provides the error signal, so that when the above condition is met the current in the load, the loudspeaker, is independent of the current in the dumpers and hence distortion is solely dependent on the quality of the error amplifier, which because it is small can be very good.

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For further details on current dumping and other Quad products write to Dept. WW
The Acoustical Manufacturing Co. Ltd., Huntingdon, Cambs., PE18 7DB Telephone (0480) 52561

**"Something wonderful happens when $Z_1Z_3=Z_2Z_4$"** *


* Elektor Electronics Magazine No. 8. Dec. 1975

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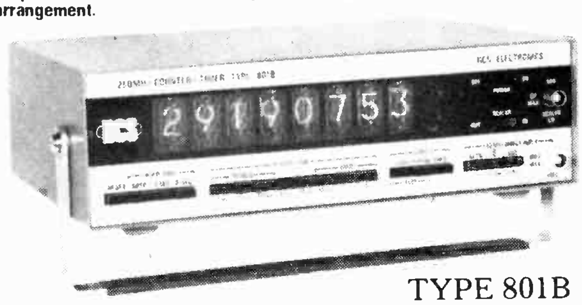
AVOMETER 8

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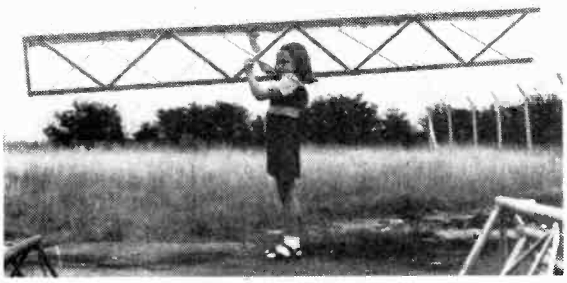

IT'S:
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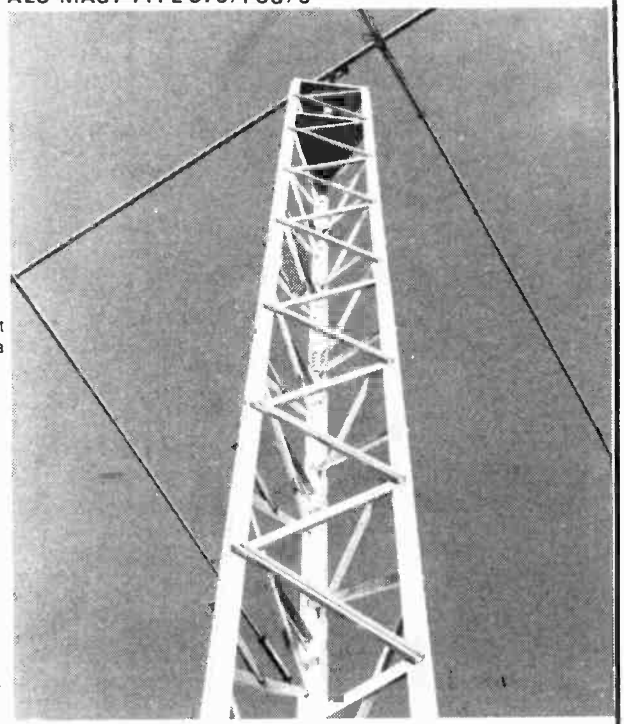

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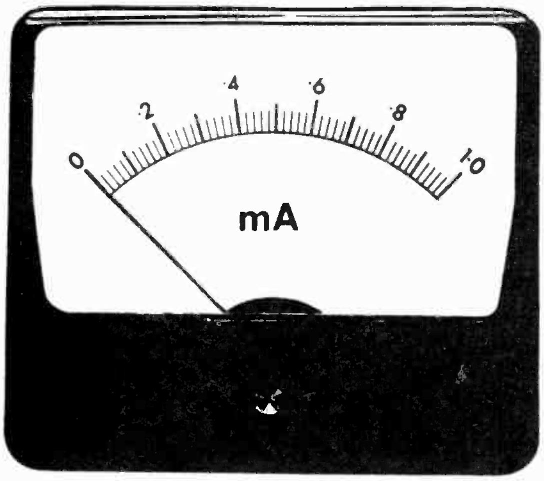
WW—048 FOR FURTHER DETAILS

# METER PROBLEMS?

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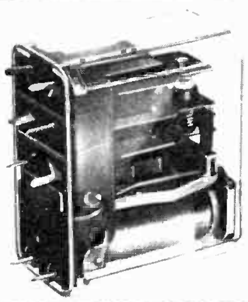

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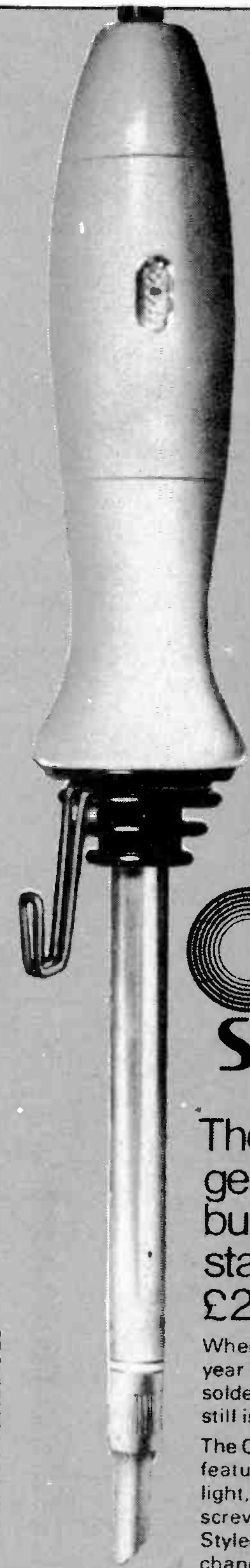

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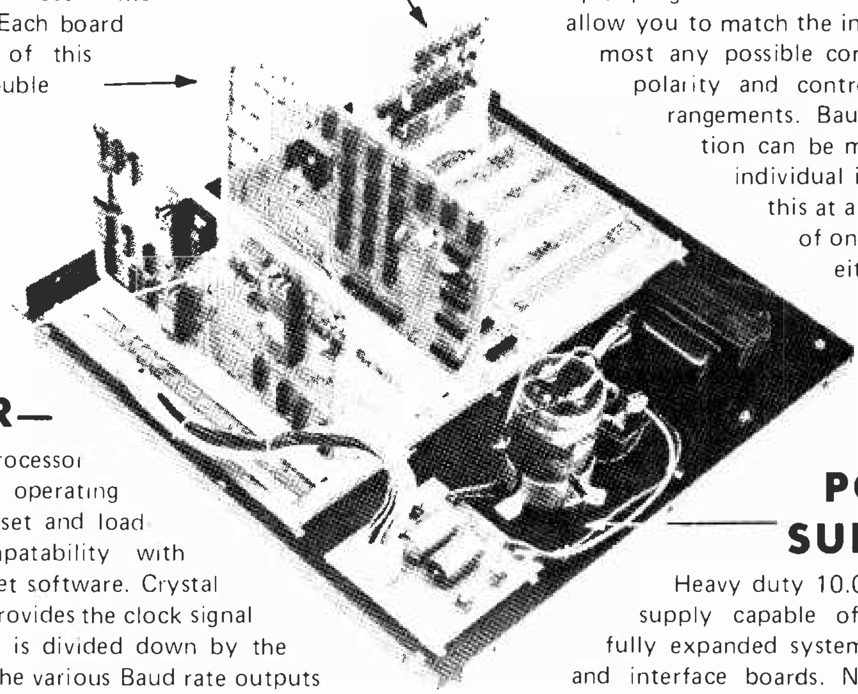

## PROCESSOR—

"Motorola" M6800 processor with Mikbug® ROM operating system. Automatic reset and loading, plus full compatability with Motorola evaluation set software. Crystal controlled oscillator provides the clock signal for the processor and is divided down by the MC14411 to provide the various Baud rate outputs for the interface circuits. Full buffering on all data and address busses insures "glitch" free operation with full expansion of memory and interfaces.

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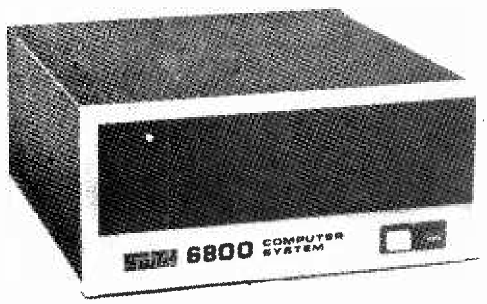


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| TBA120 | FM IF | 0.75 |
| TBA120S | FM IF | 1.00 |
| sn76660n | FM IF | 0.75 |
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| CA3123E | AM rad | 1.40 |
| HA1197 | AM rad | 1.40 |
| TBA651 | AM rad | 1.81 |
| MC1350 | agc gain | 1.00 |
| ua753 | fm gain | 1.80 |
| LM1496 | Bal mix | 1.25 |
| MC1310P | mpx dec | 2.20 |
| KB4400 | as above | 2.20 |
| ca3090aq | mpx dec | 4.35 |
| HA1196 | mpx dec | 4.20 |
| LM380 | 2w AF | 1.00 |
| LM381 | preamp | 1.81 |
| tda2020 | 15w AF | 2.99 |
| tca940E | 10w AF | 1.80 |
| tba810as | 7w AF | 1.08 |
| LM301an | op amp | 0.39* |
| ua741 | op amp | 0.34* |
| LM3900 | op amp | 0.68* |
| 7805uc | 5v/1amp | 1.55* |
| tda1412 | 12v/½A | 0.95* |
| 78M20 | 20v/½A | 1.20* |
| 78M24 | 24v/½A | 1.20* |
| ua723cn | variable | 0.80* |
| NE550a | as above | 0.80* |
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| icl8038cc | sig gen | 4.50* |
| NE555v | timer | 0.70* |
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| NE567v | tone dc | 2.50* |
| NE560B | hf pll | 3.50* |
| NE561B | hf pll | 3.50* |
| NE565K | lf pll | 2.50* |
| MC1312 | quad | 1.50 |
| 11C90 | 650mhz | 14.00* |
| ZTX107 | 50v/.3w | 0.14 |
| ZTX108 | 30v/.3w | 0.14 |
| ZTX109 | 30v/.3w | 0.14 |

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|---|---|---|
| BC413 | lo noise | 0.18 |
| 40238 | shld RF | 0.25* |
| BF224 | .6ghz RF | 0.22 |
| BF274 | .7ghz RF | 0.18 |
| ZTX212 | 50v/.3w | 0.17 |
| ZTX213 | 30v/.3w | 0.16 |
| ZTX214 | 30v/.3w | 0.17 |
| ZTX451 | 60v/1w | 0.18 |
| ZTX551 | 60v/1w | 0.18 |
| BD515 | 45v/10w | 0.27 |
| BD516 | 45v/10w | 0.30 |
| BD535 | 60v/50w | 0.52 |
| BD536 | 60v/50w | 0.53 |
| BD609 | 80v/90w | 0.70 |
| BD610 | 80v/90w | 1.20 |
| BF256 | 1ghz fet | 0.34 |
| E176 | p ch swt | 0.38 |
| MEM614 | (40822) | 0.38* |
| MEM616 | (40673) | 0.67* |
| MEM680 | lo noise | 0.75* |
| BA102 | vhf varic | 0.30 |
| BA121 | vhf varic | 0.30 |
| BB104 | dual var. | 0.45 |
| BB105 | uhf varic | 0.40 |
| mvam2 | dual AM | 1.48 |
| mvam115 | 15v/AM | 1.05 |
| mvam125 | 25v/AM | 0.90 |

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| AM IFts with cap | | 0.30 |
| FM IFts with cap | | 0.33 |
| eg | | |
| YHCS11098AC2 | | 0.30 |
| YHCS12374AC2 | | 0.30 |
| YHCS11100AC2 | | 0.30 |
| KALS4520A | | 0.33 |
| KACSK586HM | | 0.33 |
| LLC238 | 7mm | 0.33 |
| LLC4827 | 7mm | 0.33 |
| LLC4828 | 7mm | 0.33 |
| CFS10.7 ceramic | | 0.50 |
| BLR3107N | mpx | 1.90 |
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| 7408 | 16p | 7444 | £1.10 | 7493 | 40p | 74161 | 88p | 74199 | £1.80 |
| 7409 | 16p | 7445 | 78p | 7494 | 87p | 74162 | 88p | 74293 | £1.35 |
| 7410 | 15p | 7446 | 83p | 7495 | 60p | 74163 | 88p | | |
| 7411 | 20p | 7447A | 74p | 7496 | 69p | 74164 | £1 | | |
| 7412 | 21p | 7448 | 68p | 74100 | 94p | 74165 | £1 | | |
| 7413 | 28p | 7450 | 15p | 74107 | 30p | 74166 | £1.23 | | |
| 7414 | 60p | 7451 | 15p | 74109 | 50p | 74170 | £1.95 | | |
| 7416 | 30p | 7453 | 15p | 74121 | 25p | 74173 | £1.45 | | |
| 7417 | 30p | 7454 | 15p | 74123 | 60p | 74174 | 99p | | |
| 7420 | 15p | 7460 | 15p | 74125 | 50p | 74175 | 74p | | |
| 7421 | 35p | 7470 | 30p | 74126 | 50p | 74176 | 99p | | |
| 7422 | 20p | 7472 | 25p | 74132 | 75p | 74177 | 99p | | |
| 7425 | 20p | 7473 | 30p | 74135 | 68p | 74179 | £1.38 | | |
| 7426 | 25p | 7474 | 30p | 74141 | 60p | 74180 | 99p | | |
| 7427 | 25p | 7475 | 30p | 74145 | 72p | 74181 | £1.95 | | |
| 7428 | 35p | 7476 | 30p | 74147 | £1.40 | 74184 | £1.45 | | |
| | | 7480 | 50p | 74148 | £1.58 | 74185A | £1.45 | | |
| | | 7481 | 98p | 74150 | £1.58 | 74190 | £1.38 | | |

**CMOS**

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|---|---|---|---|---|---|
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| 4001 | 19p | 4026 | £1.65 | 4075 | 23p |
| 4002 | 19p | 4027 | 60p | 4081 | 19p |
| 4006 | £1 | 4028 | 86p | 4093 | 80p |
| 4007 | 19p | 4029 | £1.16 | 4501 | 20p |
| 4008 | 98p | 4030 | 55p | 4502 | 95p |
| 4010 | 56p | 4031 | £2.34 | 4507 | 60p |
| 4011 | 19p | 4033 | £1.50 | 4508 | £2.84 |
| 4012 | 19p | 4034 | £2 | 4511 | £1.50 |
| 4013 | 50p | 4035 | £1.28 | 4518 | £1.13 |
| 4014 | £1 | 4036 | £2.40 | 4520 | £1.26 |
| 4016 | 50p | 4037 | 99p | 4527 | £1.60 |
| 4017 | 95p | 4038 | £1 | 4528 | £1.05 |
| 4018 | £1 | 4040 | £1 | 4536 | £3.85 |
| 4019 | 52p | 4041 | 86p | 4555 | 85p |
| 4020 | £1.05 | 4042 | 80p | 4556 | 85p |
| 4021 | 95p | 4043 | 95p | 4583 | 80p |
| 4022 | 95p | 4044 | 99p | | |
| 4023 | 19p | 4046 | £1.32 | | |
| 4024 | 75p | 4047 | 96p | | |
| | | 4048 | 63p | | |
| | | 4049 | 55p | | |
| | | 4050 | 50p | | |
| | | 4052 | 92p | | |
| | | 4053 | 95p | | |
| | | 4054 | £1.10 | | |
| | | 4060 | £1.10 | | |
| | | 4066 | 50p | | |
| | | 4069 | 24p | | |
| | | 4070 | 38p | | |
| | | 4071 | 25p | | |

**OP AMPS**

| | |
|---|---|
| 301A 8 | 35p |
| 709 14 | 46p |
| 741 8 | 22p |
| 741 14 | 20p |
| 741 TO99 | 48p |
| 747 14 | 70p |
| 3900 | 50p |

**VOLTAGE REGS**

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|---|---|
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| 309K TO3 | £1.30 |
| 723 14 | 46p |
| 7805 TO220 | £1.30 |
| 7812 TO220 | £1.30 |
| 7815 TO220 | £1.30 |
| 7905 TO220 | £1.95 |
| 7912 TO220 | £1.95 |
| 7915 TO220 | £1.95 |

**LINEAR**

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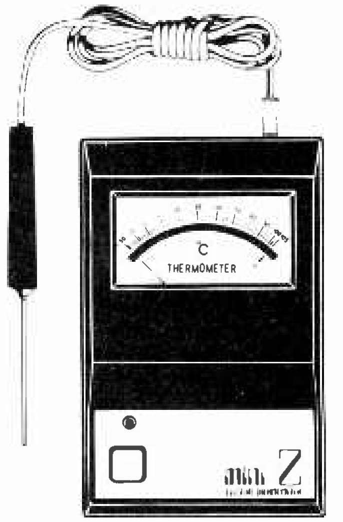
|---|---|
| TAA550B | 35p |
| TAA661B | £1.40 |
| TBA120S | 68p |
| TBA641A | £1.88 |
| TBA800 | 90p |
| TBA810S | £1.16 |
| TCA270SQ | £2.21 |
| TDA2020 | £3.56 |
| 380 14 | £1 |
| 555 8 | 36p |
| 556 14 | 80p |
| 710 14 | 32p |
| 711 14 | 32p |
| 1310 14 | £1.78 |
| 2501B | £2.20 |
| 3045 14 | 45p |

**All Prices include V.A.T.**

WW—029 FOR FURTHER DETAILS

# ELECTRONIC INDUSTRIAL THERMOMETER

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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 with carrying case, Probe and internal 1½ volt standard size battery.

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(Phone 01-837 7937)

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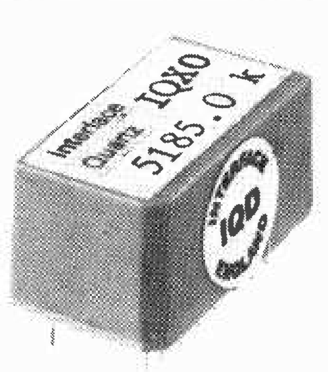


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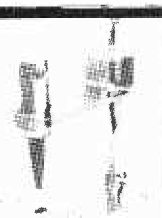
Write or phone for full details Price **£10** inc VAT P&P £1

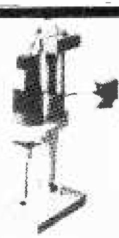
## S2 Drill Stand



Robust all metal with ample throat dimensions Adjustable height can [illegible] ever with lever [illegible] feed Spring return Will accept both P1 & P2 drills

Price **£18.50** inc VAT P&P 106p
P2 Drill **£16.50** inc VAT P&P 86p

## S1 Drill Stand



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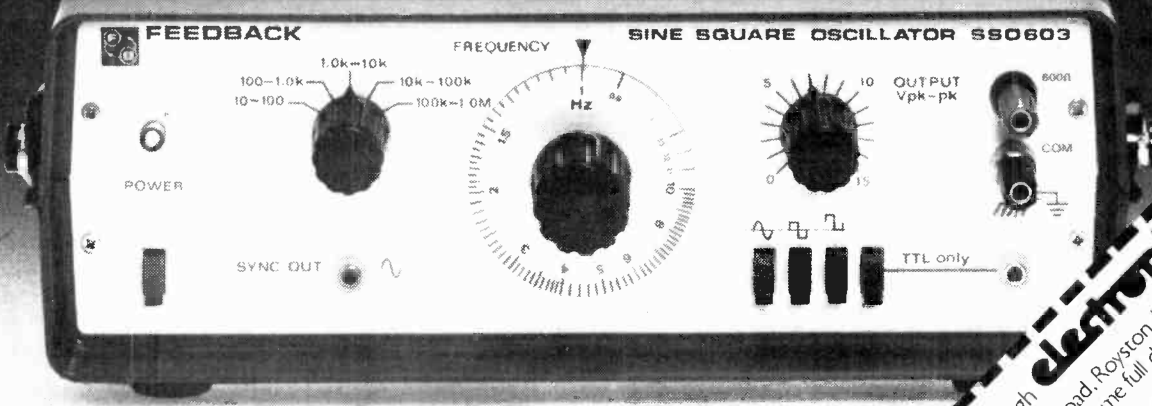


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# carbon film RESISTORS

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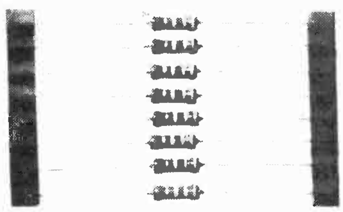

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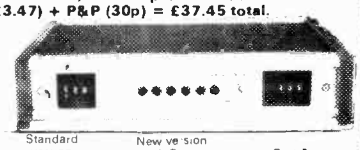
Catronics

# NEW FACILITIES
AVAILABLE FOR
# WW TELETEXT DECODER

**'Board 3' is now available as an additional unit to update the *'Wireless World'* Teletext Decoder to give double height characters, colour background, conceal/reveal, etc., as described in last month's issue of *'Wireless World.'* Our Kit includes plated-through hole P.C.B., all components and installation instructions. Price £33.68 + VAT (£3.47) + P&P (30p) = £37.45 total.**



Our main kits contain all the printed circuit boards and components necessary to build the complete decoder.

A reprint of the series of articles is available at £1.50 + large 15p SAE (included free in complete kit).

| PRICES INCLUDE VAT | Standard version using 2513 | New version with Texas X887 | Post & Packing |
|---|---|---|---|
| **Set of 5 PCBs** | £21.70 | £21.65 | 30p |
| **Component Kit (incl. PCBs)** | £120.95 | £133.70 | £1.50 |
| **Add-on Unit for lower case PCB** | £2.70 | — | — |
| **Component Kit (incl. PCB)** | £13.75 | — | — |
| **Cabinet** | £14.85 | £14.85 | £1.00 |

**PLATED THROUGH hole PCBs for TEXAS version only at additional cost of £27.00**
**COMPONENTS ALSO AVAILABLE SEPARATELY — SAE for price list**
**READY BUILT & TESTED DECODERS — £241.87 + £5 Carr.**
**DE LUXE VERSION WITH NEW FACILITIES — £292.50 + £5 Carr.**

# WW MATRIX H DECODER

Based on the design for a MATRIX H DECODER published in June issue of *Wireless World*, with subsequent corrections, this Catronics Decoder is now generally available from stock in two versions:
**Kit: comprising P.C.B.s, i.c. and all components to mount on the boards at £39.30.**
**Ready built: housed in attractive cabinet with integral power supply and STEREO/QUAD switching at £89.37**
**These prices include Sansui Royalty Fee, VAT and P&P.**


# VHF FREQUENCY COUNTERS

**200MHz, 7 digit, D.F.M.** for direct readings up to the mobile radio VHF High Band
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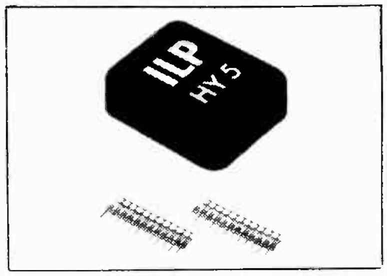
WW—821 FOR FURTHER DETAILS

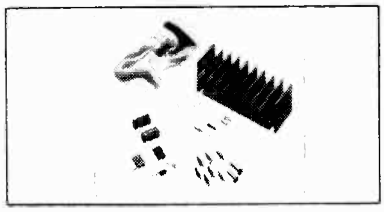
# 15—240 Watts!

## HY5
### Preamplifier



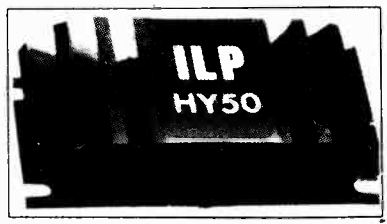

The HY5 is a mono hybrid amplifier ideally suited for all applications. All common input functions (mag Cartridge, tuner, etc.), are catered for internally, the desired function is achieved either by a multi-way switch or direct connection to the appropriate pins. The internal volume and tone circuits merely require connecting to external potentiometers (not included). The HY5 is compatible with all I.L.P. power amplifiers and power supplies. To ease construction and mounting a P.C. connector is supplied with each pre-amplifier.
**FEATURES:** Complete pre-amplifier in single pack — Multi-function equalization — Low noise — Low distortion — High overload — two simply combined for stereo
**APPLICATIONS:** Hi-Fi — Mixers — Disco — Guitar and Organ — Public address
**SPECIFICATIONS:**
INPUTS Magnetic Pick-up 3mV. Ceramic Pick-up 30mV. Tuner 100mV. Microphone 10mV. Auxiliary 3-100mV. input impedance 47kΩ at 1kHz
OUTPUTS Tape 100mV. Main output 500mV R.M.S.
ACTIVE TONE CONTROLS Treble ± 12dB at 10kHz. Bass ± at 100Hz
DISTORTION 0.1% at 1kHz. Signal/Noise Ratio 68dB
OVERLOAD 38dB on Magnetic Pick-up. SUPPLY VOLTAGE ± 16-50V
**Price £5.22 + 65p VAT P&P free**
HY5 mounting board B1 48p + 6p VAT P&P free

## HY30
### 15 Watts into 8Ω



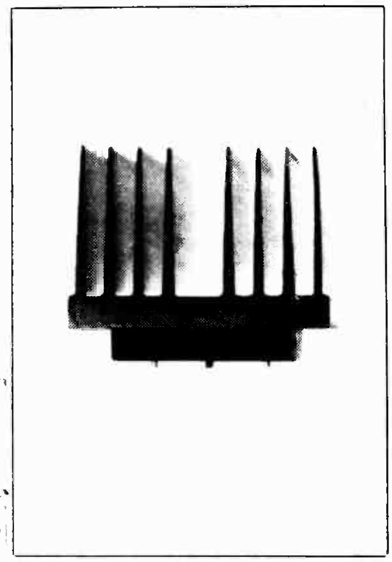
The HY30 is an exciting New kit from I.L.P. It features a virtually indestructible I.C. with short circuit and thermal protection. The kit consists of I.C., heatsink, P.C. board, 4 resistors, 6 capacitors, mounting kit, together with easy to follow construction and operating instructions. This amplifier is ideally suited to the beginner in audio who wishes to use the most up-to-date technology available.
**FEATURES:** Complete kit — Low Distortion — Short, Open and Thermal Protection — Easy to Build
**APPLICATIONS:** Updating audio equipment — Guitar practice amplifier — Test amplifier — Audio oscillator
**SPECIFICATIONS:**
OUTPUT POWER 15W R.M.S. into 8Ω. DISTORTION 0.1% at 15W
INPUT SENSITIVITY 500mV. FREQUENCY RESPONSE 10Hz-16kHz — 3dB
SUPPLY VOLTAGE ± 18V
**Price £5.22 + 65p VAT P&P free.**

## HY50
### 25 Watts into 8Ω




The HY50 leads I.L.P.'s total integration approach to power amplifier design. The amplifier features an integral heatsink together with the simplicity of no external components. During the past three years the amplifier has been refined to the extent that it must be one of the most reliable and robust High Fidelity modules in the World.
**FEATURES:** Low Distortion — Integral Heatsink — Only five connections — 7 Amp output transistors — No external components
**APPLICATIONS:** Medium Power Hi-Fi systems — Low power disco — Guitar amplifier
**SPECIFICATIONS:** INPUT SENSITIVITY 500mV
OUTPUT POWER 25W RMS in 8Ω. LOAD IMPEDANCE 4-16Ω. DISTORTION 0.04% at 25W at 1kHz
SIGNAL/NOISE RATIO 75dB. FREQUENCY RESPONSE 10Hz-45kHz — 3dB
SUPPLY VOLTAGE ± 25V. SIZE 105.50.25mm
**Price £6.82 + 85p VAT P&P free**

## HY120
### 60 Watts into 8Ω

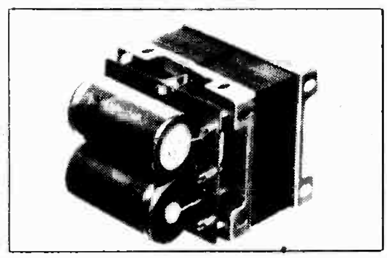


The HY120 is the baby of I.L.P.'s new high power range, designed to meet the most exacting requirements including load line and thermal protection, this amplifier sets a new standard in modular design.
**FEATURES:** Very low distortion — Integral Heatsink — Load line protection — Thermal protection — Five connections — No external components
**APPLICATIONS:** Hi-Fi — High quality disco — Public address — Monitor amplifier — Guitar and organ
**SPECIFICATIONS:**
INPUT SENSITIVITY 500mV
OUTPUT POWER 60W RMS into 8Ω. LOAD IMPEDANCE 4-16Ω. DISTORTION 0.04% at 60W at 1 kHz
SIGNAL/NOISE RATIO 90dB. FREQUENCY RESPONSE 10Hz-45kHz —3dB. SUPPLY VOLTAGE ± 35V
Size 114 x 50 x 85mm.
**Price £15.84 + £1.27 VAT P&P free.**

## HY200
### 120 Watts into 8Ω

The HY200 now improved to give an output of 120 Watts, has been designed to stand the most rugged conditions, such as disco or group while still retaining true Hi-Fi performance.
**FEATURES:** Thermal shutdown — Very low distortion — Load line protection — Integral Heatsink — No external components
**APPLICATIONS:** Hi-Fi — Disco — Monitor — Power Slave — Industrial — Public address
**SPECIFICATIONS:**
INPUT SENSITIVITY 500mV
OUTPUT POWER 120W RMS into 8Ω. LOAD IMPEDANCE 4-16Ω. DISTORTION 0.05% at 100W at 1kHz
SIGNAL/NOISE RATIO 96dB. FREQUENCY RESPONSE 10Hz-45kHz — 3dB. SUPPLY VOLTAGE ± 45V
SIZE 114 x 100 x 85mm
**Price £23.32 + £1.87 VAT P&P free.**

## HY400
### 240 Watts into 4Ω



The HY400 is I.L.P.'s "Big Daddy" of the range producing 240W into 4Ω! It has been designed for high power disco or public address applications. If the amplifier is to be used at continuous high power levels a cooling fan is recommended. The amplifier includes all the qualities of the rest of the family to lead the market as a true high power hi-fidelity power module.
**FEATURES:** Thermal shutdown — Very low distortion — Load line protection — No external components
**APPLICATIONS:** Public address — Disco — Power slave — Industrial
**SPECIFICATIONS:**
OUTPUT POWER 240W RMS into 4Ω. LOAD IMPEDANCE 4-16Ω. DISTORTION 0.1% at 240W at 1 kHz
SIGNAL/NOISE RATIO 94dB. FREQUENCY RESPONSE 10Hz-45kHz — 3dB. SUPPLY VOLTAGE ± 45V
INPUT SENSITIVITY 500mV. SIZE 114 x 100 x 85mm
**Price £32.17 + £2.57 VAT P&P free.**

## POWER SUPPLIES

PSU36 suitable for two HY30's **£5.22** plus 65p VAT P/P free
PSU50 suitable for two HY50's **£6.82** plus 85p VAT P/P free
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PSU90 suitable for one HY200 **£12.65** plus £1.01 VAT P/P free
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# EUROTECH

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| Fribourge Charge Amp Type TA-3/D | £85 |
| SE Labs 19" Rack Comprising OSC Type 511/S and 6 off Carrier Amps Type 423/1 | £350 |
| 6v 25 Amp. Power Supply Units | £25 |
| D.M. Digital Voltmeter. Type 2022S | £240 |
| Electro Scientific Industries Portametric PVB 300 | £180 |
| Stanley Lab. Counter Timer SL111 | £350 |
| Flure 8800A D.V.M. | £500 |

## OSCILLOSCOPES

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| Type 551 with Power Supply | £350 |
| Type 545A with 1A2 Dual Trace Amp | £485 |
| Type 585 with Type 82 Dual Trace | £550 |
| Type 581A with Type 82 Dual Trace | £550 |
| Type 7603 | P.O.A. |
| Type 7313 | P.O.A. |
| Plug in Modules | |
| Type CA, G, H, L, K | £80 each |
| Type 3A75 Amp. 4MHZ | £80 |
| 3A8 Operational Amp | £75 |
| 3T77 and 3S76 Sampling | £250 |
| 82 Dual Trace Amp | £135 |
| 1A4 Four Trace Amplifier | £550 |

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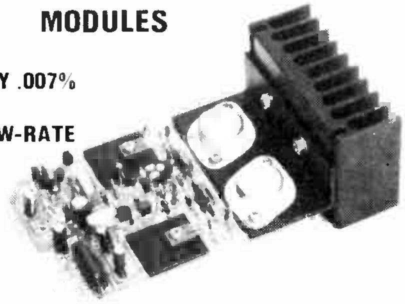
# AUDIBLY SUPERIOR AMPLIFICATION

## HIGH DEFINITION — 'MUSICAL' — POWER AMP MODULES



★ **T.H.D. TYPICALLY .007% @ 10W, 500Hz**

★ **ZERO T.I.D. (SLEW-RATE LIMIT 16 V/μS)**

Module size:
120 × 80 × 25 mm. using glass fibre pcb with ident and solder resist.
**Illustrated with light duty heatsink.**

CRIMSON ELEKTRIK power amplifier modules are fast gaining a reputation as the best sounding, most musical modules available. Perhaps the most important features of this design are exceptional freedom from crossover distortion (due to the use of output triples) and zero T.I.D. The amplifier is protected against open and short circuit loads and yet will drive a highly reactive lower impedance load, which is more representative of a real loudspeaker. Square waves maintain their rise times up to full power whilst simulated electrostatic loads are easily handled, with negligible overshoot and a settling time of 12 S. Other specs S N · 110dB. Rise time 10 S. Sensitivity 775mV. DC coupled 5Hz 35kHz -3dB. THD · 015% 100mW-clipping, 500Hz.

CRIMSON ELEKTRIK power supplies are in kit form for maximum flexibility and feature a low field slimline toroidal transformer with a 120-240v primary and screen, two large capacitors, bridge rectifier and all fixings.

Heatsinks are attractive black anodised extrusions, 80mm wide.

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| **POWER AMP MODULES** | | | |
| CE 608 60Wrms/8 ohms | 35v dc | £16.30 | £16.30 |
| CE 1004 100Wrms/4 ohms | 35v dc | £19.22 | £19.00 |
| CE 1008 100Wrms/8 ohms | 45v dc | £23.22 | £22.70 |
| **POWER SUPPLIES** | | | |
| CPS 1 For 2xCE608 or 1xCE1004 | | £12.85 | £14.20 |
| CPS 2 For 2xCE1004 or 2 or 4xCE608 | | £14.55 | £17.90 |
| CPS 3 For 2xCE1008 | | £15.85 | £19.20 |
| **HEATSINKS** | | | |
| Light Duty | 50mm 2 C/W | .90 | £1.30 |
| High power | 100 mm 1.4° C/W | £1.60 | £2.40 |
| Disco/group | 1500mm 1.1° C/W | £2.30 | £3.65 |

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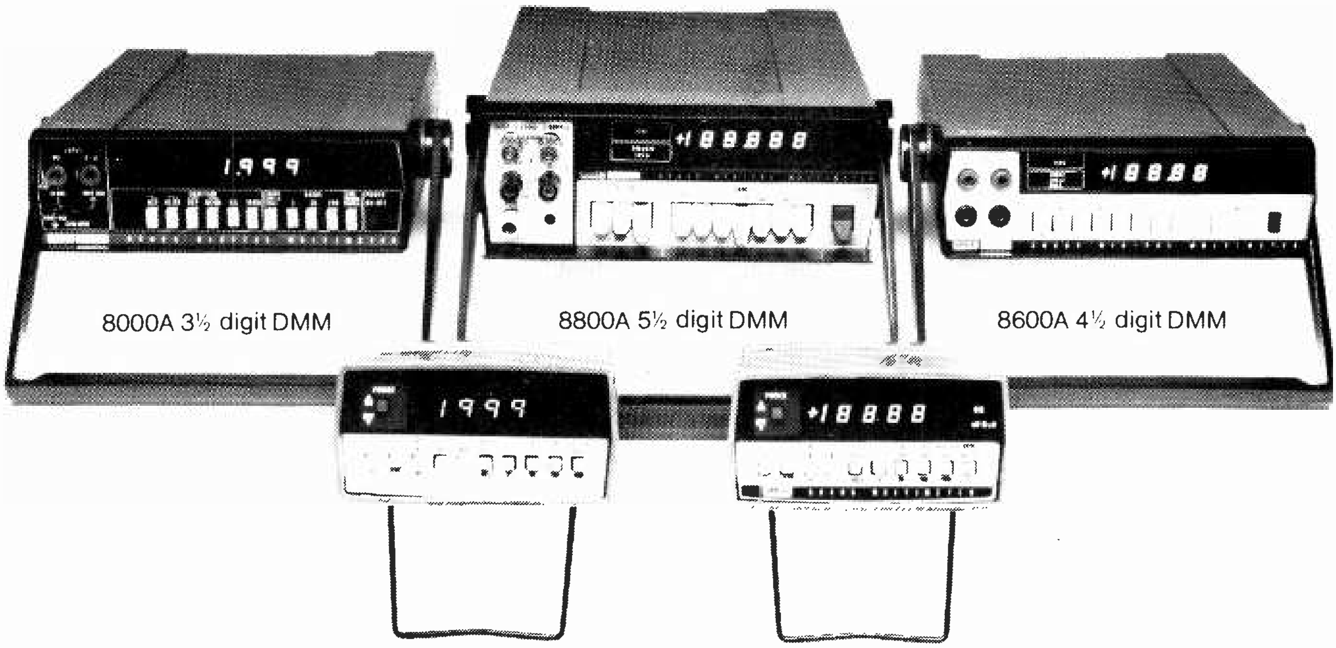


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# wireless world



## Testing time for the video disc

THIS YEAR the public will be presented with a new electronic toy – the video disc. After five years of development the Philips/MCA optical system has emerged as a front-runner and will be marketed as a commercial product in the USA in 1978 and in Europe in 1979. It's a front-runner because it obviously works well, is presentable and convenient as a piece of consumer equipment, offers discs recorded on both sides, has the backing of a large programme library, and has imbued the managements of Philips and MCA with enough confidence to start a large-scale marketing campaign. Of course, it's not the first. The Telefunken/Decca mechanical system was launched commercially in Germany in 1975; but sales so far have been disappointing and it would be very surprising if this system, with its limited playing time of ten minutes, gained wide acceptance.

The only question hanging over the Philips/MCA product – and indeed any video disc system that might emerge – is whether the public will buy it. This question can be divided into two parts: (a) do they want it? and (b) can they afford it? Philips/MCA are convinced that both of these can be answered in the affirmative. First of all they are starting their marketing operations in the richest parts of the world – the USA and Western Europe – where the greatest amount of disposable income lies waiting to be tapped; it's only a matter of calculation. Secondly, in such a situation, whether people want something they have not yet possessed or experienced is only an academic point: there are well known techniques for persuading them that they *do* want it. Nonetheless the makers are well aware that there are other, competing claims for even the largest disposable income. At the recent Video Disc 77 conference in London the Philips principal speaker, Mr W. Zeiss, said of the programmes "There are limits to the extent to which consumers may wish to purchase such material." One of the directly competing products in this field is, of course, the video cassette, with its ability to record as well as play programmes. Will there be enough room for both systems in the market?

What is inevitably lacking at the moment is knowledge of the way the user will respond to this new type of information medium. It's tempting to draw on experience with the gramophone record, since video and audio discs and their players are superficially similar. Can one expect people to develop behaviour patterns of watching visual programmes similar to those of listening to recorded music? Compared with gardening or playing football, both are passive, indoor leisure activities, but there the resemblance ends. Music is a direct emotional and aesthetic experience; it requires very little semantic content to have its effect, only the formalities of rhythm, melody, harmony etc. Moving pictures, on the other hand, have their effect on the emotions or intellect very strongly through their semantic content – the story, drama, explanation or whatever is going on: the direct experience of colour, pattern and so on, although it can be an aesthetic end in itself in the viewing of beautiful objects or scenes, is largely a means of getting the message across.

Nevertheless the two different types of record do have one thing in common – sound. An eminent broadcaster was heard to say the other day "Of course I regard the video disc as really only a gramophone record with illustrations." No doubt he was motivated by sour grapes, but the remark may be more penetrating than it was intended to be. The video disc would in fact make a very good audio disc if it didn't prove successful for pictures.

WIRELESS WORLD JANUARY 1978

# Traffic information broadc

## Service proposed by BBC operates on a single m.w. frequ

**by S. M. Edwardson** M.I.E.E., BBC Research Department

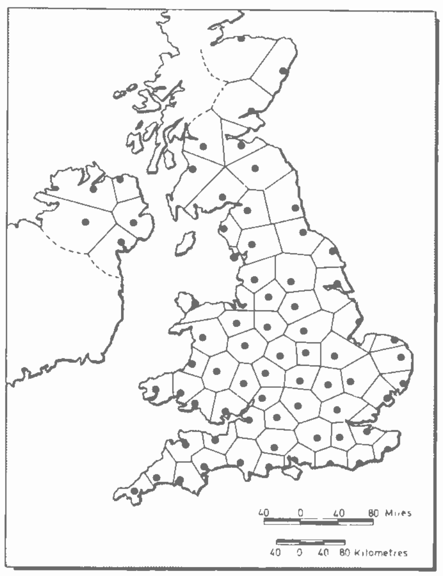
This dedicated system uses a multiplicity of low-power m.f. transmitters working on a single frequency, and a separate, fixed-tuned, low-cost receiver in the vehicle. Claimed to be less expensive than other systems, it gives drivers messages appropriate only to their local areas. Service areas of individual transmitters are defined by artificial "rings" provided by surrounding transmitters. The author sees the proposal as a possible world system.

MANY ROAD users rely mainly on radio announcements for information about abnormal traffic and road conditions, although this information is, of course, often supplemented locally by special signs and police notices on the roads. Those people who drive over familiar routes have experience to help them, but this is of little use when the unforeseen happens and their intended course is overloaded, or blocked by a burst water-main, an accident, or similar hazard.

Radio broadcasting services that carry announcements, intended to help smooth the flow of traffic, inevitably suffer from the basic disadvantage that the programmes themselves have to be interrupted for every traffic announcement. There is conflict between the wish to put over the traffic information and a natural reluctance to interrupt the main programme. Traffic announcements may be seen by the programme producer as essentially secondary in nature (except in serious emergencies) and constrained as far as possible to scheduled programme junctions, say on the hour and half-hour, with perhaps quarter-hour announcements during the rush hour. This is the practice used in Germany, Austria and Switzerland, several of whose major networks carry special motoring identification signals to activate receivers.* The inevitable fact is that traffic information takes over from the normal programme whether listeners like it or not. Areas covered by particular traffic announcements inserted into programmes tend to be very large – they will correspond in size to the service areas of the main high-powered regional transmitters together with their off-air relays – and thus many of the announcements heard by drivers relate to road conditions many miles away. Imagine a BBC Radio-4 motorist listener stuck in a traffic jam in Leeds being told that a milk float has overturned and is blocking Oxford Road, Manchester!

Local radio seems likely to be more useful. The transmitters are smaller and are situated so as to serve individual centres of population; their announcements are thus more likely to be relevant to their listener's needs. But here again there is the same basic snag that *every* listener is forced to suffer interruptions to the programme for traffic announcements whether he or she likes it or not. And what of the majority of roads not served by local radio stations? The main trunk roads and motorways between city centres can receive only the national or regional large-area services. Even on the approaches to a city or town, where a local radio service exists, a driver needs to know of its existence and its wavelength, and he must tune his receiver to it. What proportion of road users are actually being helped at present by traffic information announcements? H smoothly could the move if a better infor were introduced?

**Fig. 1.** *Dots show existing BBC sites where low-power transmitters for the proposed service could be located. Lines show expected service areas and coverage using these sites.*




About five years ago a R. S. Sandell, first propose of radio traffic-information idea has since been re improved although its basic remains unaltered. It provi important options for the listen

- Ordinary listening w interruptions by t announcements: this may be fro car radio, tuned to any frequency, cassette player, etc.
- Ordinary listening, as above, b with interruptions by local traffi announcements, as they are received.
- Traffic announcements only, with silence between announcements.

The proposal envisages a network of about seventy very-low-power medium-wave transmitters spread over the United Kingdom. Each transmitter covers an area to which specific information may be directed.

Even under rush-hour conditions, the proportion of time required for the transmission of traffic messages in any small area will normally be limited. Each transmitter in the network can therefore spend most of its time switched off, coming on the air only long enough to transmit its message. This leads to an important advantage, for transmitters can not only share the air-time, but also a single common wavelength.

The map in Fig. 1 shows 72 existing BBC sites where such low-power transmitters could be located. Only one transmitter in a group of 15 or 16 would carry a traffic information message at any moment. This would mean that there might be, say, five transmitters from the whole network on the air simultaneously, but they would be far enough away from each other to minimise mutual interference.

That all transmitters could share the same frequency is an important point: not only does it mean considerable economy in spectrum space, it also means that simple fixed-tuned receivers may be used without any manipulation by the motorist. It also leads to the exciting possibility of a single traffic-information frequency for use throughout the world. It will be evident

* Blaupunkt ARI system, see *Wireless World* April 1974, p.95.

already that the control of such a network of transmitters would have to be centrally or regionally organised. A network of telephone lines would be needed, as well as one or more small computers.

## Transmission and reception

From the beginning of the project it has been recognised that a special signal is needed to activate the traffic information receiver preparatory to the transmission of a message. Having become activated by this special "start" signal, normal listening (if any) is interrupted and the traffic-information message is then heard. At the end of the message a special "finish" signal de-activates the receiver and normal listening is resumed.

So far so good. But how to ensure that the right people receive the messages? Basically, it is a matter of network control.

Initially it was thought that with an automatic measurement, the received signal-strength would suffice to decide whether or not the receiver should be activated by the "start" signal. This was found to be rather unreliable because of deficiencies in the receiver and car installation (which ought to be simple and cheap) and because of the practical variations in field-strength. Measurements showed that, even using a frequency at the low-frequency end of the medium-wave band, fluctuations of 8 to 10dB in the signal level received on a vertical car radio aerial occurred while driving along ordinary roads. Similar fluctuations were found to occur while driving through towns but, in addition, the average field-strength was depressed by a further 8 to 10dB. Thus it was difficult to control the extent of the service area of any transmitter in an exact way, and it was recognised that there would probably be large overlaps of some service areas and some large unserved areas. It was to minimise these difficulties that the "ring system" was developed.

## The "ring system"

The basic idea can be understood with reference to Fig. 2, which shows part of an idealised lattice of traffic information transmitters, all sharing the same frequency as already described. Each transmitter has two modes of operation: it may operate either in the message-carrying mode or in the "ring" mode. Transmitter $T_0$, in this case, is the transmitter carrying the traffic information message while the surrounding transmitters, $T_1$ to $T_6$, here serve as "ring" transmitters.

They all operate in the simple sequence shown in Fig. 3. Prior to its message, the transmitter $T_0$ radiates a "start" code signal, consisting of frequency-modulation of the carrier by a 125kHz tone, with a peak deviation of ±2kHz. The six ring transmitters radiate at low power c.w. "inhibit" signals which begin just before the beginning of the "start" signal radiated by the message transmitter and end just after it. The ring transmitters remain off at all other times.

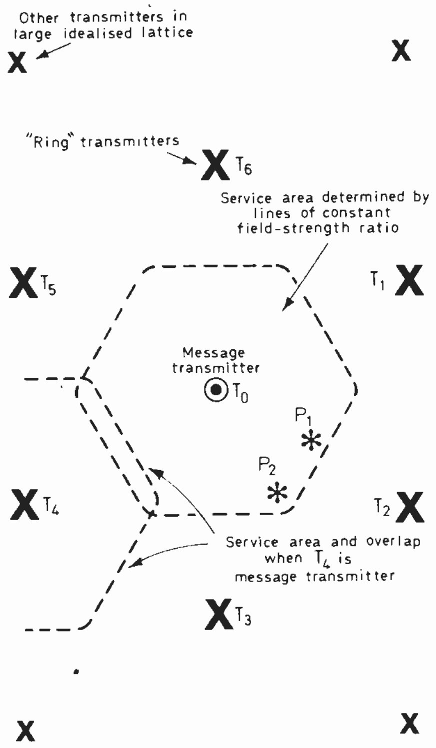



**Fig. 2.** *Part of idealised lattice of transmitters, showing one, $T_0$, acting as a "message" transmitter, surrounded by a "ring" of other transmitters, $T_1$-$T_6$, which determine its service area by f.m. capture effect.*

Suppose a receiver is located in the region of $P_1$ (Fig. 2), where signals are received predominantly from transmitters $T_0$ and $T_2$. If the carrier-level from the ring transmitter $T_2$ is sufficiently strong, f.m. capture effect will cause the "start" signal from $T_0$ to be ignored. Alternatively, if the signal from the "start" signal is the stronger, the receiver will be activated. With the high modulation index chosen (a wide deviation at a low modulating frequency), capture effect by a single ring signal is very pronounced: a 4dB increase in the carrier-level of the interfering ring signal causes a 30dB decrease in the level of the demodulated "start" tone. Where more than one ring transmitter contributes significantly to the received signal, such as at $P_2$ in Fig. 2, capture effect still operates but is less pronounced.

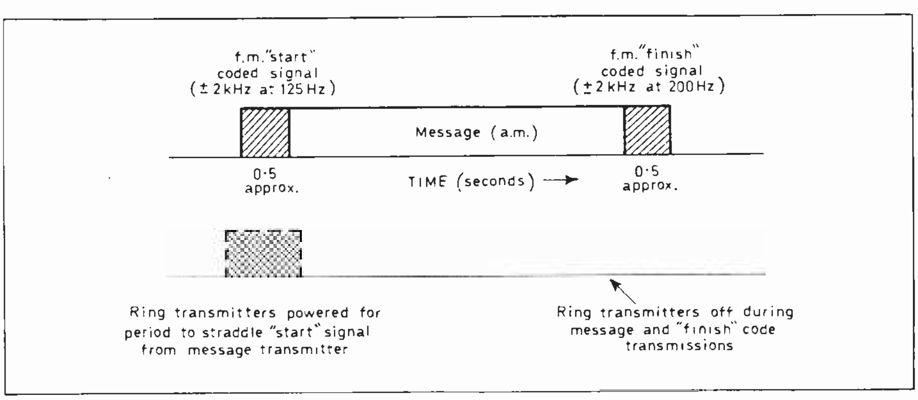
Thus it will be seen that receiver activation is determined by the *ratio* of the "message-to-ring" signal strengths rather than by their absolute values. The encircling ring of transmitters creates a well-defined limit to the service area of the message transmitter – a controlled inhibition of reception of the "start" code signal – so that, outside the service area, receivers are not activated and the message is not then heard. The message signal itself is carried by conventional amplitude modulation and has "telephone" bandwidth of approximately 300Hz to 3.5kHz.

To overcome the difficulties that might sometimes arise with particular carrier phases of the c.w. signals from the ring transmitters, these signals are, in fact, frequency-modulated by very-low-frequency random noise, with an r.m.s. frequency deviation of about 400Hz. This ensures that, during the "start" code, the signals from the ring transmitters are averaged satisfactorily in the receiver.

At the end of the message, a "finish" signal is transmitted to de-activate or mute the receiver. Again, frequency modulation of the message transmitter is used with a peak deviation of ±2kHz, but at a modulation frequency of 200kHz. During transmission of the "finish" code signals, the ring transmitters remain off and reception of the "finish" signal is then possible down to very low signal strengths and under conditions of heavy interference. This is to minimise the number of receivers that may inadvertently remain activated; this could occur, for example, if a particular vehicle happened to be passing under a bridge during the radiation of the "finish" signal.

Tests of the ring system that have been carried out both in the laboratory and using special transmitters in the London area have given very encouraging results. The signal parameters chosen are thought to be about right, but may be varied during a larger-scale trial now being planned.

**Fig. 3.** *Operating sequence of "message" transmitter $T_0$ in Fig. 2 (top) and "ring" transmitters $T_1$-$T_6$ in Fig. 2 (bottom). Ring transmitters are frequency modulated with random noise with 400Hz r.m.s. deviation.*



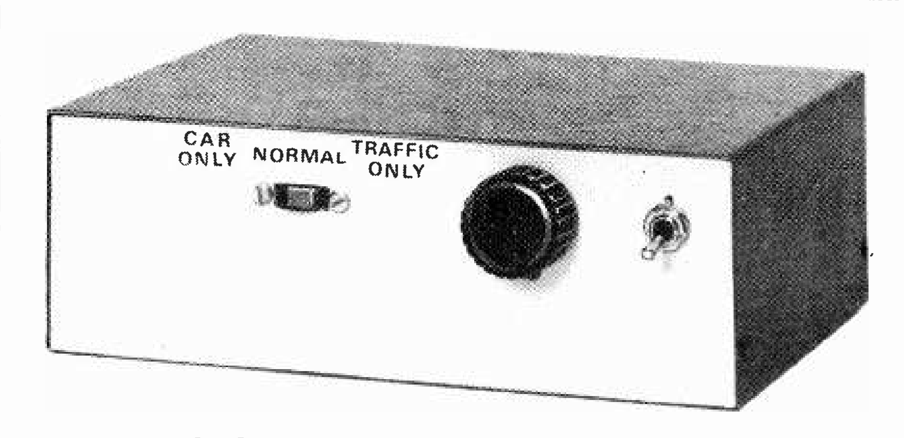



**Fig. 4.** *Vehicle equipment: an experimental add-on unit.*

## The receiver in the car

Three basic kinds of prototype receiver have been built. The first is a completely separate receiver, fixed-tuned, simple and inexpensive. The second is an add-on unit and the third is an "integrated" unit, in which the circuits of a traffic information receiver are embodied in a conventional car radio so that the two receivers are contained in one case.

The separate receiver, with its own aerial, will operate completely independently, having an integral loudspeaker. It can be mounted in any convenient position, is technically simple and would be the basic equipment for those who do not wish to have normal car radio facilities.

The integrated unit operates similarly to the add-on unit, but with the advantage of being more compact and cheaper than two separate units.

Figs. 4, 5 and 6 show photographs of an experimental prototype add-on and two commercially-manufactured prototype integrated receivers. Production models are likely to be somewhat smaller. Fig. 7 is a block diagram of a basic integrated receiver.

It is not yet possible to give an accurate estimate of the cost of future commercially manufactured receivers. A separate receiver might, with large production, cost in the region of £10, while the additional cost in an integrated receiver should be significantly less than this.

## The receiver in the home

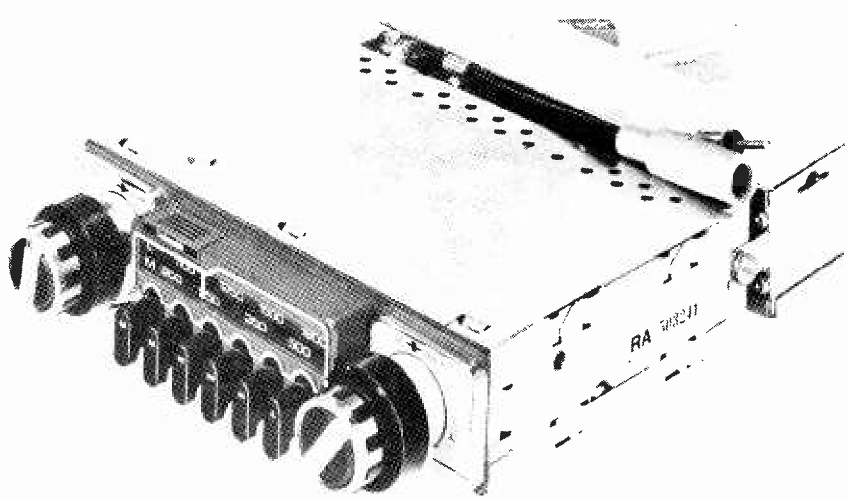
Traffic information messages could also be received in a similar way by domestic radio receivers, if they were equipped for the purpose. This might prove to be an important aspect of a traffic information service. Breakfast-time is a peak radio listening time and considerable use can be made of local traffic information by motorists before they take to the road (or decide not to do so!).

Circuit arrangements similar to those shown in fig. 7 could be used for a domestic receiver, normal listening being also available here as in the car. A substantially omni-directional aerial would be desirable for the traffic information receiver section.

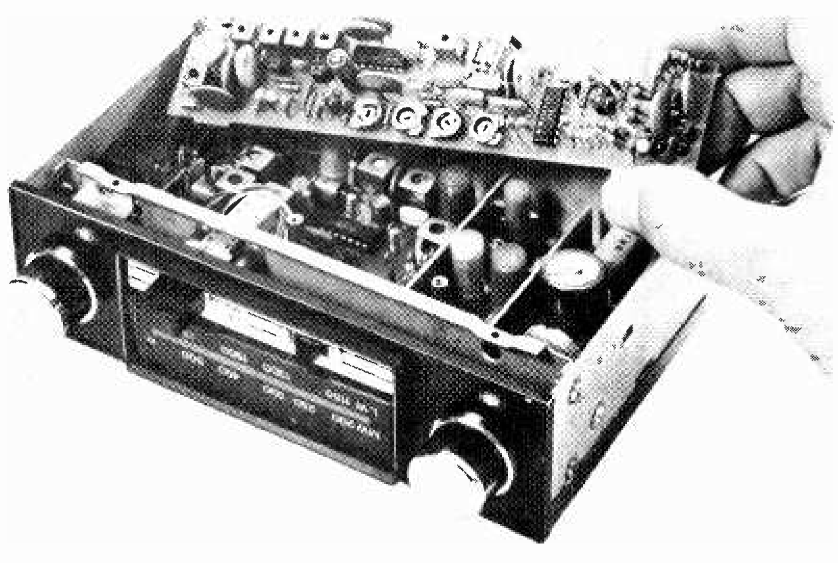
## Transmitter and coverage aspects

It is clear that the power radiated by a ring transmitter will affect the ratio of the message-to-ring signal-strengths and hence the limit of the service area of the message transmitter: an increase in ring transmitter power will push back the message service area, while a decrease in power will allow the service area to expand. Experiments indicate that, if the power of each transmitter when operating in the ring mode is lower by about 6dB to 7dB than the power when radiating a message, this should result in about the right degree of overlap between adjacent service areas.

The number of ring transmitters need not, of course, be six but may vary according to local requirements. Moreover, the power radiated by a



**Figs. 5 and 6.** *More vehicle equipment: two commercially made prototype "integrated" receivers, based on a conventional car radio. In Fig. 5 (above), the toggle switch to the left of the push-buttons, a three-position switch, controls the mode of operation as follows: upper position, car radio only operating; centre position, car radio interrupted by traffic messages; lower position, traffic messages only.*



particular transmitter in the ring mode may be made dependent upon which particular adjacent transmitter is carrying a message; this additional flexibility could be of assistance in planning by the broadcasting authority, since it makes available a means for controlling and varying the shape of each service area.

In Fig. 1 the lines show the expected coverage using existing BBC sites. There are no unwanted overlaps or unserved areas; deliberate overlaps would probably be provided, as just described, but these are not shown in the figure. The boundaries of the service areas are likely to be fairly well defined and largely independent of receiver performance.

Since only the relative powers of transmitters affect the service areas, the minimum transmitter power requirement is dictated by signal strength for good reception of messages in motor vehicles. In practice, a transmitter unit (message) power of typically about 500 watts is expected to be adequate, but the radiated power would, of course, be only a fraction of this because of aerial losses. An advantage of the proposed system is the relatively low level of total power radiated. Assuming six ring transmitters per message transmitter, the total radiated power from the UK would be under 2kW at any one time.

Transmitter requirements are unconventional in two ways. First, it is necessary both to amplitude modulate and frequency modulate the transmitter, although not simultaneously. Secondly, it is necessary to operate each transmitter at more than one output power level. Recent developments in small solid-state transmitters permit the adjustment of output power with high reliability and without gross inefficiency. The need to frequency modulate the carrier is not a difficult requirement, particularly as good linearity is not necessary. Notwithstanding the high reliability expected, it is interesting to consider what would result if a transmitter were to fail. The lost service area would, in most cases, be covered by the surrounding transmitters, whose service areas would automatically expand to cover most or all that of the failed transmitter. It is thought that this would result in a useful saving in stand-by equipment, it being understood, of course, that the announcements would be adjusted to conform to the temporarily-modified service areas. Naturally, the standard of reception might be impaired at long ranges, depending upon the overall power finally chosen for the transmitters.

## Field strength variations

The m.f. signals received by a car radio receiver fluctuate in level by as much as 10dB as the vehicle moves along the road while m.f. field-strengths in built-up areas are 8dB to 10dB lower than in adjacent open country. The ring system is relatively insensitive to variations of level, relying as it does upon the ratio of signals arriving simultaneously from different directions and, hence, upon the operation of the ring system. A field trial to measure the ratios of received signal-strengths in such circumstances has therefore been carried out.

It was found that the ratio of the strengths of the signals received simultaneously from two transmitters on the same frequency can vary locally over a range of 2dB to 3dB. Wider variations have been found in a few localities and are thought to be due to overhead wires and steel structures. In very bad cases fluctuations over a range of about 10dB have been found, but fortunately these are confined to relatively small areas.

The effect of local variations in field-strength ratio will therefore be to "roughen" the otherwise smooth boundaries of the service areas. Since it is expected that an overlap of a few miles between service areas will be required for the proper dissemination of information, these local effects are not expected to be serious. Nevertheless, consideration is being given to ways of minimising them.

## Interference

The proposed traffic information service is local in nature, involving radiation from only a few low-power transmitters at any one time, and it is unlikely to cause significant interference to other services. Co-channel interference to the traffic information service, however, could be created by other transmitters in the same network. It is necessary, here, to distinguish between message periods and the periods occupied by the f.m. coded signals.

Tests have shown that an information service of this type would need a protection ratio of 18dB, which is sufficient for interference from other

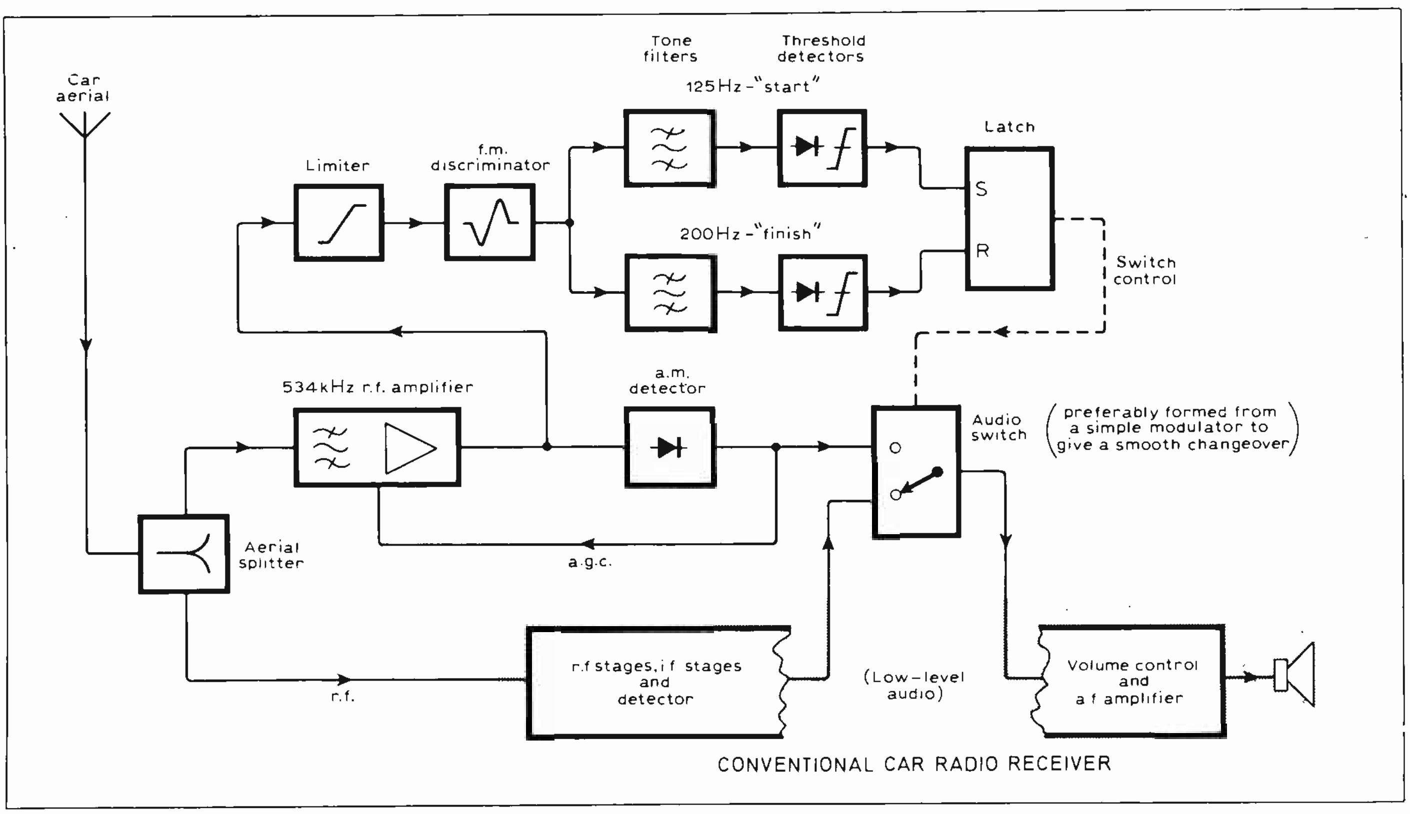



**Fig. 7.** *Block diagram of a basic "integrated" receiver using a conventional car radio.*

co-channel a.m. transmissions during the message period. The network of transmitters can be planned and operated in such a way that, in the absence of sky-wave interference, up to five message transmitters may operate simultaneously without causing undue mutual interference, because they are sufficiently well spaced. Interference from other services is also unlikely to be significant during the daytime. After dusk, however, and sometimes in winter daytime, interference from longer-range sky-wave signals might be experienced from other transmitters in the network or from transmitters of other services. The effect of this depends upon the relative strength of the local signals and, for the small service areas envisaged, sky-wave interference from one message transmitter to another is not expected to be a serious problem.

Co-channel interference from the f.m. coded signals of distant message transmitters could cause difficulties in two ways. They would be a potential source of trouble at times when local transmissions are not taking place but a "start" signal is received from a distant station. In this case, a "false start" might occur and a motorist would then receive a weak and irrelevant message. The rugged nature of the f.m. coded signals, which can penetrate down to very low field-strength values and through conditions of heavy interference, would increase the probability. Various simple solutions are possible – for example, in a quiescent area a transmitter could be powered but without modulation. This would provide a protective "blanket" of c.w. signal against unwanted "start" signals, preventing activation of receivers by "capture effect" in exactly the same way as the ring transmitters.

Interference from f.m. coded signals may also be heard if a "start" signal or "finish" signal is radiated by a distant station while a local message is being received. Such interference would be heard as a very brief "bleep" and may not be found disturbing. Tests are in progress, however, to assess its importance; the results will help to determine the form of network control. For example, this kind of interference would be avoided completely if it were arranged for control signals never to be radiated during the message period of any other transmitter.

Interference from other (non-traffic service) transmitters would cause problems similar to those for conventional a.m. broadcasting and is therefore unlikely to be serious for an information service of the type described. The effects of interference depend, of course, on the choice of carrier frequency: the traffic information service will require a suitable frequency assignment which could be either inside or outside the normal broadcasting bands. It is worth noting that, because the total radiated power of the traffic network at any time is likely to be in the range 1 to 2kW, it is unlikely to constitute a serious new source of interference to existing or planned broadcasting stations.

## Network control

As already stated the switching and feeding of a network of transmitters, together with the control and processing of information, will probably require the use of one or more small computers. The form of control will depend upon the number of control centres, which will be connected to the transmitters by land-lines and necessarily interdependent to some extent.

It will be necessary to establish a number of basic rules and priorities before setting-up the network, particularly with regard to simultaneous transmissions, the alternative "message" and "ring" roles of the transmitters, etc. Computer control will make it possible to change these rules as the situation dictates, e.g. to accommodate day and night-time propagation and interference conditions, to accommodate rush-hour traffic, and major emergencies.

## Some other possibilities

Sections of motorways could be served by low-power transmitters, perhaps with aerials located along the central reservation. The range of these transmissions would be very restricted, so that their signals would be received only by vehicles on the motorway. The use of the ring system in conjunction with such an arrangement would allow: (a) signals intended for a motorway to be received *only* on the motorway (as above); or (b) signals intended for an area through which a motorway passes *not* to be received on the motorway (motorway transmitters in this case would carry ring signals); or (c) signals intended for an area through which a motorway passes *also* to be received on the motorway (motorway transmitters in this case would remain off).

In much the same way, limited areas such as city centres could have separate transmitters of very low power for separate announcements. Such a facility could be considered, if appropriate, for emergency or special purpose installations.

Consideration is also being given to the transmission of additional coded signals to provide extra facilities. Such signals may, for example, be used by receivers to distinguish automatically between old and new messages, or to select messages intended for various categories of vehicle.

## The present situation

A committee has now been set up to examine the needs and possible benefits as well as to assess the ways in which a traffic information system could be operated effectively. This committee is formed from specialists representing Government departments, the police and the broadcasting authorities, and is looking at several other aspects not covered in this article. For example, the committee is trying to make an estimate of possible benefits. It is difficult to evaluate intangible advantages such as reduction of stress but attempts are being made. The organisation and cost of information gathering is quite a problem too. The committee is also considering the case for a public trial of a system which, if recommended, is likely to start during 1978.

It is interesting to look at possible overall future costs. Assume that half the vehicles in the UK are to be equipped and that half of these will be equipped with a self-contained receiver or will convert their existing installation at a cost of about £10, while the remainder will be equipped with a completely new combined car radio and traffic information receiver at a cost of, say, £40. This leads to an overall cost for receivers of about £175m. The capital cost of the low-power transmitter network would be about £3m, giving a total of just under £180m. The corresponding estimated cost for the Blaupunkt ARI system, mentioned earlier, is £550m for receivers plus a relatively small amount for the additional equipment to add special signals to the existing broadcast programme signals. The cost of gathering the traffic information has not been taken into account but this aspect is currently being studied in some detail. It would of course be similar for any system disseminating roughly the same amount of traffic information.

To summarise, the BBC proposal offers the motorist the following main advantages: (1) Drivers who have selected the service will receive messages appropriate to their local area. (2) Drivers are not troubled by irrelevant messages. (3) Drivers may listen to whatever programme or in-car entertainment they wish (including silence), automatically interrupted by messages as they are received. (4) Other listeners to normal radio programmes are not irritated by irrelevant (to them) traffic announcements. (5) The system, being dedicated, can be designed properly to meet traffic information requirements. (6) The system is flexible and can be extended or contracted as the need arises. (7) Only one operating frequency is required. (8) The in-car installation capable of giving these facilities is inexpensive.

**Acknowledgements.** The author thanks the Director of Engineering of the BBC for permission to publish this article and acknowledges the work of his colleagues in the BBC Research Department who collectively developed the proposed system. □

# NEWS OF THE MONTH

## Sound centenaries — it's later than you think

FOR THE half of the audio world that recognises Thomas Alva Edison as the true inventor of recorded sound, Christmas this year is a time for special celebration. It was on December 24th 1877 that Edison, then only thirty years old, filed the first phonograph patent application at the US Patent Office. The other half of the audio world, mainly French or Francophile, has already celebrated the centenary. It was in April 1877 that the French poet Charles Cros filed the description of an armchair idea to record sound photo-mechanically with the French Academy of Sciences.

For *Wireless World* readers the most important centenary date, that of electrical recording, is yet to come. It remains to be seen what year and date is taken for this event. One thing, however, is certain; the date will be earlier than many readers would expect.

Electrically recorded discs and electric reproducers first arrived in 1925 and sparked a decade of invigorating squabbles between the pro-acoustics (such as Compton Mackenzie, then editor of the *Gramophone*) and the pro-electrics (Percy Wilson, then technical adviser for the same magazine!) The electric revolution came about thanks largely to the work in 1924 by a team of engine ers at Bell Labs under J. P. Maxfield and H. C. Harrison. But there will certainly be no need to wait until 2024 or 2025 for the electrical centenary.

If the same criteria adopted by the French to judge Charles Cros the inventor of recorded sound are adopted to judge the source invention of electrical recording then the centenary date will be October 22nd 1978. It was on that day in 1878 that Edison filed the final part of his British Patent No. 1644 and this document contains a description and sketch of a phonograph in which the "diaphragm (is) vibrated by electro-magnetism".

If the consensus of opinion is that the centenary of electrical recording must wait until a hundred years from whenever the first all electric recording was replayed by all electric means then it may be necessary to wait until the year 2000. It was in 1900 that the Dane Valdemar Poulsen exhibited his magnetic wire or strip recorder at the Paris Exposition, a year after he had patented it.

Another possibility is that the centenary should date from the invention of the thermionic valve, which made amplification and thus acceptable replay a practical possibility. Here there may be another surprise for casual historians. Although Fleming in 1904 was the first to patent the diode as a means of high frequency current rectification, eg for radio reception, it was Edison again in 1883 who noted and patented what subsequently became known as the "Edison effect" – the flow of electrons through a vacuum from one electrode to another. – *Adrian Hope.* □

## Telecommunications orders from SAPO

GEC announce that in the past few months they have received orders worth over £1 million for private branch exchange equipment. Customers include the Bank of England, British Steel, Caterpillar tractors, Debenhams, Marks and Spencer, Royal Insurance and Tarmac. In October Unilever ordered £60,000 worth of GEC wideband multiplex equipment for their private telecommunications network connecting 177 factories, offices, computer centres and distribution depots. The systems gives direct dialling connection to 30,000 telephone extensions and access to the public network. GEC's most recent export order is for £4 million worth of stored programme control equipment for the South African Post Office. The equipment will go to Witwatersrand, where it will replace electromechanical register translators in 36 director exchanges. □

## Three new Consultancies

INDEPENDENT Telecommunications Consultants has been formed by Kenneth Green and Christopher Milburn, formerly of Office Planning consultants, and Kerr Inglis, formerly of Reliance. Green was also with the Post Office, occasionally seconded to the Home Office and the Royal Corps of Signals. Milburn was at one time telecommunications manager for British Caledonian, and has spent 30 years in telecommunications and aviation. Inglis once worked in banking and, at Reliance, was national accounts executive sales manager. The firm's address is in Gloucester Place London NW1.

Four former executives of Prowest Electronics, an EMI subsidiary, have formed Pro-Bel Ltd to make and sell professional broadcasting equipment. They are Derek Owen, David Streel and Graham Pitman, of Pro-Bel, and John Wilson of Link Electronics, with which, said a statement, "Pro-Bel will work very closely".

The Rupert Neve group, makers of sound mixers, have started a consultancy specialising in "the application of electronics to industrial processes". Nevenco, as the new venture is called, is particularly interested in applying electronics to improving methods of manufacture. □

# Acoustician, heal thyself

D'ARBLAY Sound Studios of Poland Street, London, have produced a set of six cassettes which aim to help musicians and others to understand the technicalities of record production. They describe them as "rightly acclaimed" and "definitive." Yet the man in charge of this project and of the studio, Mr Aaron Gershfield, told *Wireless World* he didn't know what RIAA was. The only director of D'arblay involved in the project, Miss Jackie Soo, said she didn't know anything about audio.

Among the dubious definitions contained in a glossary which goes with the set of cassettes, available at £30 from D'arblay, is that the coincident microphone technique is "responsible for the sound from stereo headphones appearing to be inside the head."

Under "Decibel" we learn that 0 dB is the "threshold of hearing." Feedback is something to do with tape delay and echoes, according to the booklet, and compliance is the "ratio of applied energy to effective energy in a transducer."

When we told D'arblay they had made a lot of mistakes they said they had had similar reports from other journalists who had seen the "workshop" as it is called, and were going to correct the mistakes in the booklets by having them reprinted.

But the tapes themselves also contain several errors. Studio equipment, for example, is said to be able to handle a dynamic range of only 20 to 30 dB, and the examples of wow and flutter demonstrate only that nobody at D'arblay knows what the words mean.

The author of the booklets, whom mercy compels us to leave anonymous, is a lecturer at London University and we phoned him at Goldsmith's College, where he works full time. He left Southampton University in 1971 with a third class honours degree in physics.

He explained that he had not written the glossary himself. The entries had come from a number of sources. "I suggested them to D'arblay and they were to rewrite them into a usable form." This was necessary because he was having to write the booklets for the course at a rate of one a week as well as doing his full time job at Goldsmith. He had also left them to fill in other details and this had led to inaccuracies when the books were printed.

He admitted, however, that he had been responsible for saying that the dynamic range was 30dB.

He said he had met those at D'arblay when they were attending an evening course he was giving on audio visual equipment.

D'arblay told *WW* that the sound quality of the press samples was not very good, but they had had to get them out in a hurry. Since then they had had some tape heads refurbished and the quality had improved. This might account for some doubt as to whether the tapes were Dolby encoded or not.

As well as the cassettes, buyers are offered a musician-finding service for groups short of, say, a guitarist, a free visit to the studio and, possibly, free demonstration records if they agree to be managed by D'arblay, who will either place them with a record company or record them themselves.

Even here, though, there is some doubt as to the extent of their contracts within the record companies since at the press launch on October 25 Aaron Gershfield said he was still getting the record companies interested and D'arblay were to hold a reception for the record companies after they had entertained the press. There seems at any rate little reason to suppose anyone should gain from filling in all the personal details that D'arblay hope each of their first 10,000 purchasers will send back to them, including a photo. □

# Hitachi — is it a Godsend or a Trojan horse?

THE government's reluctance to announce a decision about whether or not to allow Hitachi to build a tv factory at Washington New Town, Tyne and Wear, is understandable. The factory could provide up to 500 jobs in an area of high unemployment. But it could also throw 6,000 people out of work in the British electronics components industry.

The British television industry is only working at half its capacity, and demand is unlikely to rise much about its present 1.5 million sets a year. In an interview, Mullard managing director Jack Akerman told *Wireless World:* "We are running out of resources, and television manufacture needs zinc, gold, silver and aluminium, all of which are in short supply. Yet we are proposing to invite in a manufacturer – any manufacturer: I would say the same even if it were not Hitachi – to make goods we don't want with resources we haven't got which will also undermine the existing industry in this country. If they were going to make batteries or something which didn't use up resources, or artificial hearts, or products which would benefit mankind, then all right. But the goods they want to make are already over-provided."

Mullard are, however, having talks with Hitachi to see if some agreement on tube supply can be reached. Hitachi's proposal is to make one third of their production small sets which would then not need to be imported. The rest would be in the larger screen sizes which the PAL licence currently prevents their exporting to Europe and which, at the moment, represent 60% of the British market. In the first year Hitachi would make 25,000 26in. sets using 110° 20AX tubes, if Mullard were to supply them, and 25,000 22in. sets using bulkier but cheaper 90° tubes.

The talks centre around the adjustments needed to the Hitachi set and Mullard 110° tube for the 26in set, and the possibility of Mullard's setting up a new production line for the 22in set. Akerman is not optimistic about either proposal. He describes the efforts to design a set around the 20AX tube as "a charade", and the other idea "would cost us millions". Supplying Hitachi with a mere 25,000 tubes would mean that other manufacturers would be forced to cut back on orders from Mullard because of the competition Hitachi offered, and the gain in business would merely be offset by losses elsewhere. In addition, he asserts, "By 1980 all tubes will be 110° and the 90° tube will be as dead as a dodo."

The details of Hitachi's plans have not been published (and there is no reason why the Japanese should risk a commercial disadvantage by publishing them) but the fear is that even if Hitachi were to secure their factory by promising to use around half British components they would not keep their word. There would, indeed, be no way to keep them to it. According to a report by stockbrokers W. Greenwell & Co, "If after a couple of years Hitachi announced that the prices of Mullard tubes were no longer competitive and it wished to import tubes from its part owned plant in Finland, what sanctions could exist for enforcement?"

Akerman agrees and, even though he has some admiration for the Sony and Matsushita operations, he put it this way: "Sony and Panasonic could stop buying British tubes and components tomorrow and there isn't anything you could do about it." He doesn't think, however, that they would. "They are honourable people. When they make a promise they keep to it."

The Finnish plant is probably the main source of distrust of Hitachi. Half of the 800,000 tubes they plan to make in the next three years are to go overseas, including Britain. Of the 40% shareholding not owned by the Finnish government half is owned by the Finnish Company Salora, and the rest by Hitachi, and to make things worse, £3 million of the equipment that will make the tubes came from the Thorn factory at Skelmersdale. Under an agreement with the EEC there are no trade barriers between the EEC and Finland, and the British makers believe the intention of Hitachi in helping set up the Finnish factory is to switch from British to Finnish tubes once their commitment to British components has enabled them to set up a British factory. The Finns, on the other hand, say that Hitachi's involvement in such decisions, with a holding of only 20%, will be minimal. "They are providing only some know-how," the firm's managing director was recently quoted as saying.

*Akerman: "Tvs already over-provided."*

Some reports of Hitachi's plans claim that the expansion they plan in the first five years will be in the 90° tubes which it would be most difficult for Mullard to provide. These, then, would come from Finland.

Given a foothold within the EEC, lower labour and transport costs and, come 1979, the end of the PAL licence agreement and, Akerman maintains, the Japanese could fulfil their intention to "dominate the European tv industry by no later than 1985."

Added to all the, admittedly circumstantial, evidence of Japanese intentions are the claims that the Thorn factory whose equipment was up-to-date enough to be bought for Finland was closed as a deliberate act to prepare the way for the Japanese onslaught. The assertion is based on the low price levels of imported tubes before the closure and the speed with which they rose afterwards. An alternative explanation is, of course, that they were merely reacting to changed conditions.

Skelmersdale, too, was a depressed area. What makes the government's decision so difficult is that, should Hitachi decide to go elsewhere in Europe, as they have threatened to do, they will still be able to attack the British market from within the EEC, albeit with slightly more expensive components, yet we will not even have the consolation of the 500 jobs they were offering. □

# Standards battle looms over digital tape

BY THE end of next year 3M say they will be selling digital sound recorders they have developed jointly with the BBC. The 3M company will be selling three systems based on two machines, a stereo version and one with 32 audio tracks, both using 1in tape. The packing densities rise to well above those quoted in earlier reports, as high as 30,000 bits per inch, and the BBC's major contribution was in error correction. Although the machines can use good quality helical scan video tape 3M have produced a tape which they say gives better results. It will run at something like 45in/s past 16 vertically-stacked, in-line (not staggered) record and 16 playback heads, which will give 13 information and three parity bits. Playing time will be around 45 minutes.

Those who have worked on the project believe that the sound produced is remarkably undistorted and noise-free. According to figures released by 3M the system is achieving a signal to noise ratio of better than 90dB, compared with an analogue best of 68dB with additional improvements of 10 to 20dB using noise reduction.

An advantage of any digital recording system is that the quality of the sound does not deteriorate with each copy, or generation, from one tape machine to another, so that the final stereo result after processing from the 32-track master should be as good as the original. The BBC say there has been no need to add a dither signal to compensate for the crumbling effect caused by quantisation noise at low sound levels.

Much of the work was done at 3M's laboratories at Camarillo, California, then at the headquarters at St Paul, Minnesota.

BBC sources say that the collaboration with 3M was closer than the corporation had ever had with an outside company before, and they are anxious to stress that they had sought similar contacts with British firms, such as EMI, five years ago without any result. As a large tape user the BBC had frequent contact with 3M, who were anxious to collaborate once the efforts to find British partners had failed.

Estimates put the price of the digital 32-track recorder at around $150,000, which many will say is more than the recording industry can afford. To be competitive the price will have to fall to that of the 32-track machine which MCI are expected to launch some time next year. That will sell for around £30,000, though the 3in tape it uses is expected to sell for at least £100 a reel. One informed guess at the future of digital recording put practical machines at least three or four years away, and they would become commonplace only six or more years from now.

Those involved in the 3M project, however, expect that there will be other digital machines on the professional market before long and that as a result a standards battle will develop. The Japanese, as we reported last month, are making great strides in adapting domestic video machines for sound. These are not yet regarded as of professional standard, but they will give playing times of up to three hours, though the BBC say that 45 minutes is all that is usually required for professional recording since musicians' union rules forbid sessions any longer than 20 minutes unless at a live performance. □

## Morse — at a pulse a second

THE American military establishment is looking for $2.5 million to build a communications link between Chicago and Puget Sound, 2,000 miles away. But it's a link with a difference: it is to use a beam of neutrinos.

The difficulties of adapting neutrino beams to practical communications will be immense. A stream of protons hitting a metal target gives off a stream of mesons, which then decay into neutrinos and muons. But the accelerated protons need energies of around 400,000 MeV and it has been estimated that, with decay tunnels, any beam generator would have to be at least 0.5km long.

Since the neutrinos have so little interaction with their surroundings it will also be difficult to detect them. A large mass of sea-water would be needed so that the neutrinos would interact to give off muons. The muons would then be absorbed, emitting Cerenkov light as it did so. It would be the light which would be used to transmit the message to normally inaccessible submarines.

Here again the speed of transmission would be very slow, some authorities say about 100 times slower than Morse code, or about one bit per second.

Because of the size and complexity of the transmission and detecting equipment it is extremely unlikely that any submarine could carry it, so the equipment would be permanently based. The submarine would come over or near the detector at pre-arranged times, receive its message and go away. It is a one way communication system. Its advantage would be that the signal could not be interfered with. There are accelerators that can produce the neutrino beam, such as the CERN accelerator in Geneva, or Fermilab, the site of the hoped-for experiment in Chicago. □

## IN BRIEF

● Link House publications are to launch a new magazine dealing with professional sound recording and the music business in April 1978. It will be called *Sound International*.

● International Aeradio is to provide a computer-aided despatch system for the City of Winnipeg's fire, police and ambulance services. The $2.8 million contract is for equipment to reduce the time taken to record and transmit information to vehicles.

● After 20 years in operation, the journal of the Post Office Engineer's Union reports, one of the first microwave telecommunications links at Braewynner-Thrumster has been taken out of service.

● 12GHz radio propagation studies delayed by the launch failure of the European Orbital Test Satellite (OTS) can now start at the IBA's research department at Crawley Court, Winchester. The experiments are now going ahead using Sirio, the Italian geostationary satellite launched last August.

● Intime Electronics have been appointed sole UK agents for JFD fixed and variable capacitors. The 3,000 standard and special piston trimmers and miniature ceramic fixed and variable capacitors will be added to Intime's range of monolithic ceramic fixed capacitors in various packages.

Intime also announce a range of eight colour coded variable ceramic disc capacitors from between 1 and 3pF to between 10 and 45pF. Q range is said to be at least 500 from 400kHz to 1.4KHz.

● Nine lectures on video recording will be given at the South London College on Tuesday evenings beginning on Jauary 17. The fee is £6 and the organiser is Mr A. A. Rowlands, telephone 01-670 4488.

## City Audio, OFT acts

THE Director General of Fair Trading has started court proceedings against two people connected with City Audio, a cassette supplier which went into liquidation in May 1976 owing £44,000. It is alleged that 400 people had sent money to the mail order firm and had not received either goods or a refund. The action is being taken against the major shareholder in the firm trading as City Audio, Mr John William Pound, and a director of the firm, Mr Barry Took.

At the time of the liquidation Mr Pound said that he had not become a director of the firm because he had been acting as a consultant to various local authorities in the London area on audio visual equipment. At the creditors' meeting it was stated that he had been signing cheques on the firm's behalf even though he was not an officer of the company. The company's assets included an M registration Jaguar XJ6 whose use, it is alleged, was reserved exclusively for Pound.

Another reason for his reluctance to become a director, however, may have been that at the time of the liquidation he was an undischarged bankrupt, and therefore unable to hold a directorship. Since then he has been conditionally discharged from bankrupty. At the time of his bankruptcy he was carrying on wholesale and publishing businesses from accommodation addresses in Regent Street, London, and Croydon and was a partner in an estate agent's business which had been an office equipment firm, as well as consultant to, among others, the GLC.

The OFT's action follows the alleged failure of the two defendants to give written assurances that "conduct detrimental to the interests of consumers" will cease. After the City Audio collapse Mr Pound had started another mail order business trading from Baker Street. □

# The Woodpecker — the West has one too!

THE HIGH-POWER interference in the h.f. region of the frequency spectrum, nicknamed "The Woodpecker" because it sounds like a woody chatter, is not alone. (See "Mystery Soviet over-the-horizon tests", Feb. 77 issue.) The General Electric Company, in Syracuse, USA, is now more than two years into a 38.8 million dollar contract for an early warning radar system which, like the now infamous Woodpecker, is of the over-the-horizon-backscatter (o.t.h.b.) type.

Work on the American radar system involves tests in a nominal frequency range from 6 to 30MHz using a pulse compression waveform having a typical pulse repetition frequency of 40 pulses per second.

The radar transmitter used in the tests is sited in Maine in the USA and has twenty-one 100kW transmitters – normally used seven at a time – and an antenna of the wire-fence type, 2,276 feet wide by 135 feet high. This dipole-element antenna is steered by computer to scan in azimuth and elevation using six frequency bands. The receiver site, 100 miles away in Columbia Falls, has a 5,816 foot long antenna feeding 96 three-stage superheterodyne receivers.

The backscatter system depends on ionospheric propagation and uses the 250- to 350km-high F2 layer as the principal refracting medium. With this layer, surveillance ranges of between 1000 and 4000km (with a practical maximum at 3000km) can be achieved with single-hop propagation, and more than 4000km can be obtained when reflections from the sea result in further hops. This is ample range since target detection at 2500km is considered to give adequate warning for defence purposes.

For any given ionospheric electron density there is a maximum usable frequency (m.u.f.) which is capable of being refracted downward to reach a specified ground range a certain skip distance from the radar transmitter. Consequently, to cover a particular ground range, the operating frequency has to be altered, and to scan the total range of some one million square miles requires typically three separated operation frequencies relating to different ionospheric layers – the m.u.fs for skip distances of 1000, 2000 and 3000km, for example. In addition, the frequencies must change with the time of day, geographical location, season and sunspot activity because all of these affect the maximum electron densities and height distributions of the ionosphere. For simultaneous coverage or rapid scanning in sequence, the radar requires frequencies approximately ±25% about a centre value.

However, since effective target areas using h.f. radar are very much greater than those obtained from conventional microwave radars, especially those related to aircraft and missiles where resonance and near-resonance effects arise due to the relationship between target size and radar wavelengths, the disadvantages associated with ionospheric radar tend to be compensated.

When presenting his paper "The application, design and performance of o.t.h. radars" at the recent Radar 77 conference, Mr W. Fenster of GEC was asked jokingly by a delegate, "What are you going to do about those damned communicators in the h.f. bands?"

His equally jocular reply was, "Oh, we'll just switch on."

However, he did go on to explain that, although efforts are made to ensure that transmission frequencies are chosen to coincide with clear channels, stations operating in the target area or elsewhere are not necessarily heard at the transmitter site due, again, to the nature of ionospheric propagation.

If one compares this story about the Americans with what has been observed of the Russians, there is a remarkable similarity, and it is reasonable to suppose that neither the West nor the East will experience interference from their own transmitters because they are either behind or inside the skip distances of their transmitter beams. Who, then, can blame the Russians for ignoring requests to stop *their* tests? RA. □

*Twenty years after Sputnik the true impetus of the space race emerges*

# Satellite war-games, the latest score

AS AMERICAN defence spending comes up for its periodic review we may expect to hear more stories about the Russian arms build-up. Yet the unfolding story of the military use of satellites tells us a great deal about the super-power war game which reflects credit on neither side.

A recent estimate of the number of military satellites in use said the Russians had 661 and the Americans 337 in orbit, though according to Farooq Hussain of the Department of War Studies at King's College, London, the numbers change from month to month as satellites come in and out of use. The picture is further confused by the number of dormant or "dark" satellites in orbit which may be used at some future date.

Recent reports have concentrated on the Russian "Hunter-killer" satellites which are designed to seek and destroy communications and spy satellites used by the other side. They would work by sidling disingenuously up to the target and then blowing themselves to smithereens, taking their neighbour with them. Hussain points out, however, that these are rather crude, unselective devices. There would be no point in using such killer satellites to take out one enemy satellite at a time since that would leave the enemy with any number of others that he could use instead. A high degree of redundancy has been built into the military satellite programme for that and other reasons. If the killer satellites are to destroy a reasonable number of satellites at once the explosion would have to be so large that it would take out a number of Russian satellites as well, especially if the Russians have, as is alleged, nearly twice as many military satellites as the US.

**Elaborate m.i.r.v.**

Now the United States Air Force has awarded a £33 million contract to the Vought corporation of Dallas, Texas to develop an American hunter killer satellite which may give a new turn of speed to the arms race.

The Americans plan to build a system which knocks out the target by collision rather than explosion. It would seek out its target by identifying its heat pattern. Every artificial satellite has a highly individual heat "fingerprint" which could lead a hunter killer to it, leaving even a close neighbour unscathed.

In addition, the intense competition for military contracts in the US has led to advances in technology, particularly in computers, which have left the Russians standing. The American system could carry a number of warheads which, with the greater computer power available to the US, could be assigned to a string of trajectories which would take in the maximum number of enemy satellites at one launch.

For that reason Hussain describes the American hunter killer as "an elaborate m.i.r.v. (multiple independently-targetable re-entry vehicle). Like everything else it began as a bargaining chip. The Cruise missile was intended as a bargaining chip at first but it turned out to be more useful to keep the thing instead of developing a more expensive bomber."

Therefore whether or not the Russians are the villains of the piece the reaction of the American defence community to the recently re-started Russian killer satellite tests has been just what the US war industry ordered. The American journal *Electronics* said in October that "acceleration of military space programs to counter new Soviet anti-satellite satellites coupled with enhancement of US reconnaissance capabilities could produce explosive growth in space electronics over the next decade." From $790 million next year spending would rise to $1.2 billion in 1982, and that would be the rate for the following five years. Hussain estimates that the US has already spent something like $2 billion on military satellites and their back up.

Up to now neither super-power has destroyed any of the other's satellites since this is forbidden under the terms of the 1972 SALT agreement. But a rather cynical American spokesman said in November that the agreement did not prevent the testing of such techniques.

**Interfered with**

Another reason for leaving the enemy's satellites alone, especially spy satellites, is that they are the means by which the SALT agreement is monitored. They provide a useful means of telling the other side that you aren't up to anything, so avoiding a future nuclear war, which neither side wants, as a result of misinformation.

Nevertheless there have been numerous occasions when it appears that satellites have been interfered with deliberately — as when they are interrogated by light or other radiation to test the wavebands they are absorbing — or accidentally, as when the satellites pass through strong electric or magnetic fields. In both cases the satellite may suffer a large build-up of static electricity which then discharges through the payload and ruins the circuitry. C.m.o.s. circuits are particularly susceptible to this kind of damage.

One complication has been that it is sometimes difficult to tell whether a satellite has failed accidentally or because of deliberate interference. This has led to great refinement of diagnostic techniques, and improvements in materials technology have produced improved shielding and protection, for example, of solar arrays. The solar arrays themselves have been improved greatly so that, for instance, they are transparent to any radiation they do not need to absorb for powering the satellite.

**Killer rays**

Until the announcement of the Vought contract it was thought that any American anti-satellite device would use radiation, whether of ion bombardment or lasers. Earlier this year there were reports, highly exaggerated as it turned out, that the Russians had been developing a "death ray" that could be used against infantry or, of course, satellites.

Now, it appears, the Americans have been developing a laser which could destroy enemy satellites, particularly the Russian killer satellites. President Carter shocked the group of congressmen he told about the development at a private meeting early in November by making clear that this was an offensive and not just a defensive weapon.

According to *Flight International*, the Americans are thinking of equipping the next generation of military satellites with laser weapons working at X-ray wavelengths which will be powered by nuclear energy.

Whether such devices represent a worthwhile use of scarce resources is a question that each person working on such projects must answer for himself. But it seems clear that with each new round of such contracts the dependence of companies and individuals on their continuance makes the likelihood of a halt in the weaponry build-up recede still further. □

# Engineers' inquiry to be in private

BETWEEN the July announcement of a committee of inquiry into the engineering profession and the naming of the members of the committee (expected by the end of November), its chairman, Sir Monty Finniston, has been persuaded that the inquiry should be held in private. When *Wireless World* spoke to Sir Monty in the summer (*WW* September, p.49) he said that he wanted "to conduct it openly". Indeed, he expressed surprise that the question should even be asked.

The Department of Industry, however, told us in November that, although they were still considering the matter, and the committee themselves might decide otherwise, it was likely the hearings would be in private. One reason given is that the committee has a lot of work to do and public hearings would slow the process down. Another is that, according to the Department, those giving evidence would feel unable to speak freely at public hearings.

The DoI has accepted the CEI's offer to arrange 16 regional conferences around the country which engineers can attend and at which they can make their views known.

The enquiry's first session was booked for September 14, so it is already behind schedule. The delay in starting the hearings may be attributable to the difficulty of finding committee members who are both knowledgeable about engineering and acceptable to all those interested in the inquiry's findings. The industry minister, Mr Eric Varley, is having particular difficulty over the choice of a representative of professional employees. In the view of some the natural choice is John Lyons, the general secretary of the Electrical Power Engineers Association, now the Engineers and Managers' Association. It was the EPEA which successfully carried the TUC resolution calling for the inquiry two congresses ago. But the EMA, as it is now called, is in dispute with TASS, the technical and supervisory section of the AUEW, over the recruitment of engineers, and as a result is now at loggerheads with the TUC. Lyons's nomination would meet TASS's stern opposition. Nevertheless "16 or 17" names have been submitted, and the announcement is expected at any time. □

# Topics from the Radar 77 conference

## The first joint IEE/IEEE radar symposium in the UK

by **R. Ashmore,** Communications Editor, Wireless World

The international radar conference was held this year at the institution of Electrical Engineers in London. The symposium, Radar 77, was organised for the first time by the Electronics Division of the IEE in association with the IEEE Aerospace and Electronic Systems Society. It was also supported by the Institute of Mathematics and its Applications, the Institute of Physics and the IERE. The following text is based on extracts from the conference papers.

IN THE four years since the last radar conference the world market for radar equipment for both civil and military radar equipment has continued to flourish[1]. The most promising areas of radar technology are those associated with the cost-effective extraction of unambiguous data from the radar returns and the utilization of the data in a way which gives maximum operational flexibility to the end user.

In terms of hardware and practical techniques this means that first of all radar sensors must be equipped to withstand the onslaught of electronic counter measures. This design requirement begins in the aerial and new aerials are now coming into production with coverage patterns offering exceptionally low off-beam sensitivity to jamming over a very wide band of frequencies. This minimizes the effects of all but main beam jamming. Separating wanted data from large amounts of unwanted returns caused by meterological and topographical conditions, and in the case of defence systems from deliberate man-made interference, presents a fascinating technological challenge, and it is in this area that some of the more exciting advances have been made in recent years.

High power pulse Doppler radar can give extra good performance in this kind of environment because of the noise performance of the transmitter and the resolution and stability of the filtering and gating systems.

Good signal processing also leads to good radar visibility, and in recent years the availability of cheap reliable i.cs and storage has opened up new possibilities for producing cost-effective systems.

Moving target indication systems use velocity filters to remove all returns from static objects and accept only finite velocity components. The latest systems split up the velocity range into bands, each having their own filters, so that moving targets are detected against a smaller number of unwanted targets. These clean radar responses can be readily stored or transmitted over narrow band channels.

Over the last twenty or twenty-five years, because of the large size and cost of computing equipment, general-purpose control machines have been used for radar to take the total computing load. More recently, over the past five years or so, these have given way to "distributed processing" methods in which computers are used freely, and communicate with each other through simplified communications channels.

### Recent advances in radar technology[2]

The more recent advances in radar technology have largely been due to advances in solid state technology and automatic data processing. As a result pulse compression techniques of increasing complexity are being used in transmitters to achieve higher resolutions. In antenna design, phased arrays are being used in more applications, and sidelobe levels have been improved considerably.

Adaptive techniques have also been used with considerable success and, in some frequency bands, all solid state amplifiers have been produced. In addition, digital processing techniques have enabled signal processing in receivers to be improved. Most of these advances result in better rejection of unwanted signals, higher resolution of targets, possible identification of targets, much improved sub-clutter visibility, and automatic detection tracking.

Phased array techniques coupled with solid state techniques (such as l.s.i. and s.a.w.) and signal processing (digital filtering, fast Fourier transforms, digital m.t.i. and microprocessors etc.) have resulted in greater flexibility in radar design. These advances could not be forecast ten years ago, and it is just as difficult for anyone to forecast where we will be ten years from now.

### Man-portable surveillance radar[3]

An experimental man-portable multibeam radar, capable of maintaining continuous surveillance over a 60° sector, was described in one paper. The equipment, which should also be capable of observing fleeting targets that may not be seen by single radars, measures only 260 × 300 × 170mm including its battery.

The radar operates by illuminating the surveillance sector with a broad beam and detecting the target returns by means of eight narrow receiving beams. A surface acoustic wave (s.a.w.) network is used for beamforming at an intermediate frequency and, after mixing to video by means of a reference signal generated by another s.a.w. device, the signal returns are digitized and filtered to remove unwanted clutter. Integration takes place before display. The equipment also includes headphones to allow a target to be identified by its Doppler signature.

Separate aerials are used for transmit and receive, each comprising an array of sandwich wire elements, and the transmitter aerial elements are weighted to provide a flood-light beam. To minimize power consumption the digital processing is performed as slowly as possible with a low p.r.f. To do this a magnetron transmitter is required, as this is the only device capable of emitting the required power at such a low p.r.f. The receiver aerial comprises an array of 15 elements with a 16th element adding an a.f.c. loop. Mixing to i.f. is performed by an array of 16 microwave integrated circuit (m.i.c.) mixers fed by a 16-way m.i.c. power splitter from a solid-state local oscillator.

After amplification the amplitudes from all the channels are matched using attenuators, which also introduce a cosine weighting to improve sidelobe performance. Information from the 16 channels is then multiplexed into a single channel and passed through an a-to-d converter. After filtering to remove stationary clutter the output is modulus detected, integrated and fed to the display. The main display is formed by a l.e.d. matrix. Although this equipment is basic in nature it uses some of the most advanced technologies available.

### Sea state and oceanic winds[4]

Satellite and radar techniques for weather forecasting are attractive because they are capable of obtaining instantaneous data from remote environments. In the case of h.f. radar this is especially true because wind conditions above the sea can be determined, in addition to the sea state itself. Coverage depends on the propagation mode used. A ground radar operating at m.f. or h.f. from a coastal site or sea platform, and using a vertically-polarized surface-wave, gives a maximum range of about 200km, covering up to $12 \times 10^4$ square kilometres of ocean. Skywave radar, on the other hand, operates at h.f. and gives a maximum range of 3,500km by a single-hop F-layer reflection (or more by 2-hop reflection) giving a maximum coverage of $40 \times 10^6$ square kilometres. However, due to multipath ambiguities it is difficult to use at ranges less than 700km.

The technique relies on extracting information from the Doppler spectrum of the received signal. High quality ground wave data enables surface-wind direction, sea-state, sea-wave directional spectra and frequency spectra and the radial component of sea surface current to be determined. At this time, using sky-wave data, it is only possible to map surface winds, but work in progress promises that all the above parameters, except surface currents, will be possible. Some of this work is being carried out by Birmingham University who are using a modified h.f. backscatter ionosonde, located in Gloucestershire. Using this system and a method devised by Long and Trizna[5] they have found wind directions in the North Atlantic by examining the Doppler spectra. The antenna used is a 300m long array consisting of 49 vertical broadband monopoles in front of a reflector screen. At 10MHz, the beamwidth is nominally 6° with the sidelobe levels being reduced by tapering the elements, but a total sector of 60° may be covered by scanning in steps of 2° or multiples of 2°. The transmitter delivers 100kW of pulse power and is normally used with 500μs pulses giving a range resolution of 75km. A p.r.f. of 20Hz is chosen to achieve a range of 7,500km. A ±10Hz Doppler shift is used to distinguish between approach and recede Doppler frequencies even though, for combined oceanic and ionospheric frequencies, a band width of ±5MHz is adequate.

### Automatic collision avoidance

For automatic anti-collision on vehicles, such as railway stock, one has the choice between microwave and laser frequencies. Laser systems result in very sharply defined radiation patterns without unwanted sidelobes, even for small antennas. A prototype laser secondary radar of this kind has been developed by the Technical University in Vienna, Austria, and used, in conjunction with the Vienna Rail Traffic Administration, in underground trains[6].

The system uses identical receivers and transmitters in both the primary and secondary radar equipment. The transmitter contains a driver circuit and a pulsed gallium-arsenide semiconductor laser and its collimating optics. The receiver consists of receiver optics, a silicon photodiode and amplifier circuits. The distance between two trains, one carrying primary radar at the front and the other a transponder at the rear, is computed in the primary radar equipment by a single processor. The measured range value is indicated on a display and transmitted to the transponder by digitally modulating the primary laser pulses. These are demodulated at the transponder and displayed. Radar beam divergence must not be too small and transmitted power must be reasonably high to ensure successful system operation in curves and, by reflections from tunnel walls etc, in sharp turns. Consequently, the system needs a semiconductor laser array in the transmitter and a large photodiode area in the receiver.

In the trials, the electro-optic system proved to be satisfactorily insensitive to the excessive levels of electromagnetic interference near the rail. Range performance, accuracy, speed measurements and data transmission also proved to be consistent with the theoretical calculations and consequently adequate for collision avoidance applications.

A second paper[7], "F.m./c.w. radar with high resolution range and Doppler applied to anti-collision radar for vehicles" was concerned with rear-end-collision type traffic accidents on high-speed roadways.

To determine the safe distance to the preceding vehicle when two vehicles are travelling at speed, it is necessary to measure the distance and relative speed between the two vehicles, in addition to other parameters such as deceleration, road conditions and driver reaction time. Standard Electrik Lorenz of West Germany, in co-operation with Daimler-Benz, have devised and constructed an anti-collision system which consists of a f.m./c.w. radar sensor and a warning microprocessor. Unlike systems using infrared or ultrasonic measurement techniques, this system is fully operational even under adverse weather conditions. The radar equipment consists of a Gunn oscillator transmitter which is frequency modulated with a sawtooth. This modulation frequency must be highly stable to evaluate relative speed and therefore it is derived from a crystal oscillator in a frequency synthesizer.

The incoming signal is converted to a video frequency, passed through a low-noise video amplifier (amplitude weighted) and a main amplifier and then a high-pass filter so that the field strength of close targets can be equalized. The microprocessor is used to calculate the safety interval for the condition from the relative speed of the two vehicles.

The system gave operational characteristics as follows: Range 130m, distance resolution and accuracy 10 ±2.5m, relative speed range -30 to +160 ±2.5km/h, resolution 10km/h and system reaction time less than 0.1s. The horizontal and vertical beam widths used were about 2.5° and 6° respectively. It was found that false alarm problems encountered are due to the momentary acquisition of objects such as posts and signs on the side of the road, interference in curves, roadway separators and guard rails. The microprocessor is programmed to suppress these false signals as much as possible by a series of logic and comparisons. Momentary targets can be eliminated by time discrimination and alarms due to curves may be suppressed by slewing the antenna and/or limiting the maximum range of the radar sensor. False alarms due to extended target objects such as guard rails, can be eliminated by the f.m./c.w. principle of independent speed determination.

Trials so far have shown that the system meets, and in some respects exceeds, expectations. It has been found that the antenna must be located at a height of about 50cm above the ground. This height is a compromise since, any lower and the amount of dirt on the radome increases, which can lead to a reduction in range, and any higher and there is an increase in interference due to multi-path propagation. □

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*To be continued.*

*For a review of over-the-horizon radar see News story 'The Woodpecker! – the West has one too'.*

# New i.c. for f.m. receivers

## An improved i.f. circuit with a high s-to-n ratio

by **L. R. Avery,** RCA Ltd

The well tried and tested CA3089E has been available for the last eight years and during this time it has become widely used throughout the receiver industry. The device has, however, been criticised over certain limitations. With these limitations in mind, and following discussions with receiver manufacturers, RCA has designed the CA3189E. This article describes the new i.c. and shows a practical circuit suitable for evaluating the device.

THE CA3189E features a high-gain limiting i.f. amplifier, single-coil quadrature detector, a.f.c. output, separate audio output, signal-level meter output, adjustable threshold-delayed r.f. a.g.c., noise and deviation muting.

The i.f. amplifier consists of three differential amplifier stages which provide a typical input limiting sensitivity of 12μV. The cascode input stage, shown in Fig. 1, provides a low input capacitance and high gain for use with ceramic filters. The input transistors $Tr_1$ and $Tr_2$ are optimised for low emitter-base input capacitance consistent with high frequency performance and low noise. Load resistances of about 2kΩ are used so that the required gain may be achieved in three stages. Darlington emitter followers are used to provide buffering and d.c. level shifting to the following stage as shown in Fig. 2.

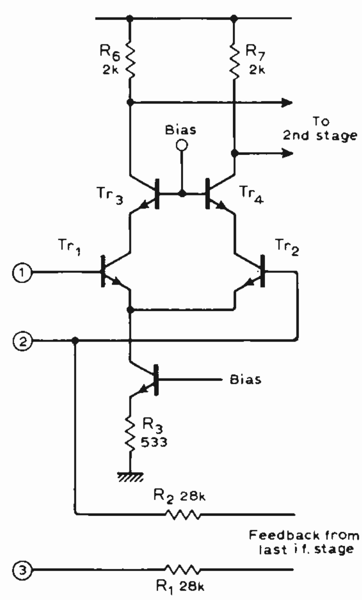
One problem with any wideband high-gain limiting amplifier is noise. If the amplifier bandwidth is made significantly higher than the operating i.f. frequency, two otherwise out-of-band signals can be multiplied together resulting in a noise component which is now in the pass band. The higher the amplifier gain the worse this problem becomes. A typical limiting sensitivity of 12μV, with a frequency response curtailed above 15MHz has been found to provide the optimum performance compromise. Restricting the i.f. bandwidth has the added advantage that printed circuit board layout requirements are not so critical as the CA3089E with its 25MHz bandwidth.

### Deviation and noise muting

The noise muting circuit operates by detecting the absence of a limited carrier, or sufficient holes in a fully limited carrier to provide a suitable muting signal. Sensitivity of the noise muting circuit has been adjusted so that when the r.m.s. signal level falls below about 120mV the muting output voltage on pin 12 rises, as shown in Fig. 3. This circuit is therefore well suited for inter-station noise muting but does not work so well when tuning into or out from a strong signal. From Fig. 4, it can be seen that in the presence of a strong signal the noise muting circuit may receive sufficient signal level to return the muting output voltage to a demuting level whilst the receiver is more than 300kHz from the correct tuning point.

Examining the audio output at pin 6 in this tuning condition shows that the d.c. level is a long way from that of the correctly tuned point, and is in fact following the detector's "S" characteristic. Because a sudden d.c. shift from the reference level takes place in the audio output a "thump" will occur in the loudspeaker unless steps are taken to reduce the speed of the muting/demuting action. The same problem occurs in reverse if tuning through a station.

When sufficient holes appear in the carrier, the muting output goes high




◀ **Fig. 1.** *Cascode input stage.*

**Fig. 3.** *Noise mute output characteristic.* ▼

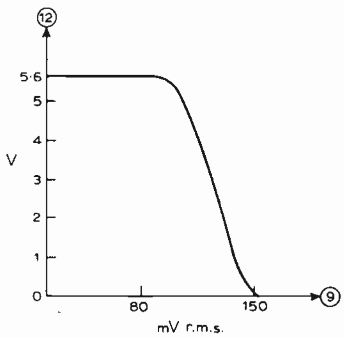
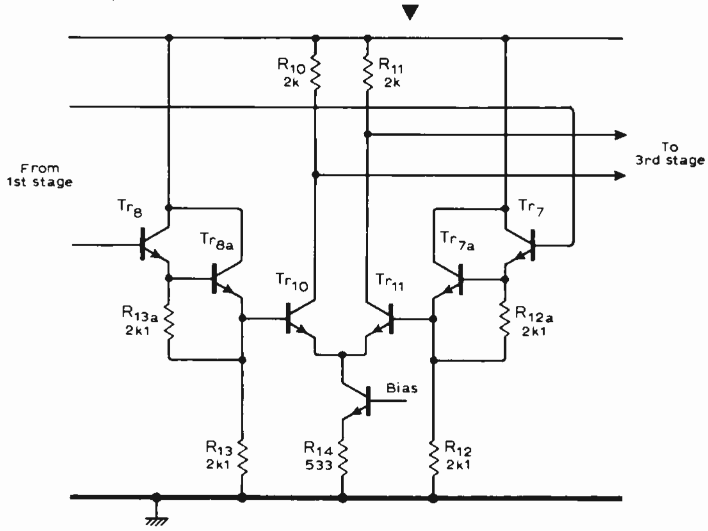



**Fig. 2.** *Darlington emitter follower buffers.* ▼



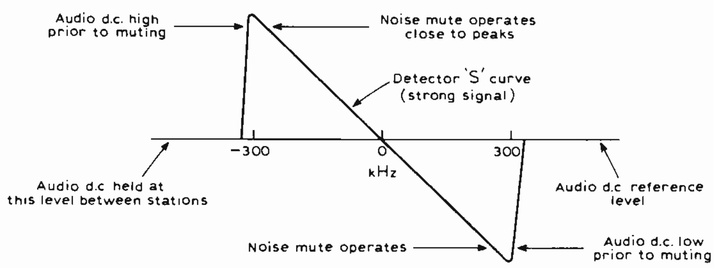



**Fig. 4.** *Operating points of the noise mute circuit on the detector S curve.*

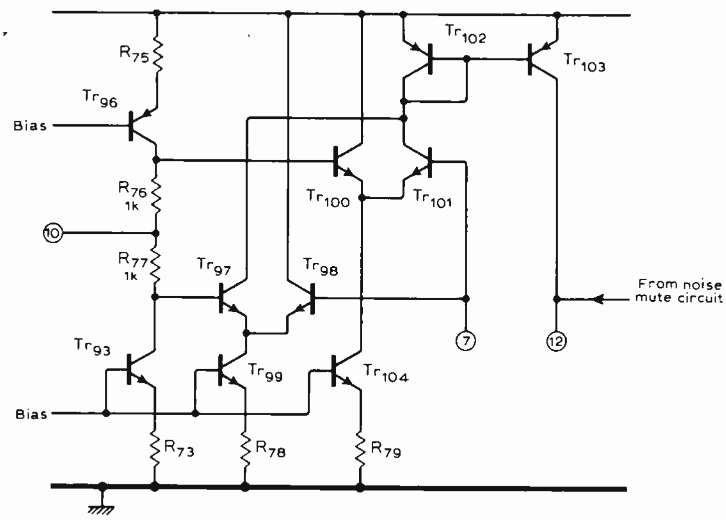



**Fig. 5.** *Deviation mute circuit.*

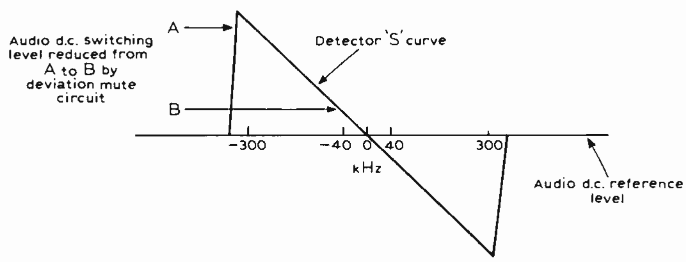



**Fig. 6.** *Reduction of d.c. shift in the audio output.*

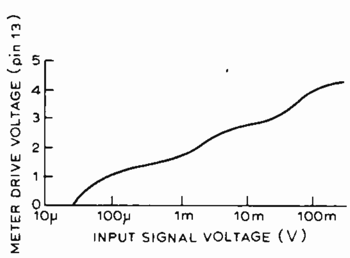
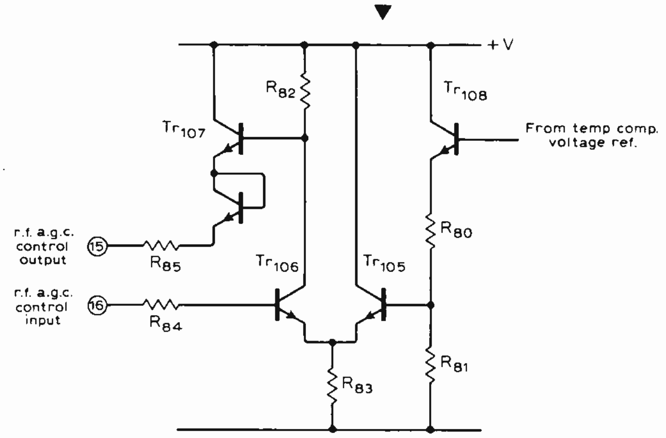



**Fig. 7.** *Typical signal strength meter characteristic.*

**Fig. 8.** *R.f. a.g.c. control circuit.*




and the audio output is again returned to the reference level. One method of reducing the "thump" is to place an integrating circuit between the muting logic output at pin 12 and the audio muting control input at pin 5. However, slowing the action of the muting circuit, so that a worst-case 2V d.c. shift can be handled, requires a relatively long time constant which may be unacceptable when tuning quickly. A smaller time constant could be used if the d.c. shift were considerably smaller and preferably less than the peak audio output. This is achieved by the deviation muting circuit which consists of two accurately determined reference levels, symmetrically placed about the correct tuning a.f.c. reference, two comparators and an input from the a.f.c. circuit as shown in Fig. 5. Current sources $Tr_{96}$ and $Tr_{93}$ provide and sink an identical current of approximately 700μA. This current, through $R_{76}$ and $R_{77}$, establishes equal upper and lower reference levels symmetrically about the pin 10 a.f.c. reference level. The upper reference voltage is fed to the base of $Tr_{100}$ which, with $Tr_{101}$, forms the upper reference comparator. Similarly, $Tr_{97}$ and $Tr_{98}$ form the lower reference comparator. A common input for the comparators is taken from pin 7 and the outputs are ORed via current mirror $Tr_{102}$, $Tr_{103}$ into pin 12. With this arrangement the sensitivity of the deviation muting circuit can be controlled by varying a resistance between pin 7 and pin 10. A 15kΩ resistor gives a typical deviation sensitivity of ±40kHz, as shown in Fig. 6.

## Audio amplifier

During discussions with receiver manufacturers there was a consistent plea for better noise performance. Investigations into the cause of excessive noise in the CA3089E revealed three main sources. The i.f. amplifer, the internal stabilizer regulator, and the audio amplifier itself. The main cause of noise in the regulator circuit was the zener diode, the construction of which has been changed in the CA3189E to reflect current knowledge of low noise zener design. Additionally, the audio load resistor is now connected externally between pin 6 and pin 10 to allow decoupling of any noise. Experience with devices fabricated to date, however, indicates that only a half to one decibel improvement can be made in s.-to-n. ratio by decoupling pin 10.

## Tuning meter

The tuning meter circuit consists of three amplitude detectors fed from the output of the three limiter stages, a current summer, and an output level shifter. Under ideal zero signal conditions the current from the summer is approximately 200μA. In a practical application noise from earlier stages, particularly the r.f. and mixer circuits, causes a far higher current under zero signal conditions. Therefore, a d.c. off-

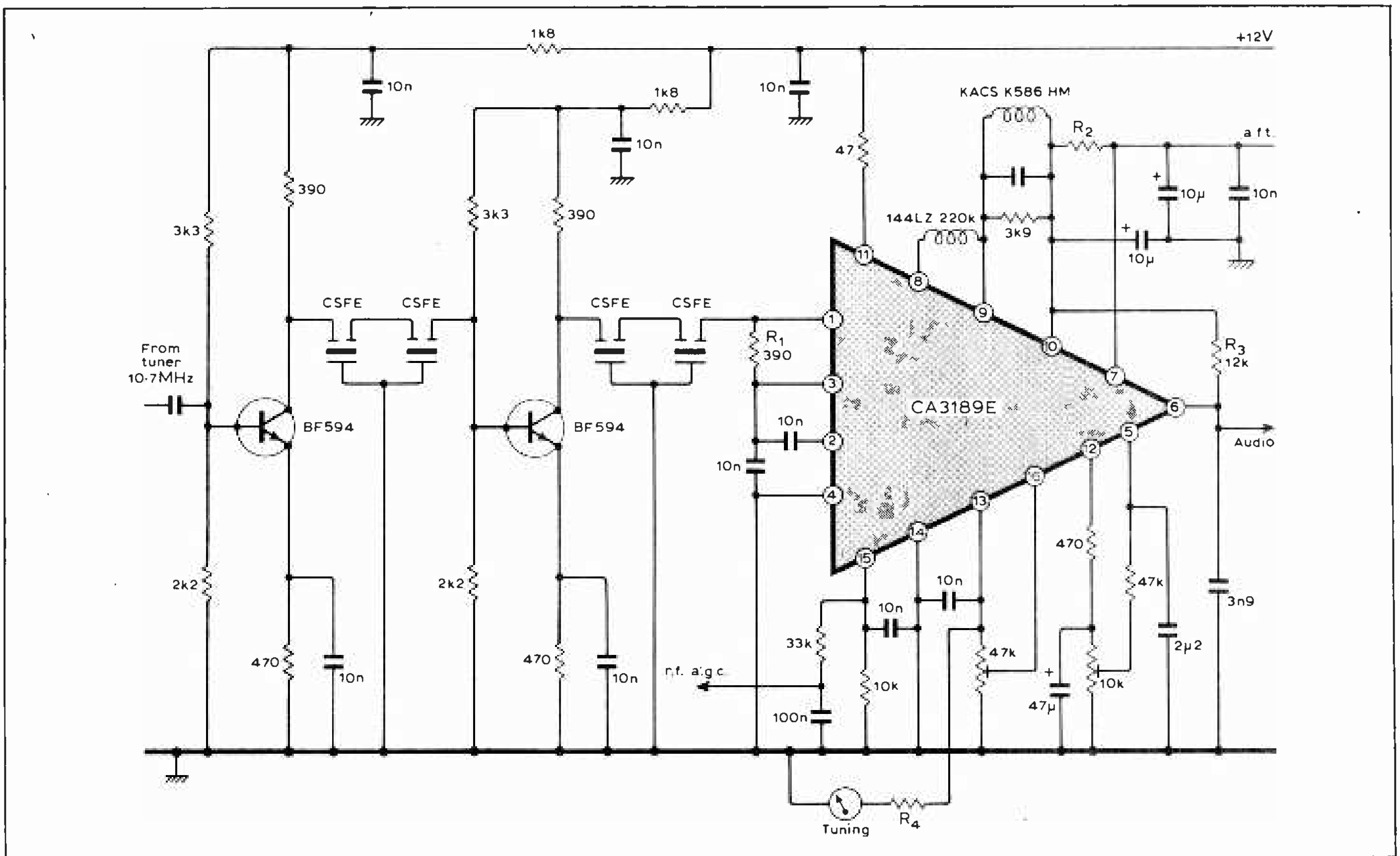



Fig. 9. *Practical circuit which achieves a s.-to-n. ratio of nearly 40dB for an input of 3μV. All filters and coils are Toko types*

set has to be built into the meter drive circuit to show a true zero under zero signal conditions. The typical meter characteristic of a CA3189E is shown in Fig. 7.

### R.f. a.g.c.

In the 3089E the threshold level of the a.g.c. circuit was fixed at approximately 10mV i.f. input, and the r.f. control voltage started at 4.5V. In the 3189E, shown in Fig. 8, the circuit offers flexibility in controlling the a.g.c. threshold and provides a d.c. output suitable for obtaining at least 40dB of control when using a dual gate m.o.s.f.e.t. stage. The point at which a.g.c. occurs can be chosen by feeding a suitable control voltage into pin 16. The threshold voltage required at this pin is 1.3V. A voltage rising from below this value to above it will cause the onset and completion of r.f. a.g.c. at pin 15. The input control voltage may be obtained from pin 13, in which case the threshold level can be varied from a nominal 200μV i.f. input, to 200mV.

### Practical circuit

The application circuit in Fig. 9 achieves a s.-to-n. ratio of nearly 40dB for an input of 3μV. Fig. 10 shows the s.-to-n. graph together with the a.m. rejection ratio. Both of these ratios are referenced to the limiting output of 1V r.m.s. Input signal in both cases is 1kHz modulation with +75kHz deviation.

Resistor $R_1$ is chosen to provide a correct terminating impedance for the particular ceramic filter used. For the Toko CSFE device a 390Ω is used. Resistor $R_2$ sets the deviation muting threshold. Using 15kΩ gives a threshold of about ±40kHz. Resistor $R_3$ sets the audio level, and with 12kΩ the recovered audio is about 1V r.m.s. By making this resistor larger, the recovered audio is increased and the s.-to-n. ratio is also increased by one or two dB. If the value is too large it will cause an increase in distortion. Fig. 11 shows the relationship between the recovered audio level and the value of $R_3$. The 3.9n capacitor from pin 6 to ground provides correct de-emphasis when $R_3$ is 12kΩ.

With a high gain device such as the CA3189E, attention to layout is important. Pin 4 should not be treated as an a.c. decoupling point for any capacitors other than the 10nF from pin 3. Decoupling capacitors should be taken to pin 14. It is preferable to use miniature plate ceramic capacitors because they have a small radiating area and a high self resonant frequency. □

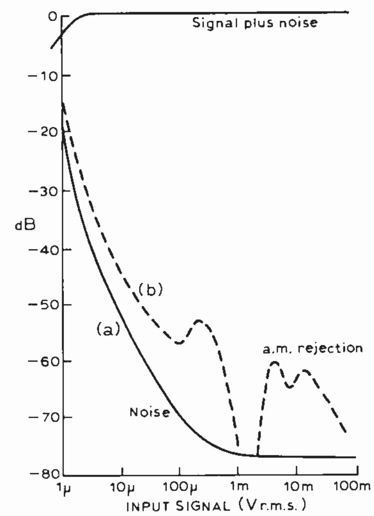



Fig. 10. *Signal noise/noise ratio for 75kHz deviation, and a.m. rejection for 400Hz 30% modulation.*

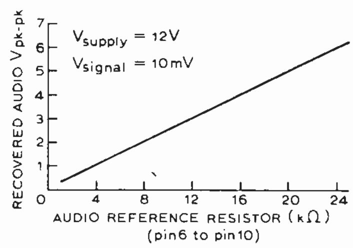



Fig. 11. *Recovered audio level for different values of reference resistor in Fig. 9.*

**A p.c.b. which accommodates the CA3189E and its associated circuitry (excluding the CSFE filter circuitry as shown in Fig. 9) is available for £2.50 inclusive from M. R. Sagin at 23 Keyes Road, London N.W.2.**

# LETTERS TO THE EDITOR

## CONTROLS FOR THE AGED

I CANNOT but endorse the complaint voiced by "Mixer" in your November issue about the lack of simple controls for some of the more ordinary radio and hi-fi gear. We are told that our nation is rapidly becoming more elderly, and our electronic suppliers have not yet reacted to this change. Recently I was asked to advise a lady in her late 80s about the purchase of a simple portable radio. Basically her needs were for a set which had a volume control and on/off switch and four push-buttons labelled Radio 1, Radio 2, etc. (though I doubt very much if Radio 1 would have been used by this person). I was amazed to find that radios with push-button station selection are no longer made. Why not? Surely manufacturers must have relatives and friends whose hands are not as precise as they used to be and are not able to cope with a tuning dial. Or do they imagine that the elderly spend their time in motor cars rather than by fireside? Car radios have push-button station selection, so it is quite technically possible.

Now before all manufacturers rush off to put an old people's set on the market with push-buttons let me tell the tale of the old lady in her 90s who lived alone and was bedridden. She had the 'phone at her bedside but as she was so feeble she had difficulty in dialling the numbers she wanted. Our ever alert Post Office comes to the rescue with a large box on the top of which was a large push-button which would connect her directly to the exchange. Yes – you have guessed it – she had not the strength to operate the push-button! All this in an age of touch-contact station selection on tv sets! Of course, when she did get the exchange they always wanted to know why she had not tried dialling the number herself because the large box with the push-button did *not* send a message to the exchange to alert them that this subscriber needed special assistance. Perhaps in the future with the arrival of microprocessors we shall have everything done just right – and by then I will be old enough to enjoy it all.

*C. Grant Dixon*
*Ross-on-Wye*
*Herefordshire*

## USING (OR NOT USING) MICROCOMPUTERS

WITH microcomputers I think the present situation is not at all a good one — for users or i.c. manufacturers. One problem is the strange fact that one must do a lot of work to get a system operating if it is to function anywhere near the capability of the hardware. Many introductory articles have been written, but usually such articles end with trivial applications. To sell a chip and about nine hundred pages of text with it — a splendid idea!

The "ready to go" systems are best described as empty systems; they are not ready to do anything. If you want a r.o.m. made you must *not* provide a neat sheet of numbers but a set of punched cards. Programming is very annoying because of the many steps required; the programmer feels he is doing a lot of work that could be done by the machine itself

Conclusion: all work and problems are shifted to the customer. Of course this does not matter if you are a very large organization like a motor car manufacturer. Small scale applications are almost impossible when you look at the programming effort required.

I hope that not too much space will be devoted to the microcomputer in your columns. If we all turn our backs to it, it might go away and come back later, a little bit more adapted to the user.

*W. Trapman jr.*
*Boskoop*
*Netherlands*

## HI FI CRI

MAY I as a mere service technician toss an idea into the Great Amplifier Debate (October letters p.60, November issue p.63) and perhaps provoke a reply from the golden-eared brigade?

These folk would have us believe that they can detect differences between, and even faults in, amplifiers whose performance is so good that it is all but beyond the present limits of measurement. "Ah yes," they will say, "but you can't measure everything you hear." That is true of course, but can I ask the cognoscenti "How do I repair your super musical super amp?" Even if I obtain the exact replacement components (though I must admit I can't tell the difference between a BC109B and a BC109C when they're handling half a volt) there is no way to test the completed repair even if I had the test gear to do it!

Perhaps our gifted brothers will make themselves available for a few hours each week at workshops throughout the country to ensure that the standards they have invented are maintained.

*D. H. Macready*
*St James*
*Northampton*

## THE SECRET WAVEMETER

IN YOUR feature "Sixty years ago" in the October 1977 issue you described my article on a heterodyne wavemeter. This was the first of thirteen articles on the technology of the thermionic valve. These *Wireless World* articles were to most of the general public the first systematic disclosure of the various new and revolutionary techniques in radio reception and transmission. Much credit is due to your journal. Professor Fleming, in the preface to the first edition of his book "The thermionic valve," published in 1919, generously acknowledges a debt to these "excellent articles" and made equally generous use of the circuits and texts.

The initials "D.J." were arbitrarily chosen by me because at the time I was a wireless officer at the Front and apprehensive of what the army would think. I had good reason for my fears. The official attitude at GHQ seemed to be that anything connected with valves was secret and sacrosanct, in spite of the fact that much information had been published in the *Proceedings of the Institute of Radio Engineers*, patents and isolated articles elsewhere. As I received a reassuring letter from the editor, a subsequent article in *Wireless World* was signed by my real name followed by "D.J." in brackets. My identity was thus flaunted and GHQ immediately took action. A strong letter was relayed through 1st Army HQ, Corps HQ and Division HQ and finally reached my signals company, asking by what authority this officer was disclosing military information to the press contrary to army regulations. I informed my commanding officer (to his great relief) that under war regulations an alternative to army channels was submission to the Press Bureau in London which had duly censored and passed my articles. This exculpation travelled back to GHQ through the same channels as the complaint and I heard nothing more. I am certain that had my thirteen articles been submitted through army channels they would have been suppressed.

The heterodyne wavemeter was important at the time because I had been entrusted with the first small-power c.w. sets to be tried out in battle conditions. I used them to effect communications between forward observations posts and a howitzer battery headquarters on Vimy Ridge. These sets were extremely effective and were extensively used in 1918 for general divisional communications with brigades and battalions in the line. During the Battle of the Lys all ordinary line communications in my divisional area were destroyed by the enemy.

*John Scott-Taggart*
*Beaconsfield*
*Bucks*

## ECONOMICAL TIME-MARK GENERATOR

REFERRING to the time-mark generator described in the November issue, I have had a similar circuit in use for some time, and in the light of my experience would offer these comments.

1. Starting with a 10MHz crystal has two advantages. It enables the faster timebases of modern oscilloscopes to be calibrated. It also enables more easily distinguishable harmonics to be used when calibrating v.h.f. receivers.

2. Unless the oscillator is supplied with a higher h.t. voltage than the 5 volts needed for the rest of the circuit, it is difficult to get a sufficiently steep wavefront to trigger the first decade divider, especially if it is a 10MHz crystal. It is therefore advisable to insert a Schmitt trigger (7413) between the oscillator and the first 7490. This will trigger from a slowly rising wavefront.

3. The setting of $C_1$ is quite critical if the highest order of accuracy is wanted. An easily available standard frequency is the BBC transmission on 200kHz, which can be picked up in most parts of the country on a few feet of wire attached to a simple tuned circuit. For example in North Yorkshire, well over 100 miles from the transmitter, I get 150mV peak to peak on a 10ft aerial attached to the top of a tuned circuit, and this is much more than adequate to display on one input to a double trace oscilloscope, while the other trace is locked to the calibrator switched to the 10μs output. There will then be exactly two radio waves for every marker, and $C_1$ should be adjusted until the radio waves are stationary on the screen. It will be found that the adjustment of $C_1$ is then much too fierce, and a better result is obtained by splitting it into a fixed capacitor in parallel with a variable of some 10pF.

4. Finally, in Fig. 3, I would query how accurate counting could be accomplished. Whichever frequency was used to lock the timebase, the other would be travelling across the face of the tube at a rate of knots too fast to count.

*W. Winder*
*Harrogate*
*Yorkshire*

## AUDIBLE AMPLIFIER DISTORTION

IN his article on amplifiers (November 1977) Peter Baxandall has rested a naively drawn case on a narrow conception of distortion. An extreme subjective position — that there is no difference to be heard between "first class, competently designed, amplifiers" — is supported by rational criteria which, though conventional, are incomplete in themselves and utterly inadequate to the task.

It is astonishing to us that there persists — at such a late date, and in the face of even our own relatively short experience with a wide variety of internationally available commercial power amplifiers — an attitude of mind that refuses to respond to the ever increasing weight of subjective evidence from enthusiasts and experienced hi-fi equipment dealers.

We do not believe it adequate — however superficially justifiable — to attack the problem by gripes against the British hi-fi press and its reviewers' shortcomings. We do believe that "first class, competently designed" power amplifiers sound different, and that the differences matter and can be rationally accounted for, and a prescription for universal good quality laid down.

In the first place we do think total harmonic distortion in the classical sense — with the harmonics weighted in Olson's manner — to be relevant. At the same time we know that pre-amplifiers and power amplifiers do sound different even though their "on paper" specifications are far superior to the programme material, from tape or disc, used in their evaluation.

If the Quad diagnostic set up (Fig 1, original article) is to be used as the ultimate test of amplifier quality why then do the Quad 303 and 405 sound different? This is not a trick question — in that the 303 has an output capacitor and the 405 does not — but what does happen if we put, say, a 2000μF capacitor between an amplifier and a loudspeaker? The sound becomes "warmer" and "muddier." Yet this intrusion would not appear in an analysis of the Quad frequency-response and phase-balancing network. (To us the Quad network — representing a passive amplifier — appears to have 12dB/octave slopes and thus to be on the threshold of instability.)

In his AES paper of 1973 Otala[1] describes a diagnostic circuit which he treats as a constant delay with one h.f. roll-off pole included to compensate for one dominant h.f. pole used passively at the input of the amplifier he describes. The reason would appear to be that the ideal amplifier will delay but not destroy the sound.

However, a 1kHz toneburst with d.c. offset (representing speech, for example) into a circuit such as the Quad diagnostic network will distort — the toneburst will tilt. But because the amplifier cancels this tilt the effect of the network is not observed. Thus a dramatic silence — suggesting no distortion. Into a loudspeaker there would be an audible change when compared with a d.c. amplifier or one with a cut off at about 3Hz or less.

Experience in the last ten years suggests that amplifiers (valve and transistor) start to sound alike when the bandwidth is extended nearly a decade on each side of the audio band (giving 3Hz—150kHz,—3dB) *at full power*; and when the distortion is about the same from 20Hz to 20kHz; and when the damping factor at the point where feedback is sampled is relatively constant over the whole audio band (implying a wide open-loop response); and when total phase change is less than 10° from 20Hz to 20kHz.

There are other subtle factors that affect the final quality. But differences in sound are not easy to express in words. Nor is it possible always to say which is right and which is wrong. But if a difference exists one must attempt always to verify, to measure and to explain.

*Tim de Paravicini and John Greenbank*
*Moonlight Electronics Ltd*
*Cambridge*

**Reference**
1. "An Audio Power Amplifier for Ultimate Quality Requirements." Jan Lohstroh and Matti Otala, Audio Engineering Society 44th Convention 20-22.2.1973, Rotterdam.

MR BAXANDALL raises several spurious arguments in an apparent attempt to prove that audio amplifier design reached its pinnacle in the mid-sixties and that further work is therefore pointless (November 1977 issue).

No serious worker in this field would doubt that extreme care and attention to detail are necessary whenever any comparative testing is undertaken. It is an established requirement that all documented experiments be prefaced by a description of "methodology". Indeed it is quite common to find that far more time and effort is expended in establishing an experimental regime and in the elimination or quantification of potential errors than in the performance of the comparative experiment itself. A further necessity is the use of "control" experiments to establish a median and to prevent "cheating" and the influence of emotional prejudice. It is regrettable that some reviewers omit this part of the scientific procedure.

Such knowledge of valid experimental technique is not unique to the BBC or to Mr Baxandall. It has been applied by anyone who has been to university.

Despite the doubts of Mr Baxandall and the apparent desperations of Mr Williamson (letters, October 1977), the most careful experimental auditioning does reveal audible differences between many audio amplifier systems. There is no magic about this or requirement for "golden ears". Nor is there any need for Mr Williamson to get on to his engineering high-horse to make blanket condemnations. The whole point has been missed. It is not seriously suggested that amplifier differences can only be heard and not measured. A great many of the "subjective" differences can now be tracked down and accounted for in engineering terms. However, not all the necessary experimental techniques have been published for obvious commercial reasons.

The Quad nulling experiment is well known but has significant limitations. A considerably more exact and elegant technique is now used by AEA in the USA and other workers in the UK. This is the technique of quantisation of the input and output signals for analysis by a digital computer. This technique enables a "real-time" comparison to be made throughout the course of a piece of music and with a great degree of accuracy; it has permitted some interesting correlations between measured errors and audible deficiencies.

I cannot believe that Mr Baxandall takes the subject seriously if he never listens to his amplifiers as part of their development programme. Apart from anything else a carefully planned series of listening tests can check an amplifier's compatibility with various loudspeakers and cartridges and identify problem areas for investigative laboratory action. Before writing this letter I was able to contact the designers of six different UK makes of high-quality audio amplifiers. In each case the designers (all qualified and experienced engineers) considered it necessary to perform listening tests in the course of their development programme. Obviously either they or Mr Baxandall are wrong.

I perceive, however, that the old men of the industry are set in their ways and are unlikely to change. No doubt Messrs. Baxandall and Williamson do not expect Quad to bring out replacements for the 303 or the 33. Personally I have more respect for Quad. And, no doubt, Mr Baxandall will not find it necessary to publish any new amplifier circuits. I find it sad that perfection has already been reached because so much sounds so imperfect.

*Stan Curtis*
*Mission Electronics Ltd*
*London, SW6*

MAY I add my support to Peter Baxandall's criticism of reviewers who describe in great detail gross differences in the performance of many of the amplifiers and loudspeakers in the top quality class when careful comparison indicates that there are no such audible differences. Moreover they claim to hear these gross differences when commercial gramophone records are the source of the test programme.

Now the distortions in any recording and replay system using commercial gramophone records are between one hundred and one thousand times greater than in any of the top quality amplifiers, while the loudspeakers used to judge the amplifier performance have distortions about one hundred times greater than the amplifiers. Not only are the distortions in a gramophone record system vastly greater than in a good amplifier, but a high proportion of the distortion is of the frequency modulation type and significantly more annoying per unit of distortion than are the harmonic and intermodulation distortions that occur in an amplifier. Perhaps one of the reviewers can provide an explanation of just how it is possible to detect the trivial distortions in a good amplifier in the presence of programme source distortions that are about one thousand times higher.

My laboratory is continuously involved in assessing the sound quality from a wide range of equipment and the most troublesome problem that we encounter is that of obtaining programme material of the high quality that is essential if valid comparisons are to be made on amplifiers and loudspeakers in the top class. We rejected commercial gramophone records as a source at least ten years ago and we confine ourselves to using first or second generation copies of 15in/s tapes played on a professional tape machine in the £2000 class. This sets a high standard and leads us to reject 80% of the studio tapes we obtain because they are significantly inferior in quality to the remaining 20%. When gramophone records must be used we employ direct cut discs.

With such high class programme material at our disposal we cannot find any trace of the gross distortions so vividly described by a small group of reviewers having facilities no more extensive than many hi-fi enthusiasts and undertaking the reviewing in their spare time. Adjectival extravagance appears to be considered an acceptable alternative to technical accuracy, a substitution that can only lead to the rejection by the industry and by the public of those magazines that indulge in these fantasies.

I would comment on an important aspect of these comparisons that is rarely appreciated. There are generally only small differences in the performances of components all in the same price class and the issue is rarely one that unit "A" is clearly better than unit "B". In practice "A" has some distortions, using the word in its widest sense, that "B" does not have, and vice-versa. The judges have to decide which of two different combinations of distortion they find least objectionable. If one comes to a decision when listening to radio station or record No. 1, it is common to find that the opposite decision is reached on station or record No. 2. Differences in the quality of the programme sources are at least as important as the differences in the performance of equipment in the top class.

I would comment on another of Peter Baxandall's points, the use of listening panels in assessing sound quality. Listening panels appear at first thought to be an excellent way of obtaining a broadly based opinion of the sound quality of a system, but actual experience leads us to doubt that view. If more than a few judges are involved in a single listening session they cannot all occupy reasonable seats, nor can they make the changeover between units being compared just at the instant when the music is appropriate for checking some specific difference in performance that they have noted. We are gradually moving away from the use of such panels unless we are specially requested to institute panel tests by a client. The procedure we now prefer is to have three or four experienced listeners compare the receivers individually, operating the changeover push-button etc., themselves while listening to high quality programme material. Each writes up his own notes and after the last man has done so, he reads the previous notes, checks for differences of opinion and when advisable re-checks any point of differences. Each listener is free to make a changeover just when he wishes to check some specific difference between the two systems being compared and he is free to continue his comparison for just as long as it takes to arrive at a soundly based opinion. We find this procedure leaves the listener much more confident in his decision than when taking part in a panel listening test. Combined with the results of measurements on the objective aspects of the two systems and an appropriate statistical analysis of the data, we believe that we obtain a more accurate indication of the performance than is obtained from the current assessment techniques.

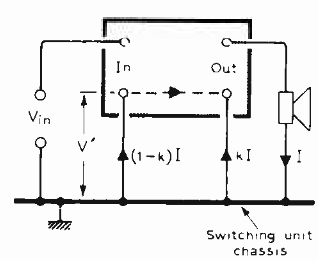
*James Moir*
*James Moir & Associates*
*Chipperfield*
*Herts*

*Mr Baxandall replies:*

I was interested to hear about the great care taken by James Moir to obtain programme input sources of the highest available quality, and I agree with his preference for conducting the tests with one listener at a time, this person being allowed to operate the changeover switch. The identity of the equipment tested, in relation to the switch positions, should not be known to the listener. I note that experience has been that, when all due precautions are carefully taken, first-class amplifiers are found to be absolutely indistinguishable.

Though Tim de Paravicini and John Greenbank say I have a narrow conception of distortion, they do not state how their conception differs from mine. I would say simply that an amplifier has perceptible distortion if it causes a perceptible quality change when introduced into a very high grade audio chain, due care being taken to match levels. Surely this is the fundamental meaning of the word? If my article is carefully read, it will be found that no other conception of the meaning is implied.

It is suggested that I refuse to respond to the ever-increasing weight of subjective evidence relating to audible differences between first-class amplifiers, and Stan Curtis says this is because, like my good friend Reg Williamson, I am "an old man of the industry, set in my ways and unlikely to change." We've had a good laugh over this – but I do, nevertheless, accept that I'm set in my ways and unlikely to change, if this is taken to mean that I view all new evidence with the initially suspicious attitude that is a proper accompaniment of a truly scientific outlook. Thus I do, indeed, refuse to respond *too easily* to evidence which is not the outcome of proper scientific procedures, which does not tie up logically with other established results, and which disagrees with my own direct experience. However, if, on further careful investigation, I find my earlier notions are proved to be wrong, then I will certainly, and gladly, change my views.




But I have found no trace of reliable evidence to support extreme notions such as that a power amplifier should be able to produce full power output from 3Hz to 150kHz, nor that its phase shift should be less than 10° at all audio frequencies. The fact that a university department somewhere or other may have concluded that something of the sort is desirable does not seem to me in itself to carry much weight.

Messrs de Paravicini and Greenbank say explicitly that they do believe that first-class competenently designed power amplifiers sound different, and it may be relevant to mention, in this context, that since writing the article, my attention has been drawn to an interesting contribution "Six amplifiers – how did they sound?" by I. G. Masters, in the *Audio Scene Canada* magazine. This says, to summarise it very briefly, that six good amplifiers were carefully compared on an A - B basis, using various loudspeakers, and "Lo and behold! – we heard some very striking differences." Some showed up badly with difficult loads, some didn't – but the tests were done at quite low power levels and no overloading was allowed to occur. It was then discovered that some amplifiers measured the same when tested separately as when tested in the comparator set-up, whereas others did not, and this led to a careful investigation of earthing arrangements in the comparator. When the unwanted earth-loop effects had been understood and cured, "we heard . . . no difference. None." A "straight wire" test was also done – "The amplifiers not only sounded the same as each other, they sounded the same as our 'straight wire'." Though no diagram is given, it seems that the essence of the situation can be represented as here shown. The various amplifiers initially had their inputs and outputs switched on the live sides only, the earthy sides being taken to the switching unit chassis "as with most (possibly all) switchers that would be found in hi-fi stores." Thus, with one amplifier switched in, the loudspeaker current, *I*, must return to the earthy output terminal of the amplifier, and if the amplifier has the earthy sides of its input and output joined together internally, as is often the case, this current can return via two paths, as shown. The portion $(1 - k)I$ thus flows in the signal input earthy connection, producing a voltage drop, $V'$, as shown, and this is injected in series with the signal source. Since *I* may be several amps, a small fraction of an ohm of lead impedance will be enough to produce a significant value of $V'$, and this value is clearly dependent on the variation of loudspeaker impedance with frequency. Some amplifiers have no low-resistance internal connection between the earthy sides of their inputs and outputs, and in such cases all the loudspeaker current must return directly to the earthy output terminal, i.e. $k = 1$. No peculiar effects then occur.

Even when double-pole switching is adopted, similar effects to those described above can occur if the wiring is not suitably arranged.

Messrs Paravicini and Greenbank ask why the Quad 303 and 405 sound different. I suggest they should carefully re-read Peter

Walker's contribution on page 135 of *Hi-Fi News* for July 1977. Provided the comparison is completely fairly done, as stated, including arranging that the overall system frequency response is not significantly different in the two cases, Quad are prepared to stake their reputation on the 303 and 405 sounding exactly alike. Differences in frequency response of the amplifiers are negligible provided the programme material is free from significant unwanted components at sub-audio frequencies.

The comment about 12dB/octave slopes in the Quad nulling test set-up indicating a system on the threshold of instability is not justified, for the elements in question are not within a feedback loop, either in the amplifier or in the separate network.

Returning to Stan Curtis's letter, he says the Quad nulling experiment is well known "but has significant limitations." Unfortunately he does not state what he regards these limitations as being. It seems to me that when properly used, in the *various ways* mentioned in my article, it is by far the most satisfactory technique for directly investigating subjective distortion in such a way that the "margins of safety" may be estimated.* I have read about the digital technique being used by Analog Engineering Associates, but whether this should be regarded as more elegant depends, I think, on one's point of view. It is certainly far more complex and expensive, and, because of this, may be said to lack the elegance of simplicity! In common with the Quad nulling technique, it operates with programme as the signal, and whereas it clearly can be made to yield vast quantities of information, not all useful, on effects going on within amplifiers, I do not see that it is a preferable technique for investigating the subjective quality of a given amplifier.

Stan Curtis finds it difficult to believe that I take the subject seriously, since I do not normally listen to amplifiers as part of the development programme. Though he may find this difficult to believe, it is nevertheless true! With regard to the compatibility of amplifiers with loudspeakers and pickup cartridges, I cannot for the life of me see why listening tests should be required, for the problem is a straightforward one involving impedances, phase angles, signal levels, protective-circuit operation etc. It does not surprise me to learn, however, that many designers do feel it necessary to resort to listening tests. Mr Curtis says "obviously either they or Mr Baxandall are wrong." But is it not, perhaps, truer to say simply that different people do things in different ways? It is a fact that a design I did for a commercial firm was not listened to at all until the circuit design was quite completed, but subsequently came top in an independent subjective assessment of many competitive designs from various countries. Quad too assure me that they adopt the attitude that if you understand what you are doing thoroughly enough, there is no need for listening tests during the design and development of amplifiers, and that they do not normally carry out such tests. Moreover, their pioneering work on electrostatic loudspeakers has shown that even loudspeaker development can with advantage be done largely on a basis of "theoretical designability," with the bare minimum of subjective testing.

Lastly, Stan Curtis finds it sad that I should believe that perfection has been reached, for, as he says "so much sounds so imperfect." I can assure him, most sincerely, that I couldn't more fully agree with this observation as far as the end product of most hi-fi systems most of the time is concerned. If it were not so, we could more frequently enjoy artistic subtleties and differences without the intrusion of technology. I also agree with him that there are many amplifiers around that fall short of the ideal performance, as judged subjectively. But I must end by repeating that I am in no doubt at all that the best amplifiers, unlike some other links in the overall chain, easily meet the requirements for subjectively perfect sound reproduction. Nevertheless, designers, including myself, will continue to bring out new designs, for there are so many reasons for doing this other than basic sound quality – power ratings, reliability, production economy, versatility of functions, etc.

*Peter J. Baxandall*
*Malvern*
*Worcs*

*As some readers will have spotted, the editor inadvertently left out two resistors, one in each input to the monitoring system.

## LOGIC DESIGN

THERE is an important principle that was not brought up in the fourth article of the "Logic design" series by Holdsworth and Zissos (May 1977 issue).

The realization of the circuit for the alarm bell output in Fig. 14 (f) is more complex than need be. Two of the cells in the merged state diagram Fig. 14 (d) indicate unstable states in which the circuit cannot remain. Therefore the outputs in these two states do not matter and the *b* output can be high. This simplifies the circuit from:

$$b = \bar{A}f\bar{a} + A\bar{f}\bar{a}$$

to

$$b = \bar{A}f + A\bar{f}$$

In this example there is not a great saving in hardware; two 2-input Nand gates are used instead of two 3-input Nand gates, but in more complex problems the savings could be significant.

One must take care in the use of this simplification as there is a delay in the transition from the unstable to the stable state. This results in an output spike of short duration which could affect a following circuit. This spike is far too short to operate the alarm bell in the illustrated problem.

*A. R. Harris*
*Biltondene Developments Ltd*
*London SW8*

*Professor Zissos and Mr Holdsworth reply:*
We agree with Mr Harris that a further reduction of the bell equation is possible by using the circuit conditions, $A=0$, $f=1$ and $a=1$ and $A=1$, $f=0$ and $a=1$ for simplification purposes. The bell equation then reduced to

$$b = \bar{A}f + A\bar{f}$$

However, in this circuit a spike will not occur as a consequence of using this simplification and it is essential for the bell to ring particularly when a fault occurs to draw the attention of the operator to its occurrence.

When the transition $S_{01}$ to $S_{23}$ is made (Fig 14(d) the input signals required are $f=1$ and $a=1$. By virtue of the design specification these signals must occur in the sequence $f=1$ followed by $a=1$. Initially the circuit will take up the condition $A=0, f=1$ and $a=0$ and the bell rings as required. The transition then takes place when $a$ becomes 1. During the transition from $S_{01}$ to $S_{23}$ $f=1$ and $a=1$ and $b=0$. When the transition has been completed $A=1$, $f=1$ and $a=1$ and again $b=0$ as required.

Similar conclusions may be drawn regarding the transition from $S_{23}$ to $S_{01}$.

Perhaps it should be noted that, due to an authors' error, state $S_{23}$ has been marked incorrectly as $S_{02}$ and the bell signal in this state should be $f\bar{a}$.

*B. Holdsworth and L. Zissos*

*Editor's note: The following remarks were unfortunately omitted from the authors' reply to Mr R. M. Hutton's letter on minimisation in logic design in the December 1977 issue. Apologies to the correspondents.*

We are not at all sure what is debatable about Example L, nor can we agree with your statement that in this example we have demonstrated the vulnerability of our method. We are aware that a change of state assignment will lead to a different solution. All other known methods of logic design are vulnerable in precisely the same way and it is up to the logic designer to examine all possible solutions if he wishes to find the simplest solution. This is perfectly easy to do in the case of a four-state state diagram but becomes increasingly more difficult as the number of state variables increases. If minimal solutions are not vital it is probably more economically sound to reduce the design time.

With respect to the relative advantages of mapping techniques in comparison with algebraic methods this is really a question of which method the designer is familiar with. Certainly students we have taught do not find algebraic methods any more difficult to use than mapping techniques and vice versa. If you refer back to article 1 on Boolean algebra you will find that there are a very limited number of rules to remember. We would not press a claim either way with respect to this point and would suggest that the designer should use the method he is most familiar with.

*B. Holdsworth and L. Zissos*

## THE DECATRON

READING T. R. Thompson's letter (November 1977 issue) about the 3NF valve "integrated circuit," brought to mind the old "Decatron" tubes, which are still available (if you know where to look). These, of course, are the equivalent of a decade counter-decoder-driver and display all in one! They haven't even done that in semiconductor i.cs to my knowledge.

*R. E. Williams*
*Tilsworth*
*Beds*

*Letters commenting on Eric F. Taylor's articles "Distortion in low-noise amplifiers" (August and September 1977) will be published in a later issue.*

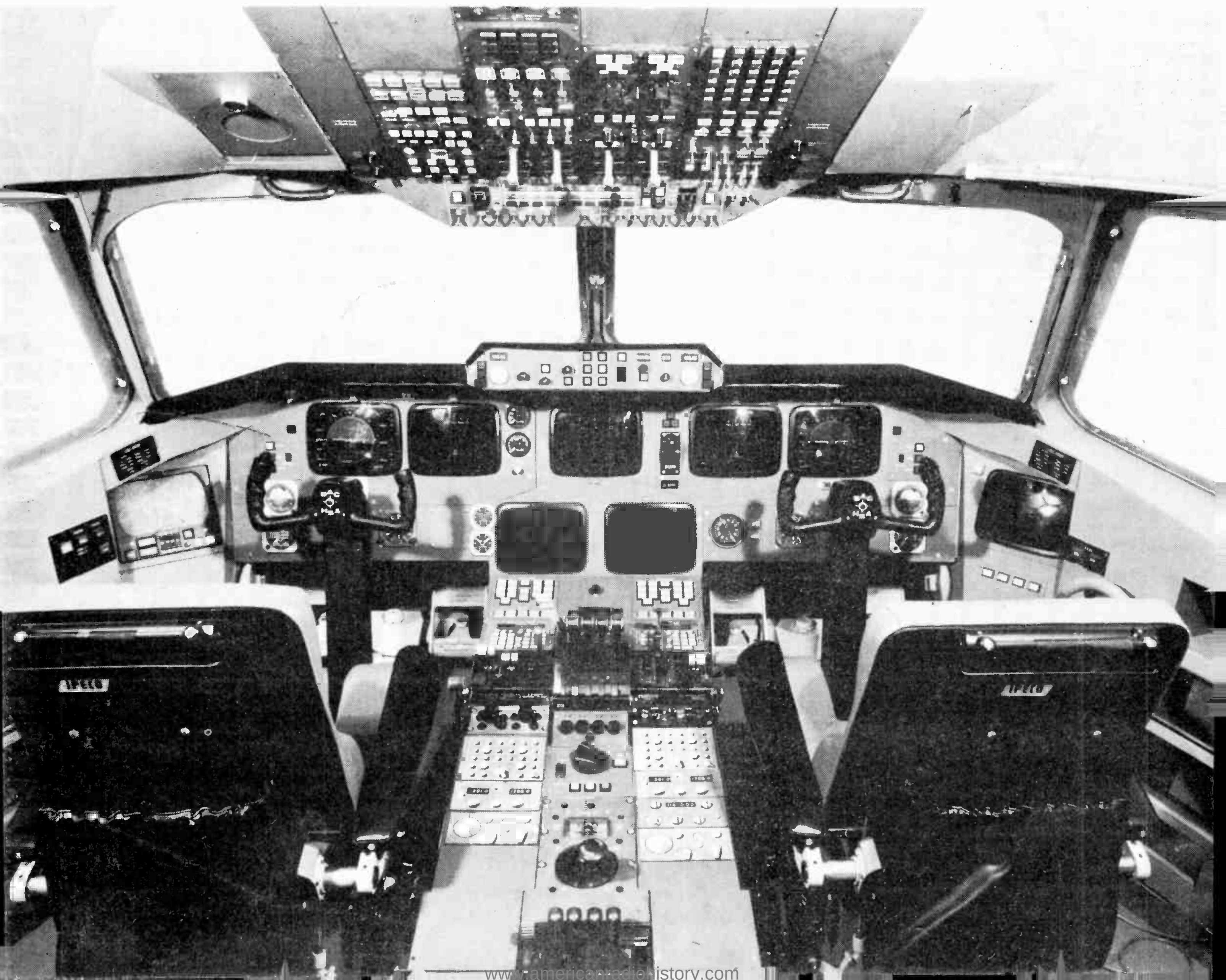
# Radio on the flight deck

## Outline of communication and other aids in civil aircraft

by Alan Bramson
M.R.Ae.S.

THE TECHNOLOGIES of practical aeronautics and wireless are of similar ages and it is interesting to contemplate how closely the two have become related. Without radio all-weather flying operations would be impossible, while the aircraft operator's demands for better radio aids have stimulated some of the most important developments in electronics. This article explains to non-flying radio people why certain branches of their endeavour have become so vital to air pilots.

Weather information, of great importance to seafaring men, is even more vital to the air pilot. For unlike his opposite number on the bridge of a large ship he cannot drop anchor and have a think when the fog comes down. The modern light touring aircraft will not fly comfortably much below 80 knots and the big passenger jets prefer to maintain more than twice that speed. Consequently there is a clear need for good air/ground communications if for no other reason than to obtain the weather and receive air traffic advice from the ground controllers. Then again a pilot cannot be sure that he will be able to fly in conditions which allow him to see the ground and read a map. For example low cloud may demand that he climbs on top or at least to an altitude that will ensure safe clearance from such obstacles as mountains, television masts or the like. In each case outside visual references are lost and map reading is no longer possible. In the early days of flying navigation under these circumstances was by dead reckoning, whereby a specialist navigator kept a "running plot" of the aircraft's position, assuming still air. At intervals he applied the forecast wind velocity to these theoretical positions to arrive at what he hoped to be the actual location relative to the surface. At night he would turn his attention to astro-navigation but these days neither method would be considered; there are very few specialist navigators and all air navigation is by pilot interpreted radio



aids or those operated from the ground. Finally, there comes a time when the pilot must descend through the cloud and land his aircraft. To do this in safety demands letting down in the certain knowledge that one will not fly into high ground or man-made obstacles. These too are conditions requiring accurate radio guidance.

So broadly speaking airborne radio may be divided into three categories: communications, navigational aids and landing aids. And since this equipment has been designed specifically with aircraft in mind it has become the fashion to name it avionics.

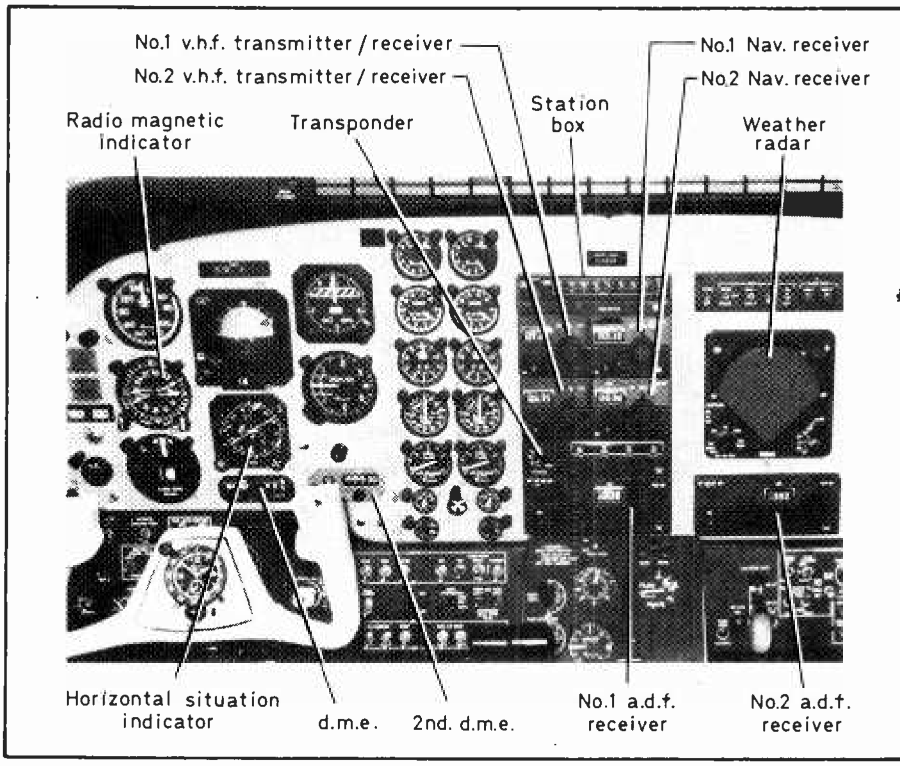
## Aircraft communications equipment

The first practical experiments in airborne radio communications in Britain were conducted by Lieut C. J. Aston, RE, and Sergeant G. R. Johnson, who, in 1907, managed to send and receive wireless telegraphy signals from a captive balloon. By 1909 tests were being made from the airship "Beta" and the following year saw the first successful two-way transmissions from a heavier-than-air machine by the Canadian pilot J. D. A. McCurdy. Since messages were sent by Morse, brevity was all important so with this in view, an internationally agreed "Q" code was adopted in which three letter groups beginning with the letter "Q" could be transmitted to convey quite lengthy messages. Because most wireless in those days was m.f., aircraft would trail a long aerial with a weight on the end. Many was the chimney pot around the old Croydon Airport that got "fished" by the biplane airliners of the 1920s and early '30s.

After a brief flirtation with h.f. radio telephony the Royal Air Force changed to v.h.f. during the early stages of the 1939-45 war and the Americans followed our example shortly afterwards. The early transceivers weighed about 25kg, had only four crystal-controlled channels and gave a modest power output of 3-5 watts. Today crystals have given way to synthesizers and 360 channels, until recent years regarded as adequate, are now being replaced by transceivers offering 720 channels at 25kHz intervals. A typical 10-watt aircraft set would weigh less than 2kg. Other equipment with up to 1440 channels and a power output of 25 watts is also available. For many years frequency selection was mechanical, one knob changing integral numbers of megahertz and another decimal fractions with the figures displayed in digital form, but current practice favours keyboard selection and electronic readout.

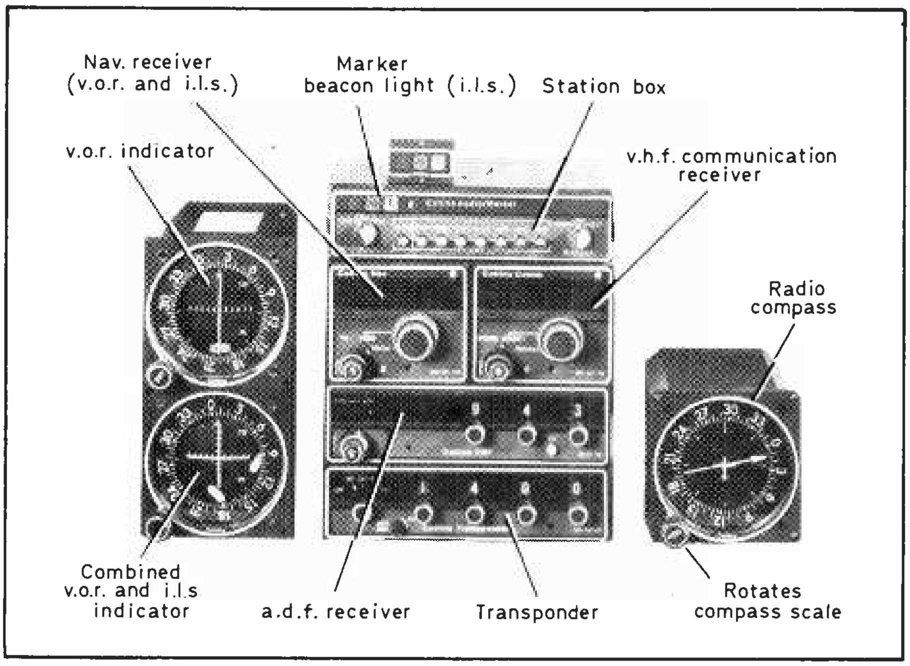
◄

*Cathode-ray tubes may be used in place of conventional instruments in future civil aircraft. This simulated c.r.t. flight deck has been built for a Government-sponsored BAC / Hawker Siddeley study to simplify information displays.*




▲ *Typical avionics installation as fitted in a small turboprop or light twin. Note that most of the equipment is duplicated.*

*Collins "Micro-line" avionics for general aviation aircraft. The receivers will store two pre-set frequencies.* ▼




Many aircraft these days carry two transceivers as an insurance against failure and for speedy access to the various ground stations. They are arranged so that the pilot may listen on both receivers simultaneously (adjusting individual volume controls to suit circumstances) with a "transmit 1/transmit 2" selector to determine which box is being used for passing messages. Even this arrangement is less than ideal because at a busy airport a number of frequencies may be in use simultaneously according to the service being provided. Thus a pilot will call "ground" on, say, 121.75MHz for taxy and airways clearance, "tower" on 118.1MHz when he is ready to move onto the runway and take-off and "approach" on 119.6MHz after becoming airborne, with an almost immediate frequency change to, say, 128.4MHz for London Airways as he enters this system and climbs to his en-route cruising level. To cater for this quick-fire need to change from one frequency to another some modern v.h.f. sets have the ability to store pre-selected frequencies for instant recall.

Although the modern v.h.f. transceiver will provide clear reception and powerful transmission for a modest weight, its range is limited to the usual "line of sight" applicable to this waveband. To cater for long range communications over such areas as the Pacific or the Atlantic larger aircraft will often carry single-sideband h.f. Its performance is outstanding and the only drawback, in so far as light aircraft are concerned, is the weight of the equipment and a price which can reach £13,000.

If he has nothing else in his aircraft the pilot with a good communications transceiver can at least obtain weather information, he can ask for radio bearing or radar assistance and air traffic control services will be able to warn him of other aircraft movements.

## Navigational aids

First attempts at radio navigation were based upon the directional properties of radio and most of the major airports had large loop aerials which could be rotated in azimuth to obtain a null on an incoming transmission, when the controller would pass to the aircraft a class "A", "B" or "C" bearing according to its accuracy. Then the loop found its way into the aircraft, thus making the radio operator independent of ground direction finding; he could provide his pilot with a fix by taking radio bearings on two or more known ground stations and plotting them on a chart.

To this day a much improved direction finding service is provided at many airfields. It accepts v.h.f. transmissions on the usual communications frequencies and displays magnetic heading from the aircraft to the station as a radial line on a cathode ray tube. Such ground equipment is known as v.d.f. or v.h.f.d.f.

**Automatic direction finding.** A development of airborne direction finding which emerged in the late 1930s and remains in use to this day is automatic direction finding (a.d.f.) It is used in conjunction with a ground transmitter, usually a purpose-built non-directional beacon (n.d.b.) operating in the m.f. bands, although broadcasting stations may be used. Having tuned to the required n.d.b., identified it by a two or three letter Morse sequence which at intervals interrupts the continuous 400Hz tone of the beacon, the operator switches the a.d.f. receiver to "comp" (or, in some sets, a.d.f.) when a radio compass situated on the instrument panel will point to the n.d.b., thus providing a relative bearing. If the pilot wishes to know what heading to steer for overhead the beacon he must add his present compass heading to that indicated by the radio compass, e.g. aircraft heading 045°, radio compass 025°, heading to beacon 070°. If the answer exceeds 360° he must subtract 360° from it — all this in his head while flying the aircraft. To relieve the pressure some radio compass presentations include a bearing scale that rotates with the aircraft's gyro compass system. These useful instruments are known as radio magnetic indicators. A.d.f. operates in the 200-1600kHz bands and modern equipment is crystal controlled and digitally tuned. The servo-controlled rotating loop aerial of earlier a.d.f. sets has for some years given way to a simple fixed aerial suppressed within the aircraft structure.

A.d.f. suffers from night effect, coastal and terrain distortion, quadrantial error (due to proximity of the metal airframe which "bends" the bearings from the n.d.bs) and a marked preference for pointing towards the nearest thunderstorm when one is active rather than the chosen n.d.b. Having said this, a.d.f. remains a useful aid, although its importance has been reduced by the advent of a more modern aid which operates on v.h.f. and is easier to interpret. This is called, v.o.r.

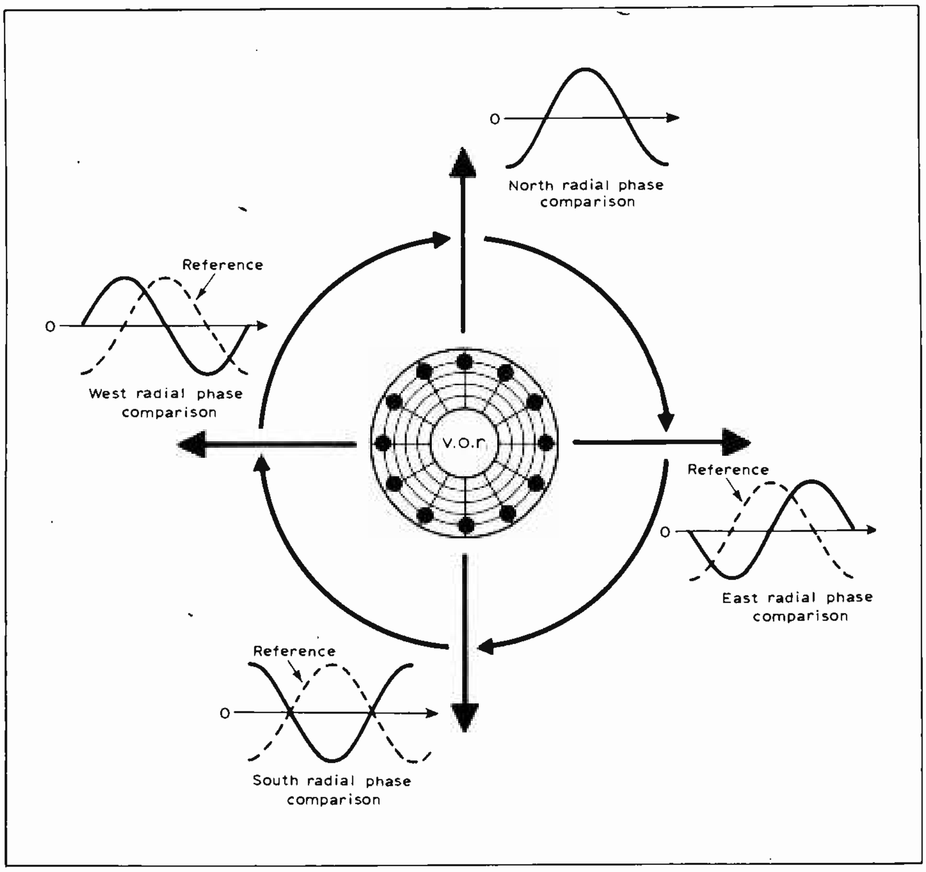



**Fig. 1.** *V.h.f. omni-directional radio range transmission showing phase relationships for north, east, south and west. The reference signal is fixed in all directions while the clockwise rotating beam changes cycle to produce an infinite number of radials, each of different phase relationship.*

**V.h.f. omni-directional radio range (v.o.r.).** Whoever gave the aid its full title obviously believed in telling the whole truth and nothing but the truth. V.o.r. is based upon the phase comparison principle. The ground station consists of a v.h.f. transmitter operating in the 108-118MHz band which emits two signals, a reference signal radiating in all directions with a fixed phase, and a beamed emission which changes phase as it rotates clockwise like the beam of a lighthouse. Thus at any particular point of the compass relative to the ground station a unique phase relationship exists between the fixed and the rotating signals (Fig 1). At 10-second intervals a two or three letter Morse identification is transmitted and some of the principal v.o.r. beacons are arranged to provide up-to-date airfield and weather information on the carrier wave.

The aircraft end of the system comprises a v.h.f. navigation receiver (known as a "nav" receiver) capable of accepting 200 or more navigation frequencies and a v.o.r. converter/indicator, an instrument, illustrated in Fig. 2, which is located on the pilot's flight panel. When the equipment is off or, for any reason, no signal is being received a warning "flag" appears. There is an omni bearing selector (o.b.s.) which allows the pilot to set the required bearing in conjunction with a moving scale. In adjusting the o.b.s. knob the pilot is really matching his equipment to the incoming phases from the v.o.r. station. The left/right deviation needle shown in the illustration will only centre when the aircraft is over the v.o.r. bearing shown on the bearing scale. V.o.r. beacons are, by the way, lined up on magnetic north. So if the pilot is unsure of his position he may select an appropriate v.o.r. facility, identify it using the automatic Morse signal, then turn the o.b.s. knob until the left/right needle lies in the centre of the instrument with the word "to" showing in the to/from indicator (see Fig. 2). Reference to the bearing scale will tell him what to steer on his compass and provided the needle remains in the centre he is on that bearing to the v.o.r. station. Should, for example, a crosswind drift him to the right the needle will move left, telling him to "fly left," each dot representing approximately 2° off track.

As the aircraft approaches overhead the beacon so the needle becomes more sensitive – think of all those radio bearings converging like cycle spokes and you will readily see why. Over the beacon the needle will swing out left or right, the to/from indicator will change to "from" and, provided the pilot holds an accurate heading, the left/right deviation needle will continue to give corrective information while the aircraft is flying away from the station. Full needle deflection, left or right, indicates a departure from selected track of 10° and since the instrument will not go beyond that deviation an adjustment of the o.b.s. knob will be required to determine aircraft bearing so that corrections can be made to regain track.

Modern v.o.r. stations operate on the Doppler principle (d.v.o.r.) and offer certain advantages over earlier transmitters, notably a reduction in ground absorption effect which occasionally "bends" the radials while the aircraft is flying at low altitudes. Being a v.h.f. aid, its range is limited, but aircraft flying at around 10,000ft can normally rely on reception at up to 80 nautical miles, high flying aircraft considerably more. However, for reasons of accuracy v.o.r. is regarded as a short-range aid; consequently beacons are spaced at 50-80nm intervals mostly within the airways system.

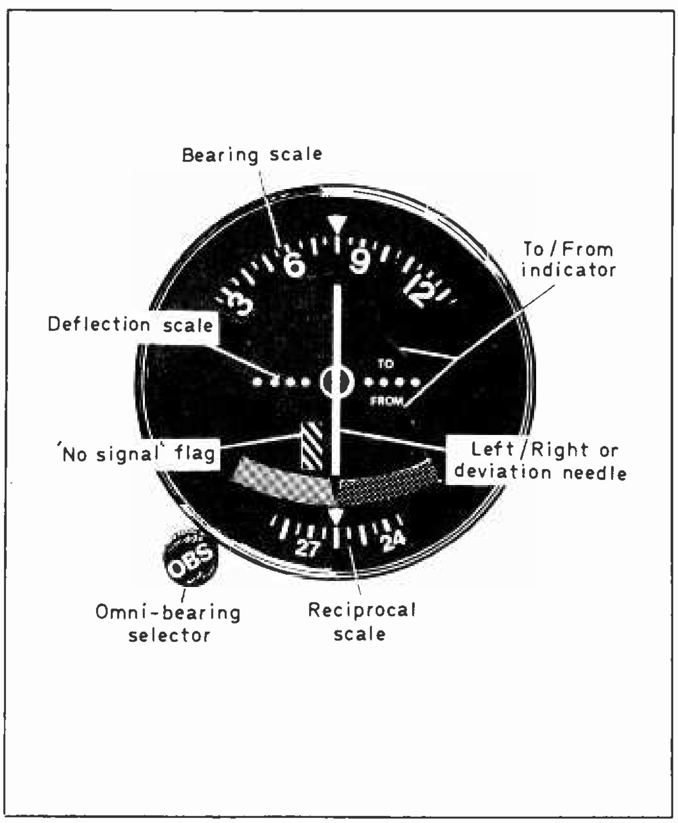
**Fig. 2.** *Typical v.o.r. converter indicator. As shown the "no signal" flag is visible but when a v.o.r. signal is being received one of the "to/from" arrowheads comes into view.*

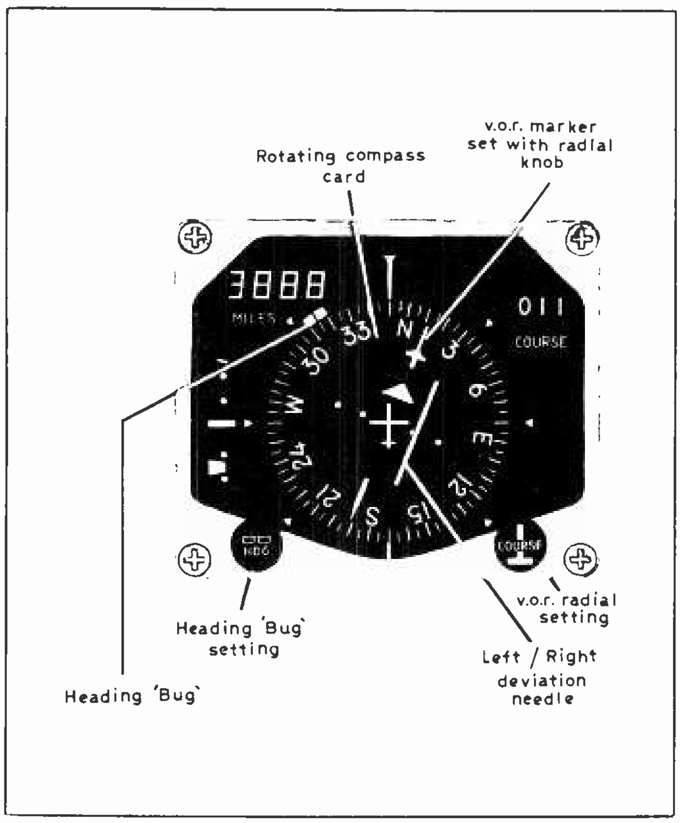
V.o.r. does not suffer from static or night effect but it is subject to the limitations of all single point radio aids that radiate bearings in that accuracy declines with distance from the station. Accuracy of the complete air/ground system is generally regarded as ±3° so at 60nm from the beacon an aircraft could be up to 3nm left or right of track. It is, on the other hand, easy to use and accuracy is good as the ground facility is approached. In its most developed form v.o.r. information is conveyed to the pilot on a pictorial display known as a horizontal situation indicator (Fig. 3). The deviation needle is attached to a compass card so that it rotates with changes of heading, so presenting itself at the correct angle relative to a small aircraft depicted in plan form on the centre of the instrument glass. When, for example, the aircraft is flying north to intercept a bearing running east to the v.o.r. transmitter an illusion is created of the aircraft symbol closing with the required track before turning to follow it, when the track (deviation needle in the instrument) will rotate and take up a vertical position.

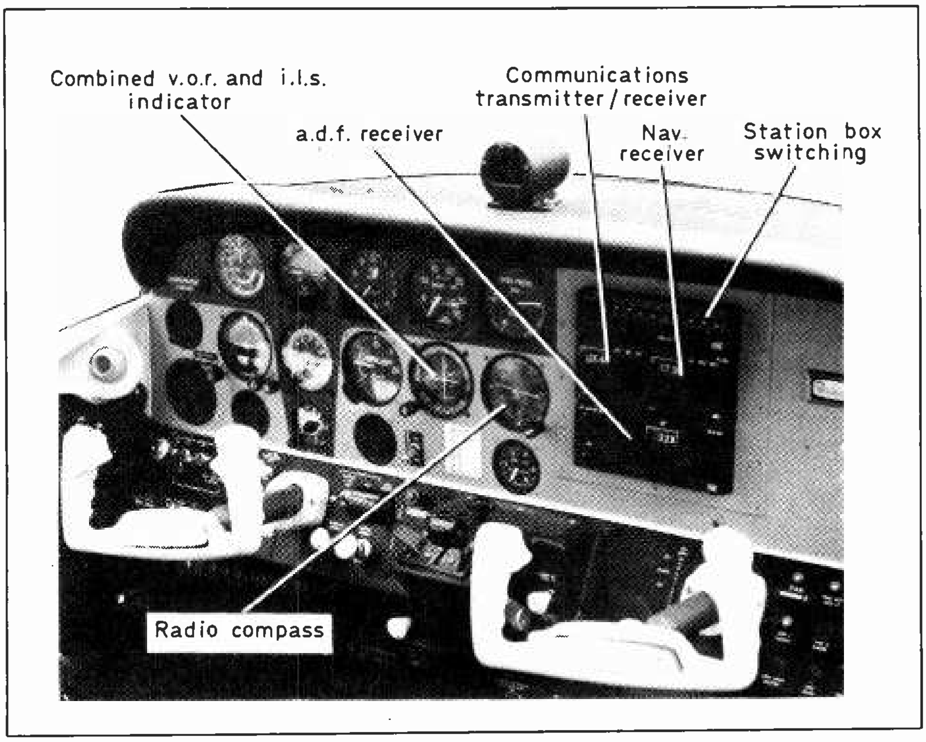
**Distance measuring equipment (d.m.e.).** Of course, a single radio aid giving bearing information from a fixed point is unable to inform the pilot of his position. All it can tell him is "you are somewhere along a line bearing *x* degrees from me". But two such aids — which could be a pair of v.o.rs, a pair of a.d.f./n.d.b. aids or one of each — will give such a position provided the two bearings cross at a good angle, 60° usually being regarded as the minimum for accuracy. However, a method of growing importance, one that has been developed from a wartime aid used by the RAF, is known as distance measuring equipment (d.m.e.). Usually the ground equipment is located at a v.o.r. station and its frequency will be paired with that of a v.o.r. beacon so that selection of a v.o.r. frequency in the aircraft automatically lines up the d.m.e. equipment. For example Clacton v.o.r. operates on 115.7MHz and its associated d.m.e. is 1191/1128MHz (the reason for two d.m.e. frequencies will be explained later).

In essence d.m.e. is a pulse and respond aid. In the aircraft is a pulse transmitter known as an interrogator which sends coded pulses on the chosen frequency. On receiving them the ground station, or responder, returns a

**Fig. 3.** *Horizontal situation indicator, a development of the instrument shown in Fig 2. The deviation needle is attached to the rotating compass card so presenting the track in correct relationship to the aircraft symbol in the centre of the dial. The heading "bug" is adjusted to provide a steering datum for the pilot and the "course" knob sets the required v.o.r. radial.*






*A typical avionics installation for a light, single-engine aircraft.*

similar coded pulse to the aircraft on the other frequency, where it is received by the interrogator during intervals when it is not transmitting. By measuring the time lapse between sending and receiving back the pulse, the distance from the ground station is determined and shown by a read-out display. Because the aircraft is some distance from the ground d.m.e. measures slant range as opposed to ground distance, but this is of little consequence except to high flying aircraft as they get near to the ground station. In other words the pilot of a jet cruising at 30400ft will never come nearer than 5nm to the ground station.

When flying to or from the ground station (as opposed to passing a beam) d.m.e. may be switched to provide the following information: (1) ground speed (this is different from air speed except when there is no wind); and (2) time to reach the station at present ground speed. The equipment is very accurate and in conjunction with v.o.r. it will provide bearing and distance information on a continuous basis.

**Radar.** Although radar is a ground aid and therefore outside the scope of this article mention should be made of weather radar, particularly since it is now being fitted to an increasing number of small aircraft. The advent of turbo-propeller and pure jet aircraft with pressurized cabins has made possible over-the-weather crusing levels. In the Dakota days 10,000ft was the maximum; today subsonic jets operate in the 30,000 to 40,000ft levels and Concorde is at its best around 60,000ft. Climbing to these levels and descending for a landing at the end of the journey often means flying through several layers of cloud. This in itself presents few problems except that some of these clouds are of the cumulo nimbus type (thunder clouds) where vertical currents may exceed 4000ft/min up and down and hailstones can attain large size, particularly in Africa where they have been recorded as large as tennis balls. At best these conditions can be very frightening for the passengers (not to mention the crew!) but there is also a real risk of severe structural damage. The fact that large cumulus or cumulo nimbus clouds should be avoided explains the need for weather radar. Indeed at one time it was the fashion to call it "cloud collision radar", an apt name as anyone who has entered one of these clouds will agree.

The scanner, which is in the nose of the aircraft, has provision for tilting so that a map of the ground ahead may be provided, coastlines in particular being clearly identified. The screen and radar controls are situated in the centre of the instrument panel within access of both pilots, and ranges up to a maximum of 150nm may be selected. Some of the modern equipment is capable of receiving an echo then presenting a "computerised" picture clearly indicating the areas to be avoided. When a particularly solid echo is returned a warning light comes on — it could be another aircraft.

**Transponders.** The growth of air traffic in certain parts of the world can only be described as staggering, particularly in Australia, South Africa, Canada and the United States. In areas such as London, where aircraft converge from all over the world, adequate separation is particularly important. Whereas in the past the air traffic control services relied almost entirely on position reports from aircraft in flight a busy terminal area, such as Paris, London or New York is now covered by a radar surveillance service. Raw information on a radar screen may at times be swamped by echos from rain or heavy cloud; consequently greater use is being made of secondary radar. The aircraft end of the system is called a transponder, a refined version of the i.f.f. (identification, friend or foe) device carried in Hurricanes and Spitfires during the Battle of Britain. In essence it is a receiver and transmitter with coding facilities that remains dormant until triggered by a pulse from a ground based radar station. The very compact aircraft installation includes a four-digit dial which may be adjusted to one of 4096 codes. So when London Airways instructs a particular pilot to "squawk four seven nine zero" the act of setting these numbers arranges time intervals in the transponder output which allow the returned signal from the aircraft to enter a pulse gate selected by the radar operator on the ground. Because it rejects all non-4790 returns from other aircraft the identification is more or less certain. And since the pulse returned from the aircraft is a powerful one, not just the echo of primary radar, the signal will not be swamped by other scatter.

Before the introduction of transponders, radar controllers would often instruct a pilot to "turn left for identification". Now, in addition to the coded return, he may request the pilot to "squawk ident", a facility controlled by the transponder switch and capable of amplifying the return signal so that it may be more readily identified on the radar screen. The facilities so far described are known as Mode A. However, Mode C transponders incorporate an encoding altimeter capable of displaying the aircraft's flight level alongside its "echo", on the radar screen. ☐

*The second and final part of this article will deal with area navigation, landing aids and developments in the future.*

## Circards completed

The Circards series of circuit design cards published by *Wireless World* will be completed with set 33, on differential, balanced and bridge amplifiers; set 34, on analogue gate applications 1; and set 35, on analogue gate applications 2. These are expected to be available during January 1978. A further book of collected Circards, "Circuit Designs 3", is planned for publication in mid-1978.

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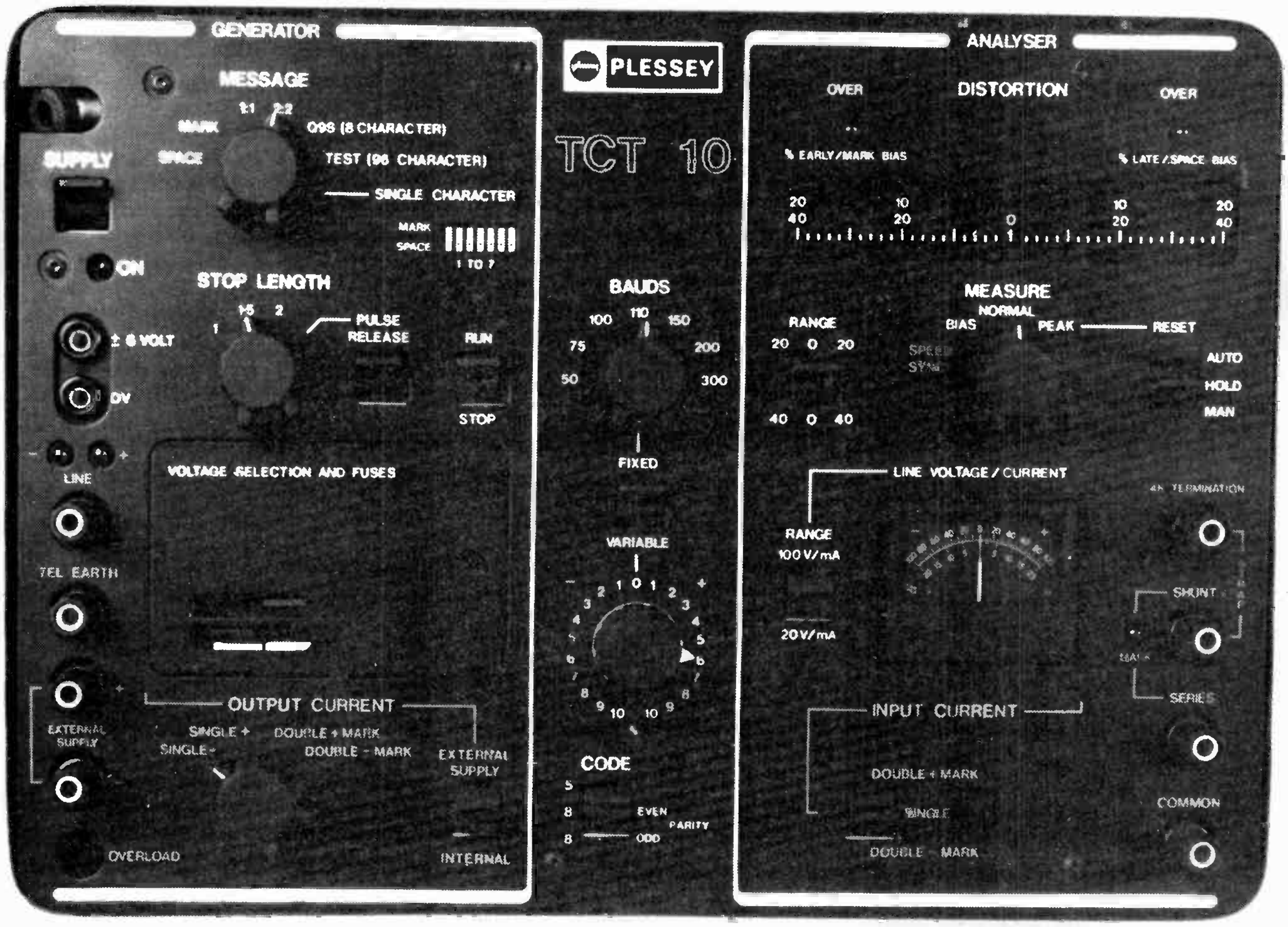


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# Audio power amplifier design

*There is nothing so practical as a really good theory* — LUDWIG BOLTZMANN

**by Peter J. Baxandall** B.Sc.(Eng.), F.I.E.E., F.I.E.R.E.

Articles describing particular amplifier designs, or advocating specific solutions to design problems, abound in the literature, and it is evident that some quite conflicting views exist on certain topics — for example, concerning the amount of negative feedback that should be used. The present approach is of a fairly broad nature, and aims to elucidate and compare various familiar and unfamiliar circuit techniques in such a way that their advantages and disadvantages may be clearly and logically appreciated.

IN EXPLOITING the very great virtues of negative feedback, the problems and difficulties that arise are largely those associated with obtaining adequate stability margins under all conditions of operation. In a.c. coupled amplifiers, there are stability problems at both low and high frequencies, but the elimination of output transformers, together with the adoption of d.c. coupled circuitry in most modern designs, has virtually removed the low-frequency problems.

## Negative feedback and slew-rate limits

Other things being equal, the larger the amount of overall negative feedback applied to an amplifier, the lower will be the distortion. However, other things are quite likely not to be equal, since, to achieve stability, it is usually necessary to introduce elements which start attenuating the forward gain, with rising frequency, at a frequency which has to be made lower and lower as the amount of overall feedback is increased. If *unsuitable techniques* are used for effecting this attenuation, increased distortion will be generated in the forward path of the amplifier *at high frequencies*, to an extent which may more than offset the advantages of the increased feedback. Indeed, drastic high-frequency internal overloading may occur, and once this has happened, the overall feedback is powerless to preserve the wanted output waveform.

The rudimentary amplifier circuit shown in Fig. 1 will serve to illustrate the point. Here the capacitor C attentuates the gain with rising frequency by making $Tr_2$ function as a Blumlein integrator. The current, $I$, supplied by the first stage includes, in addition to a component flowing to $Tr_2$ base, a component much larger at high audio frequencies flowing to C. At such frequencies, and with $Tr_2$ producing a large output voltage swing, the current demanded by C may severely tax the output capability of $Tr_1$ stage, and may, in the limit, cause $Tr_1$ to overload, i.e. cut off during part of the cycle. Whether or not this will happen can be determined quite simply, on a sine-wave basis, by calculating the current in C, which is, nearly enough, $V_{out}/X_c$. If the peak value of this current exceeds the d.c. working current of $Tr_1$, gross distortion will occur. Thus the critical condition for the onset of such distortion is

$$I_{dc} = \hat{V}_{out} \times 2\pi fC \qquad (1)$$

This relationship may be rearranged to give a convenient formula for the critical sine-wave frequency, $f_{crit}$, above which gross distortion sets in no matter how much overall feedback there is. Thus

$$f_{crit} = \frac{I_{dc}}{2\pi C\hat{V}_{out}} \qquad (2)$$

It is customary nowadays, in the above context, to employ the slew-rate concept, though it is by no means essential to do so. This concept has long been familiar to workers in other fields, particularly those of servo-mechanisms and radar. As applied to amplifier circuits, the basic relationship is simply that, for a capacitor

$$dv/dt = i/C \qquad (3)$$

Thus, with reference to Fig. 1 again, suppose the transistor $Tr_1$ is briefly cut off; then a current approximately equal to $I_{dc}$ is left flowing in $R_c$ and most of this also flows in C, producing a positive-going rate of change of output voltage

$$[dv_{out}/dt]_{max\ poss} = I_{dc}/C \qquad (4)$$

This is called the *output slew-rate limit* of the amplifier, or sometimes, in commercial practice, just the slew-rate. With the single-ended input stage of Fig. 1, the slew-rate limit for negative-going outputs will be much more rapid than the above, because $Tr_1$ can turn on much more current than it can turn off. But when a balanced long-tailed-pair input stage is used, as in most integrated-circuit operational amplifiers, the slew-rate limits in the two directions will be approximately equal.

The relationship (4) applies whatever the signal waveform may be. If, at any instant, the demanded rate of change of output voltage exceeds this value, the amplifier will fail to follow it properly. Thus, if an amplifier has an insufficient slew-rate limit, then, every now and

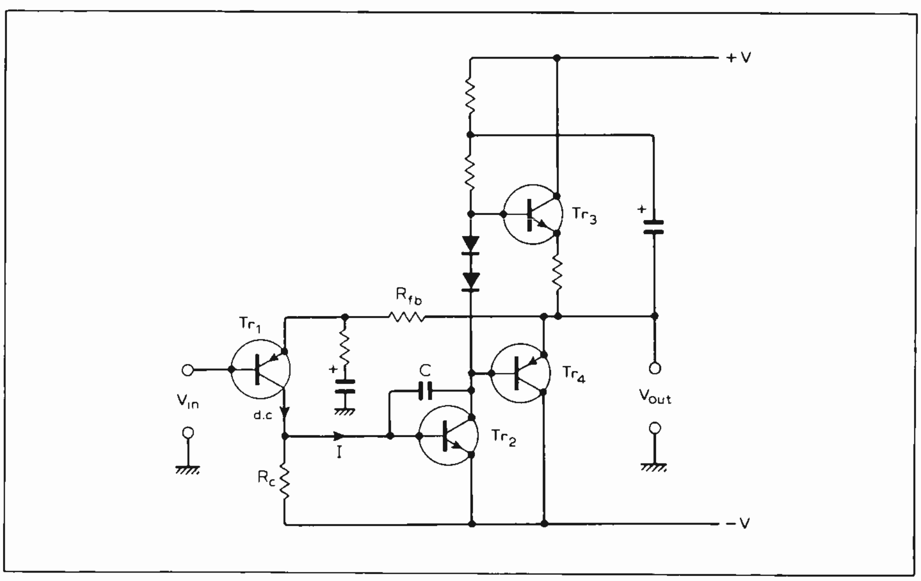



Fig. 1 *Rudimentary amplifier circuit in which the capacitor C gives rise to slew-rate limiting.*

then, on fast transients particularly, the slew-rate limit will be exceeded by the programme waveform. When this occurs, the amplifier gain will fall drastically, and all components of the signal being handled at that moment will be chopped, or modulated, by the transient. This effect, well known to enlightened designers of feedback amplifiers for decades, has nowadays, of course, become known as transient intermodulation distortion or t.i.d. (sometimes t.i.m.), as a result of several papers by M. Otala. Another, more recent, related term, due to W. G. Jung, is slewing induced distortion, or s.i.d.[1,2,3].

It is of interest to obtain the relationship between the general slew-rate limit formula (4) and the conditions which apply with sine-wave input. Substituting in (2) the value of $I_{dc}/C$ given by (4) yields

$$f_{crit} = \frac{[dv_{out}/dt]_{max\ poss}}{2\pi\hat{V}_{out}}$$

i.e.
$$f_{crit} = \frac{\text{output slew-rate limit}}{2\pi\hat{V}_{out}} \quad (5)$$

(This result can alternatively be obtained by differentiating the output voltage waveform, $v = \hat{V}\sin 2\pi ft$, and equating the peak instantaneous value of the differential coefficient to the slew-rate limit.)

In all the above, the slew-rate limit referred to is that of the amplifier *output* voltage, and this is the usual practice – especially in integrated circuit data sheets, where it is simply called the slew-rate. Thus, unless otherwise stated, slew-rate figures may be assumed to apply to the output of an amplifier. However, it is sometimes convenient to express them with respect to the input, which merely involves dividing by the amplifier's voltage gain. The corresponding equation to (5) for the input is

$$f_{crit} = \frac{\text{input slew-rate limit}}{2\pi\hat{V}_{out}} \quad (6)$$

Consideration of (5) and (6) makes it evident that what is invariant is the quotient of the slew-rate limit and the peak sine-wave voltage at any selected point in the system. Hence, more generally,

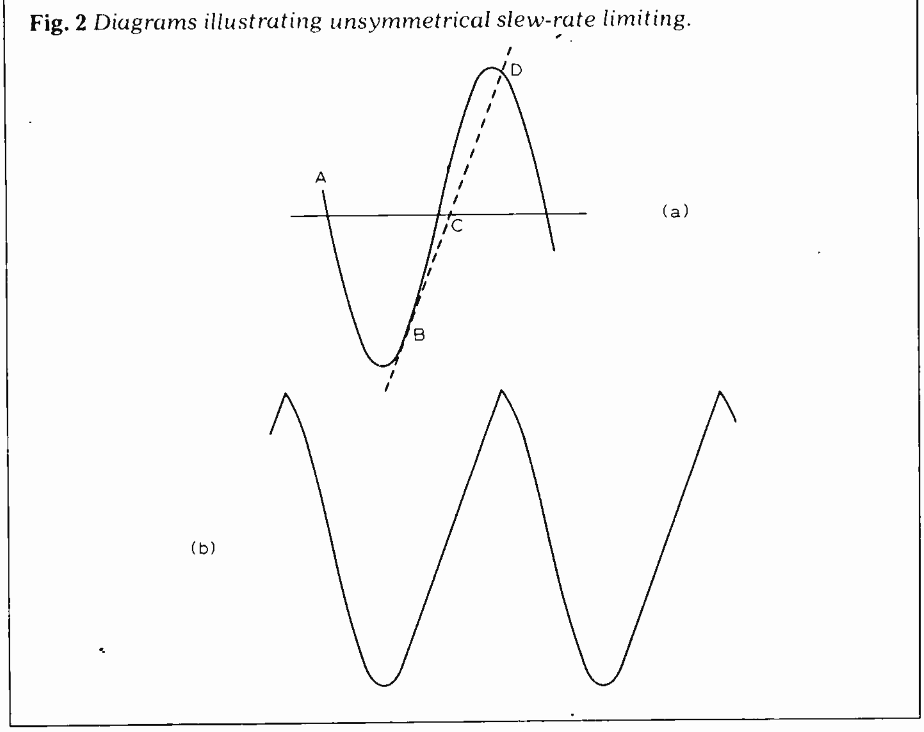
$$I = I_o e^{\frac{qV_{be}}{kT}}$$

The peak voltage $V$ is normally that for full output level. The quality of the slew-rate performance of an amplifier may thus be expressed by the slew-rate-limit figure given in *volts per micro-second per volt peak* of sine-wave signal. For example, $f_{crit}$ = 20kHz corresponds to a figure of 0.126V/µs per volt peak.

It is of interest to consider what sort of output waveform would be expected from an amplifier suffering from slew-rate limitation, on sine-wave input. Suppose initially that the amplifier is basically as in Fig. 1, having a single-ended input stage which imposes a much more severe slew-rate limit for positive-going amplifier output voltage than for negative-going. Referring to Fig. 2(a), the sine-wave represents the wanted output waveform, and the broken line represents the maximum rate of change of output voltage of which the amplifier is capable, i.e. it represents the output slew-rate limit. The actual output therefore follows the wanted waveform from A to B, but after B it follows the path BCD before joining the wanted waveform again at D. The complete output waveform is thus as shown in Fig. 2(b). Fig. 3(a) shows some experimental waveforms obtained with a circuit having the basic configuration of Fig. 1, for two different degrees of slew-rate limitation overload on sine-wave input. Fig. 3(b) shows the output waveform for square-wave input, and is a typical result for an amplifier exhibiting unsymmetrical slew-rate limitation.

The waveforms of Fig. 4 were obtained using a type LM301AN integrated circuit operational amplifier as a unity-gain inverter. The 301 circuit, very broadly speaking, has a similar type of configuration to that shown in Fig. 1, but with a balanced long-tailed-pair input stage arrangement. The external stabilizing capacitor C, more often called the compensation capacitor, had a value of 30pF. It will be seen that, as expected, the slew-rate limitation is of a nearly symmetrical nature.

**Fig. 2** *Diagrams illustrating unsymmetrical slew-rate limiting.*



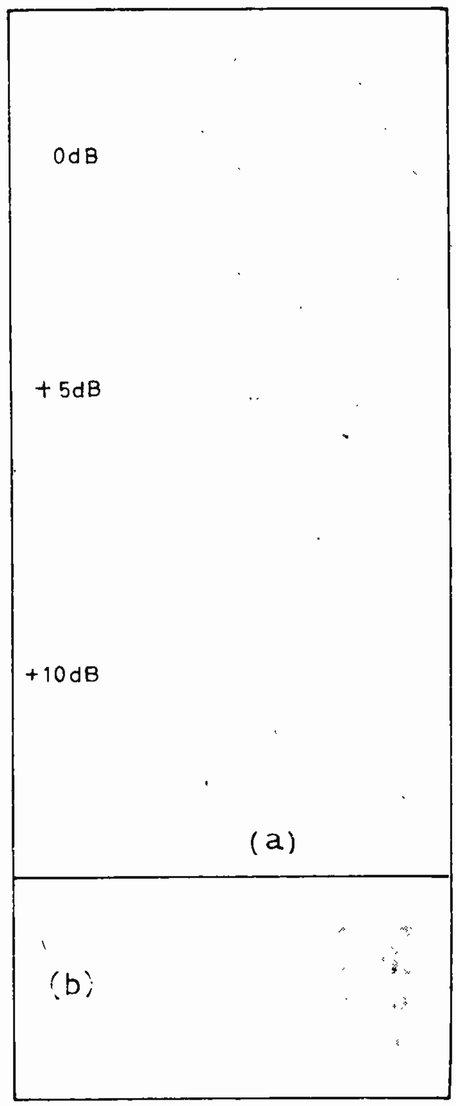
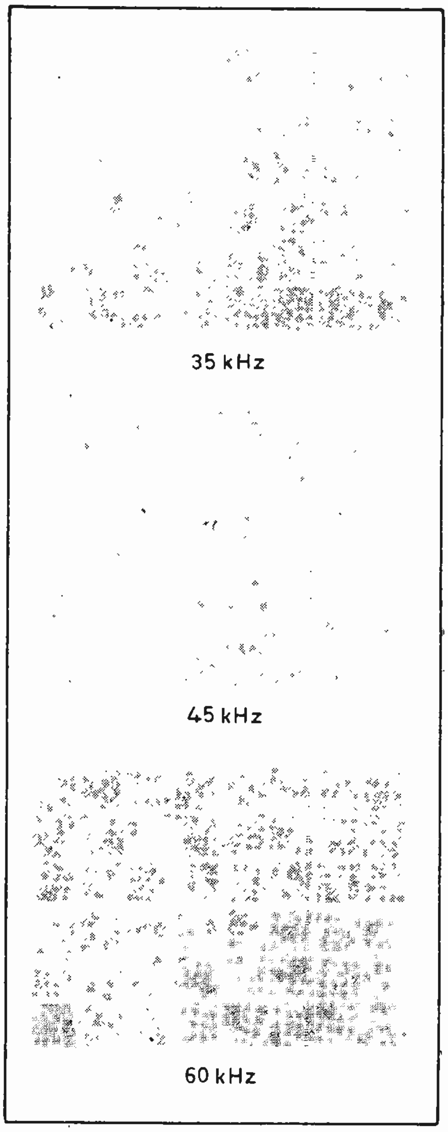




**Fig. 3** *(a) Output voltage waveforms from amplifier exhibiting unsymmetrical slew-rate limiting, for three different levels of sine-wave input, all at the same frequency. (b) Output voltage waveform for square-wave input. The negative-going transitions are not slew-rate limited.*

A great deal of attention has been given to this aspect of amplifier behaviour in recent years, and while it is certainly important to avoid significant distortion of this type, the notion that it is a fairly newly-discovered form of distortion is quite unjustified. It all boils down to the fact that, to avoid unwanted intermodulation effects, a good amplifier should be able propertly to track all normal programme waveforms, whether of a sustained-tone or a transient nature, without any internal circuits overloading in the process – surely an old and familiar notion? Indeed, I cannot do better than quote Jung, who says "there is nothing new, unique, or mysterious about slew-induced or transient intermoduation distortion"[2]. It may be added, however, that since some – but certainly not all – of the earlier transistor amplifiers suffered seriously from this type of distortion, the widespread attention that has been given to it is a good thing. But removal of significant s.i.d. is not a panacea – there are also other important causes of distortion.

**Fig. 4** *Output voltage from integrated-circuit operational amplifier for equal-amplitude sine-wave inputs at three different frequencies, showing slew-rate limiting. Scales: 1V/cm, 5μs/cm.*




As considered above, the slew-rate-limit mechanism sets a fairly sharply defined threshold, beyond which there is a rapid onset of gross distortion that the overall feedback is powerless to control. Below this threshold output level, which is, of course frequency-dependent, the distortion will be negligible only if there is sufficient overall feedback. Whether there is enough feedback to give this result depends on the details of the particular design, but in some instances there may not be enough. Thus it is of interest to consider the distortion mechanisms that are operative in the milder situation where drastic overloading does not occur.

Referring to Fig. 1, suppose we decide to apply 6dB more overall feedback to the amplifier by reducing $R_{fb}$. This is likely to necessitate doubling the value of C, for equally satisfactory stability. Thus, while we succeed in doubling the feedback loop gain at low frequencies, where C has little effect, the loop gain at higher frequencies, where C is dominant, remains as before. At a given high frequency, and a given output voltage, $Tr_1$ will have to supply twice the current to the doubled value of C, and the percentage second-harmonic distortion generated in $Tr_1$ will go up by a factor of approximately 2*. Since the amount of feedback at the high frequency involved is the same as before, the amplifier output distortion (due to distortion in $Tr_1$) will also be doubled.

Because of the doubling of the C value, the critical frequency for slew-rate limitation, above which full output ceases to be obtainable without drastic overload, is halved – see equation (2).

Quite frequently a long-tailed pair, or differential input stage, will be used in place of the single transistor $Tr_1$ shown in Fig. 1, and then, if well balanced, the dominant distortion introduced will be third-harmonic, the percentage distortion being proportional to the square of the output current [5]. (This is a characteristic of any device, e.g. a tape recorder, in which cube-law curvature is dominant.) Thus, with the low-frequency overall feedback increased by 6dB, and with C doubled as before, the third-harmonic distortion generated in the input stage will be up by a factor of 4 at high frequencies, as also will be the amplifier's output distortion due to this cause.

We thus have the situation that increasing the amount of low-frequency overall feedback, with corresponding adjustment of the stabilizing capacitor value, increases that part of the high-frequency output distortion which is due to smooth-curvature non-linearity distortion in the input stage. In many cases, below the true slew-rate-limitation overload point, this will be the main cause of distortion at high frequencies. However, with suitably modified circuit designs, to be described later, the input stage distortion may be fairly negligible.

It is interesting to consider how the above non-overloading type of distortion would be expected to vary with frequency. A long-tailed-pair input stage will first be assumed. Since, at high frequencies, the current supplied by the input stage is proportional to frequency, the percentage third-harmonic distortion generated within the stage is proportional to the square of the frequency. But because the overall-feedback loop gain is halved for each doubling of frequency, the distortion at the output of the amplifier, due to this mechanism, is proportional to the cube of the frequency. The percentage output distortion is thus proportional to $V_{out}^2 f^3$, as established by Jung. The corresponding result for a single-ended input stage, as in Fig. 1, is that the percentage output distortion, now mainly second-harmonic, is proportional to $V_{out} f^2$. This is because in any device in which square-law curvature is dominant, the percentage distortion is directly proportional to the output current or voltage.

It will thus be seen that a characteristic feature of distortion of the type discussed above, which occurs before the onset of true slew-rate-limitation overload, is that it increases quite rapidly with frequency. Fig. 5 shows the ideal cube-law relationship deduced above for the balanced input stage case. With a single-ended input stage, though the rise in distortion with frequency is more gradual, the magnitude of the distortion is liable to be much greater [5].

Jung calls the input-stage-originated distortion that occurs before the onset of true slew-rate limitation "Category I slewing induced distortion", the gross distortion that occurs at higher levels being "Category II s.i.d." It is important not to let this terminology disguise the fact that Category I s.i.d. is, after all, just straightforward input-stage smooth-curvature non-linearity distortion, which may become significant at high frequencies because of the increased current demanded from the input stage and the reduced amount of overall feedback in action.

* The percentage second-harmonic distortion produced by an ideal voltage-driven transistor, having a characteristic $I = I_0 \exp qV_{be}/kT$, approximately $25 \times (\bar{I}/I_{dc})$, where $\bar{I}$ is the peak value of the signal-current fluctuation and $I_{dc}$ is the d.c. working current. Another convenient fact is that, at any working current, the percentage second-harmonic distortion is equal to the peak value, in millivolts, of the signal voltage applied between base and emitter[4,5].

Though, as shown in Fig. 5, the high-frequency distortion due to the input stage rises rapidly with the measuring frequency applied, it should not be imagined that the harmonics generated at any one measuring frequency are boosted according to their order, in any comparable manner. Consider first the effects that would occur with the overall feedback disconnected. Referring again to Fig. 1, the harmonics in the current fed by the input stage to the $Tr_2$ stage will be attenuated in this stage in proportion to their order, because of the integrating action of the capacitor C. Thus, with the feedback loop open, the harmonics in the amplifier output voltage, due to input stage distortion, would fall off in amplitude with increasing order at a rate 20dB/decade (6dB/octave) more rapid than that applying directly to their generation in the input stage. However, with the overall feedback loop closed, and because the amount of feedback at high frequencies falls off at 20dB/decade with increasing frequency – assuming C is the only cause of loop gain attenuation – the final output distortion spectrum will have the same relative amplitudes of fundamental and harmonics as for the input stage by itself. With a long-tailed-pair input stage, and assuming the circuit not to be operating too close to the slew-rate limit point, the dominant harmonic will be the third, the higher order harmonics decaying rapidly with increasing order. Thus the type of distortion generated is relatively innocuous compared with the worst forms of cross-over distortion. The important thing is simply to arrange the design so that the magnitude of the distortion does not become too high.

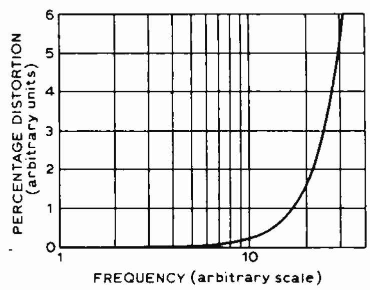



**Fig. 5** *Theoretical variation of third-harmonic distortion with frequency for amplifier with long-tailed-pair input stage, when operating below the slew-rate limit.*

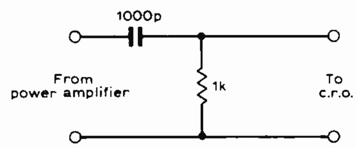



**Fig. 6** *Simple differentiator circuit used in tests. The output is 1V for an input rate of change of 1V/μs.*

## Slew-rates of programme waveforms

Gramophone records are frequently used as the programme source when subjective judgements of the performance of audio equipment are being made, so that it is of interest to know the order of slew-rate to be expected at the output of a high-grade RIAA equalized amplifier. This can easily be determined using a very simple differentiator circuit such as that shown in Fig. 6. This circuit is fed from the output of the power amplifier, and, with the values shown, gives an instantaneous output of 1 volt when the input slew-rate is 1V/μs. The objection may well be raised that the slew-rate limit may degrade the true slew-rate of the source, i.e. the pickup, but whether or not this is the case may be discovered by replacing the pickup by an oscillator and thus determining the slew-rate limit of the amplifier system. With good equipment, this will be found to be much higher than the slew-rate obtained with records.

The experimental procedure adopted was as follows. First a frequency test record was used to check that the system had a flat frequency response, within ±1dB, up to 12kHz. Then a suitable music record was selected, and the system gain was adjusted so that the input to the Fig. 6 circuit occasionally reached peak values of ±10V, but not more. The c.r.o. was then transferred to the differentiator output, the record replayed, and the maximum output voltage excursion from the differentiator during the replay was determined. The test was done with a wide variety of records, including one of the Sheffield direct-cut discs. The largest instantaneous outputs from the differentiator were caused by occasional dust clicks, and went up to over 0.40V, but on the music they never exceeded about 0.14V. The latter corresponds to a slew-rate of 0.14V/μs, which is the peak instantaneous slew-rate of a sine-wave with amplitude ±10V and frequency approximately 2.2kHz.

The implication of the above is that an amplifier with $f_{crit}$ = 2.2kHz, i.e. capable of giving full output on sine-waves up to 2.2kHz, without suffering from slew-rate limitation, and with sufficient freedom from ordinary non-linearity distortion, will reproduce such records entirely satisfactorily. I can almost hear some readers saying "this is ridiculous – it's well established that amplifiers must be free from slew-rate limiting, at full output level, up to at least 20kHz"! But has this, or anything approaching it, in fact, been properly established? I do not think so. But because of such doubts, it is worth approaching the matter from a different angle, as follows.

The maximum instantaneous recorded velocities on records occur over the band extending from about 700Hz to, perhaps, 8kHz, and are normally in the region of 30cm/s[6]. Suppose the gain of an RIAA equalized replay system is adjusted so that a 1kHz sine-wave recording with 30cm/s peak instantaneous velocity gives an output voltage of 10V peak. Since for a sine-wave voltage with peak value $\hat{V}$, the peak rate of change of voltage is $\hat{V} \times 2\pi f$, the peak rate of change of voltage for a 1kHz sine-wave of peak value 10V is 0.063V/μs. It is probably fairly unusual for a peak velocity of 30cm/s to be recorded at a frequency as high as 8kHz, but if this did happen, then, ignoring for the moment the effect of the RIAA equalization, the output slew rate would be 8 × 0.063, i.e. 0.50V/μs. However, at 8kHz, the RIAA equalization introduces a loss of 11.7dB (×3.85) relative to the response at 1kHz, so the figure of 0.50V/μs is reduced to approximately 0.13V/μs. This, it will be seen, ties up surprisingly well with the experimentally determined figure, mentioned above, of 0.14V/μs.

The Fig. 6 differentiator was also used with a master tape recording of violin music with piano accompaniment, thought to be of unusually good fidelity. When adjusted to give a peak replay voltage of 10V as before, the peak instantaneous differentiator output voltage observed was 0.083V, so that the peak slew-rate was 0.083V/μs. A 10V peak sine-wave of 1.3kHz has this same slew rate.

Similar tests done with programme from an f.m. tuner yielded generally equivalent results as far as the actual audio waveform was concerned, but with the complication that, on stereo transmissions, owing to imperfect filtering in the tuner, the (L-R) sidebands greatly increased the peak $dv/dt$ value at the differentiator output, a figure of about 0.4V/μs being obtained with the audio level at ±10V as before. By using the 10kHz filter in the audio control unit, the f.m. multiplex waveform was almost eliminated, the peak slew-rate of the remaining audio waveform being about 0.15V/μs. It is clear that without the filter, the minimum acceptable slew-rate limit in the audio amplifier would be determined largely by the amount of f.m. multiplex waveform present in the tuner output, since unpleasant intermodulation effects can occur if the amplifier is unable properly to follow this waveform. The amount of multiplex waveform in the output of f.m. tuners varies a great deal from one make to another.

The above quite low slew-rates will seem less surprising when it is remembered that the success of the pre-emphasis and de-emphasis schemes universally used in both recording and f.m. broadcasting systems is dependent largely on the fact that the high-frequency components of all normal audio waveforms are of much smaller amplitude than the lower frequency components.

### Necessary amplifier slew-rate limit

Provided an amplifier is not overloaded, and provided it has sufficient feedback to make the distortion when not slew-rate limiting adequately low, there is certainly no absolute necessity for the slew-rate limit of the amplifier to be any larger than the maximum rate of change, or slew-rate, of the waveforms handled by it. This point needs emphasising, for reading Jung's interesting articles can easily make one jump to the conclusion that there is a *fundamental* need for the amplifier slew-rate limit to exceed the maximum rate of change of the programme waveform by a large factor. That this cannot possibly be true may be seen by imagining, or actually making, an amplifier with the same broad configuration as in Fig. 1, but in which $Tr_1$ is replaced not by a simple long-tailed-pair, but by a more complex circuit having a large amount of internal feedback. Then the distortion of the part of the amplifier that precedes C will remain extremely low right up to the slew-rate-limit overload point. Such an amplifier will fail to satisfy Jung's "new slew-rate criterion" by a very large factor, and yet, provided the distortion in the output stage etc. is sufficiently low, it will give no subjectively detectable quality degradation on any normal programme material.

With an ordinary long-tailed-pair input stage, the distortion introduced by it will be mainly third-harmonic, with the higher-order harmonics well subdued, provided the amplifier slew-rate limit is made higher than the maximum slew-rate of the programme by a reasonable factor, say two or three times. The distortion will then be of much the same character as that introduced by a good tape recorder, but will be of appreciable magnitude only at high audio frequencies. Provided the distortion is held down to a reasonably low magnitude – well under that of a recording system, to be on the safe side – by sufficient overall feedback, it will not be subjectively detectable. □

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**Correction**

In the article "Audible amplifier distortion is not a mystery", in the November 1977 issue, the editor inadvertently omitted two resistors from the circuit diagram (p.65). These should be inserted one in each input lead of the operational amplifier near the right-hand side of the diagram.

## Communications tests with moving trains

TESTS WITH radio communication between signal boxes and trains were carried out in this country before the second world war, mainly on the London & North Eastern Railway. The equipment available at that time was relatively bulky, required considerable power and did not meet acceptable standards of reliability. Advances in mobile radio engineering have changed the situation, and since the middle 1960s most of the major European railways have investigated systems of radio communication with moving trains. Between 20,000 and 30,000km of route on the Continent are now equipped in this way or are awaiting delivery of systems in course of manufacture.

British Railways studied the subject in connection with the Channel Tunnel project, and although that is in abeyance it has been decided to proceed with a scheme on the recently electrified section of the Eastern Region between London, Welwyn and Hertford North. Some details of the project were given in a paper presented to the Institution of Railway Signal Engineers in London on 2 November by J. Boura and C. Kessel of the British Railways Board.

Each signalman in the King's Cross signalbox will control a group of uhf transmitting and receiving stations spaced at intervals at the line-side so as to cover the area for which he is responsible. A radio channel of four frequencies will be allotted to each area, comprising three transmit frequencies chosen to avoid mutual interference and one receive frequency. Transmit frequencies will be used in cyclic transposition along the line. The train receiver will incorporate a search and lock system by which it will lock on to the first satisfactory signal it receives from a lineside station. When the signal lever falls to $2\mu V$ it will search for another transmitter and lock again, but if an acceptable signal is not found a 'carrier fail' alarm will be displayed in the cab.

The use of synchronised transmitters within the groups was considered but would have required an accuracy of 30Hz in 450MHz and was not practicable in this situation. In passing from zone to zone a driver will reset his transmitter to the new receive frequency by pushbutton. Automatic returning could have been provided but would have increased the cost by about 60 per cent. Data transmission at 600 bauds will be used for establishing calls and the display of standard messages in the form of picturegrams. A speech circuit will also be provided.

At the signalbox the radio system will be linked with the existing computer-based train describer system which displays train identification numbers on the mimic diagram in their appropriate positions. A small computer in the signalbox radio installation will interrogate the describer computer to find the train identification number corresponding with the call signal received from a train and show both numbers in a queue type display of incoming calls on a VDU. The call signal will be unique to a particular set of vehicles, while the train running number changes according to the service the set is providing.

Contracts for the radio equipment have not yet been placed. When the paper was presented a somewhat similar system now being manufactured for the German Federal Railway by Telefunken was demonstrated. In the ensuing discussion there was some emphasis on the need to balance sophistication with reliability and cost. At present communication between trains and signalmen relies on signal post telephones, but these are specialised instruments manufactured in small numbers for the railways alone. The rapid expansion of the mobile radio and computer-linked data transmission businesses seems to hold hope of costs coming down in this area. □

## SIXTY YEARS AGO

IN AN age when even resistors are of many types and integrated circuits continue to proliferate, the following piece, from our January 1918 issue, is seen to be prophetic. Prof. Pupin evidently did not understand that insufficient bafflement of the laity was to be obtained from plain speech.

"The scientist in question, Professor M. I. Pupin, said that if there must be a new name for each new detector — a new name for everything that comes up in the course of the development of the electrical art — pretty soon the science of electro-technics will be a mass of new names, and the learning of the names will be much more difficult than the learning of the facts connected with the art.

Today the following words are in common use by radio engineers, as the names of devices in appearance similar to and in principle based upon the original audion: Oscillation valve, regenerative audion, kenotron, pliotron, electron, relay, thermionic relay, thermotron, audiotron, amplitron, detecto-amplifier, Moorhead tube, oscillion, ultra-audion, dynatron, oscilaudion and pliodynatron.

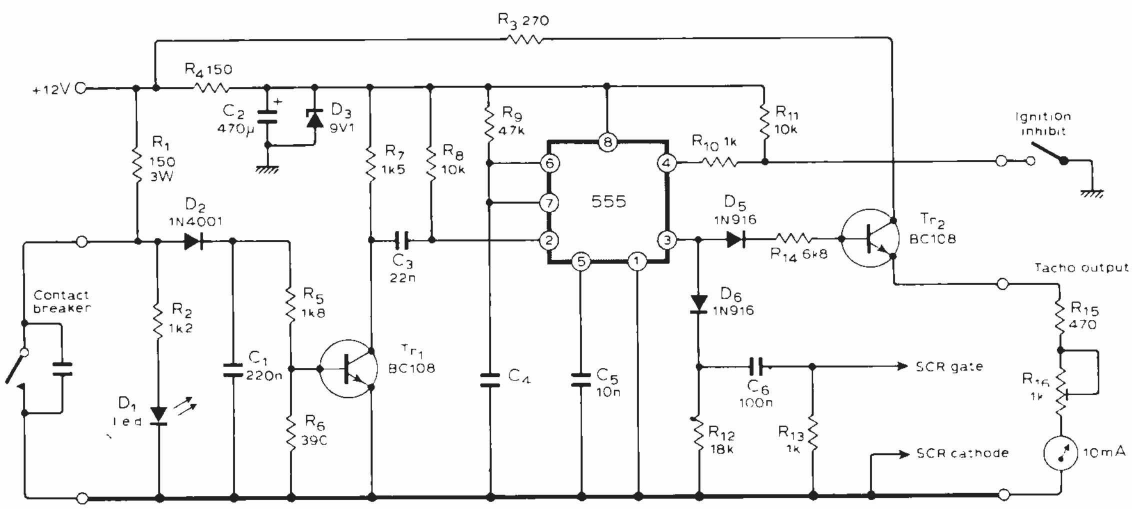
After reading the foregoing, is it any wonder that Doctor Pupin was perturbed over the advent into the electrical art of new and mongrel names? When Doctor de Forest coined the word 'audion' he pulled the bung from a barrel which contained a vast and venerable assortment of Greek and Latin derivatives, and it is evident that these have been industriously raked up and picked over to supply bewildering additions to our already involved scientific vocabulary. Here in England we are not so fond of inventing new names, although scientists have not settled down to any one title for these particular devices. In the Services, where large numbers of these instruments are in use, we believe it is the custom to refer to them simply as 'valves', fancy names being debarred altogether." □

# CIRCUIT IDEAS

## Trigger circuit for c.d.i. systems

THIS trigger circuit provides r.p.m. limiting and a tachometer output. When the contact breakers open, $C_1$ is charged via $R_1$ and $D_2$, which turns $Tr_1$ on. The negative going pulse at $Tr_1$ collector triggers the 555, which is used in the monostable mode, and the resulting positive pulse from the 555 fires the s.c.r. via $D_4$ and $C_6$. When the contact breaker closes, $D_2$ isolates $C_1$ to reduce the effect of contact bounce. Once the 555 is triggered any further trigger pulses on pin 2 have no effect until the timing period is over. This eliminates any contact bounce that gets past $D_2$ and $C_1$, and gives an effective upper limit to the engine speed. Because the timing period is constant the mark-space ratio of the 555 output, and hence the mean d.c. level, is proportional to the engine speed. A voltmeter connected to the output of the 555 can be used as an accurate tachometer. The loading effect of the meter on the s.c.r. trigger pulse is reduced by emitter follower $Tr_2$. The r.p.m. limit for a four stroke engine is given by $R = 109.1/n\ R_9\ C_4$ where $n$ is the number of cylinders. For a limit of between 8000 and 9000 r.p.m. with $R_9$ at 47kΩ, $C_4$ is 0.068μF for 4 cylinders, 0.047μF for 6 cylinders, and 0.033μF for 8 cylinders. By connecting the reset input of the 555 to the 0V line, trigger pulses at pin 2 will have no effect on the monstable so the s.c.r. will not be triggered. This can be used as an anti theft facility. The l.e.d. across the contact breakers can be useful when setting the static timing.

*K. Wevill,*
*Birmingham.*

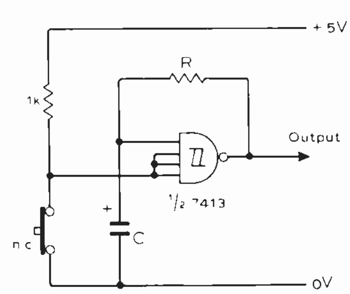



## Improved Schmitt trigger oscillator

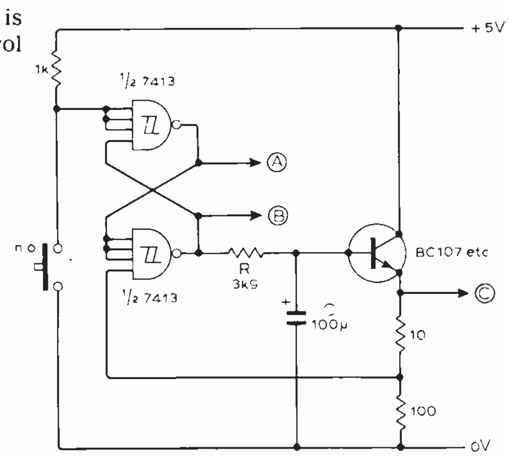
WITH a normal t.t.l. Schmitt trigger oscillator (a), closing the switch stops the circuit immediately and cuts short the last cycle. This effect is especially noticeable at low frequencies. Also, the maximum value of R is limited to approximately 1kΩ.

To avoid these problems the circuit in (b) uses the remaining half of a 7413 i.c. to form a RS bistable which ensures that the cycle is completed when the switch is opened. An emitter follower is also used which allows the value of R to be greater than 10kΩ. A t.t.l. square wave is available at point N and a low impedance exponential sawtooth at point C. Point A is high when the oscillator is running, and can be used as a control signal.

*T. P. Hopkins,*
*Haywards Heath,*
*West Sussex.*



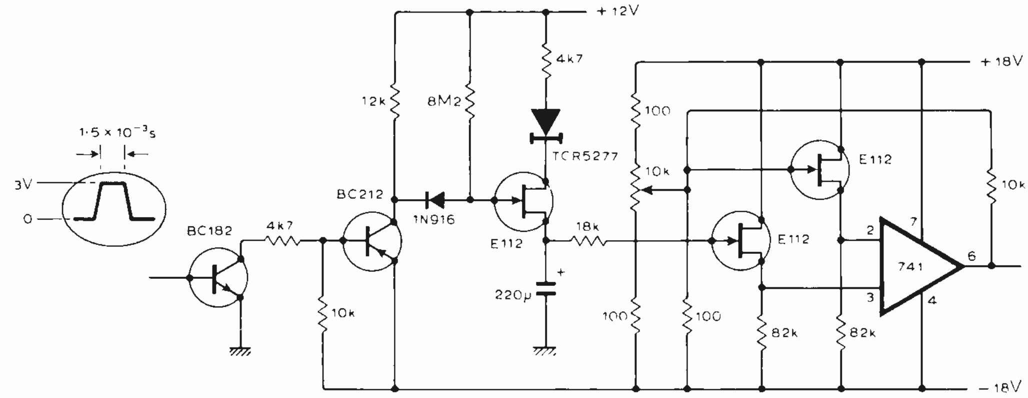

(a)




(b)

## Ramp generator

A POSITIVE ramp can be generated by dumping charges on a capacitor. The amount of charge deposited after $t$ = $^{n+1}$ pulses will be $Q = It$. After five seconds $5 \times 10^{-4}$Q will have been dumped on the capacitor which increases its volume from $V_0 = It/C$ to $V_1 = It^{n+1}/C$. This voltage is stored on the capacitor and decreases by an amount $V_d$ which is determined by the internal resistance of the capacitor and the f.e.t. gate leakage current. Without any load to the capacitor the voltage across it will decrease by $9/10^{-n}$V/min.. To obtain an output voltage which has little influence on the charge or discharge of the capacitor, a 741 with a high impedance duel f.e.t. input is used. The circuit shown generates a ramp from 0 to 5.3V.
*D. Greenland,*
*Cambridge.*




## Analogue divider and multiplier

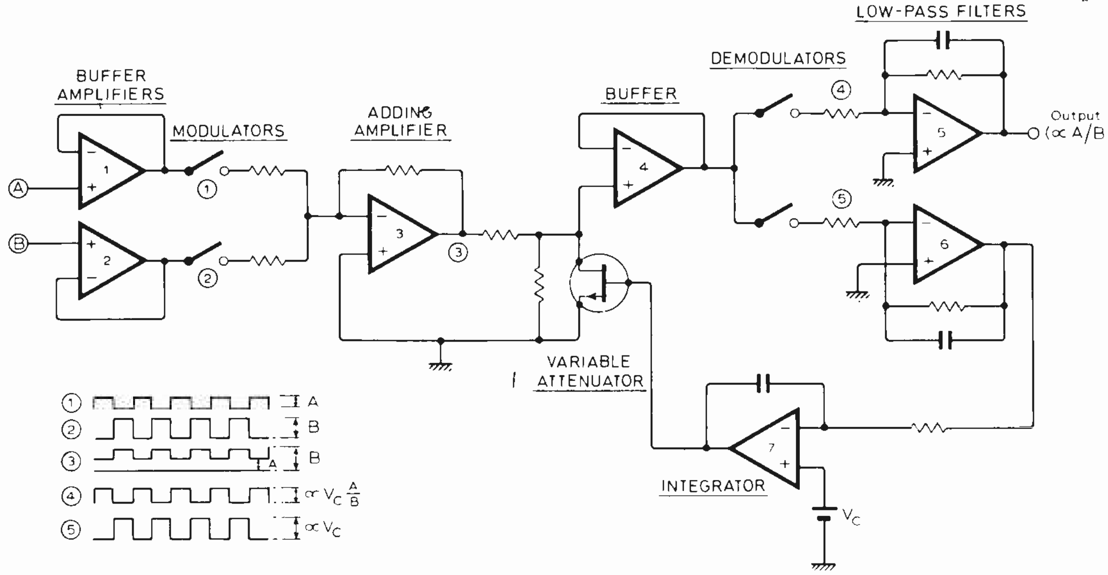
THE only non-linear device in this analogue divider/multiplier is a field effect transistor. The principle of the divider is simple, consider the quotient $Q_1 = A/B$. If the numerator and denominator of the quotient are multiplied by a factor $K$ so that $KB = 1$ or any other constant, then the value of the quotient is equal to $KA$. In the circuit the numerator and denominator pass through a buffer amplifier before being modulated. The prototype used field-effect transistors driven by two 180° out-of-phase pulse trains with a mark-to-space ratio of slightly less than unity which suppresses unwanted spikes. The modulated numerator and denominator signals are then passed through an adding amplifier before being processed by the variable attenuator, buffer amplifier, and demodulators.

The signal in the denominator channel then passes through a low-pass filter with a built-in d.c. gain, before being compared with the voltage $V_c$ (≡ $KB$) in the integrator. The resulting signal is then applied to the field-effect transistor in the variable attenuator.

In the prototype, $V_c$ was set to 10V and the d.c. gain in the low-pass filter was 60dB so that the drain-source voltage of the field-effect transistor was always less than or equal to 10mV. This low drain-source voltage is desirable because the f.e.t. operation is restricted to the linear part of its characteristics. A f.e.t. selected for low on-resistance should be used to prevent the use of an unreasonably large series resistor.

Note that the response time of the circuit depends on the size of the capacitors used in the low-pass filter and integrator. Response time can be reduced by raising the modulating frequency. For accurate division, zero offset controls are needed for $IC_{1,2,3}$ and $IC_5$.

Also, an f.e.t. input op-amp should be used for $IC_4$ to suppress offsets caused by its variable source impedance. In the prototype the accuracy was limited by the use of optical modulation to within ±0.5%. However, the author feels that this figure could be improved.
*B. P. J. van Oorschot,*
*Pretoria,*
*South Africa.*



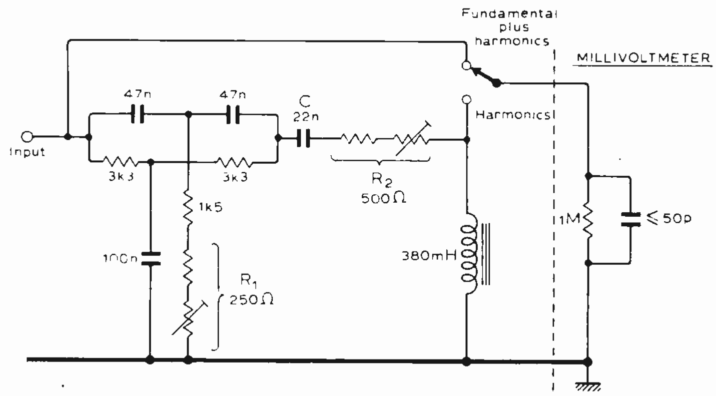
## Passive network to measure distortion

IN the common form of distribution factor meter, negative feedback equalises the response to harmonics of an applied sine wave. This feedback has the undesirable effect of making the null adjustment more critical. Less ambitious distortion measurements of low impedance sources at 1kHz can be made with this passive circuit when used with an audio millivoltmeter. A high pass LC filter removes low frequency noise in the input signal and compensates for the loss of harmonic frequencies. It also contributes about 10dB to the rejection at 1kHz so that the null adjustments are less critical. If used for setting the bias and recording levels of a tape recorder, it is much less affected by transport speed variations than a conventional instrument. Dynamic range is large because only a small fraction of the input signal appears across the inductor.

If a higher input impedance is required, 23kΩ at the fundamental reducing to 10kΩ at the fifth harmonic, all inductance and resistance values can be increased by a factor ten and the capacitance values decreased also by a factor of ten. However, this will cause an insertion loss of around a dB after equalisation.

To set up, $R_1$ is adjusted to give the best null, then $R_2$ and C are adjusted to equalise the responses at harmonic frequencies. The prototype used 2% metal oxide resistors and 5% polycarbonate capacitors. After three years use without adjustment the circuit has remained level to within ±3% over the first twelve harmonics and still measures t.h.d. to below 0.05%.

*J. B. Cole,*
*Guilden Sutton, Cheshire.*




## Touch-tune for f.m. receivers

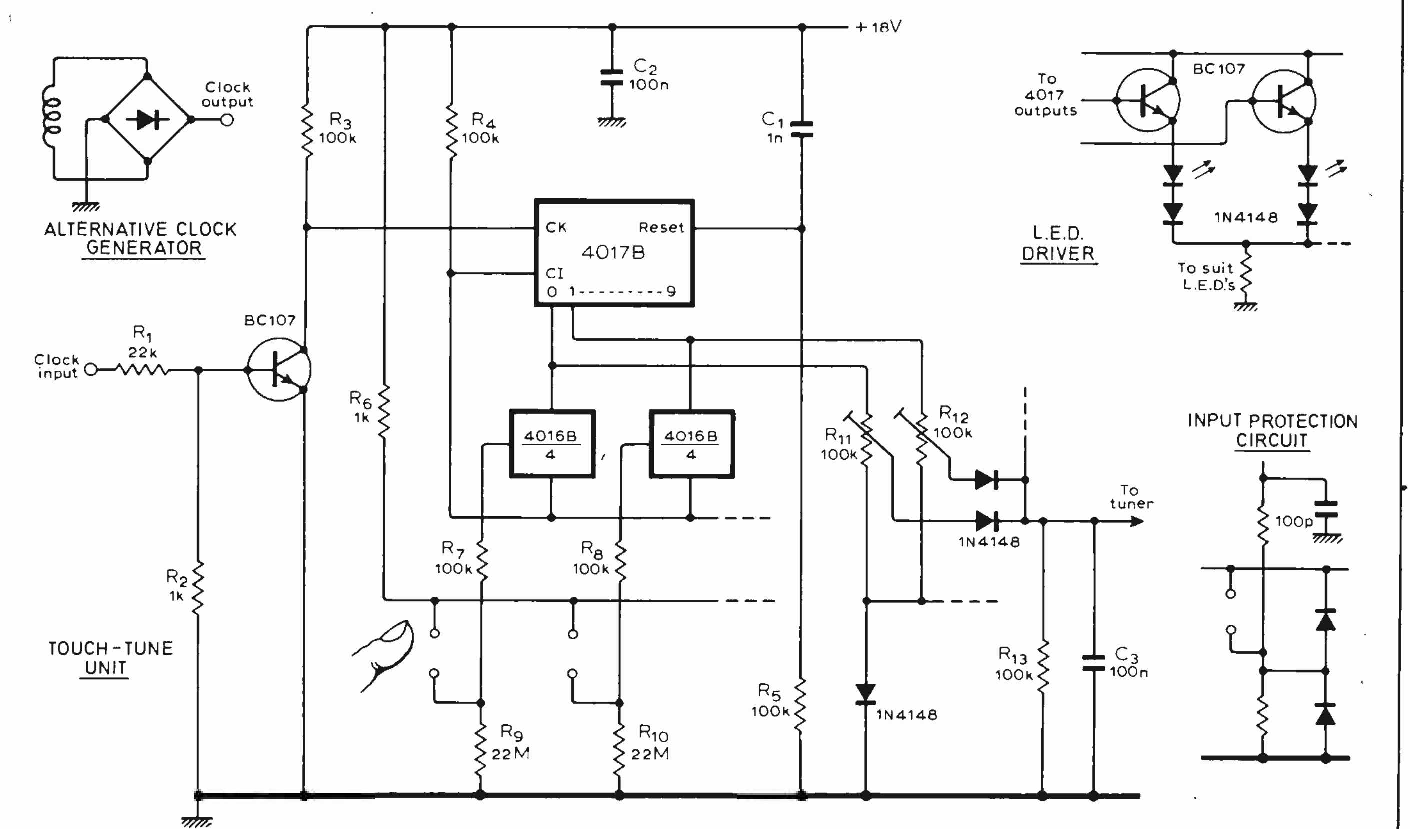
THIS circuit enables up to 10 channels to be touch tuned with a varicap supply voltage of up to 18V, and it features low drift with temperature variations. The 4017 is inhibited by $R_4$ until a channel is required. The appropriate section of the 4016 is turned on by finger contact which drives the clock inhibit line low. The 4017 counts clock pulses until the desired output goes high, and it is then inhibited again. Components $C_1$ and $R_5$ ensure that channel 0 is selected at switch on.

In a receiver using the popular 1310 decoder, the circuit can be clocked at 19kHz using the buffered output from pin 10.

Alternatively, a 100Hz clock signal can be derived from a few turns of wire, around the mains transformer, and a bridge rectifier as shown. Although no trouble has been experienced with static damage to the transmission gates, input protection as shown can be included.

For safety reasons this circuit should only be used in equipment incorporating a double wound mains transformer and an earthed chassis.

*L. Crampin & R. van der Molen,*
*Kingston on Thames,*
*Surrey.*



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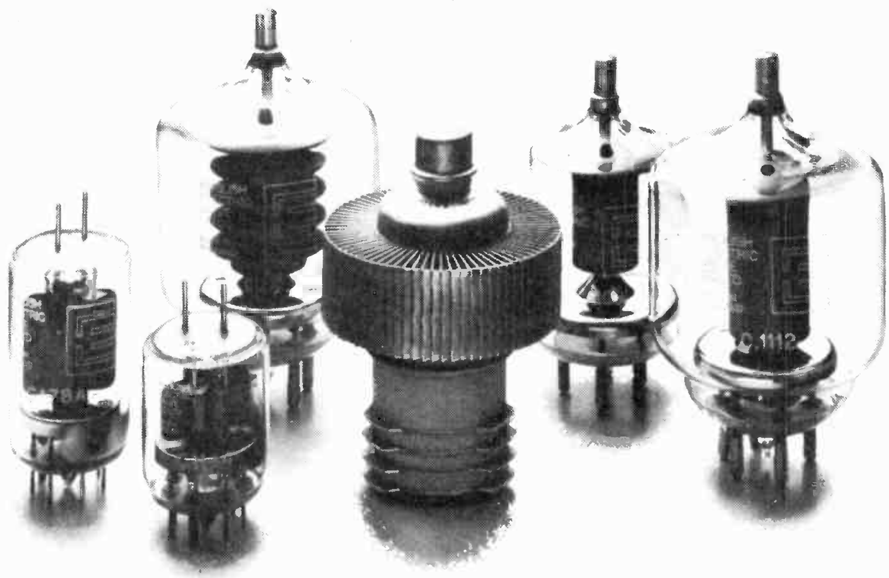

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WIRELESS WORLD, JANUARY 1978

# .Wiring by touch

## . man's Odyssey from octals to integrated circuits

by P. H. H. Jones, G3DRE

.al account of a
.ined efforts to build
equipment despite
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.byists. The author, a radio
been blind since 1940.

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very soon got tired of
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mind I decided to start
nd building a suitable
having modulation facili-
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.or gone were those lovely
which had been common on
.ess sets of old, and most
nts needed to be soldered. For
without sight this seemed to be
a problem.

### and ye shall find"

.ther was always quoting "seek
ye shall find". So I sought, and
.vered a suitable type of soldering
. This was a soldering-gun having a
made from a loop of copper wire in
shape of a hairpin, which was
ated by the output of a step-down
ansformer housed in the barrel part of
ne gun. The advantage of this gun was
.hat it heated from cold in seven seconds and cooled down in about thirty. This meant that having made the joint mechanically by poking the wire through the hole in a lug or wrapping it round first, the gun bit could be applied to the joint cold, and then the trigger pressed to heat the element when fingers had been removed.

I found applying the solder a bit of a problem at first, because aiming for the bit with the resin-cored solder was very much a hit and miss business, and blobs tended to land in the wrong, and sometimes, awkward places. It struck me, however, that if I were to flatten the round solder into a ribbon with a pair of pliers, and then break off a short length which could be wrapped round the tip of the bit, it would put just the right amount of solder in the right place. The idea worked, and I have used it ever since.

One useful indication of the solder melting to the right temperature is that when I move the tip of the bit ever so slightly a squeaking sound can be heard.

Scorched fingers are almost an occupational hazard. It usually happens through impatience, when checking a joint before allowing it to cool properly, or when wrapping my little ribbon round the iron tip before it has cooled. This scorching, however, is nothing more than annoyance, because it tends to reduce the finger's sensitivity for reading Braille.

My first building project was to construct an auditory resistance-capacitance bridge. This was based on an article which appeared in the *Braille Technical Press*, an American publication, now regrettably defunct due to the costs of production.

There are circuit diagrams in Braille, but I much prefer the step-by-step system of, for example, "the anode of $V_1$ goes through capacitor $C_2$ to one side of r.f. choke $RF_3$", and so on. The test bridge was constructed from this type of circuit description and was, and still is, a success.

Fired with enthusiasm I then made plans to build a six foot rack-and-panel transmitter. It took two years to complete. The transmitter was an all-band one, based on a Tesla oscillator. It had Class A amplification, to reduce harmonics, and finished with the "Elizabethan" power amplifier.

### The author — by himself

My father was considered to be somewhat of an expert on wireless in the early thirties, contributing regular articles on the subject to the local newspapers. This also entailed answering readers' questions in a sort of wireless agony column. My grandfather too, had a profound interest in this science, which had come into being during his lifetime. He was continually building and re-building short-wave receivers, not to receive amateur transmissions but those from government stations in all corners of the globe. He also concerned himself with the original local radio station in Sheffield.

With this sort of background, I suppose it was inevitable that I too should be bitten by the bug of wireless, as it was then so coyly termed; I much prefer this description of the system to "radio". I well recall the components I used, things of beauty made with loving care by craftsmen. Big brass variable condensers with screw terminals, sprung four-pin valveholders to mount that precious HL2, saved for out of pocket money. Transformers potted in lovely brown, crackle-painted cases.

Home construction was very popular, but for the affluent there was the commercially-made Music Magnet Three — a name to conjure with. Portable receivers were manufactured; we had one. It was like a large suitcase with a frame antenna in the lid, along with its moving-iron loudspeaker. The lower portion contained a straight four-valve receiver, an unspillable accumulator and a 120V high tension battery. A strong man could just lift it clear of the floor.

My ambition was, when I was old enough, to apply for a transmitting licence. Unfortunately the war intervened, and my loss of sight in 1940 seemed to have dashed any hopes of realising the ambition. However, after the war I started reading Braille books on radio, for now one had to pass a theory examination set by the City & Guilds Institute. I was able to get hold of a copy of the RSGB Handbook and to arrange with the City & Guilds that my examination could be in oral form. This I passed at the first attempt.

The morse test followed, and then on May 21st 1948 my ambition was realised when my Class A transmitting licence landed on the door mat.

I had already purchased an item of government surplus equipment, a B2 minor, through the RSGB distribution service. This was a crystal-controlled suitcase transmitter-receiver which covered the 80 and 40 metre amateur bands. It was, of course, a c.w. transmitter, for in those days there was an obligatory probationary period on c.w.

I had two QSO's that day, using an indoor antenna. The first was with a RAF amateur in the outer Hebrides, and the second was with a station in Paris. I had succeeded, and my boyhood dream ha. come true.

G3DR.

The circuits were produced by courtesy of local hams who spent many hours reading the descriptions to me so that I could transcribe them into Braille. The metalwork presented no problems, just hard work. Component identification presented few real problems, and I soon became familiar with octal sockets and pin connections.

Colour coding of resistors did not matter to me since I had my bridge, and this would also check capacitors.

This transmitter served me well for very many years until, inevitably, progress made it obsolete. The advent of s.s.b. had the same effect on my radio construction as the advent of superheterodynes had had on my father. I opted out

The technology involved, and the special test equipment required, meant that it would no longer be feasible for me to undertake the construction, so I reluctantly confined my activities to the key, with the occasional telephony contact on top-band.* I abandoned the h.f. bands forever. Things had changed so much that I felt that high power and elaborate antenna arrays were not to my liking.

## Transistors and miniature components

The availability of transistors to the amateur constructor opened up a new field of interest for me. They had one very great advantage for the non-sighted user, low voltage operation. Not that I had really worried about having a thousand or so volts lying behind an aluminium panel, so long as it stayed there. These little devices, transistors, seemed to be too remarkable to believe in at first. Along with them, of course, came the procession of miniature components to match, and these I found most intriguing.

I very soon discovered that the technique of using printed-circuit boards with their fine metallic tracks was one development that a sightless person could not use. The tracks could be followed using an auditory circuit continuity tester, but this proved to be extremely tedious. As I had found with Braille circuit diagrams, it is very difficult to appreciate the whole from just touching a small part. The plain ›axolin board with little holes in it ffered me a means of circuit assembly at I could use. The soldering method s still valid, and component assembly identification was fairly straight- ırd. Things were just smaller.

ave not been able to take age of the opportunities of rization which transistors and nponents offered because of the eave space between compo- feel for the location of s. Nevertheless I went full gamut of building xers and so on, for my been sidetracked for a ıe recording.

## Integrated circuits pose a problem

I returned to Ham radio a couple of years ago, with renewed enthusiasm, and bought a commercial two-metre f.m. transmitter, having a one-watt output, and with a rotatable indoor four-element antenna was once more back on the air. It is surprising how many of my early contemporaries have returned to the air with the advent of mobile rigs and repeater stations.

It amazed me how things had developed during my desertion from amateur radio. Integrated circuits and even smaller components had come on the scene. These centipede-like little blocks intrigued me, and I felt that this was something that could offer an awful lot to the sightless constructor, for anything that reduced the number of components and connections must be good.

After some frustrating hours trying to solder an eight-pin i.c. socket for an NE 555, to build a repeater time-out indicator for the one-minute operating limit, I decided that I had better cool my enthusiasm for i.cs.

My soldering technique, which had stood me in good stead for so many years, was obviously obsolete where i.cs were concerned. I had not dared to connect direct to the pins of the i.c., so I used a socket. However, the close pin spacing meant that I either bridged contacts, or adjacent wires dropped off due to the iron accidentally touching a point just off the pin being soldered, and the radiated heat softening the neighbouring joint. Also, handling tended to break off the very thin wire used.

I felt disappointed, but comforted myself with the thought that there was nothing really that I needed to build, and I was only pottering around with i.cs for an additional interest. Having heard of the logic systems, used on the repeaters, I felt that the next best thing to experimenting would be to read about what could be done.

## A solution in the making

Accordingly, I borrowed some books from the *Talking Book Catalogue*. Talking books are special large cassettes containing books which have been recorded by volunteer readers. The ones I borrowed had been specially recorded for the use of students. This somewhat mature-student course of study served only to whet my appetite to carry out some experimental work, but my big stumbling block was still the method of circuit connection, since soldering for me was most definitely out.

I was bemoaning this fact during a QSO* and the amateur I was talking to mentioned wire-wrapping, and had I considered this as a possible method for the visually-handicapped to use. The words "wire-wrapping" triggered off an almost forgotten memory of a visit our radio club had paid some years ago to a then new organisation, a computer data processing firm. The engineer in charge had allowed me to feel round the circuitry of the machine and had told by what it had been designed and wired wir... her computer controlling the

"Se... Vero E... system. I ... shall find" led me to nor had mos... preliminary ...nd their Mini-wrap technical sales ...ard of it before, cassette I had rec... the problems I had ...ms. After a seeking his opinion as to their Mini-wrap system migh... off way for the visually-ha... a undertake circuit wiring of ... The engineer's understandin... problem, and freely given enabled me to complete a fea... study of the technique. This is recorded shortly on to cassette s... other visually-handicapped elec... enthusiasts can be given infor... about the system.

When only one or two i.c. socke... to be used, soldering is a satisfa... method of connecting, because th... on the sockets are long enough ... splayed to give more room ... manoeuvre. For more ambitious ... jects, however, the wire-wrap sys... seems to be the answer to my proble...

If a designer had been asked to de... a method of wiring i.cs suitable for ... sightless to use, then I feel that a syst... similar to Mini-wrap would have be... his recommendation.

## As easy as threading a needle

Once the use of the wrapping tool ha... been mastered, the technique is ver... simple and effective. At first I found it ... little difficult to thread the stripped en... of the wire into the end of the wrapping tool, as it has to pass through a tiny hole from the inside of the tube to a groove down the outside. It is rather like threading a needle, but with practice this has become easier. The tube is then slipped over the pin that is to be wired, and then about ten turns in a clockwise direction produce a very neat spiral of wire tightly wound on to the square section pin.

The unwrapping tool provides an easy way of removing any wrong connections; a far cry from the problems of desoldering, particularly if the soldered connections had been

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Top-band: A term used by radio amateurs and referring to the 160-metre amateur band commonly used for local, normally scheduled, communications between two or more operators. During favourable night-time propagation conditions this band is useful for long-distance (DX) communications.

QSO: Part of the radio amateur's Q-code. Simply, it means "Can you communicate with . . .", but it is commonly used to refer to a 'contact' or complete communication between two amateur stations.

wrapped round a tag first, as was my way.

The i.c. sockets are not the only components available, there are socket pins into which transistors or quarter-watt resistors can be plugged. Again there is no need for solder. These socket pins can be spaced out on the circuit board, to match the spacing of the resistor length, and then wire-wrapped. There are also some pins termed "header pins", and although these are designed to be used as connecting points for flexible leads, and to be soldered, I find that the V-shaped jaws can be squeezed together effectively biting into the wire end placed between them, making an ideal way of securing components, whose connecting wires are of too thick a gauge to fit into the socket pins, without soldering.

There are also component carriers which will fit into i.c. sockets. These have pins with solder tags on the upper side to which components can be fastened. This means that the soldering can be done away from the circuit board and the carrier plugged in after assembly. For inter-board connections there is a ribbon-cable with plug terminations which fit the sockets, so here again there is no need to go to elaborate lengths to ensure that no solder splashes in the wrong place, as there would be if wires were to have been soldered to pins on the board.

## Wrapped up! please don't disturb

I have evolved one or two tricks of my own that help in using the Mini-wrap system. One problem that I always have when I am building equipment is that I am liable to disturb previous wiring through feeling to find the place for the next connection to be made. This can cause problems when handling the very thin gauge wire used in wire-wrapping. So, I thread the wire through a spare hole adjacent to the component pin that has been wrapped, taking it on to the upper side of the board; I leave supply leads on the top side and the other circuit leads I take back down the next convenient hole, to the working side. This takes the strain off the wire where it leaves the pin, and so reduces the chance of damaging wiring already completed.

With handling too, there is a possibility of distorting the pins on the i.c. sockets so that neighbouring ones might come into contact with them. A small length of 1mm internal-diameter p.v.c. sleeving slipped over the pin prevents this happening, and also serves as a "bookmark" to indicate which pins have been wired, and so reduces the chances of wiring errors.

The sockets are mounted on to the circuit board, which is a plain Veroboard with a 0.1in matrix, using self-tapping screws through the holes provided in the sockets. I have to space the sockets further out than a sighted user would, to give me room to feel to the pin base where it comes through the circuit board. To give adequate space for working on the connections, I allow at least 0.9in between the rows of sockets and 0.3in between sockets in the rows.

After the wiring has been completed, but before fitting the components, the circuit can be checked by reference to the point-to-point wiring description. For this purpose an auditory continuity tester is used, and since all the sockets are empty there is no chance of false indications being given by circuit elements such as diodes and capacitors. The i.cs and component carriers can then be inserted and hopefully the circuit will work.

## Just the beginning

My introduction to the Mini-wrap system has brought me up to date with modern technology, and at the same time opened avenues which I thought would be permanently barred.

I am now able to embark upon the experimental work that I wished to undertake. This is a project which I am working on in conjunction with St Dunstan's, the organisation that looks after the interests of the war-blinded, to produce a new generation of test equipment for the use of the visually-handicapped. ☐

# LITERATURE RECEIVED

**Solid-state amplifiers,** 10MHz-18GHz, described in a catalogue from Watkins-Johnson International, Shirley Avenue, Windsor, Berkshire SL4 5JU ............... WW401

**Switches** of push button and toggle form in latest B & R brochure. B & R Relays Ltd, Templefields, Harlow, Essex ...... WW402

**12MHz coaxial line** system for trunk telephone circuits colourfully illustrated in leaflet from Standard Telephones & Cables Ltd, STC House, 190 Strand, London WC2R 1DU ........................... WW403

**Connectors, capacitors and fasteners** in short-form catalogue, available from Intercontinental components Ltd, Clivemont Road, Cordwallis Estate, Maidenhead, Berks SL6 7DY ...................... WW404

**Semiconductors** by Ferranti described in three new booklets, obtainable from Ferranti Ltd, Electronic Components Division, Gem Mill, Chadderton, Oldham, OL9 8NP WW405

**BS2011** on basic environmental testing procedures — just revised — now available in nearly forty parts. For full list, enquiries to BSI Sales department, 101 Pentonville Road, London N1 9ND ................. WW406

**Synchronizers and Synthesizers** is the title of an applications note (No. 23 in Measurtest Series) from Marconi Instruments Ltd, Longacres, St Albans, Herts AL4 0JN. WW407

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**Teletype** 43 keyboard printer terminal briefly described in leaflet from Data Dynamics Ltd, Data House, Springfield, Hayes, Middlesex WW411

**Thermistors,** both positive and negative temp. coefficient types are set out in a catalogue from ITT Components Group Europe, thermistor Division, Stephen Street, Taunton, Somerset .............. WW412

**Micromotors,** gearboxes and linear actuators catalogue produced by Portescap (UK) 204 Elgar Road, Reading RG2 0DD .... WW408

**Resistor networks** in dual and single in-line packages, described by Erie in illustrated brochure. Erie Electronics Ltd, South Denes, Gt Yarmouth, Norfolk ........... WW409

**Transmission test set** LTL-1 works at audio frequencies, contains all facilities in one case and is described in a brochure from Venator Systems, P.O. Box 32186, San Jose, Calif., U.S.A. .......................... WW413

**Linear i.cs,** including op. amps., d-a converters and multiplexers described by Bourns in 1978 catalogue. Obtainable from Bourns (Trimpot) Ltd, Hodford House, 17/27 High Street, Hounslow, Middx TW3 1TE WW414

**Analog-Digital Conversion Notes** is a revised version of a five-year-old book from Analog Devices and costs £4.50 from A.D. at Central Avenue, East Molesey, Surrey.

**Strain-gauge load cells,** pressure transducers, torque sensors, weighing equipment and instrumentation are described in a short catalogue from Transducers (CEL) Ltd, Trafford Road, Reading RG1 8JH . WW415

**Geiger-Müller tubes** are tabulated and their applications and operation discussed in Tech. Information 40 from Mullard Ltd, Mullard House, Torrington Place, London WC1E 7HD WW416

**Moving-coil meters** are the subject of a brochure available from British Physical Laboratories, Radlett, Herts WD7 7HJ WW417

**Wire and rod inspection** for inclusions is performed by the Bergstrand Iron Detection System, which is described in a leaflet from SI Ltd, 31 Bridge St, Pershore, Worcs WR10 1AJ ............................ WW418

**Stereo reception** is a constant source of letters to the BBC, who have produced a booklet "How to get the best of BBC stereo radio" which may also, perhaps, apply to IBA stereo radio. Available free from Engineering Information Department, BBC, Broadcasting House, London W1A 1AA ........ WW421

# The maximum power transfer theorem

## Why do we not match loads to the output resistance?

by **S. W. Amos** B.Sc., M.I.E.E.

ELECTRONIC equipment contains many examples of signal sources connected to loads: a microphone feeding an amplifier, an amplifier driving a loudspeaker and an i.f. stage leading to a diode detector are a few typical examples.

In each of these a signal is transferred from a generator to a load and the circuit can be represented in essentials as in Fig. 1, in which the generator is shown with an internal resistance $r_g$ and the load is a resistance $R_L$. If it is desired to transfer maximum signal voltage from generator to load then $R_L$ should be large compared with $r_g$ but if maximum signal current transfer is required $R_L$ should be small compared with $r_g$.

To transfer maximum power from generator to load, $R_L$ should be equal to $r_g$. This can be shown readily by mathematics. The current in the load is given by $I = E/(r_g+R_L)$ and therefore the power $I^2R_L$ is equal to $E^2R_L/(r_g+R_L)^2$. This is a maximum for given values of $E$ and $r_g$ when $R_L=r_g$. When $R_L$ equals $r_g$ the voltage across the load is one half the open-circuit voltage of the generator (i.e. the value obtained across an infinite load resistance) and the current in the load is one half that delivered by the generator into a zero-value load resistance.

Now transistors and valves behave approximately as resistive generators and Fig. 1 is often used as the equivalent circuit for an active device, $r_g$ being replaced by $r_a$, the anode a.c. resistance of a valve, or $r_c$, the collector a.c. resistance of a bipolar transistor, or $r_d$, the drain a.c. resistance of a field-effect transistor. It is rare, however, in practical circuits to find an active device driving a load equal to its own internal resistance. For example a rule of thumb commonly advocated to obtain maximum output power from triode valves is $R_L = 2r_a$ whereas for pentode valves the recommended optimum load is usually a small fraction of $r_a$ (e.g. a pentode with $r_a = 100$ kilohms might require an optimum load of 7 kilohms). For transistors there is in general no apparent relationship between the optimum load and the transistor internal a.c. resistance.

Fig. 1 can also be taken as representing the output stage of an amplifier as indicated in Fig. 2, and here the generator internal resistance is shown as $r_{out}$, the output resistance of the amplifier. If the output stage of the amplifier consisted of a single transistor without feedback $r_{out}$ would be equal to $r_c$ but it is common practice in linear amplifiers to apply considerable negative feedback, one effect of which is to reduce the effective value of $r_c$. Thus $r_{out}$ is normally small compared with $r_c$ and in high-quality amplifiers is commonly only a fraction of an ohm – smaller than likely values of load resistance. The ratio of load resistance to output resistance is known as the damping factor and a typical value is 25. For maximum power output the load resistance should, according to the maximum power transfer theorem, be equal to $r_{out}$ so here is another example where the theorem is apparently ignored.

Consider a typical transistor stage which is required to deliver appreciable power. An example is the final i.f. stage in a receiver which is required to feed a diode detector. The mean collector current of such a stage might be 3mA and the mean collector voltage 9V. For a silicon planar transistor the collector a.c. resistance might be 1 megohm but if the circuit connecting the transistor to the diode is designed to present the transistor with an effective load of 1 megohm then it is immediately obvious that full advantage cannot be taken of the collector current swing available. The maximum undistorted current swing available is 3mA but this, in a 1-megohm load, will generate a collector voltage of 3kV! In fact only a 9-V collector voltage swing is possible without distortion and this can be generated across a 1-megohm load by a current swing of 0.009mA – less than one three hundredth of that available! The power output under these conditions is less than 0.05mW, certainly insufficient to drive a diode detector.

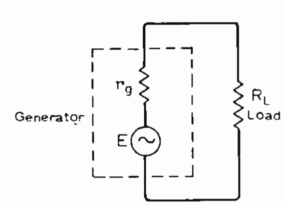



**Fig. 1.** *A purely-resistive load $R_L$ connected to a purely-resistive generator $r_g$.*

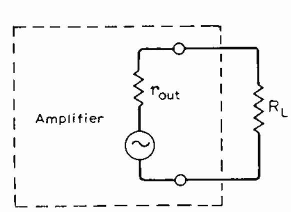



**Fig. 2.** *The circuit of Fig. 1 arranged to represent conditions at the output of an amplifier.*

Thus in this example the transistor could not be presented with a load equal to its own $r_c$ because of the enormous collector voltage excursion which would be required to make full use of the current swing available. A more practical value of collector load resistance is 3 kilohms, for this makes full use of the current swing of 3mA and the voltage swing of 9V. The power output so obtained is 13mW, quite adequate for diode detector operation.

Now consider an emitter follower stage and suppose the emitter current is 1mA. The emitter a.c. resistance will be of the order of 25 ohms and, according to the maximum power transfer theorem, this should also be the resistance of the optimum load. Let us suppose that the transistor has a supply of 9V. The emitter potential swing is then limited to $\pm 4.5$V but to generate such a value across a 25-ohm load requires an emitter current swing of 180mA! The maximum swing possible is only 1mA, giving a maximum output voltage swing of 25mV. In this example we could not use a load resistance equal to the output resistance because of the very high emitter current required.

In the two examples described above use of a load resistance equal to the output resistance necessitated a very high output voltage or output current. This was because we were attempting to obtain the maximum output power of which the active device was capable with the given values of quiescent collector voltage and current: in fact we were trying to make maximum use of the available voltage and current swings, which is a normal design procedure for stages required to deliver appreciable power. But suppose instead we give the transistor an input signal so small that even with a load resistance equal to the collector a.c. resistance the swings in collector voltage and collector current are small compared with the quiescent values. Admittedly this is an impractical form of amplifier because the output power would be minute, but the point is whether with such a small signal the optimum load is equal to the collector a.c. resistance.

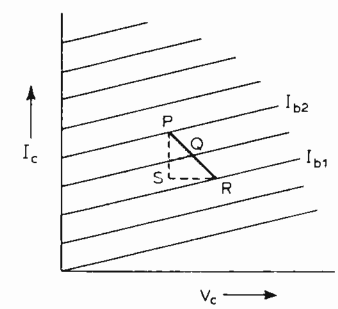
It is interesting and instructive to try to answer this question using the transistor characteristics. Fig. 3 shows an idealised set of $I_c - V_c$ characteristics, the slope of which is equal to the reciprocal of the collector a.c. resistance. Q is the quiescent point representing the static values of collector voltage and current. Through Q is drawn the load line PQR, the slope of which is equal to the reciprocal of the load resistance. If the small input signal swings the base current between the limits of $I_{b1}$ and $I_{b2}$ then the output current swing is given by PS and the output voltage swing by RS. The area of the triangle PRS is proportional to the power output: in fact if the area is expressed in terms of the horizontal and vertical scales it is equal to four times the power output. As the load resistance value is varied, the load line pivots about Q and the area of the triangle varies. For very small load values PR is nearly vertical and side RS tends to zero, whereas for very high value loads PR is nearly horizontal and PS tends to zero. Between these two extremes there is a position of PR which gives maximum area of PRS.

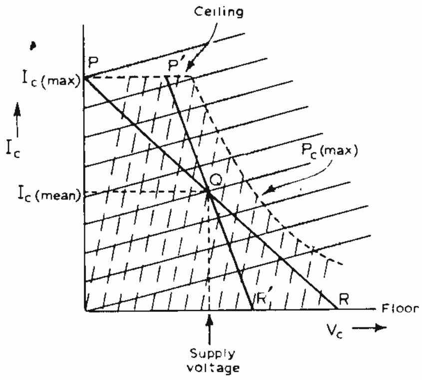
The solution to this exercise is that the area is a maximum when the slope of PR is equal to that of the characteristics, i.e. when the load resistance is equal to the generator resistance, thus confirming the maximum power transfer theorem. As we have seen this is true provided very small signals are used, and this is a useful reminder that the equivalent circuit for active devices applies only to small signals.

What has been said about the impracticality of using the theoretical optimum load in an amplifier with normal signal amplitude will help us to understand the observation made earlier that the load resistance for a high-quality amplifier is usually many times the output resistance. Let us assume initially that the output stage is a single class A amplifier. The $I_c - V_c$ characteristics of a bipolar transistor are shown in idealised form in Fig. 4. The collector current swings above and below the quiescent value when an input signal is applied and there are limits to both swings if distortion is to be avoided. On the upward swing the collector current must not exceed the maximum value $I_{c(max)}$ prescribed by the manufacturer. Moreover the collector dissipation must not exceed the maximum $P_{c(max)}$ quoted by the maker.

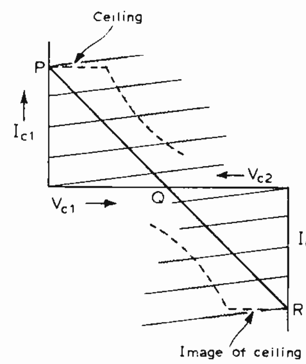
There are other causes of current limitation: in valves, for example, attempts to drive the anode current above a certain value cause the grid to go positive with respect to the cathode so

**Fig. 3.** *A load line PQR superimposed on a set of $I_C - V_C$ characteristics. The shaded area represents the power output.* ▼




▲ **Fig. 4.** *The ceiling and floor which limit the current excursions in a class A amplifier. PQR represents the optimum position of the load line. The dashed characteristics show the effect of negative feedback.*




◀ **Fig. 5.** *In a push-pull amplifier the floor is replaced by an image (skew symmetrical) of the ceiling.*

that distortion occurs in the input circuit as a result of damping due to grid current. A similar limitation occurs in junction field-effect transistors, the input circuit of which also conducts when the gate potential equals that of the source. Because of these limitations collector current must not enter the upper shaded area in Fig. 4: the boundary of this area consists of a straight line representing $I_{c(max)}$ and a curve representing $P_{c(max)}$.

Similarly the greatest negative excursion of the collector current is that which causes its value just to reach zero. Thus the area below $I_c = 0$ is another region which must not be used. The quiescent point Q is located midway between the base line (which we can call the floor) and the lower limit of the upper shaded area (the ceiling). The load line must pass through Q and, to use the full range of collector current, must touch the ceiling and the floor at its ends. It should also use the full voltage excursion between zero and twice the supply voltage: its position is thus fixed at PQR. This represents a load resistance given by the supply voltage divided by the mean collector current. It is thus independent of the a.c. resistances of the transistor.

The effect of applying voltage-derived negative feedback is to replace the $I_c - V_c$ characteristics shown solid in Fig. 4 by a new set (shown dashed) much more vertical (implying a lower effective collector a.c. resistance), more evenly spaced (showing improved linearity) and more closely spaced (indicating reduced gain). The manner in which these new characteristics may be deduced was given in an earlier article.* According to the maximum power transfer theorem the slope of the optimum load line should be equal to that of the dashed characteristics (as shown by P'QR') but clearly this is impractical because, to utilise the full voltage excursion, the current would extend well into the shaded areas as in the emitter-follower example considered earlier. The application of feedback has no effect on the position of the floor and ceiling: it, therefore, has no effect on the load line and on the value of the load resistance.

It is, of course, more usual to use a push-pull pair operating in class B in the output stage of a high-quality amplifier. The output voltage is not now accommodated between a ceiling and a floor because the half cycles of signal are handled alternately by the two transistors. There is therefore no floor as in Fig. 4. Instead the load line is bounded by two ceilings, the lower of which can be regarded as a skew-symmetrical image of the upper ceiling situated below the zero-current axis (Fig. 5). Nevertheless the result is that the optimum load line is confined between the two ceilings and fixed in position by the need to exploit the available swings in current and voltage. As before the application of feedback replaces the near-horizontal characteristics by near-vertical ones but has no effect on the position or slope of the load line. Thus the value of the optimum load is unaffected by feedback which is used to improve linearity and to reduce the value of the output resistance. □

* *Wireless World* August 1976, p.66.

# Fuses for the protection of electronic equipment

## The construction, characteristics and design considerations of fuses

by **R. A. W. Connor,** F.I.E.E.

A "simple" fuse is the most widely used, and often the most overlooked and underestimated protection component in a circuit. Although the mechanical construction of a fuse is relatively straightforward, its operation is complex. As a result, much research and development has taken place to keep up with new technologies and devices.

This article describes how modern fuses, when chosen correctly and properly installed, provide cheap, accurate and reliable protection which in many respects is superior to other switching devices.

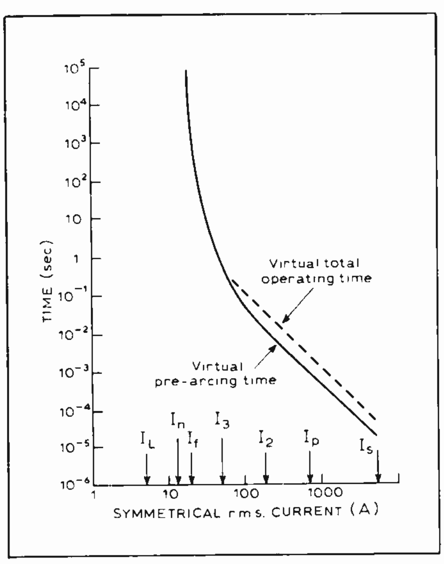
A FUSE, according to the IEC, is a switching device that by fusion of one or more of its specially designed and proportioned components opens the circuit in which it is inserted and breaks the current when it exceeds a given value for a sufficient time. The fuse comprises all the parts that form the complete switching device.

Fuses are the most common protective device and are used at rated currents up to above 2000A and in circuits operating at up to 132kV. Physically, a fuse is of simple construction but its operation is complex. The late H. W. Baxter of the ERA was one of the leading authorities and the results of some of his classic research over the period 1930 to 1950 has been published.

A fuse is one of a chain of components in a circuit, all of which rise in temperature with the passage of current. Under heavy overload or short circuit conditions there is no time for the heat to escape and the temperature of the fuse element rises rapidly to the melting point of the element. At small values of over-current a single break occurs in the element which gradually lengthens until arc extinction. At high values of fault current a large number of breaks occur almost simultaneously. With wire elements there may be 40 or more arcs per inch and the arc voltage may reach several hundred volts per inch particularly when there is a high inductance in the circuit. This high arc voltage quickly forces the current down to zero before the first peak of the fault current. Excess voltage, even a transient type, is however objectionable particularly to semiconductors, and upper limits are prescribed in many specifications. For a.c. circuits, part 1 of BS88 specifies maximum arc voltages of 1000V and 2000V with circuits rated up to 60V, and 61 to 300V respectively. Lower arc voltages can be obtained with fuses specially designed for semiconductor protection.

In a modern cartridge fuse the element is totally enclosed. For high current ratings and for specially designed semiconductor fuses the cartridge is usually filled with powered quartz, of controlled grain size, which is free from moisture and organic impurities. With this type of fuse, fire risk and damage is greatly reduced because of its ability to limit the current and thus reduce the let-through energy. Cartridge fuses are non-deteriorating and retain their characteristics almost indefinitely. The filler plays an important part in fuse operation because it cools and condenses the hot metal and vapour produced by arcing, and it also reduces the pressure on the cartridge wall. In addition, it is capable of extracting a large amount of energy from the circuit. This energy vitrifies part of the quartz which forms a fulgurite. As the fulgurite and remaining filler cools its resistance quickly increases and it is able to withstand full working voltage indefinitely. The size of the quartz particles is important because arcs are drawn into the interstices between the particles. But, because there are other conflicting requirements the choice of particle size is a compromise.

Fig. 1. *Typical t/I characteristic for a 13A plug top fuse to BS1362. Assumed values for $I_p$ and $I_L$ are 740A and 6A respectively.*




All fuses have an inverse $t/I$ characteristic of the general shape shown in Fig.1. Current $I_n$ is the rating of the fuse link, $I_f$ is the minimum fusing current and $I_L$ is the full load current of the equipment which should not be greater than $I_n$. Values $I_2$ and $I_3$ are higher currents used for descriptive purposes. The prospective current at the fuse position is denoted by $I_p$, and is the current that would flow if the fuse were replaced by a solid link of negligible impedance. The maximum current which the fuse is subjected, $I_s$, in the manufacturers certification tests must be greater than $I_p$. The current range 0 to $I_n$ is the working zone and the complete fuse should carry any current in this range without overheating. The current range $I_n$ to $I_f$ is the non-operating zone and the ratio $I_f/I_n$ is the fusing factor. This depends on the design of the fuse, and varies from about 1.2 with some designs of powder filled fuse, to as much as 2 with some semi-enclosed rewireable fuses. Any value of current above $I_f$ causes operation of the fuse although it may take an hour or more with a current only slightly above $I_f$. A small current increase in the range $I_f$ to $I_3$ results in a considerable increase in operating speed whereas a small increase in current above $I_3$ has only a small effect. With 3 pin plug top fuse links to BS:1362, $I_s$ is 6000A which is well above any likely value of $I_p$. The value of $I_p$ may be approximately determined by connecting a load at this position and measuring the supply voltage before and after application of the load. The accuracy is improved by using a heavy load. Current rating $I_n$ of a fuse in the mains supply should be at least equal to the value of $I_L$, and must also be sufficient to cater for surges. However, it should not be too large because with lower values of $I_n$ there is a better chance of clearing earth faults. The prospective earth fault current $I_E$ on the 240V mains is $I_E = 240/Z_e$ where $Z_e$ is the phase earth loop impedance at the fuse position. To meet the IEE wiring regulations $I_E$ must exceed $3I_n$ when $I_f/I_n > 1.5$, and $I_E$ must exceed $2.4I_n$ when $I_f/I_n < 1.5$. A low value of $Z_e$ is therefore necessary with high current rated fuses. In urban areas with cable sheath earthing, $Z_e$ is likely to be less than 1Ω and $I_E$ greater than 240$A^2$. Difficulties in obtaining a sufficiently low value of $Z_e$ are more likely to arise with overhead services particularly in areas of high soil resistivity. The Electric Supply Authority can often render assistance both in testing and in obtaining a good earth.

Tests at various currents between $I_f$ and $I_s$ are made in order to plot the $t/I$ characteristic. In the range $I_n$ to $I_3$ these may be made at a reduced voltage. Fig.2 shows a typical current in a fuse during a high current test in which the melting of the fuse element prevents the current reaching the maximum value. The graphical method of determining virtual pre-arcing time is superimposed in Fig.2. and shows that:

$$I^2_p\, t_{vp} = i^2 dt$$
$$t_{vp} = i^2 dt / I^2_p$$

where $I^2_p$ is the prospective current, $t_{vp}$ is the virtual pre-arcing time, and $i$ is the instantaneous value of current during the pre-arcing period. The virtual arcing time may be determined in a similar manner and can be added to the virtual pre-arcing time to give the virtual total operating time. The virtual pre-arcing time is drawn to show the mean value of the test results and the virtual arcing time is taken as the maximum value of the test results. Fig.1 shows that the arcing time is only significant at high fault currents.

The only current known to the user apart from the load current is the prospective current, $I_p$. The user needs to know a time value as shown in Fig.2 so that it can be multiplied by $I^2_p$ to obtain the heating effect of the current. Equipment can then be selected and designed to withstand this with a safety margin. Manufacturers usually present this as a characteristic with $I^2t$ in $A^2s$ as the ordinate and $I_n$ as the abscissa. Fig.3 shows total operating $I^2t$ and pre-arcing $I^2t$ for each value of $I_n$.

It is fortunate that fuses have an inverse time/current characteristic as this enables suitably chosen fuses to operate satisfactorily when in series. It is not practicable to examine or replace every fuse that has experienced a through fault, but discrimination can be achieved if the total energy let through by the minor fuse, total $I^2t$, is less than the pre-arcing energy $I^2t_{vp}$ of the major fuse. In general, discrimination is achieved if the current rating of the major fuse is twice that of the minor fuse although a lower ratio is often possible when $I_p$ is relatively low. Difficulties arise when different types of protective equipment are involved. Discrimination cannot always be achieved when rewireable fuses or miniature circuit breakers are in series with cartridge fuses. In Fig.4 the 45A rewireable fuse discriminates with the 80A cartridge fuse up to about 500A. With fault currents above 500A the cartridge fuse operates first.

Two fuses are sometimes used in the mains supply to apparatus with the erroneous belief that this is twice as good as one fuse. If the fuses are of the same type and current rating, the fuse in the neutral lead may operate first. In this condition the apparatus remains at a dangerous potential above earth. A single fuse should be used in the live lead. Sometimes the earthed chassis of equipment is accidentally or deliberately connected to the neutral. This is most undesirable for a number of reasons. Such a connection encourages part of any short circuit current to flow through the metal work to earth. This fault current may originate from other apparatus in the same premises or even from apparatus in adjacent premises. If the local earth and sub-station earth have low resistances, very high currents can flow without any effect on the fuse in the apparatus. Secondly, the neutral is used to carry unbalanced currents from other phases of the supply network and usually differs from earth by a continuously varying potential of up to several volts. The corresponding current will therefore fluctuate and cause hum and other difficulties particularly when the parallel earth paths have a low resistance. Thirdly, and even more important, the danger that arises in the event of a broken neutral. Although this is a very rare occurrence, if the break occurs between the apparatus in question and the sub-station, considerable load currents from apparatus in all premises beyond the break can flow to earth through this connection. Again,

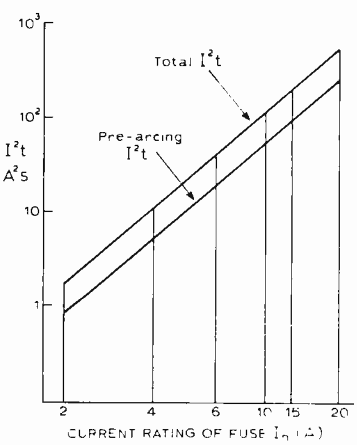



**Fig. 3.** *Typical $I^2t$ values for a family of fuses.*

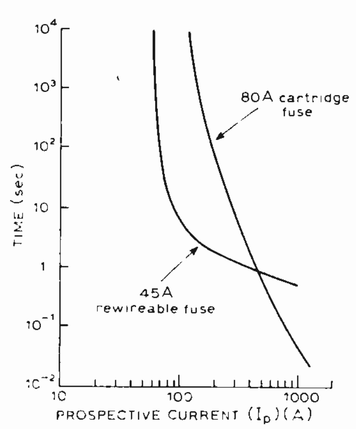



**Fig. 4.** *T/I characteristic of cartridge and rewirable fuses.*

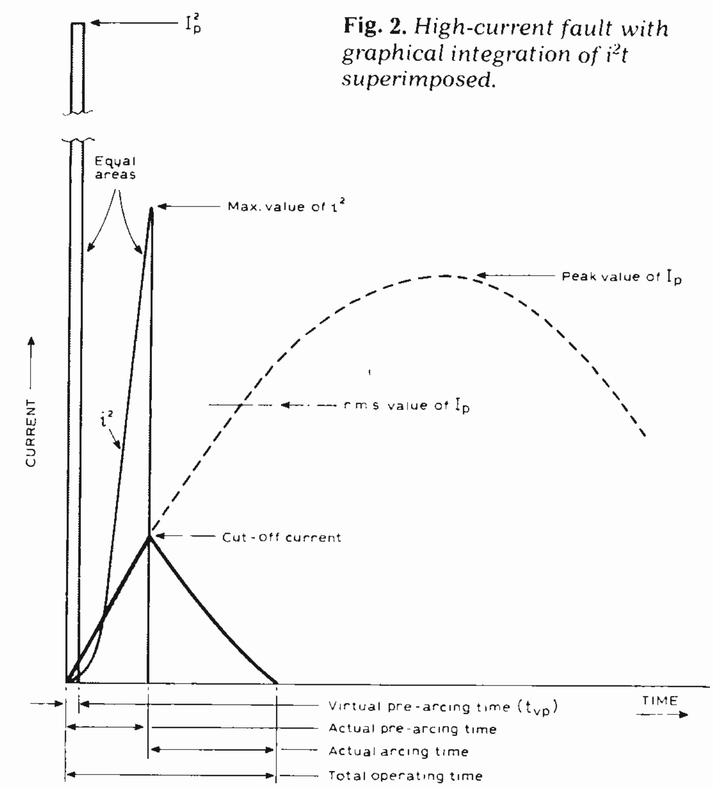



**Fig. 2.** *High-current fault with graphical integration of $i^2t$ superimposed.*

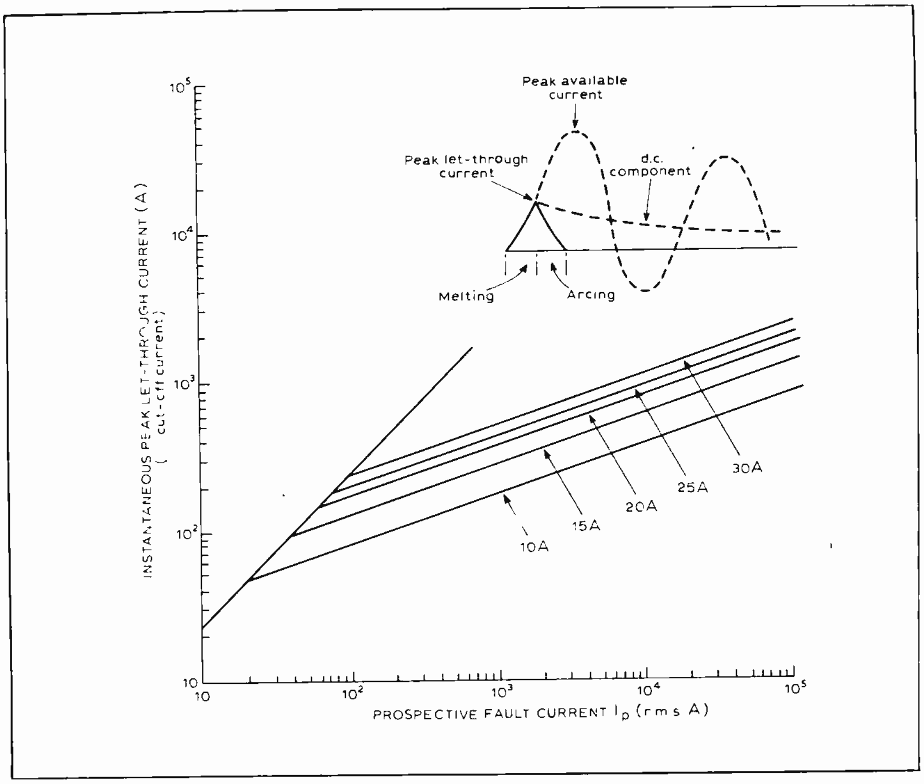



**Fig. 5.** *Cut-off characteristics for a family of 250V semi-conductor fuses.*

the fuse on the apparatus is completely unaffected. Furthermore, even if the local earth has a fairly low resistance, the metalwork of the apparatus may rise to a dangerous potential.

**Cut-off characteristics** are usually presented on equal decade logarithmic paper, and an example for a family of semiconductor fuses is shown in Fig.5. The 45° line is the transition point and is the asymmetrical fault current which is the limit of cut-off. There is no precise value but it is usually considered to be about 2.4 times the r.m.s. symmetrical fault current for circuits of less than 1000V. Cut-off currents for the individual fuses correspond to a slope of 1 in 3 because at currents greater than the transition value the cut-off current is proportional to $3\sqrt{I_p}$. In Fig. 5 all of the fuses exhibit cut-off at $I_p$ values above $10I_n$. At very high values of $I_p$ the cut-off current is quite small, particularly with fuses of lower current ratings.

**Temperature rise** is the difference between the actual temperature at the fuse position and the ambient temperature. Under a steady current the temperature rise of a fuse will increase until a steady condition is reached when the heat dissipated is equal to the heat input, $I^2Rt$ Joules where $R$ is the resistance of the fuse. At currents up to $I_n$ the temperature rise is approximately proportional to $I^2$ but usually increases at a greater rate for currents above $I_n$. Small overloads can therefore result in a large increase in temperature. A fuse may either gain heat or loose heat to the connecting cables. A considerable proportion of the total heat can be due to the resistance of the terminations and contacts. Some specifications give maximum permitted temperatures of fuses and the components parts. For example, BS 88:1975 Part I for cartridge fuses up to 1000V a.c. and 1500V d.c. gives a temperature rise limit of 65°C for bolted tin plated contacts and terminals. Some specifications do not give temperature rise limits but, specify either maximum permitted power loss or maximum resistance. For a particular fuse and a given current rating, the ratio of steady state power loss at current rating/cold power loss, is mainly constant. Because the ratio of temperature rise at rated current/stable condition hot power loss, is also reasonably constant this amounts to specifying the maximum temperature. Power loss in a fuse increases with the increased current rating. With a 32mA fuse it is about 1/3W while at the other extreme a 1250A fuse may lose 100W. Because a fuse is a temperature sensitive device it may have to be derated in ambient temperatures above 40°C. Alternatively, it may be uprated if subjected to artificial cooling.

**Potential drop** across fuses with low current ratings may exceed the voltage of the equipment being protected. At the rated current a 32mA low breaking capacity fuse to BS:4265 has a maximum potential drop of 10V. Corresponding values for 1A and 6.3A fuses are 1V and 0.2V. These high values at low current ratings are due to the very fine wire used for the elements.

Some of the factors affecting the correct choice of fuse current rating have already been mentioned. With semiconductors, however, it is also necessary to distinguish between r.m.s. and average values. Current ratings of fuses are invariably given in r.m.s. values whereas average values are given for diodes and thyristors. A comparison of these currents for half-wave and full-wave single phase rectifiers assuming that $i_{peak}$ is 1.0A shows tifiers, assuming that $i_{peak}$ is 1.0A, shows that,

| | $I_{peak}$ | $I_{r.m.s.}$ | $I_{average}$ |
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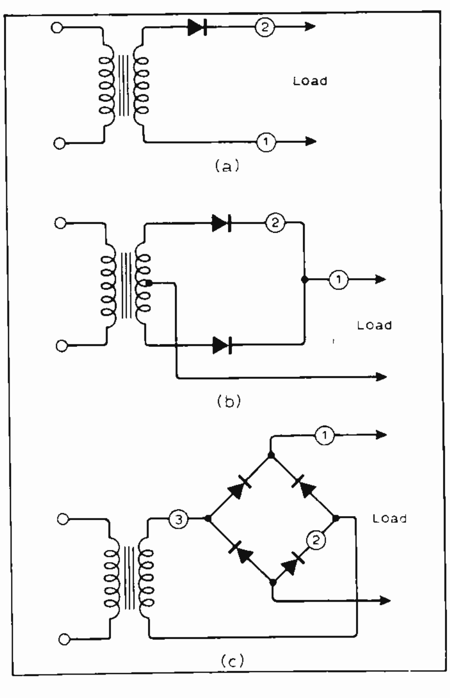
When semiconductor rectifiers are used it is also necessary to take account of the fuse position in the circuit. The three most commonly used single phase rectifier circuits are show in Fig. 6 with currents at various positions assuming that the d.c. load current is 1A. Values for other currents will be in proportion. It should be noted that the published average current for some diodes may have to be derated to $0.8I_{av}$ for battery or capacitive loads. With large installations several diodes may be used in parallel and a multi-phase arrangement can be used. It may then be desirable to connect a fuse in series with each diode in addition to main fuses. Ideally, the $t/I$ characteristic of the fuse should be below that of the semiconductor by a safe margin. Semiconductor manufacturers obtain their $I^2t$ values in less than 10ms by using a half sine wave at higher frequencies. These $I^2t$ values can be compared with the $I^2t/I_p$ characteristics of the fuse if the operating times are

Continued on p. 77

**Fig. 6.** *Half-wave rectifier with a single diode (a). The d.c. load current (1) is 1A, the r.m.s. diode current with a resistive load (2) is 1.57A. Full-wave rectifier using two diodes (b). The d.c. load current (1) is 1A, the r.m.s. diode current (2) with a resistive load is 0.785A, and with an inductive load is 0.707A. If only one fuse is used in the centre tap lead there is no protection for an undamaged diode. Full-wave rectifier (c). The d.c. load current (1) is 1A, the r.m.s. load current (2) for a resistive load is 0.785A, and for an inductive load is 0.707A. The r.m.s. current in the transformer secondary (3) for a resistive load is 1.11A, and for an inductive load is 1A.*



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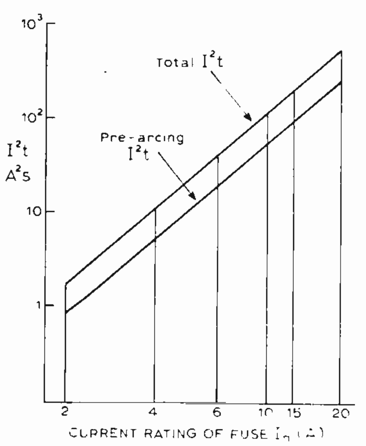


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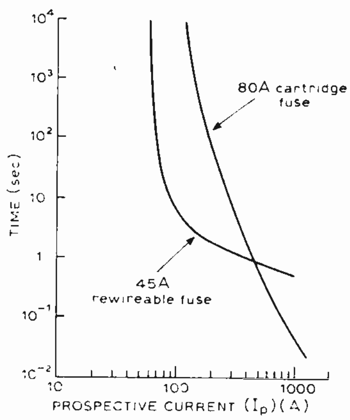


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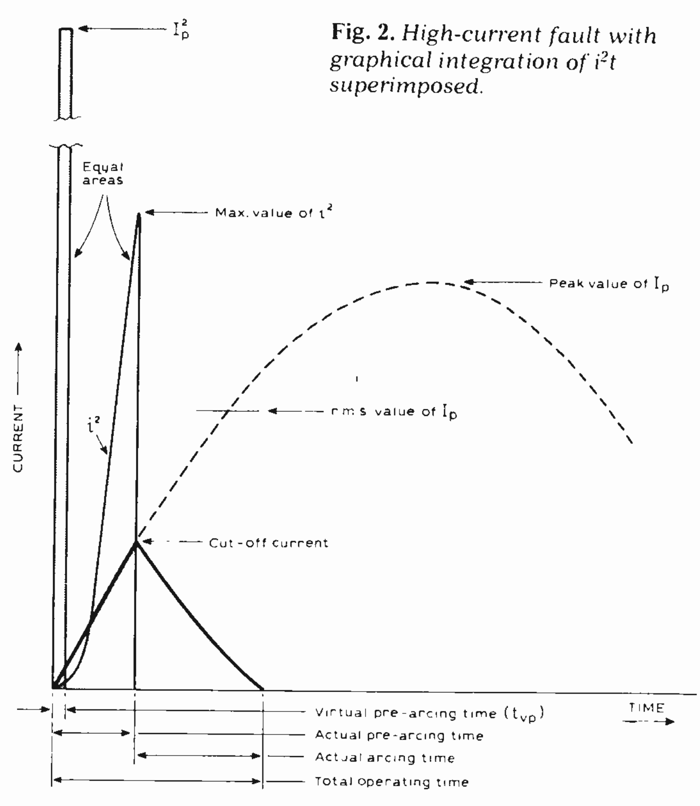


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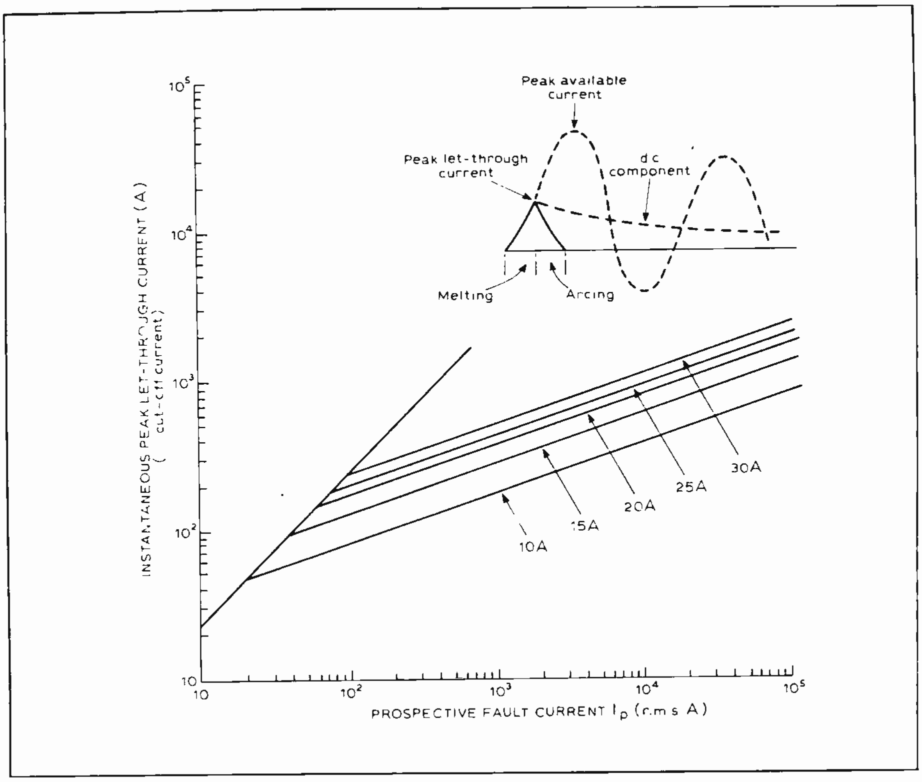


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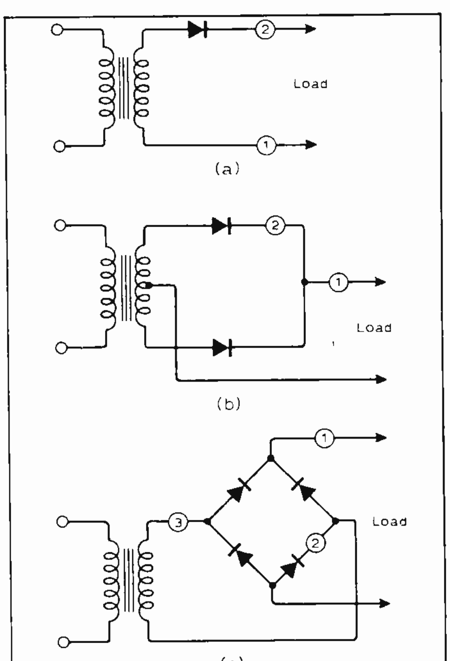


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***Continued on p. 77***

# Teletext decoder modifications

## Installation and testing of the new circuitry

by Richard T. Russell

These modifications to the teletext decoder design by J. Daniels, which was described in the November 1975 to June 1976 issues of *Wireless World*, enable the new facilities to be displayed. These include background colour, double-height characters, graphics hold and separated graphics. Circuit design was described last month: the practical details of modification are now presented.

FOR USE with decoders using 2513-type character generator r.o.m.s, it is necessary to inhibit the subtract-1 circuit on the character vertical address. It is important, however, that the graphics characters remain unchanged. To achieve this, pin 13 of $IC_{119}$, pin 2. This point is at logic 1 for alphanumerics and logic 0 for graphics.

### Installation

The addition of the new circuitry to an existing decoder should be straightforward and present few problems, particularly if the commercially available printed circuit boards are used. The following is a step-by-step description of the procedure to modify a decoder using these boards. For those using alternative methods of construction, the circuit diagram gives the i.c. and pin numbers to which the various inputs and outputs should be connected, and this should be referred to in conjunction with the following notes.

The edge contacts on digital boards 1 and 2, and on the new digital board 3, to which many of the connexions are made will be referred to by number. These numbers are marked on the printed circuit boards themselves and start at 1 at the left-hand end, as viewed from the front of the decoder. The new board has edge connexions on both sides and to distinguish these they will be referred to as C (component side) or W (wiring side).

The first step is to solder all the components in place on the new digital board 3. Take particular care with the orientation of the i.cs and make sure that all the pins have been soldered and there are no solder bridges linking adjacent pins or tracks. A close visual inspection at this stage is well worth while.

One wire link is required on the new board, and its position depends on whether a 74S262 or a 2513 character generator is used in the decoder. In the former case, link $IC_{103}$, pin 13 to 0V, and in the latter case link it to $IC_{119}$, pin 2.

Next, dismantle the decoder so that the reveal switch can be fitted and access to the undersides and edge connexions of digital boards 1 and 2 obtained. If it is necessary to remove any wires to achieve this, a note should be made so they can be returned to the correct points on re-assembly. The reveal switch may be any suitable push-to-make press-button switch, although it is essential that the body of the switch be insulated from the contacts. After this switch is fitted on the front panel of the decoder, one of the contacts may be wired to the nearest 0V point.

The following modifications to the original boards should be carried out:

- Remove the wire links between digital boards 1 and 2 at positions 11, 21, 23 and 24. These are the vertical address connexions to the character and graphics generators.

- Break the connexion to $IC_{11}$, pin 11 on digital board 1.

- Break the connexions to $IC_{41}$, pin 12, $IC_{53}$, pin 8, $IC_{57}$, pin 13, $IC_{58}$, pin 1 and $IC_{58}$, pin 2 on digital board 2.

- For decoders using the 2513 r.o.m(s), additionally break the connexions to $IC_6$, pin 11 and $IC_4$, pin 8 on digital board 1.

Connect a length of insulated wire to $IC_{11}$, pin 11 and (for 2513 decoders) to $IC_6$, pin 11 and $IC_4$, pin 8, for connexion to the new board. At this stage the new board should be mounted above digital board 1 by means of screws and half-inch spacers, using the holes originally intended for mounting the lower-case add-on board. A third hole is provided in digital board 3 to which can be attached another spacer, which will rest on digital board 1 and provide some support for the right-hand end of the new board.

Using short lengths of flexible wire, link connexions C1, C2, C3, C4, C5, C6, C8, C9, C10, C15 and C22 on the new board to the corresponding edge contacts on digital board 1 or 2. Link contacts W11, W21, W23 and W24 to the corresponding contacts on board 1, and C11, C21, C23 and C24 to those on board 2. Connect the wire from $IC_{11}$, pin 11 to C29 and, if applicable, that from $IC_6$ pin 11 to C21 and that from $IC_4$ pin 8 to C11, on the new board.

Using lengths of insulated wire make the following connexions: C7 to $IC_{41}$, pin 12; C26 to $IC_{58}$, pin 2; C27 to $IC_{69}$, pin 9 and C28 to $IC_{57}$, pin 12, all on digital board 2. Connect the reveal switch to C33 and the white output at the end of digital board 2 to W30. Remove the R, G, B connexions to the television receiver from the contacts at the end of digital board 2 and connect them instead to C31, C30 and C32 respectively. Also transfer the cut hole feed (to the front panel switches) from digital board 2 to W32, and connect a wire from the old cut hole output to C34.

All that remains is to provide the 0V and +5V connexions (C35 and C36 respectively) which may normally be commoned with the feeds to digital board 2 (see below). All the connexions having been made, the decoder may be re-assembled.

### Power supply

The new board draws approximately 0.5A from the +5V supply. If two 7805 or similar 1A regulators are used, one to feed board 1 and the other to feed board 2, it should be found that the one feeding board 2 will supply the extra current required. If, however, a single LM309K regulator is used, then an extra regulator will have to be provided for the new board. Depending on the particular mains transformer used, it may be found that the extra load causes the minimum voltage on the reservoir capacitor to drop below the +7V or so required by the regulators. In that case the principal effect will be a 100Hz modulation of the width and intensity of the teletext display. If this occurs it may be found sufficient to increase the value of the reservoir capacitor, but if this is not effective it will probably be necessary to replace the mains transformer with one having a higher secondary current rating.

### Testing

Assuming the decoder was working satisfactorily before adding the new board, and that no wiring errors are made, the modified decoder should work first time. Inevitably, however, this happy situation will not always occur. If a completely unlocked or unrecognisable display is obtained, the connexion to $IC_{11}$ pin 11 should be restored to its original point on digital board 1 as this is the most likely cause of such a fault. If this fails to restore some semblance of a normal display, the address and blanking signals to the new board should be checked with an oscilloscope or logic probe. They should all be changing between 0 and 1 logic levels and a steady value on any one would suggest a short to ground or +5V.

Once a locked display is obtained, a check can be made on the various display modes. The best test page for this is the Combined Test page on Oracle (currently p.451) which includes all of the display modes currently specified. A failure of any one of the new facilities should draw attention to the appropriate part of the circuit, whereas a more general failure would suggest a problem in the control-codes decoding section.

**Integrated circuit types**

| | | | | | |
|---|---|---|---|---|---|
| 101 | 7400 | 110 | 74177 | 119 | 7410 |
| 102 | 74174 | 111 | 7400 | 120 | 7400 |
| 103 | 7483 | 112 | 74174 | 121 | 7474 |
| 104 | 74150 | 113 | 7442 | 122 | 7402 |
| 105 | 74157 | 114 | 7474 | 123 | 7408 |
| 106 | 7402 | 115 | 74175 | 124 | 7486 |
| 107 | 74157 | 116 | 7408 | 125 | 7473 |
| 108 | 74157 | 117 | 74174 | | |
| 109 | 7408 | 118 | 7404 | | |

When the new board appears to be working correctly, a check should be made on the pages using the new facilities. Some of these are listed in the Engineering Index page on Oracle (p.450).

I would like to thank Messrs. Catronics Limited for their assistance in carrying out the printed circuit layout and supplying prototype boards. □

**Reference**

1. Broadcast Teletext Specification, September 1976. Published jointly by the B.B.C., I.B.A. and B.R.E.M.A.

*Printed-circuit patterns for the new board cannot be published, because there is insufficient space, but photocopies can be obtained from this office. Please write in and enclose a big, stamped, addressed envelope if you would like copies.*

## NRDC rejects criticism of over-selectivity

THE National Research and Development Corporation "does not propose to lower its standards to appease its critics," according to the corporation's annual report. Already four fifths of the proposals it accepts "fail to match up to expectations."

Last year the Corporation, founded 28 years ago to develop and market promising inventions from public and private firms and individuals, received 1,780 applications, compared with 1854 the previous year. One hundred new development projects were set up during the year, compared with 82 the year before.

Referring to a report published a year ago by the Select Committee on Science & Technology which criticised the NRDC for scepticism and indifference, the corporation says: "While the corporation would hope to give the appearance of enthusiasm and concern, it is sometimes difficult to leave these impressions with those, unfortunately the majority, whose proposals one has had to turn down."

At a press conference to launch the report on November 3 the NRDC chairman, Lord Schon, said, "To my knowledge, and I emphasise, to my knowledge, there is no record of anyone leaving, going away from the NRDC and making a success of their invention somewhere else."

The report says the proposals the Select Committee made for correcting "the alleged deficiencies in the functions of the corporation and the so-called mismatch between our activities and those of the Science Research Council" were based on misunderstandings of the NRDC's purpose and manner of operation. The Select Committee's general criticisms were too vague to be able to answer, but the NRDC accepted that they could do more to make their services better known to potential clients.

Income from all sources was nearly £25 million last year compared with £15 million in the previous year, which this year was about the same amount as came in from licences alone. This year's surplus before tax was £11 million, around three times that for the previous year. Development expenditure was £2 million compared with £1.35 million in 1975/76.

Among the equipment on show at a small exhibition staged at the launching of the NRDC's report was an ionisation smoke detector developed by the Fire Research Station from an original idea by the Navy.

The single-tube automatic multi-point (STAMP) detector uses a number of small-bore plastic pipes to connect various parts of a fire protection zone with a central detector. Each pipe's opening is mounted in the ceiling of the room to be protected, and samples of air are drawn into the tube by vacuum pump. Each pipe is sampled in turn, and its contents drawn into a small ionisation chamber where there is a radioactive source. If smoke is present the rate of decay of the ionisation, measured by the current in an electric field across the chamber, will increase.

In other detectors which use the technique the ionisation of the air by the source, the interaction of the smoke and the ionised air and the extraction of the remaining ions by the electric field take place in the same place and at the same time. The new device separates the three effects, giving a longer time for the smoke to interact with the ionised air, and so making the device, according to Guardian, up to 100 times more sensitive than conventional detectors. □

## Microwave landing — a degree of flap

AT TALKS held recently in Washington, the American and British civil aviation bodies, FAA and CAA, reached agreement on a series of comparative trials and demonstrations of the two leading systems of microwave landing. Side-by-side comparisons are to be made at three airports: JFK (runway 13 left), Kristiansand (runway 22) and Brussels (runway 07 left). In the New York tests, DMLS (UK) will follow TRSB (US), the reverse applying in Europe. Tracking and data reduction will be provided by the "resident" organizations, with "raw" data to be made available, and the aircraft will be a Boeing 737 at New York, a Convair 880 at Brussels and, probably, an HS748 at Kristiansand.

This agreement should bring to an end the unsatisfactory state of affairs created by the somewhat ham-fisted attempts at computer simulation of airport "scenarios". (*WW* November, p.54.) The farcical materialization of an imaginary building in the Brussels simulation, which the computer said would cause trouble and practical tests showed wouldn't, has not helped anyone to arrive at a decision; it appears the only way to do that is to hang the expense and do the flying. This has the further advantage that elevation will also be tested – Lincoln Laboratories confined themselves to azimuth simulation. Plessey say that DMLS can be installed, the flight tests carried out and the equipment removed in less than three weeks, so that costs and disruption at airports are minimal.

Mike Whitney, deputy director of telecommunications (navigation) of the CAA, who signed the agreement, insists that no one is interested in plugging either system unless they are convinced it is the best: "If tests show that TRSB is *as good as* or better than Doppler," he says, "we will withdraw our support for Doppler." In other words, the FAA can deploy so much political and commercial muscle in its dealings with ICAO, that Doppler has to be much better than TRSB to stand an even chance of acceptance.

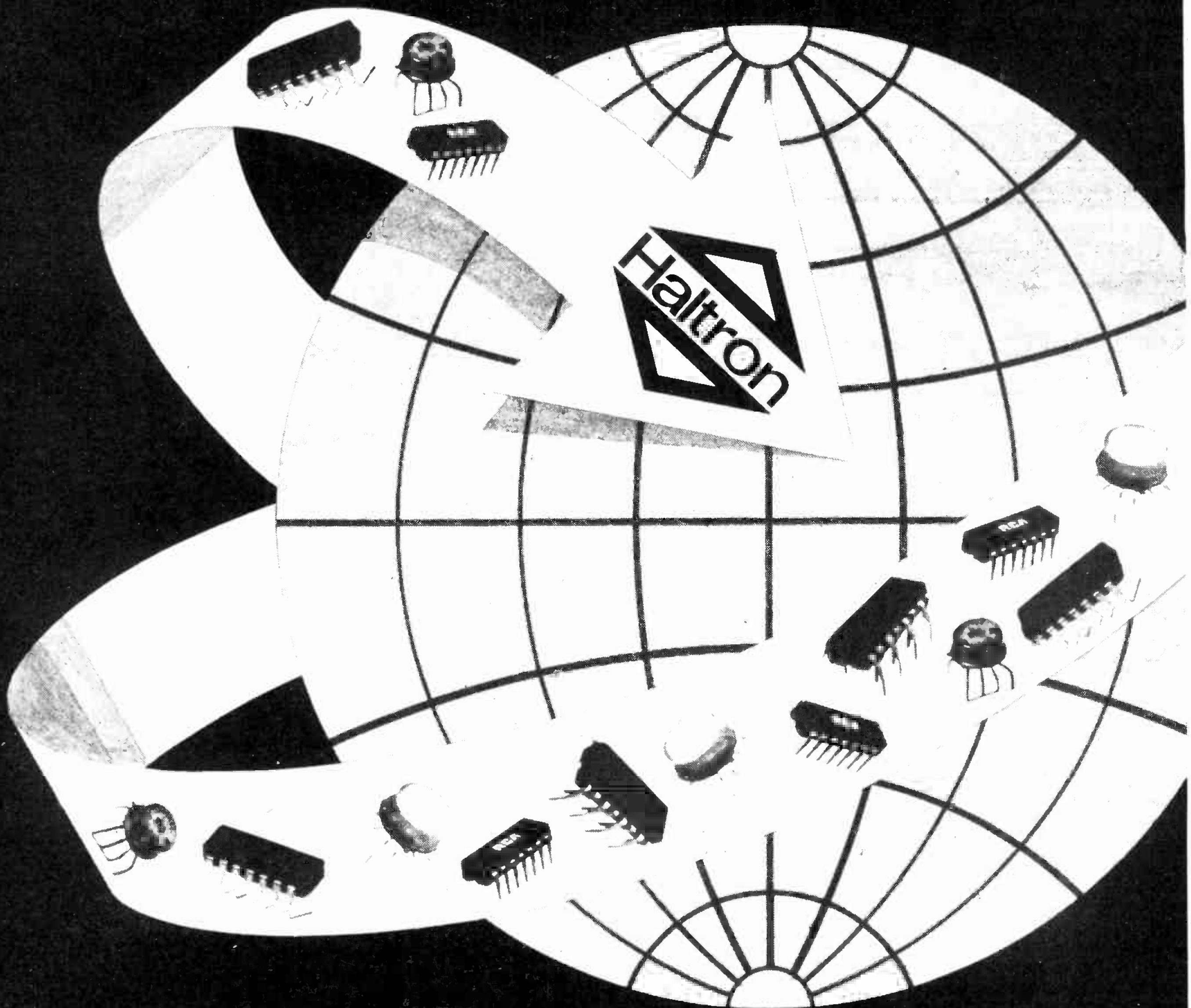
The tests will take place in January and February 1978 and must be completed and all results correlated before April, since that is when the final decision on the choice of system is to be made. □

**F.m. transceiver**

The following notes are of importance to readers contemplating building the f.m. transceiver. In Fig. 3, pins which are not used in the i.c.s. should be tied down to stop the devices oscillating, as follows: pins to be taken to either an earth or + 15V pins are pins 9, 10, 11, 12 on $IC_6$, pins 9, 10, 15 on $IC_4$, pins 7, 11 on $IC_7$. Pin 8 on $IC_{10}$ should go to earth and pin 2 on $IC_5$ should go to + 15V. In the transceiver $IC^2$ (4059) is required to operate up to 6MHz at 15V. Although the specification for this device is quoted as 3MHz at 10V, the author informs us that all of the devices he has tried have worked well.

The author suggests that a 600 ohm, 25kHz filter be used in the receiver circuit.

**Misprint corrections:** In Fig. 4, $L_2$ should not be tapped; $R_{19}$ should read $R_{29}$; and $R_{37}$ near $C_{14}$ should read $R_{34}$.


Haltron

# Microcomputer design — 3

## Practical realisation of a microcomputer system

**by C. D. Shelton*** B.Sc. (Eng.), ACGI, M.Phil, Ph.D.
in association with Shelton Instruments Ltd and NASCO Ltd

The previous two articles developed the theme of a microcomputer system in the order of microprocessor, memory, input/output and a practical example. This third article uses the term "microcomputer system" to mean a microcomputer (as defined in the November issue) acting together with a specific software package. When designing microcomputers, the most important features of the hardware are the trade-offs between prices and performance balancing hardware and software.

THIS ARTICLE begins to describe the practical realisation of a microcomputer system using principles outlined in the first two articles in this series. Referring to Fig. 4 of Part 1 (November issue) all components shown there are present in one form or another. Fig. 1 shows a version of that Fig. 4 which more nearly approximates to the kit hardware to be described. We shall deal first with input/output, then, in a later article, with memory and lastly the microprocessor itself.

The design aim for the hardware was to include as many features as possible for programme development while keeping the total cost of the components to a minimum. This aim was approached by designing from the peripherals inwards towards the central processor; and the peripherals chosen were: keyboard, serial i/o device and visual display, with a 16-line i/o as an optional extra. The price of the kit depends on the cost of the hardware, but this can be minimised by increasing the software, so it would seem that the software should be maximised. There is a feature of software which has to be borne in mind, and that is that e.p.r.o.ms (see November issue) occur in units of 1024 bytes. Again for cost reasons the maximum software allowed was fixed at 1024 bytes; in other words the software could be contained in a single MK2708 e.p.r.o.m. device.

*Shelton Instruments Ltd, the designers of the NASCOM I microcomputer kit (see November issue, p.45).

### Peripheral 1 — the keyboard

The keyboard was reduced to its simplest form and is shown diagrammatically in Fig. 2. The circuit diagram is in Fig. 3. It is arranged as a single-port peripheral and the port address has been chosen as zero ($P_0$ in Fig. 1). The hardware realisation includes two integrated circuits to obtain latched outputs and gated inputs; thus 16 lines are available for port zero, eight in and eight out. Further use has been made of the output lines by choosing a 6-bit latch and using only

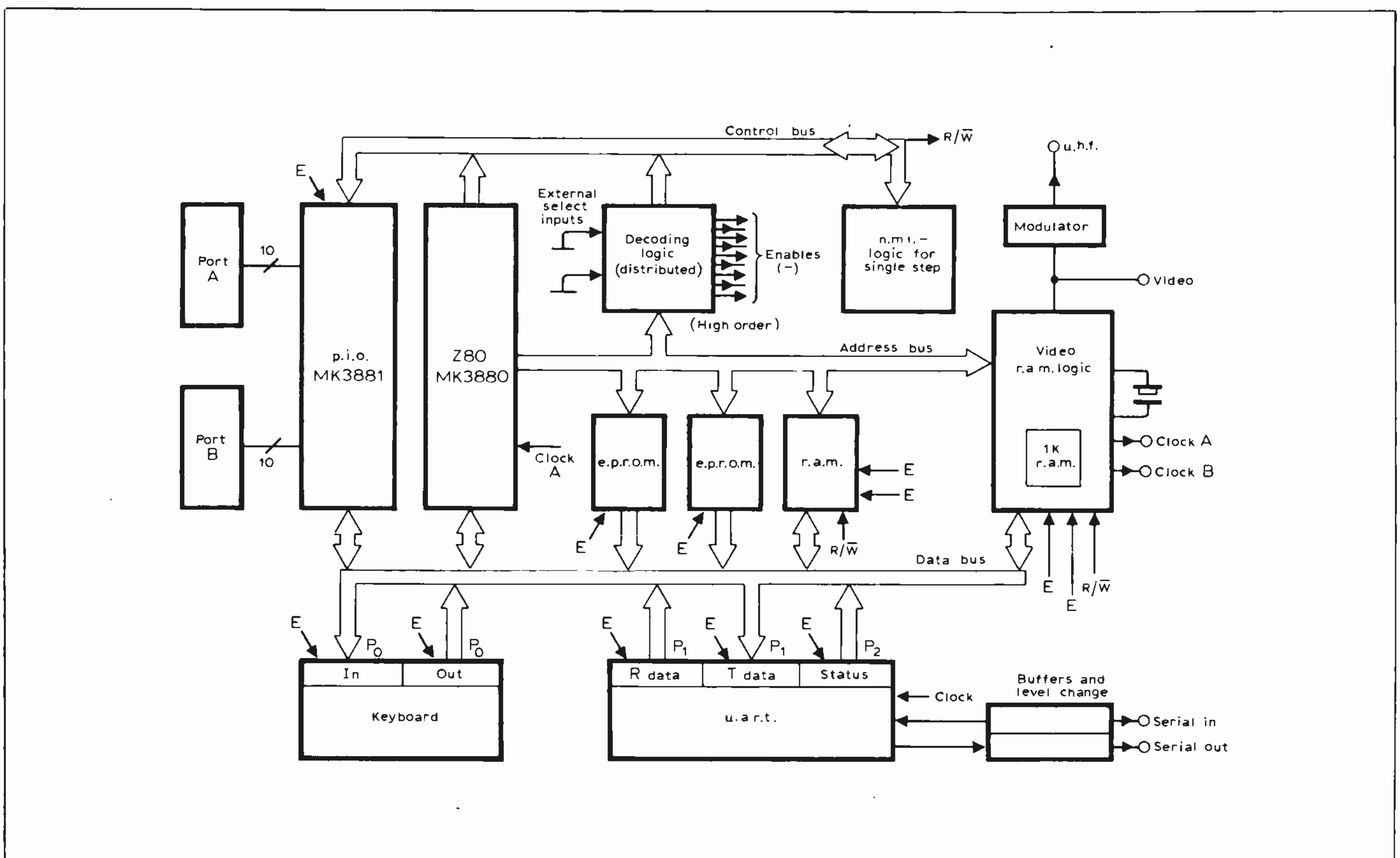



**Fig. 1.** *Block diagram of the microcomputer system. This can be related to Fig. 4 in the November issue and Figs 1 and 2 in the December issue. Part of the system is described this month, the rest in a later article.*

two of the lines for the keyboard. These two lines drive the clock and reset inputs of a counter decoder integrated circuit whose outputs are connected to columns of keys. To avoid phantom key appearances, a diode is connected in series with each contact. The matrix of keys is completed by six row lines, each driving a BC238 transistor amplifier which is connected to an integrated circuit forming the port input transmission gate. Output commands to port zero cause the data bus to be latched in an integrated circuit while input commands cause the keyboard row lines to drive the data bus.

Thus the c.p.u. has the opportunity to determine which keys on the keyboard are pressed, and it is left to the software to determine contact bounce elimination, change of state and code assignment.

There are one or two other features of note concerning port zero. The i.c. forming the port input transmission gate is an 8-bit buffer so that two bits are available to the user and do not interfere with normal keyboard operation. On the output side, the other bits of port zero from the second i.c. are used as follows:

$Q_2$: available to user

$Q_3$: a low to high transition on $Q_3$ initiates a hardware single-step logic system to be described later.

$Q_4$: when $Q_4$ is high a transistor is energised to drive a light emitting diode. The software uses this to indicate that the

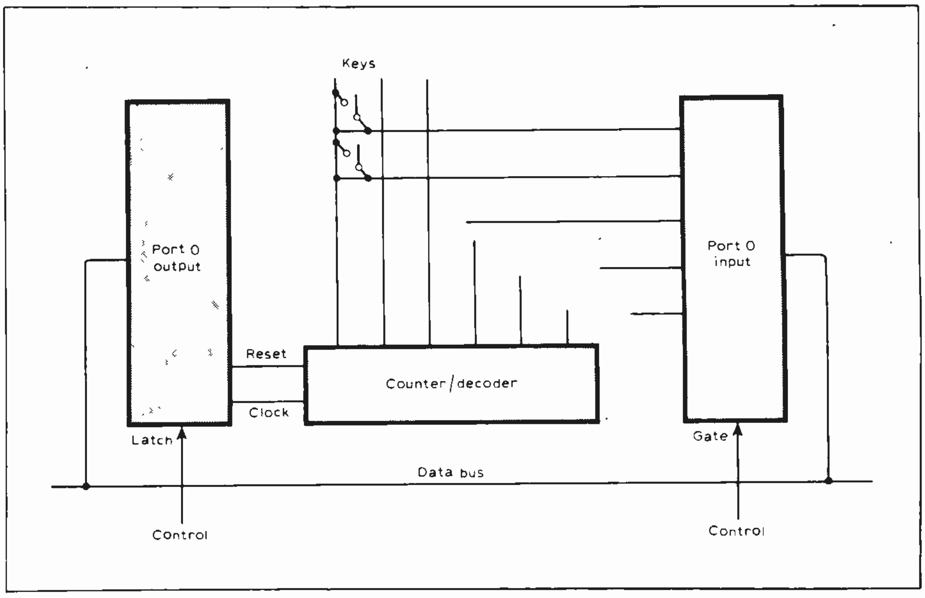



**Fig. 2.** *Simplified diagram showing essentials of the keyboard system.*

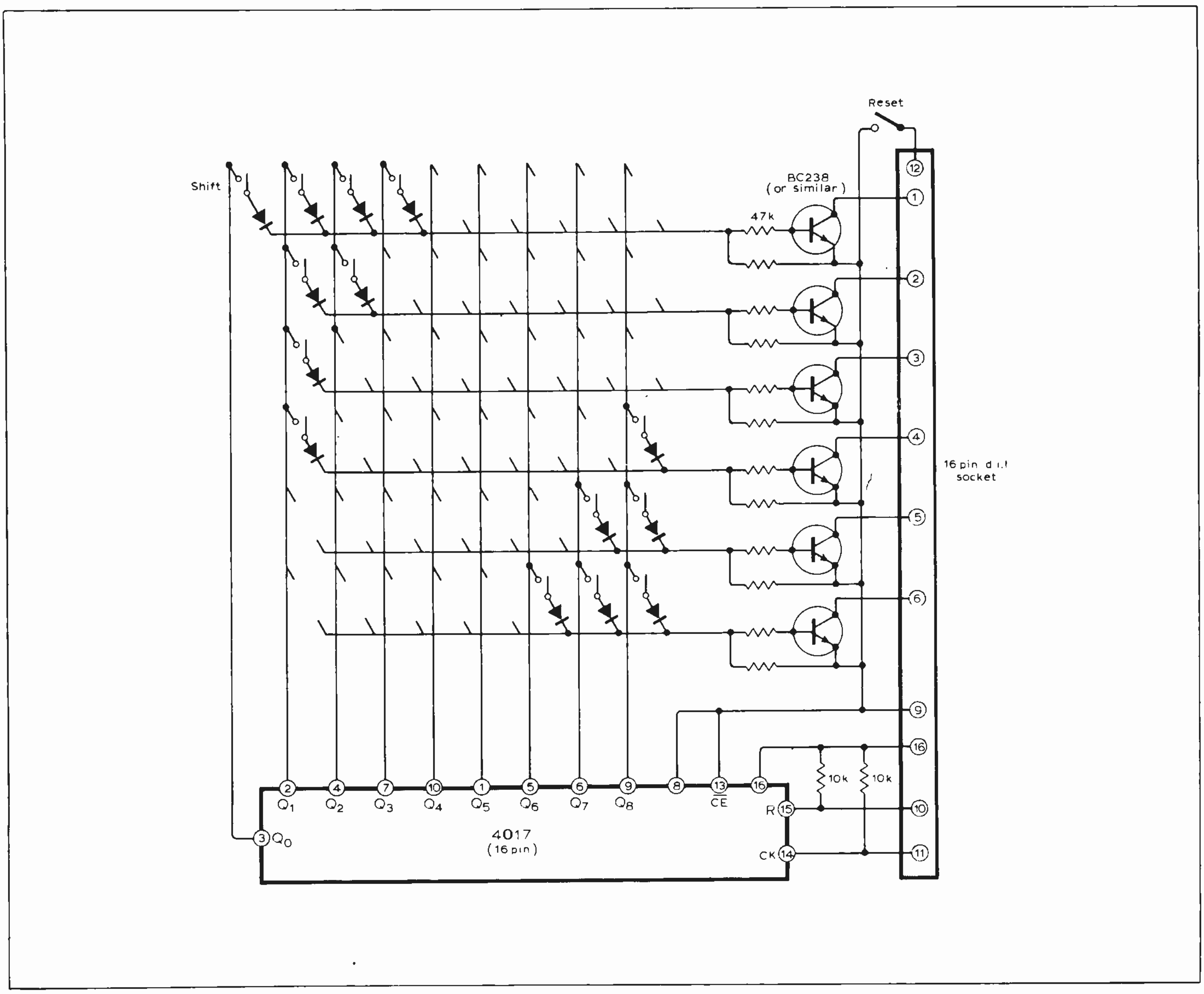



**Fig. 3.** *Circuit diagram of the keyboard and associated electronics.*

user should turn on the tape cassette drive. This can be modified to drive a relay to perform the drive start automatically.

$Q_5$: available to user.

## Peripheral 2 — the serial i/o device

Since the data in the computing system is organised in 8-bit parallel form, some method of converting this to serial form on a single wire circuit is extremely useful. The basic requirement is a method for shifting a byte "sideways" into the single wire circuit. Such an operation appears the same from the outside whether performed by shift instructions or by means of a hardware shift register. The availability of suitable shift registers at very low cost and the limitation of software space combined to decide us to use hardware for the parallel to serial conversion. The device chosen is known as universal asynchronous receiver-transmitter (u.a.r.t.). It consists essentially of two shift registers, one to transmit and the other to receive; thus transmission and reception can take place simultaneously. To the processor the device is made to appear as two ports $P_1$ and $P_2$ (see Fig. 1). Data for transmission is fed to port 1. Similarly, received data is made available by taking it from port 1. Port 2 has no output significance but an input command causes "u.a.r.t. status" to be transferred to the data bus. The main signals of the status word are:

(1) bit 7 signifies that data has been received and can be obtained from port 1.

(2) bit 6 signifies that the transmitter is free to be loaded with data on port 1.

Other bits are connected to the data bus to indicate faulty reception if needed by the software.

Details of the u.a.r.t. circuits will be given in the next article, but the following remarks may be helpful at this stage. The rate at which data is shifted is determined by applying a clock signal to the receiver and transmitter clock inputs. The source of this clock signal can be one of three generators. There is a divider chain operating from a crystal oscillator elsewhere in the system, and a 5kHz clock signal is taken from this chain for operating the u.a.r.t. at 312.5 bits per second. Since a stop bit and a start bit are added to the byte there are 10 bits in each word transmitted. (By applying +5V to a pin on the device this can be increased to 11 bits by adding another stop bit.) Note that the baud rate is 8 × 31.25 whereas the bit rate is 312.5 bit/s. Since a baud is a bit/s of information, the start and stop bits should not be included. Thus the transmission rate is 31.25 bytes per second using this clock. The second clock source is a simple oscillator using the 555 integrated circuit which can be adjusted to operate at 1760Hz, and this, when two stop bits are sent, puts the data in a format suitable for use with teleprinters. The third clock source is simply any external clock the user may care to apply.

### Serial data signal conditioning

There are basically two types of external device which will be connected to the serial i/o system. These are audio cassette recorders on the one hand and conventional teleprinters or v.d.us or serial data inputs to other computers on the other. For cassette recorders, a modulated tone is required. This is obtained by gating the 5kHz clock signal with the serial data, and the result can be attenuated if necessary by the user to suit his audio cassette recorder. The playback signal from such a recorder is a series of tone bursts corresponding to the serial data stream. A tone detector circuit is made up from an integrated circuit and associated components to recover conventional logic levels from the tone signal. The serial input to the u.a.r.t. may not be derived from two sources and so the input must be linked to the data source chosen by the user. Conventional serial devices use one of two conventions for data transmission, either RS232 or 20mA current loop. Both these are provided by discrete components and can be taken via a socket. The output is available in all three forms, RS232, 20mA loop and tone, simultaneously but the input may occur on only one.

## Peripheral 3 — parallel i/o

The parallel input/output (p.i.o. in Fig. 1) is an l.s.i. package, type MK3881 from the Z80 set of microcomputer components. The p.i.o. has its registers' addresses defined by hardware selection logic but its function is programmable. The device interfaces the Z80 c.p.u. to the user's circuits by providing 16 lines, which may be either input or output, together with additional "handshake" signals. The p.i.o. has interrupt logic to deviate programme execution on a change of external logic state if required □

*Part 4 of this series will describe the remainder of the microcomputer system. The microcomputer kit, NASCOM 1, is available from Lynx Electronics (London) Ltd., 92 Broad Street, Chesham, Bucks (tel: Chesham (02405) 75154).*

## Microcomputer show

*Wireless World* is one of the sponsors of Microsystems '78, a seminar and exhibition on microcomputers and other small digital systems to be held at the West Central Hotel, London, February 8, 9 and 10. Information from Chris Hipwell, Room 125, Dorset House, Stamford Street, London SE1 9LU. See also advertisements.

*Continued from p. 70*

superimposed. This extra information can be obtained from the fuse manufacturer. With large and expensive installations it is also necessary to take into account the effects of overload, either cyclic of non-repetitive, and the possibility of heavy currents from capacitors.

For small equipment such as radio receivers and amplifiers, miniature fuses are used. A most popular type for many years was the 1¼ × ¼in to BS:2950. These can be obtained with current ratings from 50mA up to 25A. The corresponding voltage rating is reduced from 1000V. for the lowest currents to 32V at the highest currents. The fuses are colour coded and are available in quick blowing types with a maximum voltage of 250V. Recently, the 20 × 5.2mm fuse to BS:4265 and IEC 127 has been more extensively used with current ratings from 32mA to 6.3A. With miniature quick acting fuses the element is a very fine wire and tends to have relatively high arc voltages on operation. This depends on the resistance and reactance in the circuit and the instant when the fault occurs. A number of tests made on 200mA fuses with random point-of-wave switching on a 240V circuit showed that in one case a peak arcing voltage of 350V occurred. A diode in this circuit would therefore require a maximum repetitive peak reverse voltage of 400V.

**Fuses to BS:4265** can be obtained with a wide range of operating speeds which are marked on the fuse link; FF is very quick acting, F is quick acting, M is medium time lag, T is time lag, and TT is long time lag. Various methods are used to meet the range of speeds, including the use of different materials such as silver, copper, nickel-chrome alloy or the use of two metals. Anti-surge fuses are available which withstand surges of $10I_n$ for up to 20ms. In this type the element often consists of two parts, one of which is a small spring soldered to a thin wire. Eutectic solder may be used to connect the element to the end cap and a low melting point alloy may be used for the junction.

The M effect, first described by Metacalf, is often used with medium time lag fuses. In a very precise machine operation, a small blob of solder about 2½ times the diameter of the element wire is placed on the element. The melting point of the alloy is very much lower than the wire and results in a longer operating time and a lower fusing factor.

**Acknowledgement.** The author wishes to thank Mr. P. G. Newbery of Brush Fusegear Limited for his assistance. □

# World of Amateur Radio

## The 50-million QSL man

FOR many years one of the best known addresses in the world of amateur radio has been "G2MI, Bromley, Kent". For in 1939, Arthur Milne, G2MI, took over operation of the RSGB QSL Bureau, probably the oldest, biggest and most efficient of all the bulk-handling QSL bureaux. It was formed in 1925 by Cecil Jamblin, G6BT, and operated during 1930-39 from the Society's offices at 53 Victoria Street, London, with Douglas Chisholm, G2CX, as QSL manager until the offices were closed on the outbreak of war in September 1939.

Evacuated with Post Office engineering departments to Harrogate, Arthur Milne looked after the continuing inflow of cards for pre-war contacts until security regulations brought overseas postcards under a wartime ban. But in 1946 with the restoration of amateur licences the two-way flood of QSL cards began to arrive in Bromley at something like 30,000 a week, about 1.5-million a year.

Now, some 50-million cards later, Arthur Milne and his wife Lucy Milne have handed over the running of the bureau to one of his team of sub-managers: E. G. Allen, G3DRN.

Arthur Milne has been a life-long amateur enthusiast: he held one of the old "artificial aerial" licences at the age of 15; G2MI (originally issued to McMichael Ltd at their Kilburn factory) followed in 1924 when he was 17. Now at 70 years of age he is standing aside from QSL cards but still remains the GB2RS newsreader for the south-east of England on 3650kHz on Sunday mornings where he seems all set to establish another record: he will soon read his 1000th weekly bulletin.

## In the air

"TOP BAND" (1.8MHz) users are expecting to receive a welcome New Year present in the closing down at the end of this year of the Loran A pulse stations in the UK, Iceland, Norway and Greenland that since 1946 have made it virtually impossible to use frequencies around 1900kHz after dark. During October a number of UK to New Zealand contacts were made on this band.

Test flights of the AMSAT/JAMSAT 144 to 435MHz transponder were due to be made on December 3 from an aircraft piloted by Booth Hartley, N6BH, over Southern California. This transponder is due to be launched (possibly on February 17, 1978) on the Amsat-Oscar D satellite which will become Oscar 8 if successfully orbited. This is the fourth time an amateur satellite transponder has been carried on test flights during which amateurs can use the transponder in a similar manner to when it is in orbit.

Apropos the "power game" notes (December 1977 issue), I wonder how many amateurs are aware that the Home Office still issues to some British amateurs special permits allowing the use of 1kW (d.c. input) power for such purposes as meteor scatter and moonbounce? It is a licence facility that receives little publicity!

The Raynet emergency communications and civil community services system organised by the RSGB now includes over 70 groups representing some 1800 members. A significant increase in activity during 1977 is attributed to the inclusion, in the current amateur licence, of county emergency planning officers among those who can officially call on Raynet for help.

The American FCC now appears to have abandoned industry proposals for a Class E Citizens' Band licence which would have operated within the 220MHz Region 2 amateur band. In Australia, however, amateurs have lost the use of 26.96 to 27.23 MHz with the introduction there of authorised CB operation on 18 channels (10kHz) between 27.015 and 27.225MHz with maximum transmitter output power of 4 watts (a.m.) or 12 watts p.e.p. (s.s.b.). However, the Australian authorities have stated that CB will operate exclusively on u.h.f. from June 1982.

## Hundred-up for CQ-TV

A SPECIAL 40-page edition of *CQ-TV* (journal of the British Amateur Television Club) marking its 100th issue includes a reminicent note by Mike Barlow (former G3CVO) who produced the first issue on the guardroom typewriter at Catterick Camp, while doing "National Service" in 1948. He recalls the early work of Ivan Howard, G2DUS, whose 5527 iconoscope camera gave many their first glimpse of amateur television; the first BATC convention in 1951, the year when 70-cm amateur tv was first authorised; the reorganisation of the club in 1952 when Grant Dixon, G8CGK, became its first Chairman; the first 3-mile amateur tv contact by G5ZT and G3BLV in 1952; cctv colour pictures by Grant Dixon in 1953; the first two-way colour contact between himself and Ralph Royle, G2WJ using G8CGK's equipment in April 1956.

Norrie Macdonald, GM4BVU, also reports his experiences with the working display of 30-line mechanical tv at the Baird Jubilee exhibition of the University of Strathclyde. The mechanically produced pictures were displayed electronically on a modern Baird receiver and one of the few items of equipment on which the old problem of 30-line "syncs" could be successfully overcome was a modern video cartridge machine. Pictures were crude but recognisable as a reproduction of the pictures indicates.

The Australian Post Office has granted the first Australian licence to operate an unattended amateur tv repeater station (VK5RTV) serving Adelaide. Since the output frequencies on the Australian 50cm amateur band fall within the international television allocation (Band IV) the public will be able to see the transmissions without any modification to System G receivers (426.25MHz vision carrier, 431.75MHz f.m. sound).

## In brief

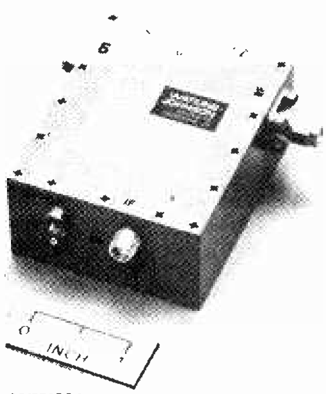
DAVID EVANS, G3OUF, a pilot with British Airways, is to become general manager of the RSGB from January 1, 1978 in succession to George Jessop, G6JP who will remain at Doughty Street until the middle of the year . . . No further distinctive prefixes for a number of US islands in the Pacific and Caribbean will be issued although existing stations will continue to use KM6, KP6, KV6, KS6, KJ6 etc. New licences will be either KH6 (Pacific) or KP4 (Caribbean) . . . An amateur tv activity week is scheduled for January 7 to 14, 1978 . . . A number of "pirates" operating in the Manchester area on 144MHz have been traced and a considerable amount of equipment confiscated . . . Mrs Sylvia Margolis (widow of G3NMR and mother of G3UML) who was public relations officer for the RSGB for some years during the 1960s and a regular broadcaster on national and local radio died recently . . . Eric Mollart of the Mid-Thames group was winner of the national final of the annual 1.8MHz direction finding contests, successfully locating three hidden stations in about 2½ hours . . . Arthur C. Gee, G2UK, is to co-ordinate the facsimile activities of members of the British Amateur Radio Teleprinter Group. British amateurs are now permitted to transmit facsimile signals in the 7, 14, 21, 28 and 144 MHz bands.

**PAT HAWKER, G3VA**

# NEW PRODUCTS

## Mixer-preamplifier

The C62-1 mixer-preamplifier has been specifically designed for use in the satellite communications band. It has a gain ripple of less than 0.1dB and its gain variation over its entire frequency range is typically less than 0.5dB. Due to the low v.s.w.r. on the l.o. and i.f. ports (1.25:1) and the r.f. port



WW301

(1.4:1), isolators can be elimated from most applications. The C62-1 has a conversion gain of 18±0.5dB and an overall noise figure from 10 to 10.5dB with +10dBm of l.o. drive power applied. Power requirement is 21mA at −15V. Watkins-Johnson, Shirley Avenue, Windsor, Berkshire SL4 5JU.

**WW301**

## Modular power supply

Power supplies in the 482 series are based on a driven inverter system design. They have facilities for voltage programming, current and voltage limiting and inhibiting. The standard series covers voltages up to 30kV and power levels up to 20W. All of the units are short circuit and flashover protected. Hartley Measurements Limited, Kenward House, Hartley Wintney, Basingstoke, Hampshire.

**WW302**

## Marine products

Five communications and navigation products, launched by International Marine Radio Company, include a direction finding receiver, type DF770, and two transmitters, types IMR 764 and ST1680A. The DF770, which conforms to UK specifications, is designed for on-board merchant vessels and enables ships' positions to be established using navigational beacons. The IMR 764 is a reserve transmitter which meets reserve and medium frequency UK specifications in addition to having the 2182kHz emergency RT distress frequency. Type ST1680A is a main transmitter. The other two products are a shipborne telex system known as Microtor and a modular automatic telephone exchange called the ETX. International Marine Radio Company Limited, Peall Road, Croydon, Surrey.

**WW303**

## Twin rotary wafer switches

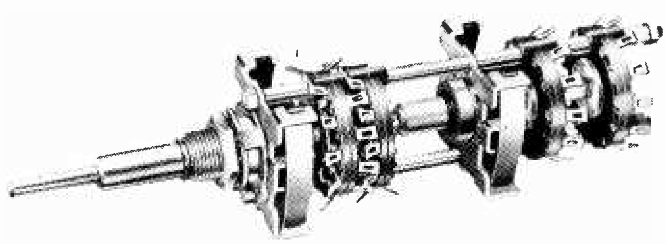
N.S.F. Switches & Controls Ltd have increased their MA moulded wafer range to include models having concentric shafts. These models enable two separate switches or controls with different functions to be accommodated. There are four models having overall wafer dimensions and switch positions as follows: type MM, 34.3mm by 24; type MK, 38.1mm by 12; type ML, 36.6mm by 35; and type MSD, 49.2mm by 12. N.S.F. Limited, Switches and Controls, Keighley, Yorkshire BD21 5EF.

**WW304**

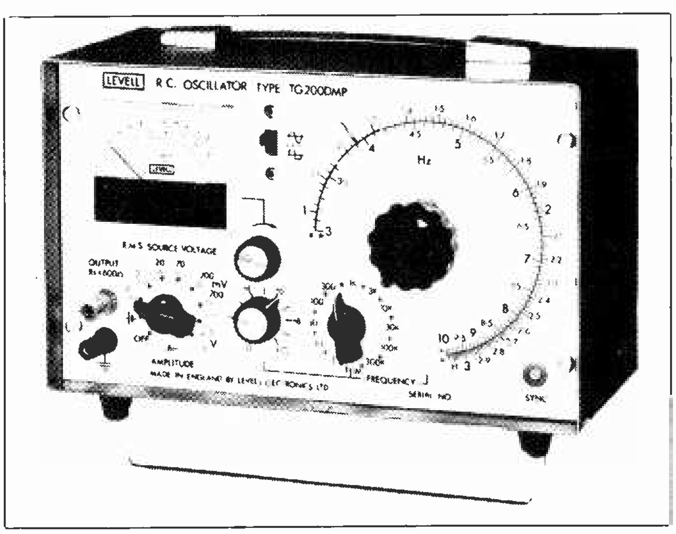
## R.C. oscillators

Improvements have been made to the specifications of the TG200 series of RC oscillators from Levell Electronics Ltd. These include reduced sinewave distortion and improved frequency accuracy. The TG200DMP model has a frequency range from 1Hz to 1MHz in 12 ranges and includes a 0 to 1% fine control. Accuracy is ±1.5%±0.01Hz up to 100kHZ and ±2% up to 1MHz. Sinewave outputs are from 7V r.m.s. down to less than 200μV with a source resistance of 600Ω. Distortion is less than 0.05% from 50Hz to 15kHz, less than 0.1% from 10Hz to 50kHz, less than 0.2% from 5Hz to 150kHz and less than 1% at 1Hz and 1MHz. Levell Electronics Limited, Moxon Street, Barnet, Herts. EN5 5SD.

**WW305**



WW304




WW305

## Slotted optical switches

Optical switches in the series OPB813 to 815 have gallium-arsenide l.e.d.s coupled with n-p-n silicon phototransistors. They are housed in plastic and include an infrared transmitting filter

WW306

ambient light applications and dust protection. Maximum ratings for the diode are: forward current, 50mA; peak forward current, 3A; reverse voltage, 3V; and power dissipation, 100mW. For the output sensor the ratings are: $V_{CE}$ 30V; $V_{EC}$ 5V; $I_C$ 30mA, and power dissipation, 150mW. Minimum on-state collector currents range from 0.5 to 1.8mA and the operating temperature range is −55 to 100°C. Norbain House, Arkwright Road, Reading, Berkshire RG2 0LT.

**WW 306**

## Infrared detectors

Two infrared detectors have been developed specifically for the intruder alarm industry. The PPC 522C has a 2×2mm ceramic pyroelectric detector element with an impedance matching j.f.e.t. preamplifier. A thick metal end cap on a TO5 header ensures that rapid changes in ambient temperature will not give rise to false alarms, and a thick germanium

window excludes radiation below 6.5 micron but gives maximum transmission at 10 microns – the wavelength at which maximum heat radiation is omitted by the human body. The PPC 1821C has a similar specification to the 522C except that the detector element measures 2×1mm and has a TO18 header. The devices have a voltage response of 500V/W and a noise equivalent power of $6\times10^{-9}$ W/$\sqrt{}$Hz. Plessey Optoelectronics and Microwave Unit, Wood Burcote Way, Towcester, Northamptonshire.
**WW 307**

## Audio recording system

A portable two-channel recording system, the CMS2000, from Bell and Howell, when used with a monitor will record audio and

**WW 308**

time code signals simultaneously at 1⅞ in/s. A carrier operated relay (c.o.r.) input allows the recorder to monitor and record data remotely and automatically. Start time from the c.o.r. command is 15ms. Two or more CMS2000 modules can be interconnected to provide continuous and overlapping recording of data while unattended. Bell and Howell, Electronic & Instruments Division, Lennox Road, Basingstoke, Hampshire RG22 4AW.
**WW 308**

## Bit rate generators

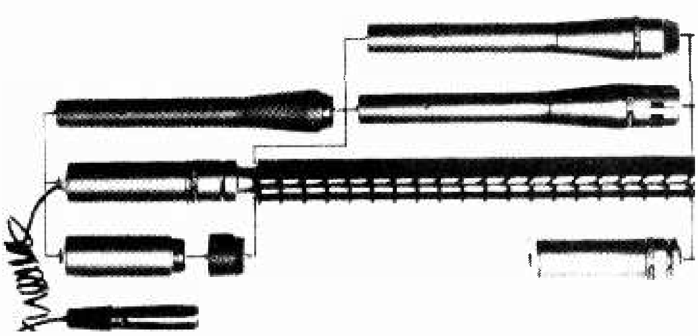
Two programmable, c.m.o.s. bit-rate generators, the HD4702 and the HD6405, operate at 2.4567MHz and dissipate only 4.5 and 4mW respectively. The HE4702 can be programmed to provide any one of 13 commonly used bit rates, and the HD6405 can extend this to 15 selectable rates. The 4702 has on-chip t.t.l. compatible pull-up circuitry and is identical in specification and pin configuration to the 4702 devices. The 6405 has standard high impedance c.m.o.s. inputs. Memec Limited, The Firs, Whitchurch, Nr. Aylesbury, Bucks.
**WW 309**

## Condenser microphone system

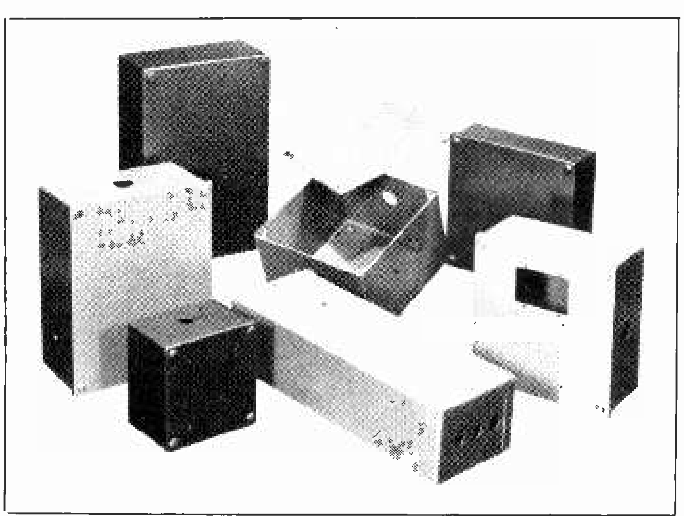
A modular professional microphone system, introduced by Electro-Voice S.A., consists of a number of elements which can be interchanged to fit specific applications. System C, as it is called, includes two preamplifiers, one for handheld applications and one for boom applications. Four interchangeable capsules are available: omnidirectional, cardioid, hypercardioid and a shotgun type registered as Cardeline. Gulton Europe Limited, Electro-Voice Division, Maple Works, Old Shoreham Road, Hove, Sussex BN3 7EY.
**WW 310**

## Digital meter chip

The ADD3701 is a c.m.o.s. i.c. which requires only a display, an external 5V voltage reference and a digital drive to form a 3¾-digit digital voltmeter reading up to 3.999 units. This device adds to National Semiconductor's ADD3501 3½-digit device, for readings up to 1.999, which was introduced earlier this year. The ADD3701, which has automatic polarity and an on-chip clock, includes input protection up to 200V and will drive 0.5 or 0.7in common-cathode l.e.d. displays. Price is £8.72 each for quantities of 100. National Semiconductor Limited, 19 Goldington Road, Bedford MK40 3LF.
**WW 311**



**WW 310**



**WW 312**

## Sheet metal enclosures

A wide range of standard instrument enclosures, from Actu Engineering, can be supplied in various finishes including primer, stove enamal or epoxy resin paint. The enclosures include features such as welded seams, cover seals, conduit "knock-outs" and windows. The company can also produce enclosures to customers' designs. A brochure is available, and Actu will quote for "specials" upon receipt of customers' drawings. Actu Engineering, Vale Road, Hartcliffe Way, Bristol BS3 5RU.
**WW 312**

## Wire strippers

A wire stripping tool, from Eraser International Ltd, is designed to remove film-type insulations from round wires of sizes between 11 and 33 s.w.g. The CF centrifugal wirestripper has three blades which automatically ad-

**WW 313**

just to the wire size. The cutters, which operate at low voltage for safety, are supplied complete with a "variable speed" transformer. Eraser International Limited, 2/3 Hampton Court Parade, East Molesey, Surrey KT8 9HB.
**WW 313**

## Automatic distortion meter

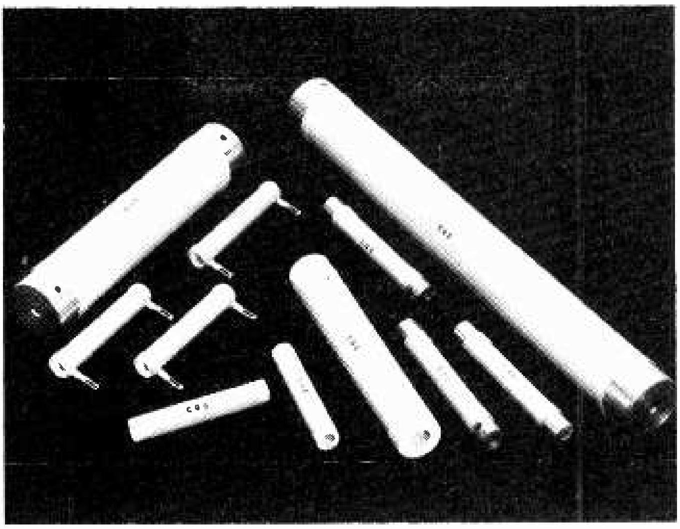
The model DM-155A distortion meter measures distortion to 0.01% (t.h.d.) full scale and has automatic frequency tuning, balance and fine level setting. Residual distortion is claimed to be as low as 0.0018%. The meter, which has nine distortion ranges from 0.01 to 100% full scale, covers the fundamental frequency range from 10Hz to 110kHz and includes terminals for harmonic analysis or for an oscilloscope display. The DM-155A can be used as a 30μV to 300V full-scale a.c. voltmeter having a bandwidth of from 10Hz to 300kHz. Cost is £970 plus v.a.t. Lyons Instruments Limited, Hoddesdon, Herts.
**WW 314**

## Power divider

A four-way, coaxial power divider, from Southern Microwave Laboratories Ltd, covers the full military communications band from 200 to 400MHz. The unit is designed to offer close amplitude and phase tracking characteristics between channels of ±0.1dB and 5 degrees respectively. This performance, coupled with a power handling capacity of 100W c.w., makes the device most suitable for antenna multiplexing. The unit measures 270×127×12mm. Southern Microwave Laboratories Limited, 103 Station Road, Hayling Island, Hants PO11 0EE.
**WW 315**

## High power resistors

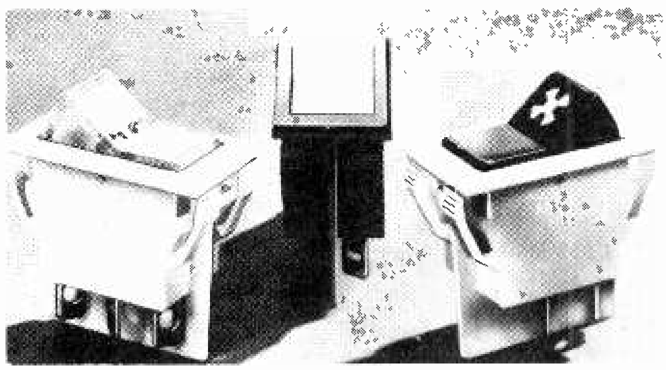
The HVR series comprises high-voltage, high power resistors capable of dissipating 50W in air and 100W when oil cooled. The resistors, which are manufactured using thick film techniques, have a maximum working direct voltage of 125kV. Because of their low residual inductance, they are capable of operating at high frequencies. Three methods of termination are available: radial lugs, plain silver band and tapped brass insert. The CGS Resistance Company Limited, Marsh Lane, Gosport Street, Lymington, Hampshire SO4 9YQ.
**WW 316**



WW 316

## Rocker switches

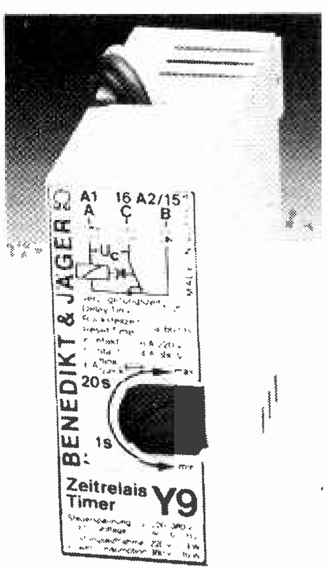
Refinements have been made to the Arrow 92 series of rocker switches. In addition to having smoother outlines and rounded edges, the illuminated versions have serrations inside instead of outside the switch. The illuminated-window versions, which previously had coloured insets, may now use a series of snap-in transparent windows. These windows can have legends printed on them to order, or legends can be written on translucent slides that fit into slots in the windows. The push-on spade terminals have also been improved. Rocker switches in the 92 series are nylon moulded and are rated at 250V, 16A. Arrow-Hart (Europe) Limited, Plymouth Road, Estover, Plymouth PL6 7PN.
**WW 317**



WW 317

## Star-delta timer

An electronic timer called the Y9 has been specifically designed for star-delta motor starter applications. It offers continuously variable timing periods ranging from 0 to 20s and a dwell time of 75ms. The Y9 will operate from any supply in the voltage range 220 to 415V at 40 to 60Hz, without modification. The timer requires only 25 x 67mm of panel space. B & R Relays Limited, Edinburgh Way, Harlow CM20 2DJ.
**WW 318**




WW 318

## Fibre-optic telephone system

A two-station, fibre-optic audio communication system, from Belling & Lee Ltd., comprises two telehone units, two fibre-optic transmitter and receiver modules and an interconnecting duplex light guide assembly. The light guide assembly can be supplied in lengths up to 100m. The system is fitted with a stabilized mains power supply unit but battery operated modules are also available. Belling & Lee Ltd, Great Cambridge Road, Enfield, Middlesex EN1 3RY.
**WW 319**

## Direction finder

A digital device called the DDF300 is claimed by its makers to revolutionize small-boat radio direction finding. The hand-built unit has been designed for ease of operation and is suitable for world-wide use over the frequency range 190 to 500kHz. The frequency of the required station is selected on a keypad, a trigger is squeezed, and then the instrument is rotated for a null on its meter or earphones. On releasing the trigger the built-in non-liquid compass is locked so that the bearing does not have to be read while in use. The automatically tuned receiver is crystal driven and has a digital clock accurate to 2s per week. The unit weighs only 1.2kg. Aptel Marine, A Division of A.P.T. Electronics Limited, Darwin Close, Reading, Berks RG2 0TB.
**WW 320**

WW 320

## Sinewave inverters

The Roband Rosine range of sinewave inverters is designed for h.f. mobile communications, where low radiated and conducted interference are of vital importance. Fully protected units are available with outputs of either 115V/60Hz or 240V/50Hz at 100W (12V, 24V or 28V input) or 300W (24V or 28V input), with power factors down to 0.2 lagging. The units are said to be compact, rugged and proof against humidity, shock and vibration. A military version is also available. Roband Electronics Limited, Charlwood Works, Charlwood, Surrey RH6 0BU.
**WW 321**

## One-chip processor

At around £1.70 in production quantities, Intel's 8021 microprocessor is a single-package system intended for use in domestic machines, test gear, cars and many other control and timing applications. Briefly, it is characterized by an 8-bit word, 64 bytes of r.a.m., 1K programme storage, 21 I/O lines, a programmable event or interval counter to economize on programme space and a built-in clock oscillator. A 5V, fairly rough, supply will power the device. Programmes are in masked r.o.m. for production, but are developed using an e.p.r.o.m. and an emulator. Intel Corporation (UK) Limited, 4 Between Towns Road, Cowley, Oxford OX4 3NB.
**WW 322**

## Reed switches

Reed switches in a range from Astralux are miniature, high reliability devices designed for general electronic switching functions. The switches range in size from 0.07in diameter by 0.47in length to 0.207in diameter by 2.07in length. Switching configurations include single-pole/single-throw, single-pole/double-throw and a magnetically biased changeover switching for latching applications. Astralux Dynamics Limited, Brightlingsea, Colchester, Essex CO7 0SW.
**WW 323**

## P.c.b. fault finder

The 2220 Bug Hound is claimed to simplify the process of locating a shot, open, bad i.c., or other faults found on p.c.bs. A current-tracing probe on the Bug Hound enables the operator to stay on the correct track when tracing a fault, even in areas where several tracks run close together. The fault finder also has a microvoltmeter with two single point probes, a 10mA current source, and a joint (conductivity) tester. Genrad Limited, Bourne End, Bucks.
**WW 324**

WW 324

# SIDEBANDS by Mixer

## Help!

NORMALLY, the people in this office are easy-going, lovable, generous to a fault and kind to animals. We just get on with producing *Wireless World* every month, in the best way we know how, parrying telephone calls with absent-minded ease. But about once a month, our newest arrival on the staff, who is not one to mince his words, turns a rather attractive shade of puce and announces his imminent resignation.

It rather looks as though we must have been helpful to someone, somewhere, sometime, because when anyone, anywhere, anytime can't remember what Rank's 'phone number is, or who handles some foreign company in the UK, they ring us. Now, flattered as we are that people with problems should turn to us in their hour of need, we feel impelled to point out that a large number of the questions we have to deal with could be answered by the questioner himself, quite easily, by reference to the telephone directory.

The most recent offer of resignation from my apoplectic colleague was caused by his being asked just such a question while he was at a critical stage in the preparation of an article. It was not possible to answer immediately so he promised to ring back later. He found the answer (from Directory Enquiries) and rang back — twice — with no success, except in attracting a certain amount of coolness from the enquirer's secretary. When contact was finally made, the chap said: "Oh, thanks — I just wanted to know for interest."

We do like to help when we can, but we don't run a free information service. We have a journal to produce and if interrupted too often tend, like anyone else, to make mistakes. Besides, the next time he says he's going to leave, he might mean it.

## Status quo?

THE Irishman with both legs in one trouser leg discovered the effect, quite by chance. It had been a bit of a night and Seamus had this problem with his trousers, which he discovered was eased if he took one leg out and put it in the other half trouser. So he thought that, as moving one leg had helped, moving both would be even better, and he finished up back in Square One.

What I hadn't realised is that a close relative of the above philosopher is actively engaged in the recording industry. A recent record sleeve from America bears the following exhortation:

"Audiophile Note: For optimum transient response and spatial clarity we recommend that the polarity of BOTH channels be reversed at the speaker terminals (+ output terminal on power amplifier to — terminal on speaker and vice-versa), however this procedure is not necessary for perfectly satisfactory playback."

My colleagues in the office and the correspondent who told us about it are all at a loss to explain what Sheffield (for it is no other) mean by it. The only halfway reasonable explanation is that somehow the polarities became mixed up in the recording process so when the drum goes bang the speakers suck instead of blowing.

## Come the revolution

LIFE was so much easier to cope with a million years ago. At least, I suppose it was. Try not to upset the local dinosaur and keep a wary eye on the beetle-browed lot in the next suite of caves and life must have been one long riot. No tax inspectors, no 'Crossroads,' no commuting through the rush hour and nobody any brighter than anybody else. They can't have been, or how come the man who invented the wheel never got round to tyres?

Well, it's different now, and you've only to look at one of the new rash of microcomputer magazines to have that suspicion confirmed. The articles are fairly obviously written by beings who knowwhat's what in computing;it's just that no-one ever gets to the point of actually saying what it's all for. I've looked, in a cursory way, at dozens of articles on programming microprocessors and microcomputers and am consistently left with the feeling that it's all a huge, expensive joke.

Well, honestly! You read a six-page article on some devilishly ingenious programme, honed to the last instruction for economy of memory and execution time, and what does it do? — wait for it — it plays 'On Ilkla Moor B'aht 'at'! This is actually a major leap forward, because not only does it do *something*, it also means that I've understood the article. For I have to admit that most of these articles appear to display a pretty precarious hold on reality. Information on connecting this to that, pressing buttons A and B or what the programme is supposed to do is considered to be too trivial to mention – a supposition which must help a lot to exclude undesirables.

But take heed, I intend to break down the first law of computing — the Law of Comprehensive Incomprehensibility. I have been presented with a microcomputer kit, and when I find out what all the bits are and recovered from the fact that nowhere in the kit is there a piece of paper to tell me what to do with the wretched thing when I've glued the bits together, I shall arrive on the microcomputer scene like an avenging angel. All will be explained to fellow-sufferers from the effects of the First Law, and chaps in cloth caps will come into their own.

## Dog watch

THOSE among you who have demonstrated their supreme good taste by reading this page regularly will have realized by now that press handouts (releases, in the pidgin) hold a good deal of fascination for me. It's mainly the language in which they are written, but the complete denial of the existence of competitors and the claims for ultimate truth and beauty can raise these communications almost to the level of an art form. They sometimes put me in mind of a Coldstream guardsman I used to know – long, elaborate and full of wind.

In the general welter of handouts that pour in every day, we don't often get the chance to savour the full delights of each separate one. Some have all the punch and attack of an underdone beefburger and others hit you between the eyes immediately. But one came in today that I consider leaves most of the others standing. It was sent to us by a firm offering digital watches, although, after reading it, one feels that the writer might be more profitably employed in re-writing the works of Rossetti in more poetic vein.

There are two pages of it and nowhere in the whole piece does it say anything about the performance of, or facilities offered by the watches. It goes on at length about the case styling and the lengths to which the company went to obtain the 'perfect' watch. It is given the name of a medal, and much of the handout is taken up with a description of the medal and its most famous recipient. And, after all this, it turns out that the watches are not made by the firm at all – the electronics are Japanese and the case is Swiss.

Still, we are assured that "each second is divided into 32,768 parts" to achieve the highest possible accuracy. And they say this is worth saying again and they go right ahead and do just that. I don't really understand for whom this handout is written. It can't be for anyone who understands electronics and I would think most jewellers and watchmakers would find it fairly ill-judged. Perhaps the writer thought it would make us read it and mention it just because it is so utterly idiotic. If so, he's succeeded, but I'm not going to advertise his watches for him.

# THE DYNAMIC DUO

The C15/15 is a unique Power Amplifier providing Stereo 15 watts per channel or 30 watts Mono and can be used with any car radio/tape unit. It is simply wired in series with the existing speaker leads and in conjunction with our speakers S15 produces a system of incredible performance.

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The amplifier is sealed into an integral heatsink and is terminated by screw connectors making installation a very easy process.

The S15 has been specially designed for car use and produces performance equal to domestic speakers yet retaining high power handling and compact size.

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15 Watts per channel into 4Ω
Distortion 0.2% at 1KHz at 15 watts
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Input Impedance 8Ω nominal
Input sensitivity 2 volts R.M.S. for 15 watts output
Power line 10 - 18 volts
Open and Short circuit protection
Thermal protection
Size 4 × 4 × 1 inches

C15/15 Price £17.74 + £2.21 VAT P & P free

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4Ω Impedance

S15 Price per pair £17.74 + £2.21 VAT P & P free

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WW—031 FOR FURTHER DETAILS

# Communications 78

**Communications Equipment and Systems**

National Exhibition Centre, Birmingham, England.
Tuesday 4-Friday 7 April 1978

## You are invited to Communications 78

Communications 78 is the world's leading exposition for selling communications equipment and systems, providing an international focal point for the latest technological advances in the fields of PTT telecommunications, fixed and mobile radio communications and defence communications.

## Active backing

Trebled in size since the last event in 1976, Communications 78 is being supported by more than 200 international exhibitors and has the active backing of the International Telecommunication Union (ITU), representing the interests of 153 governments; the British government through the Ministry of Defence, the Home Office and the British Overseas Trade Board; Post Office Telecommunications; the Electronic Engineering Association (EEA) and the Telecommunication Engineering and Manufacturing Association (TEMA).

## Integral conference

The integral conference is being organised by The Institution of Electrical Engineers (IEE) in association with the Institution of Electronic and Radio Engineers (IERE), the UKRI section of the Institute of Electrical and Electronics Engineers (IEEE) and the IEEE Communications Society.

Communications 78 is being held for the first time at the National Exhibition Centre, Birmingham - the UK's premier exhibition complex - from Tuesday 4 April to Friday 7 April 1978. The exhibition will be open daily from 09.30 - 18.00 hrs. (17.00 hrs. on last day).

Admission to the exhibition is free to bona fide users and specifiers of communications equipment and systems. The coupon below may be presented as an admission ticket to Communications 78 or, if you require more detailed information, please complete and send it to: Tony Davies Communications, c/o Industrial and Trade Fairs Ltd., Radcliffe House, Blenheim Court, Solihull, West Midlands B91 2BG, England.

**Please send me details of**

the exposition ☐
the conference ☐

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WW—043 FOR FURTHER DETAILS

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**£100 off this super Hi-Fi system the MATSI TFS60**

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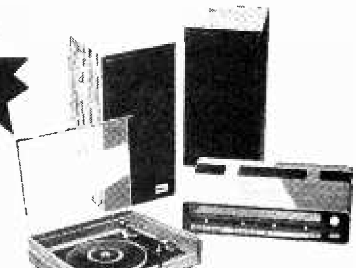
**Lion House**

**BUDGET HI-FI DEPARTMENT**



You can now purchase this fantastic Hi-Fi system complete for only £147.95 at what must be a fraction of it s value today.
System consists of:– the famous MATSI TFS60 Tuner/AMP; a really top quality receiver from one of Japan's leading manufacturers, 15 watts per channel FM/MW/LW, two NAD 6 speakers fitted with AR units and a Goldring belt-drive turntable with magnetic cartridge complete with an attractive plinth & cover of ultra modern design. Leads etc supplied free.

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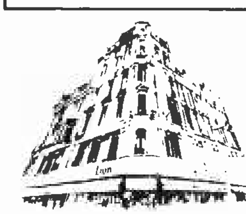

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WW—026 FOR FURTHER DETAILS

# SEMICONDUCTORS - COMPONENTS

## TRIACS

| 2 Amp Volts | TO5 Case No | Price |
|---|---|---|
| 100 | TR12A/100 | £0.31 |
| 200 | TR12A/200 | £0.51 |
| 400 | TR12A/400 | £0.71 |

| 10 Amp. Volts | TO48 Case No | Price |
|---|---|---|
| 100 | TR110A/100 | £0.77 |
| 200 | TR110A/200 | £0.92 |
| 400 | TR110A/400 | £1.12 |

| 6 Amp Volts | TO66 Case No | Price |
|---|---|---|
| 100 | TR16A/100 | £0.51 |
| 200 | TR16A/200 | £0.61 |
| 400 | TR16A/400 | £0.77 |

| 10 Amp Volts | TO220 Case No | Price |
|---|---|---|
| 400 | TR110A/400P | £1.12 |

**DIACS**
BR100 £0.23 D32 £0.23

## SUPER UNTESTED PAKS

| PAK | No. | Order No. | Price |
|---|---|---|---|
| U50 | 100 Germ Gold bonded OA47 diode | 16130 | £0.60 |
| U51 | 150 Germ OA70/81 diode | 16131 | £0.60 |
| U52 | 100 Silicon Diodes 200mA OA200 | 16132 | £0.60 |
| U53 | 150 diodes 75mA 1N4148 | 16133 | £0.60 |
| U54 | 50 Sil Rect Top Hat 750mA | 16134 | £0.60 |
| U55 | 20 Sil Rect Stud Type 3 Amp | 16135 | £0.60 |
| U56 | 50 400mW Zeners DO7 Case | 16136 | £0.60 |
| U57 | 30 NPN Trans BC107 8 Plastic | 16137 | £0.60* |
| U58 | 30 PNP Trans BC177/178 Plastic | 16138 | £0.60* |
| U59 | 25 NPN TO39 2N697/2N1711 sil | 16139 | £0.60 |
| U60 | 25 PNP TO59 2N2905 silicon | 16140 | £0.60 |
| U61 | 30 NPN TO18 2N706 silicon | 16141 | £0.60 |
| U62 | 25 NPN BFY50/51 | 16142 | £0.60 |
| U63 | 30 NPN Plastic 2N3906 silicon | 16143 | £0.60* |
| U64 | 30 PNP Plastic 2N3905 silicon | 16144 | £0.60* |
| U65 | 30 Germ 0071 PNP | 16145 | £0.60 |
| U66 | 15 Plastic Power 2N3055 NPN | 16146 | £1.20 |
| U67 | 10 TO3 Metal 2N3055 NPN | 16147 | £1.20 |
| U68 | 20 Unijunction trans TIS43 | 16148 | £0.60 |
| U69 | 10 1 amp SCR TO39 | 16149 | £1.20 |
| U70 | 8 3 amp SCR TO66 case | 16150 | £1.20 |

Code No s mentioned above are given as a guide to the type of device in the pak The devices themselves are normally unmarked

## COMPONENT PACKS

| Pack No. | Qty. | | Order No. | Price |
|---|---|---|---|---|
| C1 | 200 | Resistor mixed value approx (Count by weight) | 16164 | *£0.60 |
| C2 | 150 | Capacitors mixed value approx (Count by weight) | 16165 | *£0.60 |
| C3 | 50 | Precision resistors Mixed values | 16166 | *£0.60 |
| C4 | 80 | ⅛th W Resistors mixed preferred values | 16167 | *£0.60 |
| C5 | 5 | Pieces assorted ferrite rods | 16168 | *£0.60 |
| C6 | 2 | Tuning gangs MW/1W VHF | 16169 | *£0.60 |
| C7 | 1 | Pack wire 50 metres assorted colours single strand | 16170 | £0.60 |
| C8 | 10 | Reed switches | 16171 | *£0.60 |
| C9 | 3 | Micro switches | 16172 | *£0.60 |
| C10 | 15 | Assorted pots | 16173 | *£0.60 |
| C11 | 5 | Metal jack sockets 3 x 3 5mm 2 x standard switch types | 16174 | *£0.60 |
| C12 | 30 | Paper condensers preferred types mixed values | 16175 | *£0.60 |
| C13 | 20 | Electrolytics trans types | 16176 | *£0.60 |
| C14 | 1 | Pack assorted hardware — Nuts bolts grommets etc | 16177 | *£0.60 |
| C15 | 5 | Mains slide switches ass | 16178 | *£0.60 |
| C16 | 20 | Assorted tag strips and panels | 16179 | £0.60 |
| C17 | 15 | Assorted control knobs | 16180 | *£0.60 |
| C18 | 4 | Rotary wave change switches | 16181 | *£0.60 |
| C19 | 2 | Relays 6 — 24V operating | 16182 | *£0.60 |
| C20 | 1 | Pak copper laminate approx 200 sq ins | 16183 | £0.60 |
| C21 | 15 | Assorted fuses 100mA-5 amp | 16184 | £0.60 |
| C22 | 50 | Metres PVC sleeving assorted size and colour | 16185 | £0.60 |
| C23 | 60 | ½ watt resistors mixed preferred values | 16188 | *£0.60 |
| C24 | 25 | Presets assorted type and value | 16186 | *£0.60 |
| C25 | 30 | Metres stranded wire assorted colours | 16187 | £0.60 |

## SLIDER PAKS

| Pack No. | Qty. | | Order No. | Price |
|---|---|---|---|---|
| S1 | 6 | Slider potentiometers mixed values | 16190 | *£0.60 |
| S2 | 6 | Slider potentiometers all 470 ohms | 16191 | *£0.60 |
| S3 | 6 | Slider potentiometers all 10k lin | 16192 | *£0.60 |
| S4 | 6 | Slider potentiometers all 22k lin | 16193 | *£0.60 |
| S5 | 6 | Slider potentiometers all 47k lin | 16194 | *£0.60 |
| S6 | 6 | Slider potentiometers. all 47k log | 16195 | *£0.60 |

## CERAMIC PAKS

Containing a range of first quality miniature ceramic capacitors Unrepeatable value

| | | Order No. | Price |
|---|---|---|---|
| MC1 | 24 miniature ceramic capacitors 3 of each value — 22pf 27pf 33pf 39pf 47pf 68pf 82pf | 16160 | *£0.60 |
| MC2 | 24 miniature ceramic capacitors 3 of each value — 100pf 120pf 150pf 180pf 220pf 330pf & 390pf 270pf | 16161 | *£0.60 |
| MC3 | 24 miniature ceramic capacitors 3 of each value — 470pf 560pf 680pf 820pf 1000pf 1500pf 2200pf & 3300pf | 16162 | *£0.60 |
| MC4 | 24 miniature ceramic capacitors 3 of each value — 470pf 560pf 680pf 820pf 1000pf 1500pf 2200pf & 3300pf | 16163 | *£0.60 |

## ORDERING

Please word your orders exactly as printed not forgetting to include our part number

## V.A.T.

Add 12½% to prices marked* Add 8% to others excepting those marked † these are Zero

## CARBON POTENTIOMETERS

**SINGLE GANG** with wire end terminations 6mm x 50mm plastic shaft 10mm bushes supplied with shake proof washer and nut Tolerance ±20 of resistance

| LINEAR TRACK Value | No. | Price | LOG TRACK Value | No. | Price |
|---|---|---|---|---|---|
| 1K | 1831 | *£0.22 | 4K7 | 1842 | *£0.22 |
| 2K2 | 1832 | *£0.22 | 10K | 1843 | *£0.22 |
| 4K7 | 1833 | *£0.22 | 22K | 1844 | *£0.22 |
| 10K | 1834 | *£0.22 | 47K | 1845 | *£0.22 |
| 22K | 1835 | *£0.22 | 100K | 1846 | *£0.22 |
| 47K | 1836 | *£0.22 | 220K | 1847 | *£0.22 |
| 100K | 1837 | *£0.22 | 470K | 1848 | *£0.22 |
| 220K | 1838 | *£0.22 | 1M | 1849 | *£0.22 |
| 470K | 1839 | *£0.22 | 2M2 | 1850 | *£0.22 |
| 1M | 1840 | *£0.22 | | | |
| 2M2 | 1841 | *£0.22 | | | |

**DUAL GANG** These high-quality pots are fitted with wire end terminations 6mm x 50mm plastic shaft 10mm bushes supplied with shakeproof washer and nut Track tolerance ±20 but matched to within 2dB of each other

| LINEAR TRACK Value | No. | Price | LOG TRACK Value | No. | Price |
|---|---|---|---|---|---|
| 4K7 | 1851 | *£0.68 | 4K7 | 1860 | *£0.68 |
| 10K | 1852 | *£0.68 | 10K | 1861 | *£0.68 |
| 22K | 1853 | *£0.68 | 22K | 1862 | *£0.68 |
| 47K | 1854 | *£0.68 | 47K | 1863 | *£0.68 |
| 100K | 1855 | *£0.68 | 100K | 1864 | *£0.68 |
| 220K | 1856 | *£0.68 | 220K | 1865 | *£0.68 |
| 470K | 1857 | *£0.68 | 470K | 1866 | *£0.68 |
| 1M | 1858 | *£0.68 | 1M | 1867 | *£0.68 |
| 2M2 | 1859 | *£0.68 | 2M2 | 1868 | *£0.68 |

**SINGLE GANG SWITCHED** Fitted with double pole on-off switches The switch action is incorporated within the rotary action of the pot Switch rating 1 5 amps at 250V AC

| LINEAR TRACK Value | No. | Price | LOG TRACK Value | No. | Price |
|---|---|---|---|---|---|
| 4K7 | 1870 | *£0.48 | 4K7 | 1879 | *£0.48 |
| 10K | 1871 | *£0.48 | 10K | 1880 | *£0.48 |
| 22K | 1872 | *£0.48 | 22K | 1881 | *£0.48 |
| 47K | 1873 | *£0.48 | 47K | 1882 | *£0.48 |
| 100K | 1874 | *£0.48 | 100K | 1883 | *£0.48 |
| 220K | 1875 | *£0.48 | 220K | 1884 | *£0.48 |
| 470K | 1876 | *£0.48 | 470K | 1885 | *£0.48 |
| 1M | 1877 | *£0.48 | 1M | 1886 | *£0.48 |
| 2M2 | 1878 | *£0.48 | 2M2 | 1887 | *£0.48 |

## VEROBOARDS

### DRILLED COPPER P.C.B.

| .1 Pitch Size | No. | Price | .15 Pitch Size | No. | Price |
|---|---|---|---|---|---|
| 2 5" x 5" | 2201 | £0.46 | 2 5" x 17" | 2209 | £1.13 |
| 2 5" x 3 75" | 2202 | £0.39 | 2 5" x 5" | 2210 | £0.42 |
| 2 5" x 17" | 2203 | £1.42 | 2 5" x 3 75" | 2211 | £0.31 |
| 3 75" x 5" | 2204 | £0.52 | 3 75" x 17" | 2212 | £1.51 |
| 3 75" x 3 75" | 2205 | £0.46 | 3 75" x 5" | 2213 | £0.57 |
| 3 75" x 17" | 2206 | £1.82 | 3 75" x 3 75" | 2214 | £0.42 |
| 4 75" x 17 9" | 2207 | £2.34 | 2 5" x 1" (pack of five) | 2216 | £0.52 |
| 2 5" x 1" (pack of five) | 2208 | £0.57 | | | |

### DRILLED PLAIN P.C.B.

| .1 Pitch Size | No. | Price | .15 Pitch Size | No. | Price |
|---|---|---|---|---|---|
| 3 75" x 17" | 2217 | £1.18 | 2 5" x 17" | 2221 | £0.78 |
| 3 75" x 2 5" | 2218 | £0.26 | 3 75" x 17" | 2222 | £1.00 |
| 5" x 3 75" | 2219 | £0.42 | 2 5" x 5" | 2223 | £0.26 |
| | | | 2 5" x 3 75" | 2224 | £0.21 |
| | | | 5" x 3 75" | 2225 | £0.36 |

**VERO SPOT-FACE CUTTER**
Order No 2231 **Price £0.68**

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***Purchase books to the value of £5.00 from the list below and choose any 60p pak from this page FREE.***

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| BP3 | Handbook of Tested Transistor Circuits | 40p |
| BP6 | Engineers and Machinists Reference Tables | 40p |
| BP7 | Radio & Electronic Colour Codes and Data Chart | 15p |
| BP10 | Modern Crystal and Transistor Set Circuits for Beginners | 35p |
| BP14 | Second Book of Transistor Equivalents | 95p |
| BP15 | Constructors Manual of Electronic Circuits for the Home | 50p |
| BP16 | Handbook of Electronic Circuits for the Amateur Photographer | 60p |
| BP18 | Boys and Beginners Book of Practical Radio & Electronics | 60p |
| BP22 | 79 Electronic Novelty Circuits | 75p |
| BP23 | First Book of Practical Electronic Projects | 75p |
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| 224 | 50 CMOS IC Projects | 95p |
| 225 | A Practical Introduction to Digital IC s | 95p |
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| RCC | Resistor Colour Code Disc Calculator | 10p |

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## LINEAR PAKS

Manufacturer s Fall Outs which include Functional and part Functional Units These are classed as out-of-spec from the maker s very rigid specifications but are ideal for learning about I C s and experimental work

**U721 30 ASSORTED LINEAR TYPES**
709-741-747 748-710-588 Etc
ORDER No 16227 Price *£1.50

**U76SD FM STEREO DECODER**
5 I C s 76110 Eqv to MC1310P-MA767 Data supplied with pak
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**U76A AUDIO POWER OUTPUT AMPLIFIERS**
8 Assorted types SL403 76013 76003 Etc Data supplied with pak
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## 74 SERIES PAKS

Manufacturer s Fall Outs which include Functional and part-Functional Units These are classed as out-of-spec from the maker s very rigid specifications but are ideal for learning about I C s and experimental work

**74G** 100 Gates assorted 7400-01-04-10-50-60 etc Order No 16224 £1.20

**74F** 50 Flip-Flops assorted 7470-72 73-74-76-104-109 Etc Order No 16225 £1.20

**74M** 30 MSI Assorted Types 7441 47-90-154 Etc Order No 16226 £1.20

## VEROBOARD PAKS

VB1 Approx 30 sq ins various sizes all 1" matrix Order No 16199 £0.60

VB2 Approx 30 sq ins various sizes 15" matrix Order No 16200 £0.60

## ELECTROLYTIC PAKS

A range of paks each containing 18 first quality mixed value miniature electrolytics

**EC1** Values from 47mFD to 10mFD Order No 16201 *£0.60

**EC2** Values from 10mFD to 110mFD Order No 16202 *£0.60

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## C280 CAPACITOR PAK

75 Mullard C280 capacitors mixed values ranging from 01uF to 2 2uF complete with identification sheet Order No 16204 *£1.20

## CARBON RESISTOR PAKS

These paks contain a range of Carbon Resistors assorted into the following groups

| | | | | Order No | Price |
|---|---|---|---|---|---|
| R1 | 60 mixed | ⅛w | 100ohms 820ohms | 16213 | *£0.60 |
| R2 | 60 mixed | ⅛w | 1Kohms 8 2Kohms | 16214 | *£0.60 |
| R3 | 60 mixed | ⅛w | 10Kohms-82Kohms | 16215 | *£0.60 |
| R4 | 60 mixed | ⅛w | 100Kohms-820Kohms | 16216 | *£0.60 |
| R5 | 40 mixed | ½w | 100ohms 820ohms | 16217 | *£0.60 |
| R6 | 40 mixed | ½w | 1Kohms 8 2Kohms | 16218 | *£0.60 |
| R7 | 40 mixed | ½w | 10Kohms 82Kohms | 16219 | *£0.60 |
| R8 | 40 mixed | ½w | 100Kohms 820Kohms | 16220 | *£0.60 |
| R9 | 60 mixed | ⅛w | 1 Meg 10Megohms | 16230 | *£0.60 |
| R10 | 40 mixed | ½w | 1 Meg-10Megohms | 16231 | *£0.60 |

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### JUMBO SEMICONDUCTOR PACK

Transistors - Germ and Silicon Rectifiers Diodes Triacs Thyristors I C s and Zeners ALL NEW AND CODED Approx 100 Pieces Offering the amateur a fantastic bargain PAK and an enormous saving Identification and data sheet in every pak

ORDER NO 16222 **£2.25**

**P&P.**

Postage and Packing add 25p unless otherwise shown Add extra for airmail Minimum order £1 00

# BI-PAK

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**SHOP AT** 18 BALDOCK ST., WARE, HERTS
OPEN 9 to 5 30 Mon.-Sat.

# BI-PAK

**High quality modules for stereo, mono and other audio equipment.**

NEW

## PUSH-BUTTON STEREO FM TUNER

OUR PRICE ONLY **£20.45**

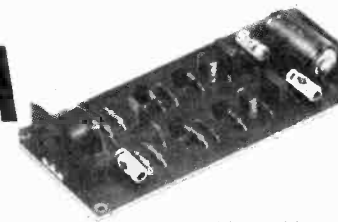
**Fitted with Phase Lock-loop Decoder**

The 450 Tuner provides instant program selection at the touch of a button ensuring accurate tuning of 4 pre-selected stations, any of which may be altered as often as you choose, by simply changing the settings of the pre-set controls.
Used with your existing audio equipment or with the BI-KITS **STEREO 30** or the **MK60** Kit etc. Alternatively the **PS12** can be used if no suitable supply is available, together with the Transformer **T538**.
The S450 is supplied fully built, tested and aligned. The unit is easily installed using the simple instructions supplied.

- ★ FET Input Stage
- ★ VARI-CAP diode tuning
- ★ Switched AFC
- ★ Multi turn pre-sets
- ★ LED Stereo Indicator

**Typical Specification:**
***Sensitivity 3μ volts***
***Stereo separation 30db***
***Supply required 20-30v at 90 Ma max.***

## MPA 30



Enjoy the quality of a magnetic cartridge with your existing ceramic equipment using the new M.P.A. 30, a high quality pre-amplifier enabling magnetic cartridges to be used where facilities exist for the use of ceramic cartridges only.
It is provided with a standard DIN input socket for ease of connection. Full instructions supplied. **£2.85**

## VAT ADD 12½%

## POSTAGE & PACKING

***Postage & Packing add 25p unless otherwise shown. Add extra for airmail. Min. £1.00***

## STEREO PRE-AMPLIFIER

## PA 100

OUR PRICE **£13.75**

A top quality stereo pre-amplifier and tone control unit. The six push-button selector switch provides a choice of inputs together with two really effective filters for high and low frequencies, plus tape output.

Frequency Response + 1dB 20Hz 20KHz Sensitivity of inputs
1 Tape Input 100mV into 100K ohms
2 Radio Tuner 100mV into 100K ohms
3 Magnetic P U 3mV into 50K ohms
P U Input equalises to R1AA curve with 1dB from 20Hz to 20KHz
Supply – 20-35V at 20mA
Dimensions 299mm x 89mm x 35mm

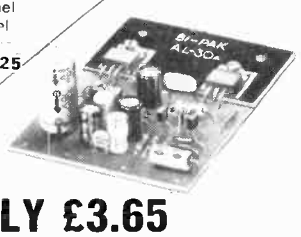
**MK. 60 AUDIO KIT:** Comprising 2 x AL60's. 1 x SPM80. 1 x BTM80. 1 x PA100. 1 front panel and knobs. 1 Kit of parts to include on/off switch, neon indicator, stereo headphone sockets plus instruction booklet. **COMPLETE PRICE £35.00** plus 85p postage

**TEAK 60 AUDIO KIT:** Comprising Teak veneered cabinet size 16¾"x11½"x3¾" other parts include aluminium chassis, heatsink and front panel bracket plus back panel and appropriate sockets. **KIT PRICE £13.25** plus 85p postage

## NEW AL30A

**10w R.M.S. AUDIO AMPLIFIER MODULE**

The AL30A is a high quality audio amplifier module replacing our AL20 & 30. The versatility of its design makes it ideal for record players, tape recorders, stereo amps, cassette and cartridge players. A power supply is available comprising a PS12 together with a transformer T538, also for stereo, the pre-amp PA12.



SPECIFICATION

- Output Power 10w R.M.S.
- Supply 22 to 32 volts.
- Load Impedance 8 to 6ohms.
- Input Impedance 50K.
- Sensitivity 90mv for full output.
- Total Harmonic Distortion Less than .5% (Typically .3%).
- Frequency Response 60Hz to 25KHz – 2db.
- Max. Heat Sink Temp 80 c.
- Dimensions 90 x 64 x 27mm

**ONLY £3.65**

## STEREO 30

**COMPLETE AUDIO CHASSIS**

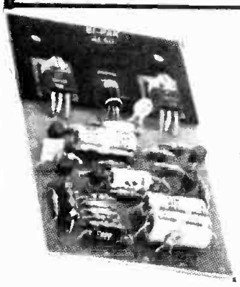
**7+7 WATTS R.M.S.**

*P & P 45p*

**£16.25**

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 pick-up, stereo tuner, stereo tape deck etc. Simple to install, capable of producing really first class results, this unit is supplied with full instructions, black front panel knobs, main switch, fuse and fuse holder and universal mounting brackets enabling it to be installed in a record plinth, cabinets of your own construction or the cabinet available. Ideal for the beginner or the advanced constructor who requires Hi-Fi performance with a minimum of installation difficulty (can be installed in 30 mins).

**TRANSFORMER £3.25** plus 50p p & p
**TEAK CASE £5.45** plus 70p p & p



## AL 60

**25 Watts (RMS)**

**★ Max Heat Sink temp 90C. ★ Frequency response 20Hz to 100KHz ★ Distortion better than 0.1 at 1KHz ★ Supply voltage 15-50v ★ Thermal Feedback ★ Latest Design Improvements ★ Load — 3,4,8, or 16 ohms ★ Signal to noise ratio 80db ★ Overall size 63mm. 105mm. 13mm.**

Especially designed to a strict specification. Only the finest components have been used and the latest solid-state circuitry incorporated in this powerful little amplifier which should satisfy the most critical A F enthusiast.

**£4.35**

NEW

## PA12

**NEW PA12 Stereo Pre-Amplifier completely redesigned for use with AL30A Amplifier Modules. Features include on/off volume Balance, Bass and Treble controls. Complete with tape output.**

*Frequency Response 20Hz-20KHz (—3dB). Bass and Treble range 12dB. Input Impedence 1 meg ohm. Input Sensitivity 300mV. Supply requirements 24V .5mA. Size 152mm x 84mm x 33mm.*

**£6.70**

## PS12

Power supply for **AL30A, PA12, SA450,** etc.

Input voltage 15-20v A.C. Output voltage 22-30v D.C. Output current 800 mA Max. Size 60mm x 43mm x 26mm.
**Transformer T538 £3.20**

OUR PRICE **£1.30**

## Stabilised Power Supply Type SPM80

SPM80 is especially designed to power 2 of the AL60 Amplifiers, up to 15 watts (R.M.S.) per channel simultaneously. With the addition of the Mains Transformer **BMT80,** the unit will provide outputs of up to 1.5A at 35V. Size 63mm. 105mm. 30mm. Incorporating short circuit protection.
**Transformer BMT80**
**£5.40 + 86p postage**

**£3.75**

# BI-PAK

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**HERTS.**

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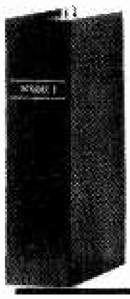
OPEN 9 to 5.30 Mon./Sat

# NEW PRODUCTS!

# NRDC-AMBISONIC 45J


## SURROUND SOUND DECODER



The **first ever** kit specially produced by Integrex for this British NRDC backed surround sound system which is the result of 7 years' research by the Ambisonic team. W.W. July, Aug., '77.
The unit is designed to decode not only 45J but virtually all other 'quadrophonic' systems (Not CD4), including the new BBC Matrix H.10 input selections.
The decoder is linear throughout and does not rely on listener fatiguing logic enhancement techniques. Both 2 to 3 input signals and 4 or 6 output signals are provided in this most versatile unit. Complete with mains power supply, wooden cabinet, panel, knobs, etc.

Complete kit, including licence fee £45.00 + VAT
Or ready built and tested. £61.50 + VAT

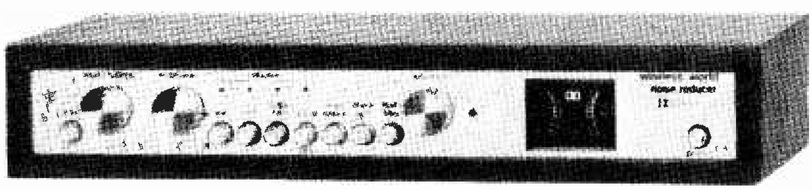
## INTRUDER 1 RADAR ALARM

**With Home Office Type approval**

As in "Wireless World", designed by Mike Hosking, 240V ac mains operated and disguised as a hardbacked book. Detection range up to 30 feet. Complete kit. Exclusive designer approved kit £46.00 + VAT, or ready built and tested. £54.00 + VAT

# *Wireless World* Dolby(TM) noise reducer

*Trademark of Dolby Laboratories Inc.*



Featuring:
- switching for both encoding (low-level h.f. compression) and decoding
- a switchable f.m. stereo multiplex and bias filter.
- provision for decoding Dolby f.m. radio transmissions (as in USA).
- no equipment needed for alignment.
- suitability for both open-reel and cassette tape machines.
- check tape switch for encoded monitoring in three-head machines.

**Typical performance**

Noise reduction better than 9dB weighted.
Clipping level 16.5dB above Dolby level (measured at 1% third harmonic content)

Harmonic distortion 0.1% at Dolby level typically 0.05% over most of band, rising to a maximum of 0.12%

Signal-to-noise ratio: 75dB (20Hz to 20kHz, signal at Dolby level) at Monitor output

Dynamic Range >90db

30mV sensitivity.

Complete Kit **PRICE: £39.90**+VAT

Also available ready built and tested . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . **Price £54.00**+VAT

Calibration tapes are available for open-reel use and for cassette (specify which) . . . . . . . . . **Price £2.20**+VAT *

Single channel plug-in Dolby(TM) PROCESSOR BOARDS (92 x 87mm) with gold plated contacts are available with all components . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . **Price £8.20**+VAT

Single channel board with selected fet . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . **Price £2.50**+VAT

Gold Plated edge connector . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . **Price £1.50**+VAT *

Selected FETs **60p** each+VAT, **100p**+VAT for two, **£1.90**+VAT for four

Please add VAT @ 12½% unless marked thus*, when 8% applies (or current rates)

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master charge

We guarantee full after-sales technical and servicing facilities on all our kits, have you checked that these services are available from other suppliers?

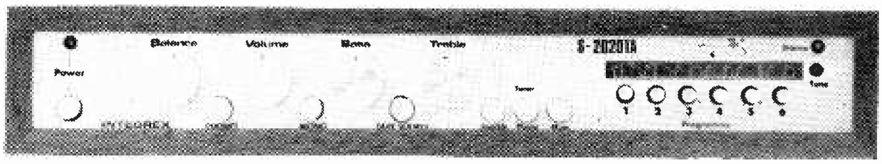
# INTEGREX LTD.

*Please send SAE for complete lists and specifications*
**Portwood Industrial Estate, Church Gresley,**
**Burton-on-Trent, Staffs DE11 9PT**
**Burton-on-Trent (0283) 215432 Telex 377106**

# INTEGREX

## S-2020TA STEREO TUNER/AMPLIFIER KIT

**SOLID MAHOGANY CABINET**



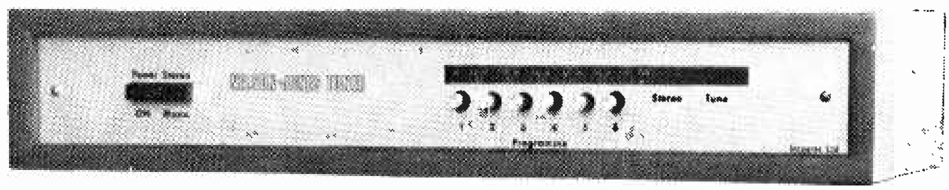
***A high-quality push-button FM Varicap Stereo Tuner combined with a 24W r.m.s. per channel Stereo Amplifier.***

**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. Power on/off FET transient protection. All sockets, fuses, etc., are PC mounted for ease of assembly. Tuner section uses 3302 FET 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 @ 1.2μV. THD 0.3%. Pre-decoder 'birdy' filter.

**PRICE: £58.95**+VAT

## NELSON-JONES STEREO FM TUNER KIT

***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.***

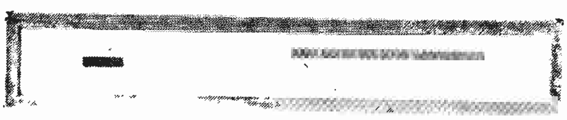


**Brief Spec.** Tuning range 88—104MHz. 20dB mono quieting @ 0.75μV. Image rejection — 70dB. IF rejection — 85dB. THD typically 0.4%.
IC stabilized PSU and LED tuning indicators. Push-button tuning and AFC unit. Choice of either mono or stereo with a choice of stereo decoders.

*Compare this spec. with tuners costing twice the price.*

**Mono £32.40**+VAT
**With ICPL Decoder £36.67**+VAT
**With Portus-Haywood Decoder £39.20**+VAT

## STEREO MODULE TUNER KIT

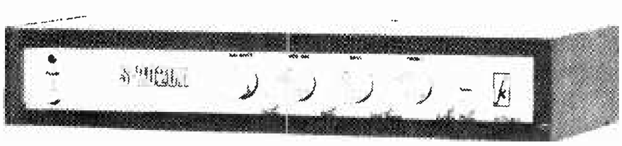


***A low-cost Stereo Tuner based on the 3302 FET RF module requiring no alignment. The IF comprises a ceramic filter and high-performance IC Variable INTERSTATION MUTE. PLL stereo decoder IC. Pre-decoder 'birdy' filter Push-button tuning***

Sens. 30dB S/N mono @ 1.2μV
THD typically 0.3%
Tuning range 88—104MHz
LED sig. strength and stereo indicator

**PRICE: Stereo £31.95**+VAT

## 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***

***Power 'on/off' FET transient protection.***

**Typ Spec.** 24+24W 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: £33.95**+VAT

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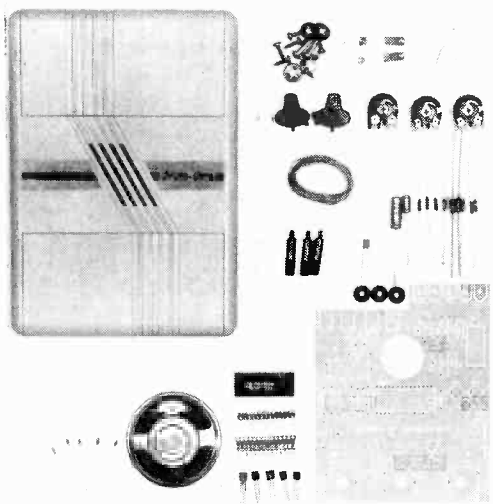
**ALL THE ABOVE KITS ARE SUPPLIED COMPLETE WITH ALL METALWORK, SOCKETS, FUSES, NUTS AND BOLTS, KNOBS, FRONT PANELS, SOLID MAHOGANY CABINETS AND COMPREHENSIVE INSTRUCTIONS**

---

**BASIC NELSON-JONES TUNER KIT** £14.28+VAT
**BASIC MODULE TUNER KIT (stereo)** £16.75+VAT
**PHASE-LOCKED IC DECODER KIT** . . . £4.47+VAT
**PUSH-BUTTON UNIT** . . . . . . . . . . . . . £5.00+VAT
**PORTUS-HAYWOOD PHASE-LOCKED STEREO DECODER KIT** . . . . . . . . . . . . . . . . . . . . . £8.00+VAT

# Build a microprocessor electronic musical door chime which can play 24 different tunes!

## *A complete* Chroma-Chime *Kit for only £18 inc. p.&p. & VAT.*



Plays:

| | |
|---|---|
| Greensleeves | Cook House Door |
| God Save the Queen | The Stars & Stripes* |
| Rule Britannia* | Beethoven's Ode to Joy |
| Land of Hope and Glory | William Tell Overture |
| Oh Come All Ye Faithful | Soldier's Chorus |
| Oranges and Lemons | Twinkle, Twinkle Little Star |
| Westminster Chimes* | Great Gate of Kiev |
| Sailor's Hornpipe | Maryland |
| Beethoven's "Fate Knocking" | Deutschland uber Alles |
| The Marseillaise | Bach |
| Mozart | Colonel Bogie |
| Wedding March | The Loralile |

*These tunes play longer if the push button is kept pressed

* Handsome purpose built ABS cabinet
* Easy to build and install
* Uses Texas Instruments TMS1000 microcomputer
* Absolutely all parts supplied including I.C. socket
* Ready drilled and legended PCB included
* Comprehensive kit manual with full circuit details
* No previous microcomputer experience necessary
* All programming permanently retained is on chip ROM
* Can be built in about 3 hours!
* Runs off 2 PP3 type batteries.
* Fully Guaranteed

* *A great introduction to the fascinating world of microcomputers.*
* *Save pounds on normal retail price by building yourself.*

The Chroma-Chime is the world's first electronic musical door chime which uses a pre-programmed microcomputer chip to generate tunes. Instead of boring old buzzes, dings or dongs, the Chroma-Chime will play one of its 24 well known tunes from its memory using its tiny 'brain' to all the music synthesizing! Since everything is done by precise mathematics, it cannot play the notes out of tune.

The unit has comprehensive built-in controls so that you can not only select the 'tune of the day' but the volume, tempo and envelope decay rate to change the sound according to taste.

Not only visitors to the front door will be amazed, if you like you can connect an additional push button for a back door which plays a different tune!

This kit has been carefully prepared so that practically anyone capable of neat soldering will have complete success in building it. The kit manual contains step by step constructional details together with a fault finding guide, circuit description, installation details and operational instructions all well illustrated with numerous figures and diagrams.

To CHROMATRONICS, River Way, Harlow, Essex, U.K.

Please send ☐ Chroma-Chime Kits at £18·00 each including VAT and post and packing

PLEASE USE BLOCK CAPITALS

Name ____________________

Address ____________________

I enclose cheque/PO value £ ____________

or debit my ACCESS/BARCLAYCARD account No.

☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

Signature ____________________

N.B. The CHROMA-CHIME is also available, fully assembled, price £24·95 inc VAT and post and packing.

Please allow 7-21 days for delivery.

WW 1/78

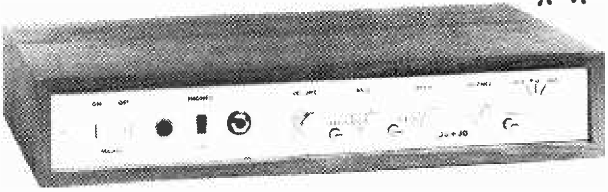
The CHROMA-CHIME is exclusively designed by

**CHROMATRONICS**

River Way, Harlow, Essex.

# T20 + 20 AND T30 + 30 20W, 30W AMPLIFIERS

**



Designed by Texas engineers and described in Practical Wireless, the Texan was an immediate success. Now developed further in our laboratories to include a Toroidal transformer and additional improvements, the slimline T20 + 20 delivers 20W rms per channel of true Hi-Fi at exceptionally low cost. The **easy to build** design is based on a single F/Glass PCB and features all the normal facilities found on quality amplifiers including scratch and fumble filters, adaptable input selector and headphones socket. In a follow-up article in Practical Wireless further modifications were suggested and these have been incorporated into the T30 + 30. These include RF interference filters and a tape monitor facility. Power output of this model is 30W rms per channel.

| Pack | T20 | T30 |
|---|---|---|
| 1. Set of low noise resistors ... | £1.60 | £1.70 |
| 2. Set of small capacitors ..... | £2.60 | £3.40 |
| 3. Set of power supply capacitors | £2.20 | £2.50 |
| 4. Set of miscellaneous parts ... | £3.50 | £3.50 |
| 5. Set of slide, mains, P.B. switches | £1.50 | £1.50 |
| 6. Set of pots., selector switch . | £2.80 | £2.80 |
| 7. Set of semiconductors, ICs, skts. | £7.25 | £7.75 |
| 8. Toroidal transformer—240V prim. e.s. screen ............... | £5.60 | £7.20 |
| 9. Fibreglass PCB ........... | £3.50 | £3.90 |
| 10. Set of metalwork, fixing parts | £5.20 | £6.20 |
| 11. Set of cables, mains lead .... | £0.40 | £0.40 |
| 12. Handbook ............... | £0.25 | £0.25 |
| 13. Teak cabinet 15.4" x 6.7" x 2.8" | £4.50 | £4.50 |

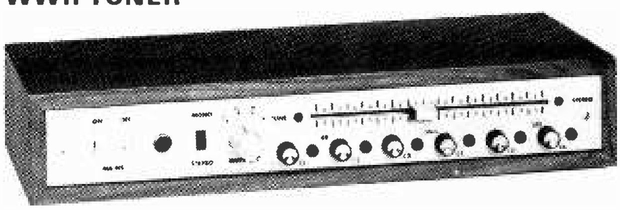
One each of Pack 1-13 are required for complete stereo amplifier. Total cost of individually purchased packs T20 + 20 £40.90, T30 + 30 £45.60.

**SPECIAL PRICES FOR COMPLETE KITS**

**T20 + 20 KIT PRICE £33.10** **T30 + 30 KIT PRICE £38.40**

## WWII TUNER

**

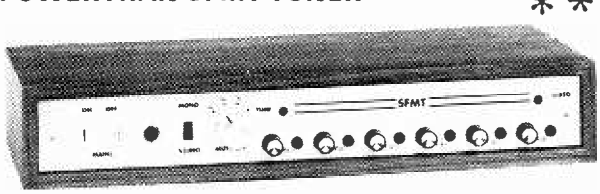


Following the success of our **Wireless World FM Tuner Kit** this cost reduced model was designed to complement the **T20 + 20** and **T30 + 30** amplifiers and the cabinet size, front panel format and electrical characteristics make this tuner compatible with either. The frequency meter of the more advanced model has been omitted and the mechanics simplified, however the circuitry is identical and this kit offers most outstanding value for money. Facilities included are switchable afc, adjustable, switchable muting, LED tuning indication and both continuous and push-button channel selection (readily adjusted by controls on the front panel).

**SPECIAL PRICE FOR COMPLETE KIT £47.70** AVAILABLE AS SEPARATE PACKS — PRICES IN OUR FREE CATALOGUE

## POWERTRAN SFMT TUNER

**



The requirement was a simple, low cost design which could be constructed easily without special alignment equipment but which still gives a first class output suitable for feeding any of our very popular amplifiers or any other high quality audio equipment. Not finding a suitable published circuit, the requirement was met by design and development work in our own laboratories and this tuner, which uses a pre-aligned front end module can be set up with the aid of nothing more sophisticated than a multi-meter. A phase-locked-loop is used for stereo decoding and controls include switchable afc, switchable muting and push-button channel selection (adjustable by controls on the front panel). This unit matches well with the T20 + 20 and T30 + 30 amplifiers.

**PRICE FOR COMPLETE KIT £35.90** AVAILABLE AS COMPLETE KIT ONLY

**Wireless World Amplifier Designs.** Full kits are not available for these projects but component packs and PCBs are stocked for the highly regarded Bailey and 20W class AB Linsley-Hood designs together with an efficient regulated power supply of our own design. Suitable for driving these amplifiers is the Bailey Burrows pre-amplifier and our circuit board for the stereo version of it features 6 inputs, scratch and fumble filters and wide range tone controls which may be either rotary or slider operating. For tape systems a set of three PCBs have been prepared for the integrated circuit based high performance stereo Stuart design. Details of component packs are in our free Catalogue.

| | |
|---|---|
| 30W Bailey Amplifier | |
| BAIL Pk 1 F/Glass PCB | £1.00 |
| BAIL Pk 2 Resistors Capacitors, Potentiometer set | £2.35 |
| BAIL Pk 3 Semiconductor set | £4.70 |
| 20W Linsley-Hood Class AB | |
| LHAB Pk 1 F/Glass PCB | £1.05 |
| LHAB Pk 2 Resistor Capacitor Potentiometer set | £3.20 |
| LHAB Pk 3 Semiconductor set | £3.35 |
| Regulator Power Supply | |
| 60VS Pk 1 F/Glass PCB | £0.85 |
| 60VS Pk 2 Resistor Capacitor set | £2.20 |
| 60VS Pk 3 Semiconductor set | £3.10 |
| 60VS Pk 6A Toroidal transformer (for use with Bailey) | £8.80 |
| 60VS Pk 6B Toroidal transformer (for use with 20W LH) | £7.25 |
| Bailey Burrows Stereo Pre-Amp | |
| BBPA Pk 1 F/Glass PCB (stereo) | £2.80 |
| BBPA Pk 2 Resistor Capacitor Semiconductor set (stereo) | £6.70 |
| BBPA Pk 3R Rotary Potentiometer set (stereo) | £2.85 |
| BBPA Pk 3S Slider Potentiometer set with knobs (stereo) | £3.10 |
| Stuart Tape Recorder | |
| TRRP Pk 1 Replay Amp F/Glass PCB (stereo) | £1.30 |
| TRRC Pk 1 Record Amp F Glass PCB (stereo) | £1.70 |
| TROS Pk 1 Bias Erase/Stabilizer F/Glass PCB (stereo) | £1.20 |

## SQ QUADRAPHONIC DECODERS

These state of the-art circuits described by CBS are offered as kits of superior quality with close tolerance capacitors metal oxide resistors and Fibreglass PCBs designed for edge connector insertion. Further information on these kits is given in our FREE CATALOGUE

| | |
|---|---|
| M1 Basic matrix decoder | £5.90 |
| L1 Full logic decoder | £17.20 |
| L2A Full logic decoder with variable blend | £22.60 |
| L3A As L2A but with high performance discrete component front end | £30.10 |
| (or with carbon film resistors) | £25.90 |
| SQM1 30 Decoder complete with 30W rear channel amplifiers. Complete kit matches T30 + 30 amplifier | £40.75 |

## Value Added Tax not included in prices
## UK Carriage FREE

**PRICE STABILITY:** Order with confidence! Irrespective of any price changes we will honour all prices in this advertisement until January 1st, 1978, if this month's advertisement is mentioned with your order. Errors and VAT rate changes excluded.
**U.K. ORDERS:** Subject to 12½% * surcharge for VAT (i.e. add ⅛ to the price). No charge is made for carriage. *or at current rate if changed
**SECURICOR DELIVERY:** For this optional service (U.K. mainland only) add £2.50 (VAT inclusive) per kit
**SALES COUNTER:** If you prefer to collect your kit from the factory, call at Sales Counter (at rear of factory). Open 9 a.m.-4.30 p.m. Monday-Thursday

## SEMICONDUCTORS as used in our range of quality audio equipment

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 2N699 | £0.20 | BC107 | £0.10 | BF257 | £0.40 | MPSA05 | £0.25 | TIP30C | £0.60 |
| 2N3055 | £0.45 | BC108 | £0.10 | BF259 | £0.47 | MPSA12 | £0.35 | TIP41A | £0.70 |
| 2N3442 | £1.20 | BC109 | £0.10 | BFR39 | £0.30 | MPSA55 | £0.25 | TIP42A | £0.80 |
| 2N3711 | £0.09 | BC109C | £0.12 | BFR79 | £0.30 | MPSA65 | £0.35 | TIP41B | £0.75 |
| 2N3904 | £0.17 | BC125 | £0.15 | BFY51 | £0.20 | MPSA66 | £0.40 | TIP42B | £0.90 |
| 2N3906 | £0.20 | BC126 | £0.15 | BFY52 | £0.20 | MPSU05 | £0.50 | 1N914 | £0.07 |
| 2N5087 | £0.25 | BC182 | £0.10 | CA3046 | £0.70 | SBA750A | £1.90 | 1N916 | £0.07 |
| 2N5089 | £0.25 | BC212 | £0.12 | LM301AN | £0.55 | SL301 | £1.30 | 1S920 | £0.10 |
| 2H5457 | £0.45 | BC182L | £0.10 | LP1186 | £6.50 | SL3045 | £1.20 | | |
| 2N5459 | £0.45 | BC184L | £0.11 | MC1310 | £2.20 | SN72741P | £0.40 | | |
| 2N5460 | £0.50 | BC212L | £0.12 | MC1351 | £1.05 | SN72748P | £0.40 | | |
| 2N5461 | £0.50 | BC214L | 0.14 | MC1741CG | £0.65 | STCR53 | £2.40 | | |
| 2N5830 | £0.35 | BCY72 | £0.13 | MFC4010 | £0.95 | TIL209 | £0.20 | | |
| 40361 | £0.40 | BD529 | £0.65 | MJ481 | £1.20 | TIP29A | £0.40 | **FILTERS** | |
| 40362 | £0.45 | BD530 | £0.55 | MJ491 | £1.45 | TIP30A | £0.45 | FM4 | £1.00 |
| 74004 | £0.35 | BDY56 | £1.60 | MJE521 | £0.60 | TIP29C | £0.55 | SFJ10 7MA | £1.50 |

# NEW PROJECTS

### LINSLEY-HOOD LOW DISTORTION OSCILLATOR

A Wien bridge audio oscillator (10Hz-100KHz) with sine or square wave output (1mV-1V) published in Wireless World September, October 1977

| | |
|---|---|
| Pack 1 Fibreglass PCB | £1.65 |
| Pack 2 Capacitors, 2% metal oxide resistors | £2.60 |
| Pack 3 Transistors, IC, IC socket, thermistor | £3.90 |
| Pack 4 Potentiometers and switches | £2.80 |

### ERIC F. TAYLOR PRE-AMPLIFIER

A low noise, low distortion (0.005%) stereo pre-amplifier for use with magnetic pick-up (RIAA equalization)

| | |
|---|---|
| Pack 1 Fibreglass PCB (Stereo) | £1.45 |
| Pack 2 Metal oxide resistors, capacitors (Stereo) | £3.20 |
| Pack 3 Transistors, ICs, IC sockets, zeners (Stereo) | £4.20 |

For further details of these please ask for our NEW PROJECTS LIST

**QUALITY:** All components are brand new first grade full specification guaranteed devices. All resistors (except where stated as metal oxide) are low noise carbon film types. All printed circuit boards are fibreglass, drilled roller tinned and supplied with circuit diagrams and construction layouts.

**AFTER-SALES BACK-UP:** Servicing facilities (very rarely required for our kits) are available for all ** complete kits. Further details will be sent on request.

**FOR FURTHER INFORMATION PLEASE WRITE OR TELEPHONE FOR OUR FREE CATALOGUE**

DEPT WW12

# POWERTRAN ELECTRONICS

PORTWAY INDUSTRIAL ESTATE
ANDOVER, HANTS SP10 3NN

ANDOVER
64455

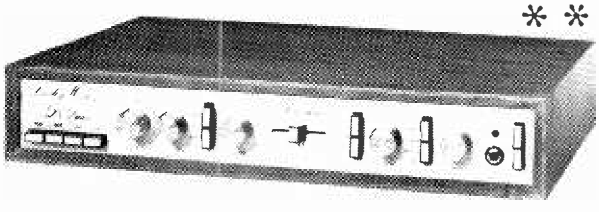
MUSCAT & OMAN FRANCE DENMARK GAMBIA AUSTRALIA HONG KONG NAURU GERMANY TUNISIA LUXEMBOURG NIGERIA FINLAND SOUTH AFRICA CZECHOSLOVAKIA AUSTRIA

NEW GUINEA ISRAEL GUERNSEY CYPRUS BELGIUM UGANDA BRUNEI TRINIDAD SOUTH WEST AFRICA ITALY JAVA SIERRA LEONE WINDWARD ISLANDS CANADA MALTA

# AUDIO KITS OF DISTINCTION FROM POWERTRAN

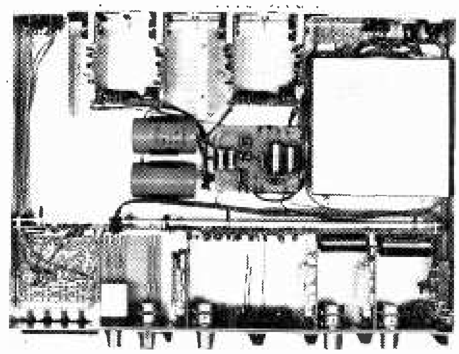
## NEW! DE LUXE EASY TO BUILD LINSLEY-HOOD 75W AMPLIFIER

* *



Available as Separate Packs

Details in Free Catalogue



Internal view of De Luxe Kit

**SPECIAL PRICE FOR COMPLETE KIT £99.30**

The standard model of our kit for Mr Linsley-Hood s 75 watt design has for a long time offered exceptional performance for a very modest cost (just look at prices for comparable high quality high power ready built units!) Features of the amplifier include very low distortion (less than 0 01%) 75W rms per channel power output rumble filter variable slope scratch filter variable transition frequency tone controls tape monitoring facilities and individually adjustable inputs This model is based on 5 circuit boards which not having the controls mounted on them can if desired be effectively used separately in high performance audio systems not based on our metalwork

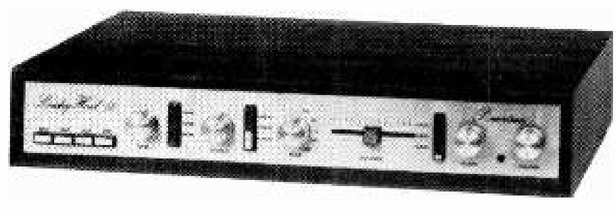
Our new De Luxe model uses 14 boards which interconnect with gold plated contacts and have the potentiometers and switches fitted to them There are 3 boards for each power amplifier 1 board for the power supply and 7 boards for the stereo pre amplifier This system almost eliminates internal wiring making construction delightfully straightforward and as each board can be easily removed in seconds from the chassis checking and maintenance is so simple that even newcomers to electronics will be able to cope competently with the kit Additional features of our new model are inclusion of latest circuit improvements generously sized heatsinks for heavy duty use even in tropical climates and metal oxide resistors throughout for long-term stability and reliability

### PACK PRICES FOR STANDARD KIT

| Pack | | Price |
|---|---|---|
| 1. | Fibreglass printed circuit board for power amp | £1.15 |
| 2. | Set of resistors, capacitors, pre-sets for power amp | £2.50 |
| 3. | Set of semiconductors for power amp | £6.50 |
| 4. | Pair of 2 drilled, finned heat sinks | £1.10 |
| 5. | Fibreglass printed-circuit board for pre-amp | £1.90 |
| 6. | Set of low noise resistors, capacitors, pre-sets for pre-amp | £4.10 |
| 7. | Set of low noise, high gain semiconductors for pre-amp | £2.40 |
| 8. | Set of potentiometers (including mains switch) | £3.50 |
| 9. | Set of 4 push-button switches, rotary mode switch | £5.40 |
| 10. | Toroidal transformer complete with magnetic screen/ housing primary: 0 117-234 V: secondaries: 33-0-33 V, 25-0-25 V | £10.95 |
| 11. | Fibreglass printed-circuit board for power supply | £0.85 |
| 12. | Set of resistors, capacitors, secondary fuses, semiconductors for power supply | £5.40 |
| 13. | Set of miscellaneous parts including DIN skts., mains input skt., fuse holder, interconnecting cable, control knobs | £6.20 |
| 14. | Set of metalwork parts including silk screen printed fascia panel and all brackets, fixing parts, etc. | £8.20 |
| 15. | Handbook | £0.30 |
| 16. | Teak cabinet 18.3" x 12.7" x 3.1" | £10.70 |

2 each of packs 1-7, 1 each of packs 8-16 inclusive are required for complete stereo amplifier. Total cost of individually purchased packs ..... £90.80

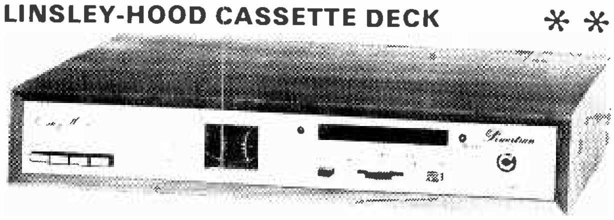
## STANDARD LINSLEY-HOOD 75W AMPLIFIER



**SPECIAL PRICE FOR COMPLETE KIT £79.80**

## LINSLEY-HOOD CASSETTE DECK

* *



**SPECIAL PRICE FOR COMPLETE KIT £79.60**

| Pack | | Price |
|---|---|---|
| 1. | Stereo PCB (accommodates 2 rep. amps, 2 meter amps, bias/erase osc. relay) | £3.35 |
| 2. | Stereo set of capacitors, M.O. resistors, potentiometers for above | £7.95 |
| 3. | Stereo set of semiconductors for above | £8.50 |
| 4. | Miniature relay with socket | £2.90 |
| 5. | PCB, all components for solenoid, speed control circuits | £3.80 |
| 6. | Goldring-Lenco mechanism as specified | £18.50 |
| 7. | Function switch, knobs | £1.90 |
| 8. | Dual VU meter with illuminating lamp | £6.95 |
| 9. | Toroidal transformer with E.S. screen prim. 0-117V, 234V, Sec. 15V | £4.90 |
| 10 | Set of capacitors, rectifiers, I.C. voltage regulator for power supply (Powertran design) | £2.80 |
| 11. | Set of miscellaneous parts, including sockets, fuse holder, fuses, interconnecting wire, etc | £3.40 |
| 12. | Set of metalwork including silk screened fascia, panel, internal screen, fixing parts, etc | £7.10 |
| 13. | Construction notes | £0.25 |
| 14. | Teak cabinet 18.3" x 12.7" x 3.1" | £10.70 |

One each of packs 1-14 inclusive are required for complete stereo cassette deck. Total cost of individually purchased packs ...... £83.00

Published in Wireless World (May, June August 1976) by Mr Linsley-Hood, this design although straightforward and relatively low cost nevertheless provides a very high standard of performance To permit circuit optimization separate record and replay amplifiers are used the latter using a discrete component front-end designed such that the noise level is below that of the tape background Push button switches are used to provide a choice of equalization time constants, a choice of bias levels and also an option of using an additional pre-amplifier for microphone use The mechanism used is the Goldring-Lenco CRV, a unit distinguished in its robustness and ease of operation Speed control and automatic cassette ejection are both implemented by electronic circuitry This unit which is powered by a toroidal transformer and uses metal oxide resistors throughout offers an excellent match for the Wireless World Tuner and the Linsley-Hood 75 Watt Amplifier

## WIRELESS WORLD FM TUNER

* *

**SPECIAL PRICE FOR COMPLETE KIT £70.20**

| Pack | | Price |
|---|---|---|
| 1. | Fibreglass printed board for front end IF strip, demodulator, AFC and mute circuits | £2.15 |
| 2. | Set of metal oxide resistors, thermistor, capacitors, cermet preset for mounting on Pack 1 | £4.80 |
| 3. | Set of transistors, diodes, LED, Integrated circuits for mounting on Pack 1 | £5.25 |
| 4. | Pre-aligned front end module, coil assembly, three section ceramic filter | £8.50 |
| 5. | Fibreglass printed circuit board for stereo decoder | £1.10 |
| 6. | Set of metal oxide resistors, capacitors, cermet preset for decoder | £2.60 |
| 7. | Set of transistors LED, integrated circuit for decoder | £2.90 |
| 8. | Set of components for channel selector switch module including fibreglass printed circuit board, push-button switches, knobs, LEDs, preset adjusters, etc. | £9.40 |
| 9. | Function switch, 10 turn tuning potentiometer, knobs | £5.80 |
| 10. | Frequency meter, meter drive components, fibreglass printed circuit board | £10.35 |
| 11. | Toroidal transformer with electrostatic screen. Primary: 0-117V 234V, secondary: 15V | £4.90 |
| 12. | Set of capacitors, rectifiers, voltage regulator for power supply | £2.10 |
| 13. | Set of miscellaneous parts, including sockets, fuse holder, fuses, inter-connecting wire, etc | £2.05 |
| 14. | Set of metalwork parts including silk screen printed fascia panel, acrylic silk screen printed tuning indicator panel insert, internal screen, fixing parts, etc. | £8.30 |
| 15. | Construction notes | £0.25 |
| 16. | Teak cabinet 18.3" x 12.7" x 3.1" | £10.70 |

One each of packs 1-16 inclusive are required for complete stereo FM tuner. Total cost of individually purchased packs ..... £81.15

Designed in response to demand for a tuner to complement the world-wide acclaimed Linsley-Hood 75W Amplifier this kit provides the perfect match The Wireless World (Skingley and Thompson) published original circuit has been developed further for inclusion into this outstanding slimline unit and features a pre-aligned front end module excellent a m rejection and temperature compensated varicap tuning which may be controlled either continuously or by push-button pre-selection Frequencies are indicated by a frequency meter and sliding LED indicators, attached to each channel selector pre-set The PLL stereo decoder incorporates active filters for birdy suppression and power is supplied via a toroidal transformer and integrated regulator. For long term stability metal oxide resistors are used throughout

## EXPORT A SPECIALITY!

Our Export Department can readily despatch orders of any size to any country in the world Some of the countries to which we sent kits last year are shown in this advertisement To assist in estimating postal costs our catalogue gives the weights of all packs and kits This will be sent free on request by airmail, together with our Export Postal Guide which gives current postage prices

**EXPORT ORDERS:** No minimum order charge! Prices same as for U K customers but no Value Added Tax charged Postage charged at actual cost plus 50p documentation and handling Please send payment with order by Bank Draft, Postal Order, International Money Order or cheque drawn on an account in the U K Alternatively for orders over £500 we will accept Irrevocable Letter of Credit payable at sight in London

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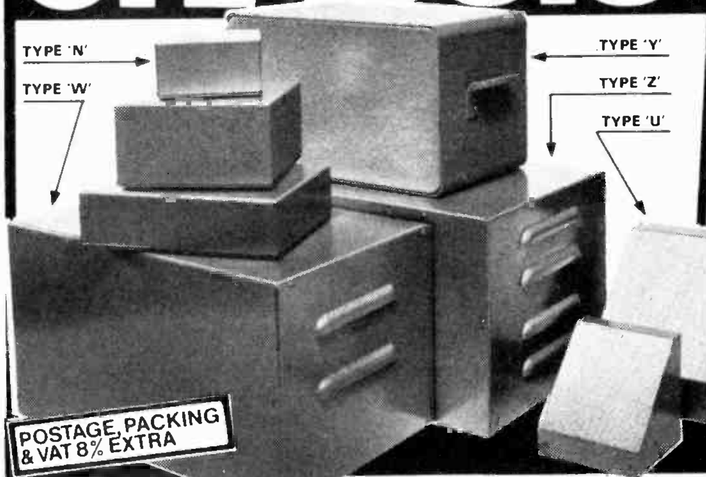
# CHASSIS & CASES




## BLANK CHASSIS

### FOUR-SIDED 16 SWG ALUMINIUM

| Size | Price | Base | Size | Price | Base |
|---|---|---|---|---|---|
| 6" x 4" x 2" | 75p | 34p | 10" x 8" x 2½" | £1.45 | 70p |
| 7" x 4" x 1½" | 70p | 37p | 12" x 7" x 2½" | £1.50 | 74p |
| 7" x 5" x 2" | 85p | 40p | 12" x 9" x 2½" | £1.70 | 88p |
| 8" x 4" x 2" | 85p | 40p | 13" x 8" x 2½" | £1.65 | 86p |
| 8½" x 5½" x 2" | £1.05 | 53p | 14" x 7" x 3" | £1.80 | 83p |
| 9" x 7" x 2" | £1.10 | 59p | 14" x 10" x 2½" | £1.95 | £1.08 |
| 10" x 4" x 2½" | £1.05 | 46p | 15" x 10" x 2½" | £2.05 | £1.15 |
| 12" x 4" x 2½" | £1.15 | 52p | 17" x 10" x 3" | £2.45 | £1.28 |
| 12" x 5" x 3" | £1.45 | 59p | | | |

VAT 8% and p.p. extra

### TO FIT OUR CASES

| Size | Price | Base | Size | Price | Base |
|---|---|---|---|---|---|
| 7" x 5¾" x 1½" | 80p | 45p | 12" x 6¾" x 2" | £1.35 | 74p |
| 7" x 5¾" x 2" | 90p | 45p | 14" x 8¾" x 2" | £1.65 | £1.00 |
| 11" x 6¾" x 1½" | £1.10 | 69p | 15¾" x 9¾" x 2½" | £2.15 | £1.22 |
| 11" x 6¾" x 2" | £1.25 | 69p | 17¾" x 9¾" x 2½" | £2.35 | £1.35 |

PANELS: Any size up to 3ft. at 86p sq. ft. 16 s.w.g. (18 s.w.g. 58p)

VAT 8% and p.p. extra

## CHASSIS WITH BASE (PLAIN ALUMINIUM)

| | | |
|---|---|---|
| 5" x 4" x 2½" | £1.10 | (16 s.w.g.) |
| 3" x 2" x 1" | 55p | (18 s.w.g.) |
| 4" x 2¼" x 1¼" | 65p | (18 s.w.g.) |
| 4½" x 3" x 2" | 75p | (18 s.w.g.) |
| 3½" x 3½" x 2¼" | 75p | (18 s.w.g.) |
| 3¼" x 3¼" x 2½" | 80p | (18 s.w.g.) |
| 6⅞" x 2⅞" x 1⅞" | 80p | (18 s.w.g.) |

VAT 8% and p.p. extra

## INSTRUMENT CASES

16 S.W.G. ALUMINIUM, SILVER HAMMER FINISH

**TYPE 'U'**

| L | W | D | Price |
|---|---|---|---|
| 3" | 3" | 3" | £1.40 |
| 4" | 4" | 4" | £1.75 |
| 5½" | 4½" | 4½" | £2.20 |
| 8" | 6" | 6" | £3.00 |
| 9¼" | 7½" | 3½" | £3.25 |
| 12" | 7" | 7" | £4.20 |
| 16" | 10" | 6" | £6.15 |
| 15" | 9" | 9" | £6.45 |

L = side to side W = back to front D = top to bottom
Type U has removable bottom or back. Type W removable front. Type Y all-screwed construction. Type Z removable back and front.

**TYPE 'W'**

| L | W | D | Price |
|---|---|---|---|
| 8" | 6" | 6" | £4.20 |
| 11½" | 5" | 7" | £4.70 |
| 12" | 7" | 7" | £5.40 |
| 15" | 9" | 8" | £7.45 |

**TYPE 'N'**
Chassis with base plate

| L | W | D | Price |
|---|---|---|---|
| 4" | 4" | 2" | £1.75 |
| 6" | 6" | 3" | £2.50 |
| 8" | 6" | 2" | £2.50 |

**TYPE 'Y'**
Louvres on back

| L | W | D | Price |
|---|---|---|---|
| 8" | 6" | 6" | £4.65 |
| 12" | 7" | 7" | £5.95 |
| 13" | 7" | 9" | £6.90 |
| 15" | 9" | 7" | £7.40 |

**TYPE 'Z'**

| L | W | D | Price |
|---|---|---|---|
| 17" | 10" | 9" | £8.80 |
| 19" | 10" | 8½" | £9.25 |

# H.L.SMITH & CO.LTD.

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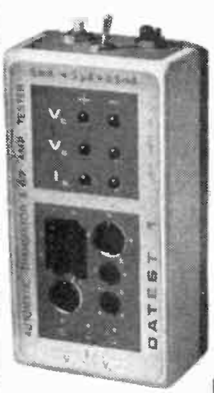

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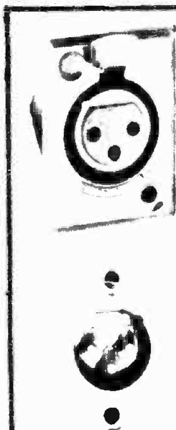

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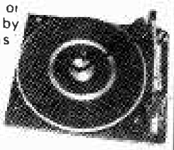
## BSR HI-FI AUTOCHANGER
**STEREO AND MONO £21.50** Post 75p



Plays 12", 10" or 7" records. Auto or Manual. A high quality unit backed by BSR reliability with 12 months guarantee A.C. 200/250V
Size 13½-11¼in. 3 speeds
Above motor board 3¾in
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with Sonotone V100 magnetic cartridge

**B.S.R. P128** with magnetic cartridge. Balanced arm Cueing device Bias Compensator **£24.50.** Post £1

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Modern design Rexine covered
Vynair front grille. Chrome fittings
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Motor board cut for BSR or Garrard deck

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Model "A" Size 12½ x 14¾ x 7½in
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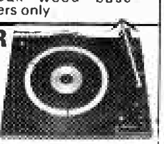
## BSR SINGLE PLAYER

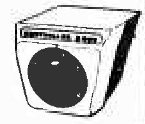


Ideal replacement or disco deck with cueing device and stereo ceramic cartridge
**£15.50**
Post 75p

## ELAC HI-FI SPEAKER
## 8in. TWIN CONE


Dual cone plastic roll surround. Large ceramic magnet. 50-16,000 c/s. Bass resonance 40 c/s. 8 ohm impedance 15 watts RMS **£5.95** Post 35p

**SMITH'S CLOCKWORK 15 AMP TIME SWITCH**
**0–6 HOURS £3.30** Post 35p



Single pole two-way Surface mounting with fixing screws Will replace existing wall switch to give light for return home garage, automatic anti-burglar lights, etc Variable knob. Turn on or off at full or intermediate settings. Brand new and fully guaranteed

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**80 Ohm Coax 8p yd.**
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Ideal 625 and colour
PLUGS **10p.** SOCKETS **10p.**
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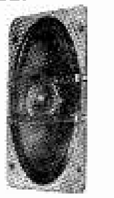

With tweeter and crossover 10 watt. 3 ohm
**£7.95** Post 45p

Ditto 15 watts. 8 ohm
**£10.50** Post 65p

With tweeter and crossover 20 watt.
Bass res. 25 c.p s.
Flux=11,000 gauss
8 or 15 ohm. 20 to 20,000 c p.s
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Teak finish For EMI 13 x 8 speakers. **£8.50** Post £1 00

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| | | | |
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| 12V 100mA | **£1.00** | 20V, 40V, 60V, 1 amp | **£3.50** |
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FULL WAVE BRIDGE CHARGER RECTIFIERS
6 or 12V outputs 1½ amp **40p**
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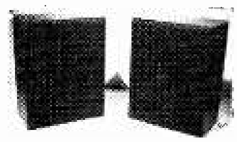

13 × 10 × 6in
50 to 14,000 cps
8 watts rms 4, 8 or 16 ohms
**£16 pair** Post £1 30

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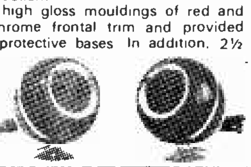
These little marvels of modern sound reproduction are ideally suited for today's domestic audio set-up. Two of these smart spheres, each with 5 watt deep throated ceramic magnets, will produce superb stereo reproduction.
The globe shaped cases in high gloss mouldings of red and green, are finished with chrome frontal trim and provided with screw-on rubber inset protective bases In addition, 2½ metres of strong lead already fitted with phono plug is supplied.
Frequency Response 100-20,000 Hz
Impedance 8 ohms
Power Capacity 5 watts



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**SHORT WAVE** 100pF air spaced gangable tuner, **95p.**
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**RESISTORS.** ¼W, ½W, 1W, 20% **2p;** 2W, **10p;** 10Ω to 10M
**HIGH STABILITY.** ½W 2% 10 ohms to 6 meg., **12p.**
Ditto 5% Preferred values 10 ohms to 10 meg., **5p.**

**ELECTRO MAGNETIC PENDULUM MECHANISM**
1 5V d c operation over 300 hours continuous on SP2 battery, fully adjustable swing and speed Ideal displays, teaching electro magnetism or for metronome, strobe, etc. **95p** Post 30p

## BAKER MAJOR 12" £15.00
Post £1 00

30-14,500 c/s 12in double cone woofer and tweeter cone together with a BAKER ceramic magnet assembly having a flux density of 14,000 gauss and a total flux of 145,000 Maxwells Bass resonance 40 c/s Rated 25W NOTE 4 or 8 or 16 ohms must be stated

Module kit, 30-17,000 c/s with tweeter, crossover baffle and instructions **£19.00** Post £1 60 each
Please state 4 or 8 or 16 ohms

**BAKER "BIG-SOUND" SPEAKERS.** Post £1 00 each

| 'Group 25' | 'Group 35' | 'Group 50/15' |
|---|---|---|
| 12in 30W **£12.00** | 12in 40W **£14.00** | 15in 75W **£26.00** |
| 4 or 8 or 16 ohm | 4 or 8 or 16 ohm | 8 or 16 ohm |

**BAKER LOUDSPEAKER, 12 INCH. 60 WATT. GROUP 50/12,** 4 OR 8 OR 16 OHM HIGH POWER FULL RANGE PROFESSIONAL QUALITY RESPONSE 30-16,000 CPS MASSIVE CERAMIC MAGNET WITH ALUMINIUM PRESENCE CENTRE DOME **£21.00** Post £1 60

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For 12in or 10in speaker 20x13x12in **£14.50** Post £2
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**SPEAKER COVERING MATERIALS.** Samples Large S A E
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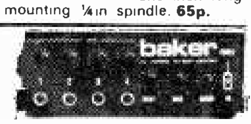


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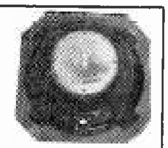

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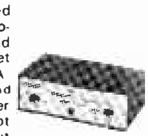

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| Voice Coil Impedance | 4 or 8 or 16 ohms |
| Maximum Power | 60 watts (120 watts U.S.A.) |
| Bass Resonance | 55 c.p.s. |
| Useful Response | 30-16,000 c.p.s. |
| Flux Density | 15,000 lines |
| Voice Coil | 1½"/38 mm |
| Overall diameter | 12½/310 mm |
| Overall depth | 4¾"/120 mm |
| Fixing holes diagonal | 13"/330 mm |
| Baffle aperture | 11"/280 mm |
| Nett weight | 10 lbs/4.5 kg. |

### GROUP 25 12 inch

| | |
|---|---|
| Voice Coil Impedance | 4 or 8 or 16 ohms |
| Maximum Power | 30 watts (60 watts U.S.A.) |
| Bass resonance | 55 c.p.s. |
| Useful Response | 30-13,000 c.p.s. |
| Flux density | 12,000 lines |
| Voice coil | 1½"/38 mm |
| Overall diameter | 12¼"/310 mm |
| Overall depth | 4¾"/120 mm |
| Fixing holes diagonal | 13"/330 mm |
| Baffle aperture | 11"/280 mm |
| Nett weight | 5 lbs./2.3 kg. |

### GROUP 35 12 inch

| | |
|---|---|
| Voice Coil Impedance | 4 or 8 or 16 ohms |
| Maximum Power | 40 watts (80 watts U.S.A.) |
| Bass Resonance | 55 c.p.s. |
| Useful Response | 30-13,000 c.p.s. |
| Flux Density | 14,000 lines |
| Voice coil | 1½"/38 mm |
| Overall diameter | 12¼"/310 mm |
| Overall depth | 4¾"/120 mm |
| Fixing holes diagonal | 13"/330 mm |
| Baffle aperture | 11"/280 mm |
| Nett weight | 6 lb.s/2.7 kg. |

### GROUP 50 15 inch

| | |
|---|---|
| Voice Coil Impedance | 8 or 16 ohms |
| Maximum Power | 75 watts (150 watts U.S.A.) |
| Bass Resonance | 45 c.p.s. |
| Useful Response | 30-13,000 c.p.s. |
| Flux Density | 15,000 lines |
| Voice coil | 2"/51 mm |
| Overall diameter | 15½/390 mm |
| Overall depth | 6"/153 mm |
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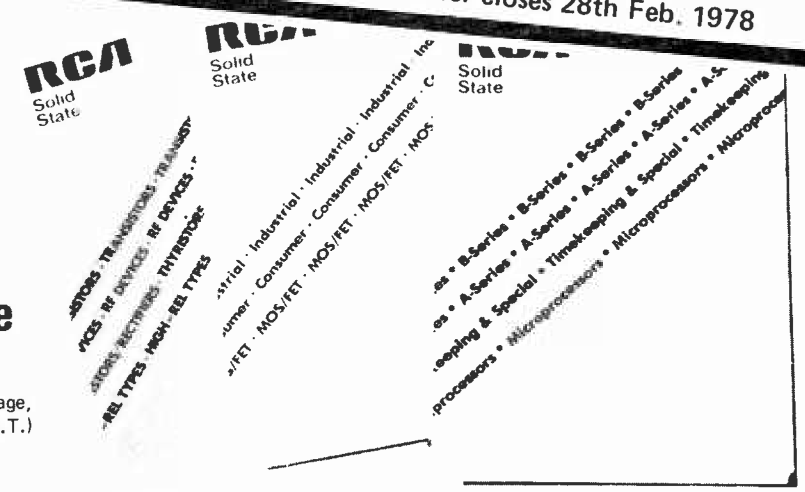


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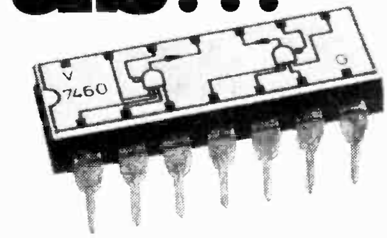


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**CONCEPT ELECTRONICS**
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## PEAK PROGRAMME AND DEVIATION MONITORING

**PPM2** DRIVE CIRCUIT WITH STANDARD PERFORMANCE UNDER LICENCE FROM THE BBC—

PPM2 is based on the ME12/9 but with an electronic floating input which withstands mains or static voltages on the signal lines. It meets BS 4297, the proposed revision of BS 4297, the proposed IEC Type 2 meter specifications and fulfills the requirements of the IBA EBU and BPO. Reviewed Studio Sound September, 1976. *Ernest Turner* meter movements 642, 643 and TWIN from stock. The TWIN is a flush mounting type and flush mounting adaptors which allow illumination are available for the 642 and 643. NEW: Illumination kits for 642 and 643, mouldings to support a 38mm festoon bulb, 12V 3W supplied.

**PEAK DEVIATION METER**

For monitoring mono or stereo FM stations either off air at the transmitter. This is a rack mounting unit calibrated in KHz, percent and decibels including a 7.5KHz deviation standard, with 400KHz and 53KHz modulating frequencies, and a high impedance probe head for use with a monitor receiver. During programme monitoring the true peak multiplex deviation with a very fast attack time meter gives much more insight into modulation levels and limiter overshoots than spectrum analyser displays or standard programme meters showing the decoded stereo signals.

**CHART RECORDER**
By itself records on inkless paper scaled 1-7 and 0-100KHz to PPM standards. Left, right, sum, difference or peak of either and, with the above unit, charts Peak Deviation.

**SURREY ELECTRONICS, The Forge, Lucks Green, Cranleigh, Surrey. GU6 7BG - STD 04866 5997**

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The second edition of this valuable three-language (English, French and German) directory gives details of 2,800 firms, including 130 from Eastern Europe. 880 products are grouped into 26 chapters, covering cables, components, computers, materials, production equipment and 21 fields of specialised application from aerospace to underwater engineering. Comprising 730 pages (A5 format), the new edition includes cross-referencing from products to manufacturers and—for the first time—from firms to products. Special attention has been paid to the indexing which is separate for each of the three language sections. European Electronics Suppliers Guide is published jointly by Verlag Fur Wirtschaftsliteratur GmbH (Zurich) and C. G. Wedgwood & Co. (London) and is available only through IPC Electrical-Electronic Press Ltd.

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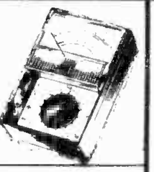

MULTI RANGE METERS Type MF15A A.C./D.C. volts 10 50 250 500 1000 Ma 0-5 0-10 0-100 Sensitivity 2000V 24 range diameter 133 × 93 × 46mm Price **£6.50** plus 50p P&P (**£7.56** inc VAT & P)

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Raytheon tag symmetrical Triac Type Tag 250/500v 10 amp 500 piv Glass passivated plastic triac Swiss precision product for long term reliability **£1.25** P&P 10p (**£1.46** inc VAT & P) (inclusive of date and application sheet) Suitable Diac **22p.**

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Double pole 15 amp 230AC Contacts (no dial) **£1.50.** P&P 30p (**£1.94** inc VAT & P)

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50 micro mirror galvo Calibrated 50-0-50 and 0-100 Mfg by Griffin & George Ltd Offered at fraction of maker's price, in original ministry packing **£12.00** P&P 60p (**£13.60** inc VAT & P)

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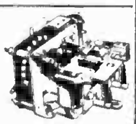
Mfg by Hendrey Relays type C2839 220/250 AC ops Contact 4C/O at 20 amp at 440 volts AC price **£6.00** P&P 75p (**£7.29** inc VAT & P)

## 230 VOLT AC FAN ASSEMBLY

Powerful continuously rated AC motor complete with 5 blade 6½" aluminium fan New reduced price **£3.00** P&P 65p (**£3.94** inc VAT & P)

## 21-WAY SELECTOR SWITCH with reset coil



The ingenious electro mechanical device can be switched up to 21 positions and can be reset from any position by energising the reset coil 230/240v A.C. operation Unit is mounted on strong chassis Complete with cover Price **£5.50** P&P 75p (**£6.75** inc VAT & P)

## VORTEX BLOWER AND VACUUM UNIT

Dynamically balanced to tally enclosed 9" rotor with max air delivery of 1.5 cubic metres per min Max static pressure 600mm W.G. Suction or blow from 2 side-by-side 37mm I.D. circular apertures fitted to base of unit Powerful continuously rated 115v a.c. motor mounted on alloy base with fixing facilities Dimensions Length 22cm x width 25cm x height 25cm

These units are ex-equipment but have had minimum use Fully tested prior to despatch Price **£12** + £1.50 P&P (**£14.58** inc VAT & P) Suitable transformer for 230/240v a.c. **£6** + £1 P&P (**£7.56** inc VAT & P)

## CENTRIFUGAL BLOWER

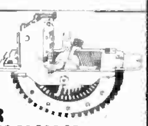
Mfg by Smiths Industries 230/240v a.c. Miniature Model Series SE7200 Size 95mm x 82mm x 82mm Aperture 38mm x 31mm 12 c.f.m **£2.75.** Post 50p (**£3.51** inc VAT & P) 115/230V a.c. 2800/3400 r.p.m. Fan type aperture 3" x 2½" VBL4/L Price **£12** Post £1 (**£14.58** inc VAT & P). Also available extremely powerful blower mfg by Fracmo

## NI-CAD BATTERIES

| | Height (mm) | Width (mm) | Length (mm) |
|---|---|---|---|
| 23 AH 1.2v Plastic Case £4 | 214 | 79 | 27 |
| 35 AH 1.2v Metal £6.50 | 219 | 75 | 29 |
| 40 AH 1.2v Plastic Case £8 | 275 | 80 | 35 |

Postage 30p per unit

## UNISELECTOR SWITCH



4 bank 25 way 75 ohm coil 36-48v D.C. operation Ex **new** equipment **£4.25.** P&P 75p Total price inc VAT **£5.40.**

## MINIATURE UNISELECTOR

12v 11 way 4 bank (3 non-bridging 1 homing) **£2.50** P&P 35p (**£3.08** inc VAT & P)

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As illustrated but fitted with 1" Lever 10 for **£2.00** P&P 30p (**£2.48** inc VAT & P)
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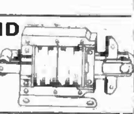
50 for **£10.00** post paid (**£10.80** inc VAT & P)
Type 3 115M 906T 10 for **£2.50** post paid (**£2.70** inc VAT & P)
Unimax USA 10 for **£4.00** plus 50p P&P (min order 10) (**£4.86** inc VAT & P)

## NEW HEAVY DUTY SOLENOID



Mfg by Magnetic Devices 240v A.C. Operation approx 20lb pull at 1.25" Price **£7.00** P&P 75p (**£8.37** inc VAT & P)
Similar to above approx 10lb pull **£3.50** P&P 60p (**£4.43** inc VAT & P)

## 230-250 VOLT A.C. SOLENOID

Similar in appearance to illustration Approximately 1½lb pull Size of feet 1⅜" x 13/16" Price **£1.00** Post 25p (**£1.35** inc VAT & P)

## 24 VOLT D.C. SOLENOIDS

**UNIT** containing **1 heavy duty solenoid approx. 25 lb. pull** at 1 in travel 2 solenoids of approx 1 lb pull at ½ in travel 6 solenoids of approx 4 oz pull at ½ in travel Plus 1 24V D.C. 1 heavy duty 1 make relay Price **£3.00** Post £1.00 (**£4.32** inc VAT & P) **ABSOLUTE BARGAIN**

## 240 A.C. SOLENOID OPERATED FLUID VALVE

Rated 1 p.s.i will handle up to 7 p.s.i Forged brass body, stainless steel core and spring ½ in b.s.p. inlet outlet Precision made British mfg PRICE **£2.75** Post 50p (**£3.57** inc VAT & P)

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INPUT 230 v. A.C. 50/60
**OUTPUT VARIABLE 0/260v. A.C.**
**BRAND NEW. All types.**

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| **200W (1 Amp) fitted A/C volt meter** | **£12.50** |
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| **1 KVA (Max. 5 Amp)** | **£19.50** |
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| 0-12v/24v 10 amp | **£12.35** p&p £1.50 (**£14.96** inc VAT & P) |
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| 0-6v/12v at 20 amp | **£11.85** p&p £1.00 (**£13.88** inc VAT & P) |

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115/230 screened primary two separate or 115v for 115 or 230v Secondary two 115v at 150 V.A. each for 115 or 230v output Can be used in series or parallel connections Fully tropicalised Length 13.5cm width 11cm. weight 15lbs Special price **£6.00.** carr £1.00 (**£7.56** inc VAT & P)

## MERCURY SWITCH

Size 27mm x 5mm 10 for **£5.00.** total including VAT **£5.72.** Min quantity 10

## STROBE! STROBE! STROBE!

### HY-LIGHT STROBE KIT Mk. IV

Latest type Xenon white light tube Solid state timing and triggering circuit 230/240 volt A.C. operation Speed adjustable 1-20 f.p.s. Designed for large rooms, halls, etc Light output greater than many (so called 4 Joule) strobes Price **£18.00** post £1 (**£20.56** inc VAT & P) Specially designed case and reflector for Hy-Light **£8.25** Post £1.00 (**£9.99** inc VAT & P)

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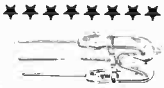
## XENON FLASH GUN TUBES



Range of Xenon tubes available from stock S.A.E. for full details

# RELAYS

Wide range of AC and DC relays available from stock Phone or write in your enquiries

**230/240V A.C. Relays:** Arrow 2 c/o 15 amp **£1.50** (**£1.84** inc VAT & P)
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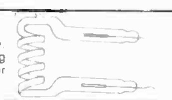
**D.C. Relays:** Open type 9/12V 3 c/o 7 amp **£1.00** (**£1.30** inc VAT & P) Sealed 12V 1 c/o 7 amp octal base, **£1.00** (**£1.30** inc VAT & P) Sealed 12V 2 c/o 7 amp octal base **£1.25** (**£1.56** inc VAT & P) Sealed 12V 3 c/o 7 amp 11-pin **£1.35** (**£1.67** inc VAT & P) 24V Sealed 3 c/o 7 amp 11-pin **£1.35** (**£1.67** inc VAT & P) (amps = contact rating) P&P on any Relay 20p
Other types available — phone for details

## FT3



High intensity multi turn voltage neon glow discharge flash tube Design for ignition timing etc **£1.50** P&P 25p (**£1.89** inc VAT & P) 3 for **£3.00** P&P 50p(**£3.78** inc VAT & P)

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230 volts AC 3 digits mfg Veeder Root type LL/144L **£1.75** P&P 25p (**£2.16** inc VAT & P)
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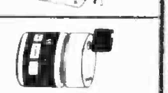
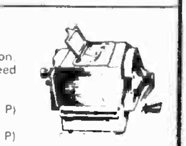
6 fig 24v d.c. resetable **£3.00** P&P 25p (**£3.51** inc VAT & P)

## BIG INCH



Tiny precision built 3 rpm USA motor size only 1 x 1 100 volt AC op supplied with resistor for 230 volt AC price **£2.37** p&p 20p 4 for **£5.40** post paid

## INSULATION TESTERS (NEW)



Test to I.E.E. spec Rugged metal construction suitable for bench or field work constant speed clutch Size L 8 in W 4 in H 6 in weight 6 lb
**500 VOLTS** 500 megohms **£40.00** Post 80p (**£44.06** inc VAT & P)
**1000 VOLTS** 1000 megohms **£46.00** Post 80p (**£50.54** inc VAT & P)
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## GEARED MOTORS

### 100 R.P.M. 115 lbs. ins.!!

115 lb ins 110 volt 50Hz 2.8 amp single phase split capacitor motor Immense power Continuously rated Totally enclosed Fan cooled In-line gearbox Length 250mm Dia 135mm Spindle Dia 15.5mm Length 145mm ex-equipment tested **£12.00** Post £1.50 (**£14.58** inc VAT & P) Suitable transformer 230/240 volt **£8.00** Post 75p (**£9.45** inc VAT & P)

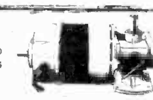
### 15 R.P.M.

Type SD48 15 r.p.m 80 lb ins input 100/120 volt A.C. Length incl gearbox 270mm Height 135mm Width 150mm Shaft drive 16mm Weight 8.5 Kilos BRAND NEW Price **£10.00** carr £1.00 (**£11.88** inc VAT & P)
Suitable transformer for use on 220/240 volt A.C. **£6.00** Post 50p (**£7.02** inc VAT & P)

## 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 This U.S.A. motor is offered in with transformer for 230/240v AC input Price type **£6.25** Post 75p (**£7.56** inc VAT & P), or less transformer **£3.75** Post 65p (**£4.75** inc VAT & P) (Type 3) 71 r.p.m 230 volt A.C. Continuously rated Non reversible **£6.50** Post 75p (**£7.83** inc VAT & P)

## FRACMO

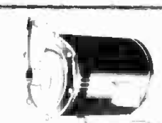


**5rpm 240V AC 50Hz 50lbs inch,** 0.7 amp sharplength 35mm dia 16mm weight 6 kilos 600 grams Price **£15.00** P&P £1.50 (**£17.82**).

## PARVALUX GEARED MOTOR

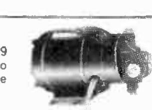
230/240V A.C. 30 rpm 50lbs inch Price **£15.00** P&P £1.50 (£17.82 inc VAT)

## A.E.G. WATER PUMP



200/240v a.c. motor 2850 rpm 480w approx 1/3 hp, driving a centrifugal pump with 1½" inlet and outlet delivering approx 40 galls per min at 10ft head Ideal for pumping or circulating any non corrosive light viscosity liquid Dozens of uses in industrial labs etc Note this pump is not self-priming Price **£15** + 75p P&P (**£17.01** inc VAT & P)

## CITENCO



FHP motor type C 7333/15 220/240v a.c. 19 rpm reversible motor, torque 14.5 kg Gear ratio 144:1 Brand new incl capacitor our price **£14.25** + £1.25 P&P (**£16.20** inc VAT & P)

## REVERSIBLE MOTOR 230V A.C.

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 (**£3.78** inc VAT & P)

## METERS 90mm Diameter

Type 65c5 D.C. Mc 0-2, 0-5, 0-20 0-50 0-100amps 0-15v d.c 0-30v d.c Type 62T2 A.C. M.I 0-1v 0-50amps 0-15v 0-300v Type 65L5 R/mc 0-300vc All at **£3.50** each P&P 50p (**£4.32** each inc VAT & P)

## 'VENNER TYPE' ERD TIME SWITCH

200/250V A.C. 2 on/2 off every 24 hrs at any manually pre-set time 36 hour spring reserve and day omitting device Built to highest Electricity Board specification Price **£7.50** P&P 75p (**£9.18**).

## SANGAMO WESTON TIME SWITCH

Type S251 200/250 V a.c. 2 on 2 off every 24 hours 20 amps contacts with override switch diameter 4" x 3" price **£6.00** P&P 50p (**£7.02** inc VAT & P) Also available with Solar dial

## A.E.G. TIME SWITCH

200/250V A.C. 1 on/1 off every 24 hrs 80 amps contacts (ideal storage heater), spring reserve Price **£10.00** P&P 50p (**£11.34**).

## A.C. MAINS TIMER UNIT

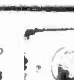
Based on an electric clock with 25 amp single-pole switch which can be preset for any period up to 12 hrs ahead to switch on for any length of time from 10 mins to 6 hrs then switch off An additional 60 min audible timer is also incorporated Ideal for Tape Recorders Lights Electric Blankets etc Attractive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

## 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 **£2.40** Post 20p (**£2.81** inc VAT & P) **50 WATT** 100, 500, 1k ohm **£2.90** Post 25p (**£3.40** inc VAT & P) **100 WATT** 1/5/10/25/50/100/250/500/1k/1.5k/2.5k/5k ohm **£4.90** Post 35p (**£5.67** inc VAT & P)
**Black Silver Skirted knob** calibrated in Nos 1-9 1½ in dia brass bush Ideal for above Rheostats **24p ea.**

## 600 WATT DIMMER SWITCH



Easily fitted Fully guaranteed by makers Will control up to 600w of lighting except fluorescent at mains voltage Complete with simple instructions **£3.95** Post 25p (**£4.53** inc VAT & P) 1000 watt model **£5.60** Post 25p (**£6.32** inc VAT & P) 2000 watt model **£9.75** Post 40p (**£10.96** inc VAT & P)

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A mains operated 4 + 4 stereo system. Rated one of the finest performers in the stereo field this would make a wonderful gift for almost any one in easy-to-assemble modular form and complete with a pair of Plessey speakers this should sell at about £30 — but due to a special bulk buy and as an incentive for you to buy this month we offer the system complete at only **£14** including VAT and postage.

## ROOM THERMOSTAT

Famous Satchwell, elegant design, intended for wall mounting. Will switch up to 20 amps at mains voltage, covers the range 0 30 C. Special snip this month **£3.00**, post and VAT paid.

## WINDSCREEN WIPER CONTROL

Vary speed of your wiper to suit conditions. All parts and instructions to make **£3.75** post and VAT paid.

## MICRO SWITCH BARGAINS

Rated at 5 amps 250V, ideal to make a switch panel for a calculator and for dozens of other applications. Parcel of 10 for **£1** VAT and post paid

## RADIO STETHOSCOPE

Easiest way to fault find, traces signal from aerial to speaker when signal stops you've found the fault. Use it on Radio, TV, amplifier, anything. Kit comprises transistors and parts including probe tube, twin stetho-set. **£3.95** VAT and postage incl.

## MULTISPEED MOTORS

Six speeds are available 500, 850 and 1,100 r.p.m. and 7,000, 9,000 and 11,000 r.p.m. Shaft is ¾ in diameter and approximately 1 in long. 230/240V. Its speed may be further controlled with the use of our Thyristor controller. Very powerful and useful motor size approx 2 in dia × 5 in. long. Price **£2** including post and VAT

## RECTANGULAR HOT PLATE

Aluminium panel with ridged top and angled underneath to strengthen it. This is approx. 10" × 4½" of flat plate. Beneath this is a 100w element and sensor switch which will maintain the surface of the plate just too hot to touch. With leads and tags. This is ideal if you are making up a food warmer or for an airing cupboard, etc. **Price £1.03.**

## HUMIDITY SWITCH

American made by Ranco, their type No. J11. The action of this device depends upon the dampness causing a membrane to stretch and trigger a sensitive microswitch adjustable by a screw, quite sensitive — breathing on it for instance will switch it on. Micro 3 amp at 250V a.c. Overall size of the device approx 3⅝in long, 1in. wide and 1⅛in. deep **75p.**

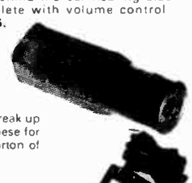
## MAINS RELAYS

With triple 10 amp changeover contacts — operating coil wound for 230V a.c. Chassis mounting one screw fixing, ex unused equipment **80p** each, post and VAT paid.

## MICRO AMPLIFIER

Ex behind the ear hearing aids complete with volume control **£2.16.**

## MERCURY BATTERIES



Bank of 7 Mercury cells type 625 which are approx ⅝in. diameter by ⅞in thick in plastic tube giving a total of 10.7V

Being in a plastic tube it is very easy to break up the battery into separate cells and use these for radio control and similar equipment. Carton of 25 batteries **£1.60.**

## PP3/PP9 REPLACEMENT

Japanese made in plastic container with leads size 2in. × 1½in × 1½in., this is ideal to power a calculator or radio, it has a full wave rectifier and smoothed output of 9V suitable for loading of up to 100mA. **£2.53.**

## SWITCH TRIGGER MATS

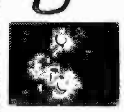
So thin is undetactable under carpet but will switch on with slightest pressure. For burglar alarms, shop doors, etc 24in × 18in. **£2.33.** Post and VAT 60p. 13in × 10in **£1.85.** Post and VAT 50p

## MAINS TRANSISTOR PACK

Designed to operate transistor sets and amplifiers. Adjustable output 6V, 9V, 12V for up to 500mA (class D working). Takes the place of any of the following batteries PP1, PP3, PP4, PP6, PP7, PP9 and others. Kit comprises main transformer rectifier, smoothing and load resistor condensers and instructions. Real snip at only **£1.50.** VAT and postage 50p


## DRILL CONTROLLER

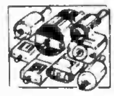
Electronically changes speed from approximately 10 revs to maximum. Full power at all speeds by finger-tip control. Kit includes all parts, case, everything and full instructions. **£3.45** including post and VAT. Made-up model **£1** extra.



## SOUND TO LIGHT UNIT

Add colour or white light to your amplifier. Will operate 1, 2 or 3 lamps (maximum 450W). Unit in box all ready to work. **£7.95** plus 95p VAT and postage

## 8 POWERFUL BATTERY MOTORS



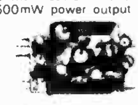
For models, Meccanos, drills, remote control planes, boats, etc. **£2.**

## ROTARY PUMP

Self priming portable, fits drill or electric motor, pumps up to 200 gallons per hour depending upon revs. Virtually uncorrodable, use to suck water, oil, petrol, fertiliser, chemicals, anything liquid. Hose connectors each end. **£2** post paid

## MULLARD AUDIO AMPLIFIERS

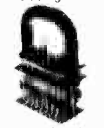
All in module form, each ready built complete with heat sinks and connection tags, data supplied. Model 1153 500mW power output **£1.50** including post & VAT.



Model 1172 1W, power output **£1.85** including post & VAT.
Model EP9000 4 watt power output **£2.90** including post & VAT. EP 9001 twin channel or stereo pre-amp **£2.90** including post & VAT

## SHORTWAVE CRYSTAL SET

Although this uses no battery it gives really amazing results. You will receive an amazing assortment of stations over the 19, 25, 29, 31 metre bands. Kit contains chassis, front panel and all the parts **£1.90** — crystal earphone **55p,** including VAT and postage

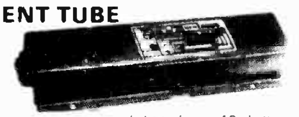


## BREAKDOWN PARCEL

Breakdown Parcel — four unused, made for compution units containing most useful computers and these computers unlike those from most computer panels, have wire end and usable length. The transistors for instance have leads over 1in. long — the diodes have ½in leads.

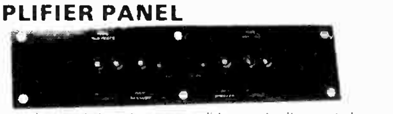
List of major components is as follows. 17 assorted transistors, 38 assorted diodes, 60 assorted resistors and condensers, 4 gold plated plugs in units which can serve as multipin plugs or as hook up boards for experimental or quickly changed circuits (note we can supply the socket boards which were made to receive these units). The price of this four units parcel is **£1** including VAT and post (considerably less than value of the transistor or diodes alone). DON'T MISS THIS SPLENDID OFFER

## FLUORESCENT TUBE INVERTOR

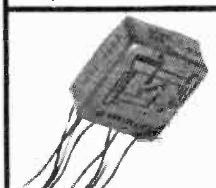


For camping — car repairing — emergency lighting from a 12v battery you can't beat fluorescent lighting, it will offer plenty of well distributed light and is economical. We offer invertor for 21" and 13 watt miniature tube for only **£3.75** with tube and tube holders as well

## AMPLIFIER PANEL



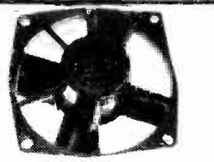
6 photo sockets and d.p. changeover slide switch all mounted on insulating board. Glossy black finish size 2" × 8¼" approx — silly price **35p,** or **£1** for six



## THIS MONTH'S SNIP

**Is a miniature sealed relay 12v dc operated with two sets of changeover contacts. The unique feature of this relay is its heavy lead out wires. These provide adequate support and therefore the relay needs no fixing. On the other hand there is a fixing bolt through one side so if you wish you can fix the relay and use its very strong lead outs to secure circuit components — an expensive relay, we are offering them at only 87p each.**

Don't miss this exceptional bargain.

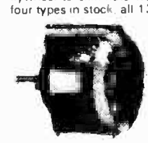


## EXTRACTOR FAN

Ex-computers made by Woods of Colchester, ideal for fixing through panel — reasonably quiet running — very powerful 2500 rpm. Choice of two sizes 5" or 6½" dia **£5** and **£6.**

## PAPST MOTORS

West German make these fine motors are noted for their performance and reliability. Special features are the rotating heavy outer which acts as a flywheel to eliminate wow and flutter and switchable reversing. We have four types in stock, all 1350 revs, including starting capacitor.



(1) Ref. No KLZ 20.50-4, 230 volts 50HZ. **£6.30.**
(2) Ref. No KLZ 32.50-4, 230 volts 50HZ **£7.28.**
(3) Ref same as above, 115 volts 50HZ **£3.30.**
(4) Ref same as above, 110 volts 60HZ **£3.30.**

## SPIT MOTOR WITH CARTER GEAR BOX

Probably one of the best spit motors made. Originally intended to be used in very high priced cookers, however this can be put to plenty of other uses for instance your garden barbeque or to drive a tumbler for stone polishing, in fact there are no ends to its uses. Normal mains operation, **£4.32** including post & VAT

## LATCHING RELAY

by Guardian Electric, mains operated it is in fact two relays mounted on a metal base plate. The relays being mounted in such a way to ensure that when one closes the other opens and vice versa thus when closed relay A would remain locked until manually released or electrically released by energising relay B. Each relay has 2 sets of 10 amp changeover contacts. Should be ideal for burglar alarms and similar applications **£2.11.**

## HONEYWELL P.B. MICROSWITCH

1-2 or 3 10 amp 250V change over microswitch thro panel mounting by lock nuts 1" dia black knob 1 switch **40p,** 2 switch **55p,** 3 switch **70p.**

## TERMS

Cash with order — delivery same day as order received. Prices include VAT and carriage unless stated but orders under £6 must add 50p to off-set packing, etc
BULK ENQUIRIES WELCOMED

# J. BULL (ELECTRICAL) LTD.
**(Dept. WW)**
**103 TAMWORTH ROAD**
**CROYDON CR9 1SG**

# IT'S FREE!

**Our monthly Advance Advertising Bargains List gives details of bargains arriving or just arrived — often bargains which sell out before our advertisement can appear. — It's an interesting list and it's free — just send S.A.E. Below are a few of the Bargains still available from previous lists.**

**FM Tuner and decoder,** 2 very well made (Japan) units, nice clear dial, excellent reproduction **£9.95** the pair £1.25 VAT
**12 Volt Heavy Duty Relay,** plug in type has three pairs of 10 amp changeover contacts. A transparent dust cover, price **£1** + 8p, suitable 11 pin base **27p** + 2p
**4 Changeover Mains Relay,** upright mounting with perspex type dust cover, the really interesting feature, is 4 sets of 10 amps changeover contacts, price **£1.62** + 12p.
**12 Volt Pump.** Designed we believe as a bilge pump this is 12 volt AC/DC motor coupled by a long enclosed shaft to a submersible pump. Suitable for water or most any fluids. Price **£1.70.** Post 80p
**Just arrived.** Fruit machines, working order, very impressive choice of several but very heavy so you must collect. **£50.**
**High Load 24 Hour Clock Switch,** made by the famous AEG Company for normal mains but with clockwork reserve has load capacity of 80 amps at 240V 50HZ. Therefore suitable for dealing with large loads of say shop lighting, water heating, storage heaters etc. etc. Has triggers for on and off once per 24 hours but extra triggers will be available. Price **£1.50** per pair. Size of clock approximately 8" × 5" × 5", totally encased but has lift up flap for ease of altering switching times. Price, new and unused **£10.65** or used but guaranteed o.k. **£6.50.**
**Enclosed 24 Hour Clock,** with contacts for breaking 10-12 amps at 240 volts. This one has two sets of on/off per 24 hours, price **£7.00**
**Smiths 24 hr. Timers-Heart only,** with over-ride similar to those used in the auto set etc. **£4.75** + 38p.
**Ditto** but in grey plastic wall mounting case, with leads ready for attaching to plug and socket, price **£6.98.**
**Light Dimmer,** our timer module with small mods makes an excellent light dimmer. Contains a 4 amp 400V SCR so it should be suitable for loads approaching 1KW. Price of module with variable resistor and instructions **£2.25.**
**Push Pull Solenoids,** mains operated solenoids which will push as well as or instead of pull. Very heavy duty, estimate this at 20lbs push or pull. 1¾ × 3⅛ × 4" made Magnetic Devices Co. **£7.50.**
**Flashing Lights,** chasing lights, random flashes, strobe effects etc. can easily be achieved using our disco switches and with Christmas just around the corner you can do something special for your home or business. These switches are offered at approximately one-fifth of their proper price, are ex-equipment but guaranteed perfect and supplied with an adaptor suitable for mains working. To get some idea of the loading number, each switch is 10 amp which is approx 2½kw so the 6 switch model could handle over 12kw's. For the light pipe or Catherine Wheel effect we suggest 12 switch model, interconnecting the switches to give fastest speed. 6 Switch model **£5.** 9 Switch Model **£9.75.** 12 Switch model **£6.20.** Also adds 50p post per switch. If you want the light pipe diagram please request this.
**Always in Stock.** Turntables with pick up lift, ideal for disco's at **£11.95,** post £2.25. We are also expecting some professional belt drive type at £25. Call or ring us for more information.
**Reed Switches,** standard 60 watt glass type. Normal open contacts glass lengths 2" diameter 3/16". 10 for **£1** + 8p, 100 for **£8** + 64p, 1000 for **£65** + £5.20
**Flat Reed Switches,** for stacking, greater quantity in confined space. Price **50p** each + 4p.
**Single Ended Types** for jobs where it is not easy to bring a lead to each end **75p** each. All these switches are normally open but can be biased to a normally closed position by fitting a magnet adjacent. The reed switch would then be opened by a magnet of opposite polarity being bought up to it.
**Ceramic Magnets** suitable for operating reed switches, central fixing hole. 10 for **£1.**
**Music Centre Transformer** 12-0-12 at 1 amp and 9 volt at ½ amp. Normal primary, uprighting, impregnated and varnished for quiet operation. Price **£2.95.** Post 54p.
**'W' Shaped Fluorescent Tubes** for porch light, box signs or where you want light evenly spaced over a confined area of approx 10" × 10", 30 watts, made by Philips price **£1.60.** Post 54p
**Plinth for BSR Record Player** still available at the record price of **95p** + 12p. This is excellent value but unfortunately being a bulky and delicate item the postage has to be **£1.50** + 12p so this is obviously only a bargain for callers.
2) A similar model also available at the same price, this is somewhat larger and has a cut out for an amplifier.
**Our Smokey Cover** can be used with the above plinths, four small locating pins are fitted to the motor board. Size approx 12½" × 14½", price **£2.50** + 32p. Post £2.00 + 16p
**Extension Speakers** 8 ohm 4-5 watts handling power. We have 5 or 6 different models in stock, cheapest being the Partytime at **£3.95** each, again only really a bargain for callers as postage is **£1.50** per speaker.
**T.V. Monitors,** an item for callers, believed to be in good working order, switchable thro' 405-525 & 625, 21" tube line systems, normal controls, volume, brightness, contrast, width etc. Price **£16.20,** 12" model **£18,** suitable for conversion into special purpose scope, etc.
**Auto Transformers** for working American tools and equipment completely enclosed in sheet metal case with American type flat output socket made for computer so obviously first class. 500 watts. With carrying handle, offered at about half price only **£15** + 80p, carriage £2 + 16p. These may be a bit soiled but are fully guaranteed. Similar but 1000 watt **£29.50** or **£6.48.** Post £1.62
**Car Starter Charger Kit.** New version. We supply two 10 amp rectifiers, 250V transformer and the start charge switch with instructions, price **£7.50** + 60p. Post £1.50p + 12p. This is probably one of the most useful pieces of equipment you can have in your garage. Sooner or later you or someone will leave something on and you will have a flat battery, this starter will get you away usually in less than 5 minutes.
**Resettable Counter** by Veederoot Company, 230/240V mains operated. Intended for surface mounting has a fixing flange at the bottom. Price **£2.16.**
**12V Drip proof Relay.** Specially designed for going under the bonnet of a car, made by one of our big manufacturers, this really has a removable semi hard rubber cover. Contacts look suitable for up to 10 amps so this could be the right one if you are thinking about making an anti-thief device. Price **£1** + 8p.
**High Speed Uniselector.** As many customers know, we have a very comprehensive stock of uniselectors as used in automatic telephone exchanges, light flashing device etc. etc. Just arrived, however, is a high speed model made by famous Plessey, this is 2 pole 32 way with make before break wipers, overall size approx 4" × 3" × 2½" price **£3.50** + 28p. Post 40p + 4p.
**Air Compressor,** with 'V' belt drive pulley, drive this by ½ h.p. motor and you have a compressor suitable for spraying, tyre pumping etc. etc. Price **£8.64** + 64p. Post £2.16
**Pneumatic Ram** for lifting, thrusting, pulling etc. etc. has 2¼" travel, looks large enough to open doors, lift, staircase, ventilators etc. Price **£7.00.** Post 80p
**3kw Tangential Heaters,** standard model with elements suitable for 1, 2 or 3kw and with safety thermostat to cut off heating if air flow is impeded. Metal impeller **£5.95.** Post £1.50
**Wall Mounting Thermostats,** by Satchwell, modern designed white, will switch to 20 amps at mains voltage, covers range 0-30c. Price **£3.**
**Solder Gun Bargain.** The ETP, this is 100 watt solder gun, a very well made tool with lamp to illuminate work, has double insulated mains transformer and is built into the shockproof thermoplastic case. Comes complete with spare tips. Mains operated of course. Price **£3.50.** Post £1.08
**Interested in Tape Control.** American made tape punches, really beautiful units full of sophisticated parts, designed we believe to automatically operate typewriters, and they can of course be used to operate other punch tape controlled machines. Reference number is NCR Class 461-2 reference 205 H8 R56. We believe these are 8 bit paper tape punches, powered from 115V 50HZ in very good condition with tape **£16.00,** carriage is £3.20
**Memories.** The memory units which work with these tape punches, again by N.C.R. are in very good condition and we believe in working order. Price and details on request.
**Tangential Blowers.** 12" long with powerful induction motor ideal for blowing heaters or general air extraction or circulation, offered at low price of **£2.70.** The motors are 110V so you will have to work them in pairs or through a dropper or mains transformer. Post £1.08 for one or two.
**Digital Panel** made for the G.P.O. for incorporation, we understand, in push button dialling units, this has the usual 10 digits, each of which when depressed operated a two pole changeover switch. Really beautifully made size approximately 4" square. Price **£3.78.**

# WERSI

## Tomorrow's Electronic Organ Kit is Here

GALAXY
The Flagship of the WERSI range of Organs

**POSSIBLY A NEW NAME TO YOU, BUT KNOWN IN OVER 25 COUNTRIES FOR THE SUPERIOR INSTRUMENTS WHICH THIS GERMAN COMPANY PRODUCE.**

- USED BY WEST GERMAN BROADCASTING SERVICE
- PLAYED BY KLAUS WUNDERLICH AND OTHER FAMOUS ORGANISTS

WERSI is the first kit producing company applying the latest achievements of the space age technology.

This has decisive effects on the technical and musical quality of WERSI's electronic organs for the do-it-yourselfer.

The application of modern integrated circuits, so-called IC's, simplifies the organ construction considerably. A single IC may replace up to 10,000 conventional electronic components.

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WERSI, however, went a step farther yet. IC's which were not available on the open market were developed for specific purposes by WERSI engineering. They are being produced by the most highly reputed IC manufacturers in the world. The result: economical electronic organs with the most up-to-date techniques and unsurpassed musical capabilities.

Without doubt, the most comprehensive kits and the most up-to-date designs available today. Just consider a few of the features

- Precision Master Generator, using MOS-LSI.
- Integrated electronic keying in $I^2L$ technology
- Unique — All switch functions are programmable.
- Even the smallest organ has drawbars in addition to fixed stops.
- Craftsman-made cabinets available in 5 veneers.
- Ready-made wiring harnesses eliminate errors.

**Send now for the 104 page full colour catalogue and 16 page price list describing the 8 organs in the range, together with the complementary kits which WERSI produce.**

To: AURA Sounds, W1, Copthorne Bank, Crawley, West Sussex
I enclose £2.00, refundable against my first order to the value £25, please send the Wersi Catalogue and price list.

**NAME** ........................................

**ADDRESS** ........................................

........................................

# TRUE PROFESSIONALS

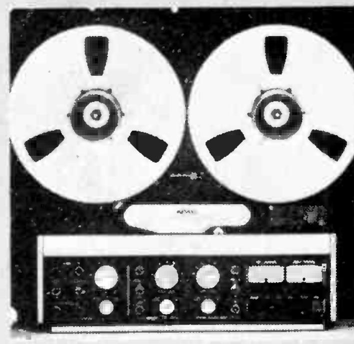
Including: EMI, Decca (UK), BBC, Pink Floyd, Hawker Sidley, Metropolitan Police, The Who, Queen, Thames TV, ITN, Capital Radio, Decca (France), Ministry of Defence, Birds Eye, Rolls Royce, Crown Agents, Madame Tussaud's, Island Music, Chappells, Dick James Music, Neve, Alice, Israel Defence Ministry, Yes Music, University of Bucharest, Pye TVT, Avon Health Authority, Government of Seychelles, Philippines Radio, London Broadcasting, Rolling Stones, Thin Lizzie, British Railways, Natural History Museum, Virgin Records, Kirilo Savic Institute of Belgrade, all British Universities, London Weekend TV, BOC, Wings, IBM, every Local Radio Station, Post Office Research, Rank Organisation, and many others.

# ACKNOWLEDGE

That ITA has more to offer:

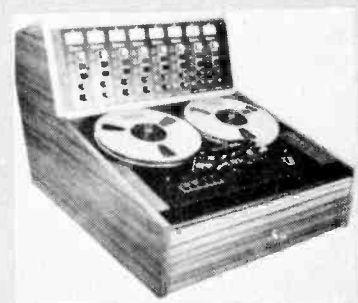
- **Location.** In Central London - easy parking.
- **Delivery.** Large stockholding covering 500 versions for immediate delivery.
- **Servicing** By Revox factory trained staff. Quickest turnaround time. Machines supplied or rebuilt for special requirements.
- **Pricing.** Check our prices - you will find them lowest ALWAYS.

# ITA's ADVANTAGES



*REVOX*
*A wide range of two channel recorders from this famous manufacturer, with tape speeds from 15/16 ips to 30 ips. Options include variable speed and sel-sync. Models include A77, B77 and 3.77 with 3 speeds and editing (designed and modified by ITA specifically for professional applications).*

*TEAC*
*Recorders for logging and studio use — tape speeds from 1⅞ to 15 ips. 2, 4 or 8 channel. A range of mixers is also available.*



*ITAM*
*4 and 8 channel recorders for studio use. Any tape speed from 1⅞ ips for logging and data recording.*

*OTARI*
*Duplicating equipment for high speed cassette copying, including the DP4050 model — the world's finest in-cassette copier, with 6 slave units*

ITA

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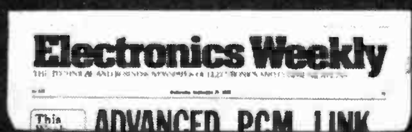
# or this

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# TRANSFORMERS

## ALL EX-STOCK — SAME-DAY DESPATCH

VAT 8%

### MAINS ISOLATING

PRI 120/240V SEC 120/240V
Centre Tapped and Screened

| Ref. | VA (Watts) | £ | P&P |
|---|---|---|---|
| 07★ | 20 | **4.40** | 79 |
| 149 | 60 | **6.20** | 96 |
| 150 | 100 | **7.13** | 1.14 |
| 151 | 200 | **11.16** | 1.50 |
| 152 | 250 | **12.79** | 1.84 |
| 153 | 350 | **16.28** | 1.84 |
| 154 | 500 | **19.15** | 2.15 |
| 155 | 750 | **29.06** | OA |
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★115 or 240 sec only

### 12 and/or 24-VOLT

Separate 12v windings Pri 220-240 Volts

| Ref | Amps 12v | Amps 24v | £ | P&P |
|---|---|---|---|---|
| 111 | 0.5 | 0.25 | **2.20** | 45 |
| 213 | 1.0 | 0.5 | **2.64** | 78 |
| 71 | 2 | 1 | **3.41** | 78 |
| 18 | 4 | 2 | **4.03** | 96 |
| 70 | 6 | 3 | **5.35** | 96 |
| 108 | 8 | 4 | **6.98** | 1.14 |
| 72 | 10 | 5 | **7.67** | 1.14 |
| 116 | 12 | 6 | **8.99** | 1.32 |
| 17 | 16 | 8 | **10.39** | 1.32 |
| 115 | 20 | 10 | **13.18** | 2.08 |
| 187 | 30 | 15 | **17.05** | 2.08 |
| 226 | 60 | 30 | **26.82** | OA |

### 50 VOLT RANGE

Primary 220-240V
SEC. TAPS 0-20-25-33-40-50V
VOLTAGES AVAILABLE
5, 7, 8, 10, 13, 15, 17, 20, 33, 40, 50V
25-0-25 or 20-0-20

| Ref. | Amps | £ | P&P |
|---|---|---|---|
| 102 | 0.5 | **3.41** | 78 |
| 103 | 1.0 | **4.57** | 96 |
| 104 | 2.0 | **6.98** | 1.14 |
| 105 | 3.0 | **8.45** | 1.32 |
| 106 | 4.0 | **10.70** | 1.50 |
| 107 | 6.0 | **14.62** | 1.64 |
| 118 | 8.0 | **17.05** | 2.08 |
| 119 | 10.0 | **21.70** | OA |

### 30 VOLT RANGE

Primary 220-240v
SEC. TAPS 0-12-15-20-24-30V
VOLTAGES AVAILABLE
3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 20, 24, 30V or
12-0-12 or 15-0-15V

| Ref. | Amps | £ | P&P |
|---|---|---|---|
| 112 | 0.5 | **2.64** | 78 |
| 79 | 1.0 | **3.57** | 96 |
| 3 | 2.0 | **5.27** | 96 |
| 20 | 3.0 | **6.20** | 1.14 |
| 21 | 4.0 | **7.44** | 1.14 |
| 51 | 5.0 | **8.37** | 1.32 |
| 117 | 6.0 | **9.92** | 1.45 |
| 88 | 8.0 | **11.73** | 1.64 |
| 89 | 10.0 | **13.33** | 1.84 |

### 60 VOLT RANGE

Primary 220-240V
SEC TAPS 0-24-30-40-48-60V
VOLTAGES AVAILABLE
6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60V or 24-0-24V or 30-0-30V

| Ref. | Amps | £ | P&P |
|---|---|---|---|
| 124 | 0.5 | **3.88** | 96 |
| 126 | 1.0 | **5.58** | 96 |
| 127 | 2.0 | **7.60** | 1.14 |
| 125 | 3.0 | **10.54** | 1.32 |
| 123 | 4.0 | **12.23** | 1.84 |
| 40 | 5.0 | **13.95** | 1.64 |
| 120 | 6.0 | **15.66** | 1.84 |
| 121 | 8.0 | **20.15** | OA |
| 122 | 10.0 | **24.03** | OA |
| 189 | 12.0 | **27.13** | OA |

### AUTO TRANSFORMERS

| Ref. | VA (Watts) | TAPS | £ | P&P |
|---|---|---|---|---|
| 113 | 15 | 0-115-210-240v | **2.48** | 71 |
| 64 | 75 | 0-115-210-240v | **3.95** | 96 |
| 4 | 150 | 0-115-200-220-240v | **5.35** | 96 |
| 66 | 300 | „ „ | **7.75** | 1.14 |
| 67 | 500 | „ „ | **10.99** | 1.64 |
| 84 | 1000 | „ „ | **18.76** | 2.08 |
| 93 | 1500 | „ „ | **23.36** | OA |
| 95 | 2000 | „ „ | **34.82** | OA |
| 73 | 3000 | „ „ | **48.00** | OA |

### HIGH VOLTAGE

MAINS ISOLATING
Pri 200/220 or 400/440
Sec 100/120 or 200/240

| VA | Ref. | £ | P&P |
|---|---|---|---|
| 60 | 243 | **5.89** | 1.32 |
| 350 | 247 | **14.11** | 1.84 |
| 1000 | 250 | **35.65** | OA |
| 2000 | 252 | **54.25** | OA |

### SCREENED MINIATURES Primary 240v

| Ref. | mA | Volts | £ | P&P |
|---|---|---|---|---|
| 238 | 200 | 3-0-3 | **1.99** | 55 |
| 212 | 1A, 1A | 0-6, 0-6 | **2.85** | 78 |
| 13 | 100 | 9-0-9 | **2.14** | 38 |
| 235 | 330, 330 | 0-9, 0-9 | **1.99** | 38 |
| 207 | 500, 500 | 0-8-9, 0-8-9 | **2.59** | 71 |
| 208 | 1A, 1A | 0-8-9, 0-8-9 | **3.53** | 78 |
| 236 | 200, 200 | 0-15, 0-15 | **1.99** | 38 |
| 239 | 50MA | 12-0-12 | **1.99** | 38 |
| 214 | 300, 300 | 0-20, 0-20 | **2.56** | 78 |
| 221 | 700 (DC) | 20-12-0-12-20 | **3.41** | 78 |
| 206 | 1A, 1A | 0-15-20, 0-15-20 | **4.63** | 96 |
| 203 | 500, 500 | 0-15-27, 0-15-27 | **3.99** | 96 |
| 204 | 1A, 1A | 0-15-27, 0-15-27 | **5.39** | 96 |
| S112 | 500 | 0-12-15-20-24-30 | **2.64** | 78 |

### BRIDGE RECTIFIERS

| | | |
|---|---|---|
| 200v | 2A | **45p** |
| 400v | 2A | **55p** |
| 200v | 4A | **65p** |
| 400v | 4A | **80p** |
| 400v | 6A | **£1.05** |
| 500v | 10A★ | **£2.35** |

★P&P 29p VAT 12½%
★VAT 8%

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240V cable input
USA 2-pin outlets 115V

| | | P&P | Ref. |
|---|---|---|---|
| 15VA | £4.96 | 96 | 113W |
| 75VA | £6.03 | 1.14 | 64W |
| 150VA | £8.48 | 1.14 | 4W |
| 200VA | £9.92 | 1.45 | 65W |
| 350VA | £12.53 | 1.64 | 53W |
| 500VA | £15.73 | 1.64 | 67W |
| 750VA | £18.55 | 1.76 | 83W |
| 1000VA | £22.68 | OA | 84W |
| 1500VA | £26.02 | OA | 93W |
| 2000VA | £37.65 | OA | 95W |

### METERS

| | |
|---|---|
| AVO8 Mk. 5 | **£71.00** |
| AVO71 | **£29.00** |
| AVO73 | **£39.10** |
| AVOMM5 MINOR | **£24.00** |
| WEE MEGGER | **£58.80** |
| AVO TT169 in-circuits transistor tester | **£30.00** |
| U4315 budget meter (42 ranges) 20Km/VDC 1000V AC/DC (9 ranges) 2.5A AC/DC 500Km resistance, in robust steel case with leads and full instructions | **£14.95** |

Avo Cases and Accessories ex-stock
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| 10 watt RMS Amplifier | **£3.66** |
| 35 watt RMS Amplifier | **£6.95** |
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| Pre-Amp for 25w | **£13.88** |
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| Power Supplies for 25w | **£3.75** |
| Transformer for 10w | **£3.09** |
| Transformer for 25w (one module) | **£4.79** |

P&P Modules **35p.** Trans. **96p**
VAT 12½% *VAT 8%

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Complete chassis, inc. 7+7w r.m.s. amps, pre-amp, power supply, front panel, knobs (needs mains trans.), **£19.05.** Mains trans **£3.57.** Teak veneered cab. **£5.25.** P&P £1.02. VAT 12½%

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AC/DC-1000Ω/V
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High quality, high performance Plug-in oscilloscope of compact design with dual trace and delay time base modes.

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**NEW LIST PRICE £260.00 £155.00**

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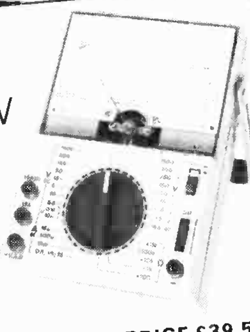

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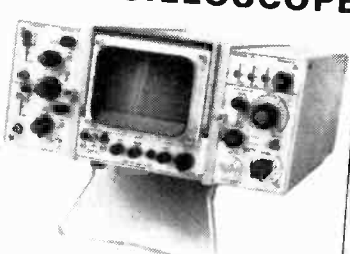

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**FREQ.:** 1-30MHz.
**TUNING:** Effective scale length of 145 feet i.e. 6" corresponding to 100KHz.
**CALIBRATION:** 100KHz signal derived from 1MHz Xtal oscillator accuracy 5 parts in $10^6$ provides check points at 100KHz intervals.
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SENSITIVITY 25mV typically 15mV-5Hz to 80MHz
Autoranging. 6 digit LED display. 10:1 attenuator

**LIST PRICE £199.00**

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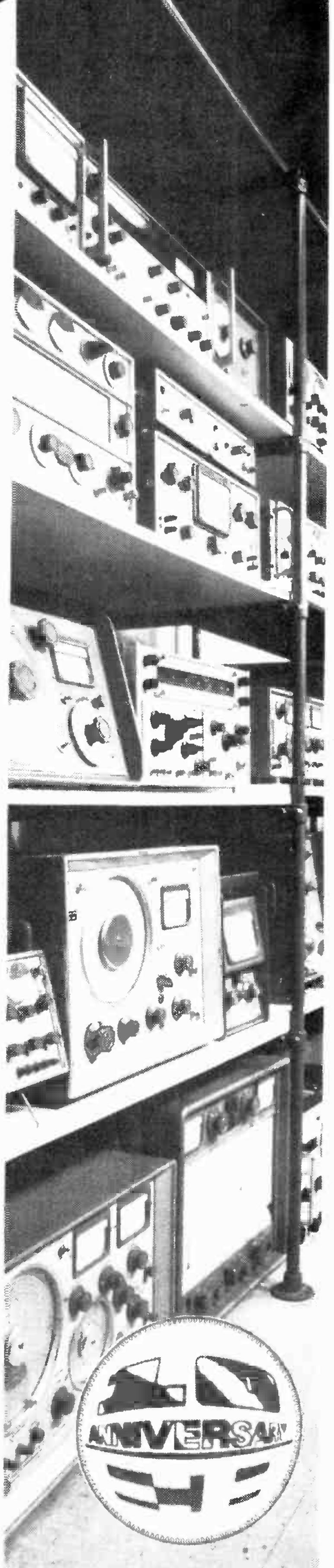


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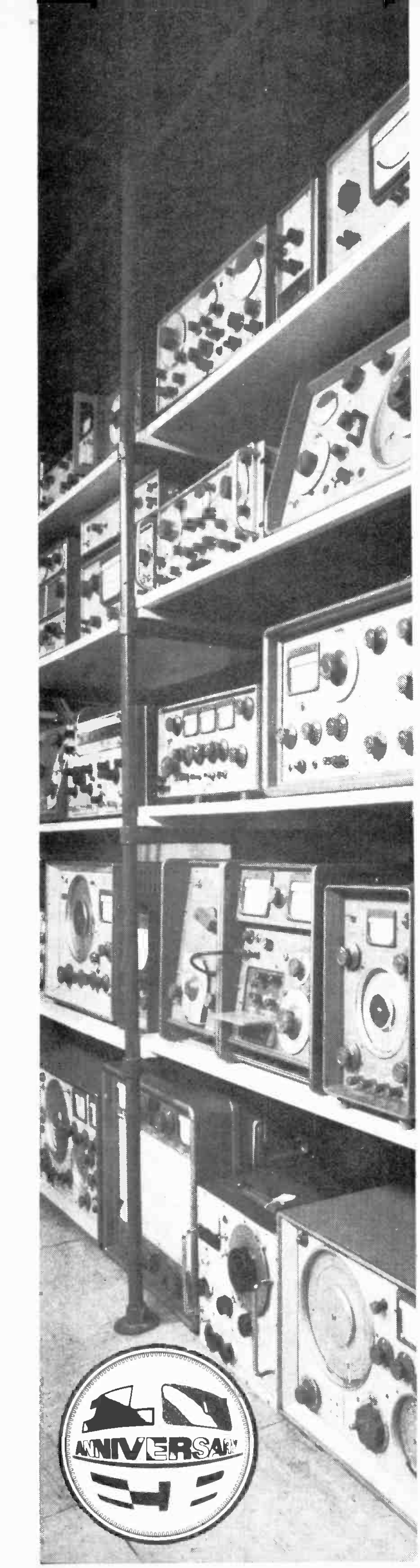

# Electronic
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## SIGNAL SOURCES

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Signal Generator J4. 10Hz-100KHz 600 ohms impedance. Sine & Square Brand new condition **£135.00**
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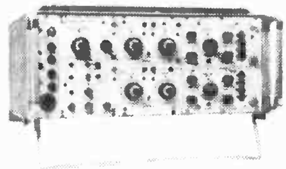

Type PG59 Pulse Generator 2 Channel, double pulse. Functions. Frequency, Width, Rise & Fall Time, Amplitude, Offset, Delay, Prepulse & Gate. Repetition Freq. 1Hz to 10MHz (20 MHz in double pulse mode). Delay & Width 25 nsecs/1sec. Full specification on request **£595.00**
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SG68A Low Distortion Oscillator. 1.5Hz-150KHz c/w BE2 battery pack. New condition **£200.00**

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10515A Frequency Doubler **£75.00**
F.M./A.M. Signal Generator 202H. F.M. A.M. C.W. & pulse coverage 54 to 216 MHz R.F. o/p 0.1µV-0.2V 50ohms Impedance **£495.00**
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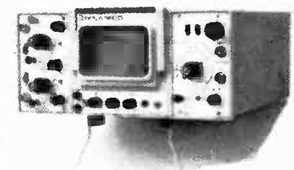

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**PROBES**
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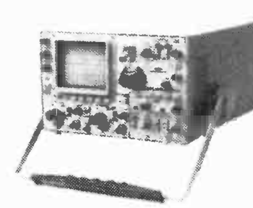
**TEKTRONIX**
DC30MHz Oscilloscope 545A c/w CA & L Plug-ins **£445.00**



Type 485 350MHz Portable, Dual Trace. 5mV/div. 1nsec/div sweep rate. Delayed sweep. Auto focus, variable trigger hold off 50 ohms internal input protection **£3,250.00**
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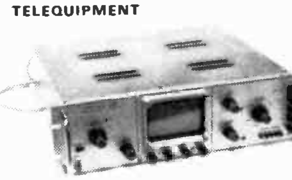
**TELEQUIPMENT**



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Modulation Meter 409 **£295.00**
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Timer Counter TC22 Measures — Frequency DC — 100MHz. 6 digit. Time, period, period average, count, totalise, pulse width, ratio **£300.00**
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R.F. Voltmeter 91 C Measurement range 1mV to 3V. Frequency range 20 KHz to 1200 MHz (with 'T' Adaptor supplied). Supplies also with R.F. probe and tip and 50Ω termination. Weight 12 lbs. **£455**

**BRUEL & KJOER**
Heterodyne Voltmeter 2006 For measurements of voltage, frequency and modulation factor AM and FM. High impedance FET probe 50Ω termination and 60 dB attenuator included. Sensitivity 50ΩV — 50V F.S.D. 100 KHz to 230 MHz. Built in reference voltage and loudspeaker for identification **£295**
Electronic Voltmeter 2409 True R.M.S. Average and Peak 2Hz to 200KHz. Sensitivity 10mV — 1kV **£250**

**FLUKE**
DC Differential Voltmeter 891A. Input ranges, 1, 10, 100, 1000V, DC with 10% overanging. Infinite input resistance 0.1100V. Absolute accuracy± 0.01% of input. 1 mV full scale Null Sensitivity. Resolution 1 ppm of range **£395**

**GENERAL RADIO**
Electronic Voltmeter 1806A AC DC 9 Resistance ± 2% accuracy Wide frequency range — up to 1500 MHz **£175**

**HEWLETT PACKARD**
R.F. Voltmeter 3406A 20µV sensitivity — average response. 1 mV sensitivity. 1 mV — 3V F.S. 8 ranges. 10KHz — 1.2 GHz **£485**

**RHODE & SCHWARZ**
Selective Microvoltmeter USVH BN 1521. 10 KHz — 30 MHz. 0.2 V — IV. F.s.d. of lowest range 1 V **£675**

## MISCELLANEOUS

**ADVANCE**
Digital Panel Meters DPM 102, 103, 112P, 201, 204, 301, 302, 303, 306, 343 **Price and specs. on application**

**ADVANCE/HOUSTON**
Omnigraphic Recorder 6520. Strip Chart XY Recorder. Chart Speeds 2''/sec to 0.05''/hour. Amplitude accuracy 0.15% F.S. Repeatability 0.1% 8½'' x 11'' record **£625.00**

**BIRD**
Coaxial Resistor 8053 10W RF coaxial load resistor **£20.00**
Wattmeter Termaline 6835 3 ranges 0-120 / 0-600 / 0-1200W 30-500MHz **£425.00**
Wattmeter Termaline 67 3 ranges 0-25 / 0-100 / 0-500W / 30-500MHz **£265.00**

**BRUEL & KJAER**
Random Noise Generator 1402 **£250.00**
Automatic Vibration Exciter 1018 **£495.00**

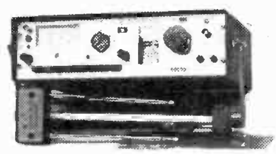
**CAMBRIDGE**
AC/DC Resistance Box, 5 decade **£70.00**

**GENERAL RADIO**
Standard Frequency Multiplier 1112A **Price & specs. on application**
Standard Frequency Multiplier 1112B **Price & specs. on application**

**MARCONI INSTRUMENTS**
R.F. Power Meter TF1152/1 **£75.00**
R.F. Power Meter TF1152A/1 **£80.00**
Coqr Gain and Delay Test Set TF2904 625 line **£505.00**
R.F. Power Meter TF2502 3 and 10 watt ranges DC-1GHz **£355.00**
L.F. Extension Unit TM6448 for use with OA 1094A series **£200.00**

**RHODE & SCHWARZ**
Standard Stereodecoder MSDC BN4193 **£850.00**
Polyscop I **£950.00**
Selektomat USWV **£800.00**
Frequency Indicator FKN **£475.00**
Type MSDC Standard Stereodecoder 30Hz-15KHz **£850.00**

**RHODE & SCHWARZ**



VHF Field Strength Meter HFV 25-300MHz in 1 band. Measurement range 100dB (µV) 50 ohm impedance **£1,750.00**
Type MSC Stereocoder BN4192/2 **£1,250.00**

**RECORD**
Chart Recorder — 500 µA Movement 1in & 6in. per hour **£70.00**

**WAVETEK**
Programmable Phase Meter 775 **£795.00**

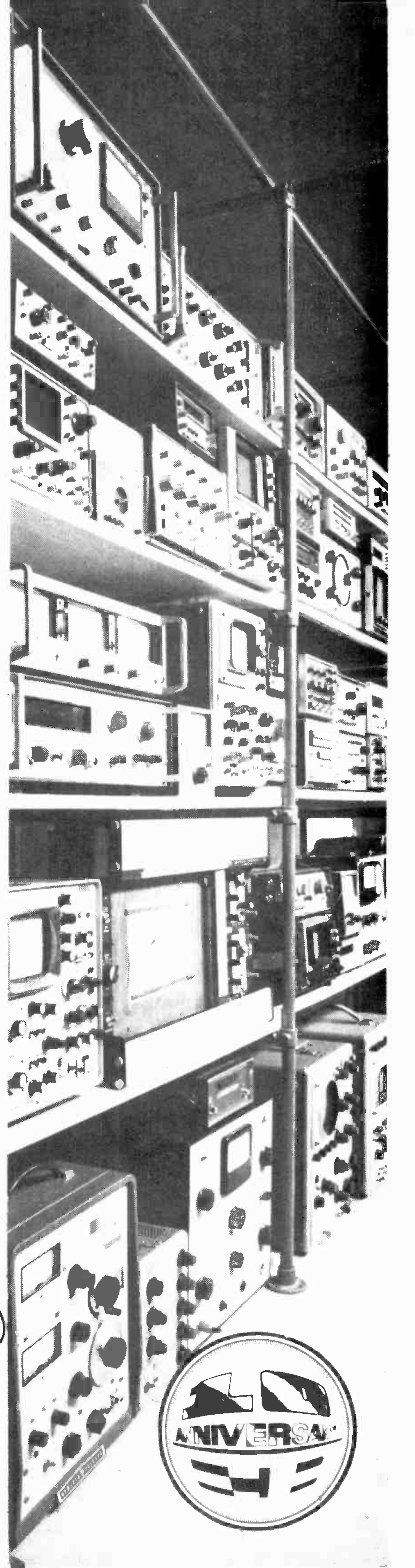
## CALIBRATORS & STANDARDS

**FLUKE**
Meter Calibrator 760A. Spec for DC Voltmeters — 0.001V to 1KV. Accuracy 0.1% Resolution 100µV. DC Ammeters — 1µA to 10A. Accuracy ±0.25% Resolution 1µA. AC Voltmeters — 0.001V to 1KV. 60Hz and 400Hz. Accuracy ±0.25%. Resolution 100µV. AC Ammeters — 1µA to 10A. 600Hz & 400Hz Accuracy ±0.25%. Ohmeters — 0 to 10M ohms. ±0.1% of setting +0.5M ohms. Resolution 1 ohm. Full spec on request **£2150.00**
Reference Divider 750A. Used for calibration of precision DC Voltmeters, Voltboxes, DC Calibrators, etc. The equipment is a 10ppm (0.001%) divider with switched input taps ranging from 1100 to 1.1V & switched output taps ranging from 1100V to 0.1V **£980.00**
Null Detector 845AB. All solid state. Designed for extremely high input impedance, sensitivity and isolation. Operates from either line or from built-in rechargeable batteries. 1µV through 100V DC end scale in 19 ranges using X1 and X3 progression. Full spec on request **£475.00**
High Voltage Divider 80E-10. Provides a highly stable, accurate means of measuring voltages up to 10KV in conjunction with differential voltmeters, d.v.m.s. and conventional potentiometers. Accuracy ±0.01% **£255.00**

## FREQUENCY SYNTHESISERS

**FLUKE**
Frequency Synthesiser 6011A. Performs functions of an oscillator, counter and level meter. 10Hz-11MHz. Output 0.4mV-5V (r.m.s.) 7 digit LED display. Accuracy ±3 parts in 10⁶ for one year. Freq. storage. Full Specification on request **£2650.00**
Frequency Syntheiser 6160A/OX. 4MHz-30MHz in 1Hz Steps. Output 1V into 50 ohms. Stability ± 1 part in 10⁸ in 24 hours. Full Spec. on request. UNUSED. BARGAIN PRICE **£675.00**

**Shown on these pages are just a few samples of our huge stock. If the item you require is not shown please give us a ring.**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**Hours of business: 9a.m.-5p.m. Mon.-Fri. Closed lunch 1-2p.m.**

WW—083 FOR FURTHER DETAILS

# VALVES

| | |
|---|---|
| A1065 | 1.25 |
| AR8 | 0.60 |
| ARP3 | 0.60 |
| ATP4 | 0.50 |
| B12H | 3.00 |
| DAF96 | 0.60 |
| DET22 | 12.85 |
| DF96 | 0.60 |
| DK96 | 0.80 |
| DL92 | 0.50 |
| DL96 | 0.70 |
| DY86/87 | 0.45 |
| DY802 | 0.45 |
| E88CC/01 | 1.30 |
| E180CC | 1.30 |
| E182CC | 3.50 |
| E810F | 6.00 |
| EA50 | 0.45 |
| EA76 | 2.00 |
| EABC80 | 0.40 |
| EAF42 | 0.70 |
| EB91 | 0.30 |
| EBC33 | 1.00 |
| EBC41 | 0.75 |
| EBF80 | 0.45 |
| EBF83 | 0.45 |
| EBF89 | 0.40 |
| EC52 | 0.40 |
| ECC81 | 0.45 |
| ECC82 | 0.40 |
| ECC83 | 0.40 |
| ECC84 | 0.35 |
| ECC85 | 0.45 |
| ECC86 | 1.25 |
| ECC88 | 0.55 |
| ECC189 | 0.80 |
| ECF80 | 0.45 |
| ECF82 | 0.45 |
| ECF801 | 0.75 |
| ECH42 | 0.85 |
| ECF81 | 0.45 |
| ECH84 | 0.50 |
| ECL80 | 0.60 |
| ECL82 | 0.40 |
| ECL83 | 1.20 |
| ECL86 | 0.55 |
| EF36 | 0.75 |
| EF39 | 1.00 |
| EF40 | 0.70 |
| EF41 | 0.75 |
| EF80 | 0.35 |
| EF83 | 1.50 |
| EF85 | 0.45 |
| EF86 | 0.45 |
| EF89 | 0.35 |
| EF91 | 0.65 |
| EF92 | 0.75 |
| EF95 | 0.45 |
| EF183 | 0.40 |
| EF184 | 0.40 |
| EF804 | 2.00 |
| EFL200 | 0.75 |
| EH90 | 0.60 |
| EL32 | 0.60 |
| EL34 | 1.20 |
| EL37 | 3.00 |
| EL41 | 0.80 |
| EL81 | 0.60 |
| EL82 | 0.60 |

| | |
|---|---|
| EL84 | 0.35 |
| EL86 | 0.50 |
| EL90 | 0.50 |
| EL91 | 1.60 |
| EL95 | 0.70 |
| EL504 | 0.80 |
| EL821 | 3.00 |
| EM31 | 0.75 |
| EM80 | 0.55 |
| EM81 | 0.60 |
| EM84 | 0.40 |
| EM87 | 1.00 |
| EY51 | 0.45 |
| EY81 | 0.45 |
| EY86/87 | 0.50 |
| EY88 | 0.50 |
| EZ40 | 0.60 |
| EZ41 | 0.75 |
| EZ80 | 0.30 |
| GZ32 | 0.65 |
| GZ33 | 2.50 |
| KT66 | 4.00 |
| KT88 | 5.00 |
| MH4 | 1.00 |
| ML6 | 1.00 |
| OA2 | 0.45 |
| OB2 | 0.45 |
| PABC80 | 0.40 |
| PC86 | 0.65 |
| PC88 | 0.65 |
| PC92 | 0.65 |
| PCC84 | 0.45 |
| PCC85 | 0.50 |
| PCC89 | 0.55 |
| PCC189 | 0.65 |
| PCF82 | 0.40 |
| PCF84 | 0.65 |
| PCF86 | 0.65 |
| PCF201 | 0.90 |
| PCF801 | 0.55 |
| PCF802 | 0.55 |
| PCF806 | 0.85 |
| PCF808 | 1.00 |
| PCH200 | 0.80 |
| PCL81 | 0.60 |
| PCL82 | 0.45 |
| PCL83 | 0.70 |
| PCL84 | 0.50 |
| PCL86 | 0.60 |
| PCL805/85 | 0.60 |
| PFL200 | 0.70 |
| PL36 | 0.60 |
| PL81 | 0.55 |
| PL82 | 0.50 |
| PL83 | 0.50 |
| PL84 | 0.50 |
| PL504 | 0.95 |
| PL508 | 0.95 |
| PL509 | 2.00 |
| PL802 | 2.50 |
| PY33 | 0.60 |
| PY80 | 0.60 |
| PY81/800 | 0.55 |
| PY82 | 0.45 |
| PY83 | 0.50 |
| PY88 | 0.50 |
| PY500A | 1.35 |
| PY801 | 0.55 |

| | |
|---|---|
| QQVO3 10 | 2.00 |
| QQVO6-40A | 14.00 |
| QVO3-12 | 2.00 |
| R19 | 0.80 |
| S104 1K | 2.50 |
| SC1/400 | 4.00 |
| SC1/600 | 4.00 |
| SP61 | 0.85 |
| TT21 | 6.50 |
| U25 | 1.00 |
| U26 | 0.85 |
| U27 | 1.00 |
| U191 | 0.75 |
| U801 | 0.80 |
| UABC80 | 0.50 |
| UAF42 | 0.75 |
| UBC41 | 0.60 |
| UBF80 | 0.50 |
| UBF89 | 0.50 |
| UBL1 | 1.00 |
| UBL21 | 0.75 |
| UCC85 | 0.50 |
| UCF80 | 0.80 |
| UCH42 | 0.80 |
| UCH81 | 0.50 |
| UCL82 | 0.45 |
| UCL83 | 0.70 |
| UF41 | 0.75 |
| UF80 | 0.40 |
| UF85 | 0.50 |
| UF89 | 0.50 |
| UL41 | 0.75 |
| UL84 | 0.50 |
| UY41 | 0.55 |
| UY85 | 0.50 |
| VR105/30 | 0.50 |
| VR150/30 | 0.50 |
| X61M | 1.50 |
| X66 | 0.75 |
| Z800U | 3.00 |
| Z801U | 3.50 |
| Z900T | 1.50 |
| 1A3 | 0.60 |
| 1L4 | 0.30 |
| 1R5 | 0.55 |
| 1S4 | 0.40 |
| 1S5 | 0.40 |
| 1T4 | 0.40 |
| 1X2B | 0.80 |
| 2X2 | 0.80 |
| 2D21 | 0.55 |
| 2K25 | 9.00 |
| 3A4 | 0.60 |
| 3E29 | 5.50 |
| 3D6 | 0.40 |
| 3S4 | 0.50 |
| 3V4 | 0.85 |
| 5B 254M | 5.50 |
| 5B/255M | 5.50 |
| 5B 258M | 5.50 |
| 5R4GY | 1.10 |
| 5U4G | 0.60 |
| 5V4G | 0.65 |
| 5Y3GT | 0.65 |
| 5Z3 | 1.00 |
| 5Z4G | 0.70 |
| 5Z4GT | 0.75 |

## PLUMBICON TUBES TYPE XQ.1020R

## Mullard—£150 each

| | |
|---|---|
| 6AB7 | 0.60 |
| 6AC7 | 0.60 |
| 6AH6 | 0.75 |
| 6AK5 | 0.45 |
| 6AK8 | 0.40 |
| 6AL5 | 0.30 |
| 6AL5W | 0.65 |
| 6AM5 | 1.60 |
| 6AM6 | 0.65 |
| 6AN8 | 0.85 |
| 6AQ5 | 0.50 |
| 6AQ5W | 0.85 |
| 6AS6 | 0.80 |
| 6AT6 | 0.65 |
| 6AU6 | 0.40 |
| 6AV6 | 0.80 |
| 6AX4GT | 0.80 |
| 6AX5GT | 1.00 |
| 6B7 | 0.75 |
| 6BA6 | 0.40 |
| 6BE6 | 0.45 |
| 6BG6G | 1.00 |
| 6BJ6 | 0.75 |
| 6BQ7A | 0.60 |
| 6BR7 | 2.30 |
| 6BW6 | 2.80 |
| 6BW7 | 1.00 |
| 6C4 | 0.40 |
| 6C6 | 0.55 |
| 6CB6 | 0.50 |
| 6CH6 | 3.00 |
| 6CL6 | 0.75 |
| 6D6 | 0.50 |
| 6EA8 | 0.80 |
| 6F8G | 0.75 |
| 6F12 | 0.65 |
| 6F17 | 1.00 |
| 6F33 | 4.20 |
| 6H6 | 0.45 |
| 6J4WA | 1.75 |

| | |
|---|---|
| 6SQ7 | 0.65 |
| 6V6GT | 0.60 |
| 6X4 | 0.45 |
| 6X5G | 0.45 |
| 6X5GT | 0.55 |
| 6Y6G | 0.95 |
| 6Z4 | 0.65 |
| 6-30L2 | 0.90 |
| 7B7 | 0.80 |
| 7Y4 | 0.80 |
| 9D2 | 0.60 |
| 9D6 | 0.75 |
| 11E3 | 11.00 |
| 12A6 | 0.60 |
| 12AL5 | 0.70 |
| 12AT6 | 0.45 |
| 12AT7 | 0.45 |
| 12AU7 | 0.40 |
| 12AV6 | 0.70 |
| 12AX7 | 0.40 |
| 12BA6 | 0.50 |
| 12BE6 | 0.60 |
| 12BH7 | 0.60 |
| 12C8 | 0.55 |
| 12EI | 4.25 |
| 12J5GT | 0.40 |
| 12K7GT | 0.60 |
| 12K8GT | 0.70 |
| 12Q7GT | 0.50 |
| 12SC7 | 0.55 |
| 12SG7 | 0.55 |
| 12SJ7 | 0.55 |
| 12Y4 | 0.40 |
| 14S7 | 1.00 |
| 19AQ5 | 0.75 |
| 19G3 | 10.00 |
| 19G6 | 6.00 |
| 19H5 | 17.00 |
| 20P3 | 0.60 |
| 20P4 | 1.10 |
| 25L6GT | 0.80 |

| | |
|---|---|
| 75 | 1.00 |
| 75C1 | 0.80 |
| 76 | 0.80 |
| 78 | 0.75 |
| 80 | 0.75 |
| 85A2 | 0.75 |
| 723A/B | 9.00 |
| 803 | 6.00 |
| 805 | 18.00 |
| 807 | 1.00 |
| 813 | 6.50 |
| 829B | 5.50 |
| 832A | 4.50 |
| 866A | 2.80 |
| 931A | 6.00 |
| 954 | 0.50 |
| 956 | 0.50 |
| 957 | 0.90 |
| 1625 | 1.00 |
| 1629 | 0.70 |
| 2051 | 1.00 |
| 5763 | 2.00 |
| 5933 | 3.00 |
| 6057 | 0.85 |
| 6060 | 0.85 |
| 6064 | 0.85 |
| 6065 | 1.20 |
| 6067 | 1.00 |
| 6080 | 3.50 |
| 6146 | 3.80 |
| 6146B | 4.20 |
| 6360 | 2.00 |
| 8020 | 5.50 |
| 9001 | 0.40 |
| 9002 | 0.55 |
| 9003 | 0.70 |
| 9004 | 0.40 |
| 9006 | 0.40 |

**C.R. TUBES**

| | |
|---|---|
| DG7-5 | 15.00 |
| DG13-2 | 22.00 |
| MW13-35 | 35.00 |
| VCR139A | 10.00 |
| 3BP1 | 8.00 |

## Add 12½% for V.A.T.

| | |
|---|---|
| 6J5GT | 0.55 |
| 6J6 | 0.35 |
| 6J7 | 0.70 |
| 6J7G | 0.50 |
| 6K7 | 0.55 |
| 6K7G | 0.35 |
| 6K8GT | 0.55 |
| 6L6M | 1.90 |
| 6L6GT | 0.60 |
| 6L7 | 0.65 |
| 6SA7 | 0.55 |
| 6SG7 | 0.60 |
| 6SJ7 | 0.60 |
| 6S37GT | 0.50 |
| 6SK7 | 0.60 |
| 6SL7GT | 0.55 |
| 6SN7GT | 0.55 |

| | |
|---|---|
| 30C15 | 1.00 |
| 30C17 | 1.10 |
| 30C18 | 1.10 |
| 30F5 | 1.00 |
| 30FL12 | 1.20 |
| 30FL14 | 1.00 |
| 30L15 | 1.00 |
| 30L17 | 1.00 |
| 30P12 | 1.00 |
| 30PL1 | 1.00 |
| 30PL13 | 1.10 |
| 30PL14 | 1.10 |
| 35L6GT | 0.80 |
| 35W4 | 0.60 |
| 35Z4GT | 0.70 |
| 50C5 | 0.70 |
| 50CD6G | 1.20 |

| | |
|---|---|
| 5FP7 | 10.00 |
| 88J | 9.00 |
| 88L | 9.00 |
| CV1526 | 10.00 |

**SPECIAL VALVES**

| | |
|---|---|
| BR189 | 250.00 |
| M503-2J42 | 65.00 |
| K301 | 7.00 |
| KRN2A | 6.00 |
| 725A | 25.00 |
| 2J/52A | 75.00 |
| CV2339 | 45.00 |
| CV5228 | 17.50 |

**POSTAGE:** £1-£2 20p; £2-£3 30p; £3-£5 40p; £5-£10 60p; over £10 free.

**VIDECON TUBE TYPE P863B**
**English Electric—£20**

**TF 801D/1/S SIGNAL GENERATOR.** Range 10-485MHz in 5 ranges R F output 0 1 V-1V. Source C M 50Ω output impedance Internal modulation at 1KHz at up to 90%
**TF 801B/2.** Spec as for 801D but minor circuit differences Few only left
**TF 995A/1 or A/2 or A/2M or A5 SIGNAL GENERATORS.** Very high class AM/FM 1 5MHz to 220MHZ Detailed spec and price on application
**TF 995/3S** with additional amplifier to give extra high output between 1 5 and 6 Mc/s

**TF 1400S DOUBLE PULSE GENERATOR WITH TM 6600/S SECONDARY PULSE UNIT.** Rep freq 10Hz to 100kHz, pulse width 0 1 to 100μ sec delay −1 5 to +3000μ sec, rise time 30N sec

**TF 144 H SIGNAL GENERATOR**
**HIGH FREQUENCY SPECTRUM ANALYSER.** MARCONI TYPE 1094A/S Basic Freq range 3 to 30 Mc/s and with LF unit from 100Hz to 3MHz Measures relative amplitudes up to 60dB
**TF 934 DEVIATION METER.** 250MHz
**TF1041 B VALVE MULTIMETER.** DC voltage from 300mV to 1 000V AC voltage from 300mV to 300V at up to 1 000MHz
**TF1370 R.C. OSCILLATOR FOR SQUARE & SINE WAVE.** Freq −31 6V rms 10Hz-1MHz square wave 0-73 2pH 10Hz-100KHz Attenuator range −50dB to +10dB Impedance 75 100, 600Ω **£145.**

## SIEMENS

**LEVEL OSCILLATOR TYPE BEL 3W518.** Frequency from 10KHz to 17MHz Modulation is external, output from +10dB to −60dB in 8 steps and in continuance with wobbler step generator Imp output 150 145 135 75, 65 ohms
**LEVEL OSCILLATOR TYPE REL 3W29.** Frequency from 0 3 to 1200Kc/s Mod ext output from +16dB to −60dB Impedance output 75, 140 600 ohms
**36' AERIAL MASTS** consisting of 6 sections 6' 8" × 2¼" dia Complete with all accessories to erect and instal
**AVO CT 160 VALVE TESTER**
**LOW RESISTANCE HEADPHONES TYPE CLB £1.50.** 40p postage VAT 12½%
**AR88 D & LF SPARES.** We hold the largest stock in UK Write for list
**RF METERS.** 0 to 8 amps 2¼" dia USA brand new **£1.50.** P&P 25p
**TELEPHONE TYPE "J"** tropicalised
10 LINE MAGNETO SWITCHBOARDS
**CABLE LAYING APPARATUS No. 11.** New production P O A

## FOR EXPORT ONLY

**RCA ET4336,** 2 Mc/2-20 Mc/s 350W also modified version of increased output to 700W
**Collins 231D** 4 5kW, 3MHz-24MHz, 10 channel Auto or manual tuning
**53 Transmitter**
**Mullard C11,** High power installation 1000W
Technical details and prices available on request

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

**VALVES AND TRANSISTORS**
Telephone enquiries for valves transistors, etc retail 749 3934 trade and export 743 0899

## RHODE & SCHWARZ

Z-g DIAGRAPH TYPE 2DU 30-420MHz 50Ω Directly measures multiterminal networks phase shift, phase angle with complementary POWER SIGNAL GENERATOR TYPE SMLM high freq resolution, internal external mod up to 3v out
**FREQUENCY SYNTHESIZER TYPE XUA.** 30Hz-30MHz with FREQUENCY INDICATOR TYPE FKM 15-30MHz, 30-100MHz
**UHF SIGNAL GENERATOR TYPE SMLM** from 30 to 303MHz
**UHF SIGNAL GENERATOR TYPE SLSD** from 300 to 300-940MHz
**FREQUENCY INDICATOR TYPE FKM** from 30 to 1 000MHz
**UHF SIGNAL GENERATOR TYPE SDR** from 300 to 1000MHz in 8 ranges
Prices on application

## TEKTRONIX

**545A.** Bandwidth DC to 30MHz (3dB down at 30MHz) ~ ½dB depending on plug-in unit Specification and price on request
**570 CHARACTERISTIC CURVE TRACE**
**517A OSCILLOSCOPES** wide band high voltage cathode ray oscilloscope designed for observing and photographically recording wave form having extremely short rise times
**REDIFON SSB TRANSISTORISED TRANSCEIVER GR410.** 2 16 c/s 200-250V 4 channels 100W p c p
**DANA EXACT FUNCTION GENERATOR MODEL 121.** Frequency range 0 2Hz to 2MHz (7 ranges) voltage controlled to 10V sweep generator 1ms to 10 sec
**TEXSCAN ELECTRONIC SYSTEM ANALYZER MODEL 9990.** Frequency range 10MHz to 300MHz with market controls
**FURZEHILL SENSITIVE VALVE VOLTMETER TYPE V200A** full scale from 10mV to 1000V in 6 steps with output amplifier
**TRAINING SET** for Radio Operators with 10 key terminals and control frequency and volume
**TRANSMITTER RECEIVER.** Transmitter Type M9 receiver Type M17 with fixed frequency Range 240MHz
**TEST SET FT2** for testing Transceivers A40 A41 A42 and CPRC26
**UNIVERSAL WIRELESS TRAINING SET No 1 Mk 2 YA 8316** to train 32 operators simultaneously on key and phone Complete installation consists of 3 kits packed in 3 special transit cases
**HARNESS "A" & "B" CONTROL UNITS "A" "R" "J1" "J2,"** Microphones No 5 6 7 connectors frames carrier sets etc

**VAT FOR TEST EQUIPMENT**
PLEASE ADD **8%**

## COLOMOR
**(ELECTRONICS LTD.)**
**170 Goldhawk Rd., London, W.12**
**Tel. 01-743 0899**
**Open Monday to Friday**
**9-12.30, 1.30-5.30 p.m.**

# BENTLEY ACOUSTIC CORPORATION LTD.

**7A GLOUCESTER ROAD, LITTLEHAMPTON, SUSSEX. Tel. 6743**
**ALL PRICES SHOWN INCLUDE V.A.T. AT 12½%**

| | |
|---|---|
| 0A2 | 0.85 |
| 0B2 | 0.40 |
| 0C3 | 0.50 |
| 0Z4 | 0.55 |
| 1A3 | 0.60 |
| 1A5GT | 0.55 |
| 1A7GT | 0.60 |
| 1B3GT | 0.55 |
| 1C2 | 1.00 |
| 1D5 | 0.75 |
| 1G6 | 1.00 |
| 1H5GT | 0.80 |
| 1L4 | 0.25 |
| 1LD5 | 0.70 |
| 1LN5 | 0.70 |
| 1N5GT | 0.75 |
| 1R5 | 0.50 |
| 1S4 | 0.40 |
| 1S5 | 0.35 |
| 1T4 | 0.30 |
| 1U4 | 0.70 |
| 1U5 | 0.85 |
| 2D21 | 0.55 |
| 2GK5 | 0.75 |
| 2X2 | 0.70 |
| 3A4 | 0.55 |
| 3B7 | 0.55 |
| 3D6 | 0.40 |
| 3Q4 | 0.80 |
| 3Q5GT | 0.70 |
| 3S4 | 0.65 |
| 3V4 | 1.00 |
| 4CB6 | 0.75 |
| 4GK5 | 0.75 |
| 5CG8 | 0.75 |
| 5R4GY | 1.00 |
| 5T4 | 2.00 |
| 5U4G | 1.00 |
| 5V4G | 1.00 |
| 5Y3GT | 0.65 |
| 5Z3 | 1.40 |
| 5Z4G | 0.75 |
| 5Z4GT | 1.00 |
| 6 30L2 | 0.90 |
| 6A8G | 1.40 |
| 6AC7 | 0.70 |
| 6AG5 | 0.35 |
| 6AG7 | 0.70 |
| 6AH6 | 0.70 |
| 6AJ5 | 0.70 |
| 6AJ8 | 0.55 |
| 6AK5 | 0.45 |
| 6AK6 | 1.50 |
| 6AK8 | 0.48 |
| 6AL5 | 0.25 |
| 6AM6 | 0.70 |
| 6AM8A | 0.70 |
| 6AN8 | 0.70 |
| 6AQ5 | 0.75 |
| 6AQ8 | 0.50 |
| 6AR5 | 1.05 |
| 6AS7 | 1.50 |
| 6AT6 | 0.60 |
| 6AU6 | 0.55 |
| 6AV6 | 0.65 |
| 6AW8A | 1.15 |

| | |
|---|---|
| 6AX4 | 0.75 |
| 6B8G | 0.75 |
| 6BA6 | 0.45 |
| 6BC8 | 0.90 |
| 6BE6 | 0.70 |
| 6BG6G | 1.00 |
| 6BH6 | 1.10 |
| 6BJ6 | 0.75 |
| 6BK7A | 0.85 |
| 6BN8 | 1.00 |
| 6BQ5 | 0.48 |
| 6BQ7A | 1.40 |
| 6BR7 | 1.00 |
| 6BR8 | 1.25 |
| 6BW6 | 3.50 |
| 6BW7 | 0.65 |
| 6BX6 | 0.40 |
| 6BY7 | 0.45 |
| 6BZ6 | 1.50 |
| 6C4 | 0.50 |
| 6C6 | 0.45 |
| 6C9 | 2.00 |
| 6C10 | 1.00 |
| 6CB6A | 0.65 |
| 6C12 | 0.55 |
| 6CD6G | 4.00 |
| 6CG8A | 0.90 |
| 6CL6 | 0.75 |
| 6CL8A | 0.95 |
| 6CM7 | 1.00 |
| 6CS6 | 0.65 |
| 6CU5 | 0.90 |
| 6D3 | 0.75 |
| 6DL7 | 0.90 |
| 6DT6A | 0.85 |
| 6EW6 | 0.85 |
| 6E5 | 1.00 |
| 6F1 | 0.80 |
| 6F6G | 0.70 |
| 6F12 | 0.70 |
| 6F14 | 0.90 |
| 6F15 | 0.85 |
| 6F16 | 1.00 |
| 6F18 | 0.60 |
| 6F23 | 1.00 |
| 6F24 | 0.80 |
| 6F25 | 1.00 |
| 6F26 | 0.45 |
| 6F28 | 0.85 |
| 6F32 | 1.00 |
| 6G6G | 1.00 |
| 6GH8A | 0.80 |
| 6GK5 | 0.75 |
| 6GK6 | 2.00 |
| 6GU7 | 0.90 |
| 6H6GT | 0.50 |
| 6J5GT | 0.65 |
| 6J6 | 0.35 |
| 6J7G | 0.50 |
| 6J7M | 0.65 |
| 6JU8A | 0.90 |
| 6K7G | 0.50 |
| 6K8G | 0.50 |
| 6K8GT | 0.55 |
| 6L1 | 2.50 |
| 6L7(M) | 1.50 |

| | |
|---|---|
| 6L12 | 0.50 |
| 6L18 | 0.60 |
| 6L19 | 2.00 |
| 6LD12 | 0.48 |
| 6LD20 | 0.80 |
| 6N7GT | 0.70 |
| 6PL12 | 0.55 |
| 6P15 | 0.48 |
| 6Q7G | 0.75 |
| 6Q7GT | 0.75 |
| 6Q7M | 0.75 |
| 6R7G | 0.70 |
| 6R7(M) | 1.00 |
| 6SA7 | 0.70 |
| 6SC7GT | 1.00 |
| 6SG7 | 0.70 |
| 6SH7 | 0.70 |
| 6SJ7 | 0.70 |
| 6SK7 | 1.00 |
| 6SK7GT | 0.70 |
| 6SQ7 | 0.70 |
| 6U4GT | 1.00 |
| 6U7G | 0.55 |
| 6U8 | 0.50 |
| 6V6G | 0.50 |
| 6V6GT | 1.00 |
| 6X4 | 0.95 |
| 6X5GT | 0.50 |
| 6Y6G | 0.95 |
| 6Y7G | 1.25 |
| 7A7 | 1.00 |
| 7B6 | 1.00 |
| 7B7 | 1.00 |
| 7D6 | 2.00 |
| 7F8 | 2.00 |
| 7H7 | 1.00 |
| 7R7 | 2.00 |
| 7V7 | 2.00 |
| 7Y4 | 0.80 |
| 7Z4 | 0.80 |
| 8D2 | 0.50 |
| 8D8 | 0.52 |
| 9BW6 | 0.90 |
| 9D7 | 0.70 |
| 9U8 | 0.45 |
| 10C2 | 0.70 |
| 10C14 | 0.52 |
| 10D1 | 1.00 |
| 10DE7 | 0.80 |
| 10F1 | 0.67 |
| 10F9 | 0.65 |
| 10F18 | 0.65 |
| 10L14 | 0.45 |
| 10LD11 | 0.75 |
| 10LD12 | 0.45 |
| 10PL12 | 0.70 |
| 10P13 | 0.80 |
| 10P14 | 2.50 |
| 10P18 | 0.65 |
| 12A6 | 1.00 |
| 12AC6 | 0.80 |
| 12AD6 | 0.80 |
| 12AE6 | 0.80 |
| 12AT6 | 0.45 |
| 12AT7 | 0.52 |
| 12AU6 | 0.50 |

| | |
|---|---|
| 12AU7 | 0.52 |
| 12AV6 | 0.60 |
| 12AX7 | 0.52 |
| 12BA6 | 0.50 |
| 12BE6 | 0.85 |
| 12BH7 | 0.55 |
| 12BY7 | 1.15 |
| 12E1 | 3.50 |
| 12J5GT | 0.40 |
| 12J7GT | 0.70 |
| 12K5 | 1.50 |
| 12K7GT | 0.50 |
| 12K8 | 0.75 |
| 12Q7GT | 0.50 |
| 12SA7GT | 0.75 |
| 12SC7 | 0.50 |
| 12SG7 | 0.55 |
| 12SH7 | 0.50 |
| 12SJ7 | 0.60 |
| 12SK7 | 0.60 |
| 12SN7GT | 0.75 |
| 12SQ7 | 0.80 |
| 12SQ7GT | 0.80 |
| 12SR7 | 0.75 |
| 13D8 | 2.00 |
| 14H7 | 0.75 |
| 14S7 | 1.00 |
| 18 | 1.25 |
| 19AQ5 | 0.65 |
| 19BG6G | 1.00 |
| 19G6 | 6.50 |
| 19H1 | 4.00 |
| 19Y3 | 0.40 |
| 20D1 | 0.70 |
| 20D4 | 2.50 |
| 20F2 | 0.85 |
| 20L1 | 1.20 |
| 20P1 | 1.00 |
| 20P3 | 1.00 |
| 20P4 | 0.84 |
| 20P5 | 1.50 |
| 25A6G | 0.70 |
| 25L6G | 1.00 |
| 25Y5 | 0.80 |
| 25Z4G | 0.50 |
| 25Z5 | 0.75 |
| 25Z6G | 0.80 |
| 28D7 | 2.00 |
| 30A5 | 0.75 |
| 30C1 | 0.80 |
| 30C15 | 1.00 |
| 30C17 | 0.90 |
| 30C18 | 2.25 |
| 30F5 | 0.70 |
| 30L1 | 0.39 |
| 30L15 | 0.75 |
| 30L17 | 0.70 |
| 30P4MR | 0.98 |
| 30P12 | 0.74 |
| 30P19/30P4 | 0.90 |
| 30P16 | 0.50 |
| 30P18 | 0.50 |
| 30PL1 | 1.25 |
| 30PL12 | 0.62 |
| 30PL13 | 1.30 |

| | |
|---|---|
| 30PL14 | 1.50 |
| 30PL15 | 1.30 |
| 35A3 | 0.75 |
| 35C5 | 0.80 |
| 35D5 | 0.90 |
| 35L6GT | 0.80 |
| 35W4 | 0.55 |
| 35Z3 | 0.80 |
| 35Z4GT | 0.70 |
| 35Z5GT | 0.80 |
| 50B5 | 0.95 |
| 50C5 | 0.70 |
| 50CD6G | 4.00 |
| 50EH5 | 0.85 |
| 50L6GT | 1.00 |
| 66KU | 1.00 |
| 72 | 0.70 |
| 77 | 0.45 |
| 85A2 | 1.40 |
| 85A3 | 1.40 |
| 90C1 | 1.50 |
| 90CV | 5.50 |
| 108C1 | 0.40 |
| 150C2 | 0.85 |
| 215SG | 0.60 |
| 303 | 1.20 |
| 305 | 1.20 |
| 807 | 1.10 |
| 956 | 0.50 |
| 1625 | 2.50 |
| 1821 | 1.00 |
| 5702 | 1.20 |
| 5763 | 2.75 |
| 6057 | 2.00 |
| 6060 | 2.00 |
| 6067 | 2.00 |
| 6146 | 4.70 |
| 6463 | 2.00 |
| 7025 | 2.00 |
| 7193 | 0.60 |
| 7475 | 1.20 |
| 9002 | 0.55 |
| 9006 | 0.45 |
| A1834 | 1.50 |
| A3042 | 6.00 |
| AC2PEN | 1.00 |
| AC2PENDD | 1.00 |
| AC6/PEN | 1.00 |
| AC/P4 | 1.50 |
| AC/PEN(7) | 1.20 |
| AC/TH1 | 1.00 |
| AL60 | 1.50 |
| ARP3 | 0.60 |
| ATP4 | 0.50 |
| AZ1 | 0.50 |
| AZ31 | 1.00 |
| AZ41 | 0.50 |
| B36 | 0.75 |
| B719 | 0.50 |
| B729 | 0.90 |
| BL63 | 2.00 |
| CL33 | 2.00 |
| CV6 | 0.60 |
| CV63 | 1.00 |

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|---|---|
| CV988 | 0.25 |
| CY1C | 1.00 |
| CY31 | 1.00 |
| D1 | 0.50 |
| D63 | 0.50 |
| DAC32 | 0.80 |
| DAF91 | 0.35 |
| DAF96 | 1.00 |
| DC90 | 0.70 |
| DD4 | 0.80 |
| DF33 | 0.75 |
| DF91 | 0.30 |
| DF96 | 1.00 |
| DH63 | 0.75 |
| DH76 | 0.50 |
| DH77 | 0.60 |
| DH81 | 1.00 |
| DK32 | 0.60 |
| DK40 | 1.00 |
| DK91 | 0.50 |
| DK92 | 1.00 |
| DK96 | 1.00 |
| DL63 | 0.70 |
| DL82 | 1.00 |
| DL92 | 0.65 |
| DL94 | 1.00 |
| DL96 | 1.00 |
| DM70 | 1.25 |
| DM71 | 1.75 |
| DW4/350 | 1.15 |
| DY51 | 2.00 |
| DY87/6 | 0.52 |
| DY802 | 0.50 |
| E80CC | 4.75 |
| E80CF | 6.00 |
| E80F | 5.50 |
| E83F | 3.50 |
| E88CC | 1.20 |
| E92CC | 4.50 |
| E180CC | 5.00 |
| E180F | 5.50 |
| E182CC | 5.50 |
| E188CC | 4.50 |
| E280F | 12.50 |
| E1148 | 0.60 |
| EA50 | 0.40 |
| EA76 | 1.30 |
| EABC80 | 0.48 |
| EAC91 | 0.55 |
| EAF42 | 1.00 |
| EAF801 | 1.50 |
| EB34 | 0.50 |
| EB91 | 0.25 |
| EBC41 | 1.00 |
| EBC81 | 1.00 |
| EBC90 | 0.60 |
| EBC91 | 0.65 |
| EBF80 | 1.00 |
| EBF83 | 0.45 |
| EBF89 | 0.40 |
| EBL21 | 2.00 |
| EC52 | 1.00 |
| EC53 | 1.00 |
| EC54 | 1.00 |
| EC86 | 0.84 |
| EC88 | 0.84 |

| | |
|---|---|
| EC90 | 0.50 |
| EC92 | 1.00 |
| EC97 | 0.75 |
| ECC32 | 1.00 |
| ECC33 | 2.00 |
| ECC35 | 2.00 |
| ECC40 | 1.00 |
| ECC81 | 0.52 |
| ECC82 | 0.52 |
| ECC83 | 0.52 |
| ECC84 | 0.50 |
| ECC85 | 0.50 |
| ECC86 | 2.00 |
| ECC88 | 0.72 |
| ECC91 | 0.35 |
| ECC189 | 1.00 |
| ECC804 | 0.90 |
| ECC807 | 2.80 |
| ECF80 | 0.65 |
| ECF82 | 0.50 |
| ECF86 | 0.80 |
| ECH35 | 2.00 |
| ECH42 | 1.00 |
| ECH81 | 0.55 |
| ECH83 | 1.00 |
| ECH84 | 0.75 |
| ECL80 | 0.55 |
| ECL82 | 0.55 |
| ECL83 | 1.50 |
| ECL84 | 0.90 |
| ECL85 | 0.80 |
| ECL86 | 0.64 |
| ECLL800 | 10.00 |
| EF22 | 1.00 |
| EF40 | 1.00 |
| EF41 | 1.00 |
| EF73 | 1.75 |
| EF80 | 0.40 |
| EF83 | 1.70 |
| EF85 | 0.45 |
| EF86 | 0.52 |
| EF89 | 0.55 |
| EF91 | 0.70 |
| EF92 | 0.70 |
| EF93 | 0.45 |
| EF94 | 0.55 |
| EF95 | 0.45 |
| EF97 | 0.90 |
| EF98 | 0.90 |
| EF183 | 0.50 |
| EF184 | 0.50 |
| EF804 | 6.25 |
| EH90 | 0.65 |
| EK90 | 0.70 |
| EL32 | 1.00 |
| EL35 | 3.00 |
| EL37 | 3.00 |
| EL41 | 1.00 |
| EL81 | 1.00 |
| EL83 | 1.00 |
| EL84 | 0.48 |
| EL86 | 0.60 |
| EL90 | 0.75 |
| EL95 | 0.80 |
| EL360 | 2.50 |

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|---|---|
| EL506 | 2.00 |
| EL509 | 2.50 |
| EM80 | 1.00 |
| EM81 | 1.00 |
| EM83 | 1.00 |
| EM84 | 1.00 |
| EM85 | 1.20 |
| EM87 | 1.45 |
| EMM803 | 2.50 |
| EY51 | 0.65 |
| EY81 | 1.50 |
| EY83 | 1.50 |
| EY86/7 | 0.45 |
| EY88 | 1.00 |
| EY91 | 0.50 |
| EY500A | 1.45 |
| EZ35 | 0.50 |
| EZ40 | 1.00 |
| EZ41 | 1.00 |
| EZ80 | 0.42 |
| EZ81 | 0.45 |
| EZ90 | 0.95 |
| FC4 | 1.00 |
| FW4/500 | 2.50 |
| FW4/800 | 2.50 |
| GY501 | 1.25 |
| GZ30 | 0.75 |
| GZ32 | 1.00 |
| GZ33 | 4.00 |
| GZ34 | 2.25 |
| GZ37 | 4.00 |
| HABC80 | 0.80 |
| HL13C | 0.60 |
| HL23 | 0.70 |
| HL23DD | 0.68 |
| HL41 | 1.00 |
| HL41DD | 1.00 |
| HL42DD | 1.00 |
| HN309 | 1.70 |
| HVR2 | 1.00 |
| HVR2A | 1.00 |
| HY90 | 0.55 |
| KT2 | 0.90 |
| KT8 | 3.00 |
| KT32 | 1.00 |
| KT41 | 1.00 |
| KT44 | 1.00 |
| KT63 | 0.70 |
| KT66 | 3.00 |
| KT71 | 1.00 |
| KT81 | 2.00 |
| KT88 | 6.75 |
| L63 | 0.65 |
| LN119 | 0.70 |
| LN152 | 0.55 |
| LN309 | 0.75 |
| LZ319 | 0.80 |
| LZ329 | 0.80 |
| M8162 | 2.00 |
| MHL4 | 1.00 |
| MHLD6 | 0.99 |
| MKT4 | 1.20 |
| MU12/14 | 1.15 |
| MX40 | 1.00 |
| N150 | 1.00 |
| N308 | 0.98 |
| N339 | 1.25 |
| N379 | 0.50 |
| N709 | 0.48 |
| P61 | 0.60 |
| PABC80 | 0.45 |
| PC86 | 0.80 |
| PC88 | 0.80 |
| PC92 | 0.55 |
| PC95 | 1.00 |
| PC97 | 0.75 |

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|---|---|
| PC900 | 0.65 |
| PCC84 | 0.39 |
| PCC85 | 0.47 |
| PCC88 | 0.61 |
| PCC89 | 0.49 |
| PCC189 | 0.60 |
| PCC805 | 0.75 |
| PCC806 | 0.70 |
| PCF80 | 0.80 |
| PCF82 | 0.45 |
| PCF84 | 0.70 |
| PCF86 | 0.57 |
| PCF87 | 0.90 |
| PCF200 | 1.35 |
| PCF201 | 1.00 |
| PCF800 | 1.00 |
| PCF801 | 0.49 |
| PCF802 | 0.80 |
| PCF805 | 2.25 |
| PCF806 | 0.70 |
| PCH200 | 1.00 |
| PCL82 | 0.62 |
| PCL83 | 0.75 |
| PCL84 | 0.46 |
| PCL86 | 0.72 |
| PCL88 | 1.50 |
| PCL800 | 1.30 |
| PCL801 | 1.25 |
| PCL805/85 | 0.65 |
| PEN4DD | 2.00 |
| PEN25 | 1.00 |
| PEN45 | 1.00 |
| PEN45DD | 1.00 |
| PEN46 | 1.00 |
| PEN453DD | 2.00 |
| PENA4 | 1.00 |
| PENDD/4020 | 1.00 |
| PFL200 | 1.12 |
| PL33 | 1.00 |
| PL36 | 0.80 |
| PL81 | 0.49 |
| PL81A | 0.75 |
| PL82 | 0.50 |
| PL83 | 0.50 |
| PL84 | 0.50 |
| PL95 | 1.00 |
| PL302 | 0.90 |
| PL504/500 | 1.05 |
| PL505 | 2.55 |
| PL508 | 1.30 |
| PL509 | 2.55 |
| PL519 | 2.80 |
| PL801 | 0.74 |
| PL802 | 3.20 |
| PM84 | 0.75 |
| PY31 | 0.50 |
| PY33/2 | 0.50 |
| PY80 | 0.50 |
| PY81 | 0.60 |
| PY82 | 0.40 |
| PY83 | 0.60 |
| PY88 | 0.60 |
| PY301 | 0.50 |

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|---|---|
| PY500 | 1.56 |
| PY500A | 1.56 |
| PY800 | 0.60 |
| PY801 | 0.60 |
| PZ30 | 0.50 |
| QP21 | 1.10 |
| QQV03/10 | 2.00 |
| QS75/20 | 1.00 |
| QS95/10 | 1.00 |
| QS150/15 | 1.80 |
| QV03/12 | 2.75 |
| QV04/7 | 3.00 |
| QV06/20 | 4.70 |
| R10 | 5.00 |
| R11 | 1.00 |
| R16 | 2.00 |
| R17 | 1.50 |
| R19 | 0.75 |
| R20 | 0.90 |
| R52 | 0.75 |
| RK34 | 1.00 |
| SP4 | 1.50 |
| SP13C | 0.75 |
| TH4B | 1.00 |
| TH233 | 1.00 |
| TP2620 | 1.00 |
| TP22 | 1.00 |
| TP25 | 1.00 |
| UABC80 | 0.45 |
| UAF42 | 0.70 |
| UBC41 | 0.70 |
| UBC81 | 0.55 |
| UBF80 | 0.50 |
| UBF89 | 0.39 |
| UBL21 | 2.00 |
| UC92 | 0.50 |
| UCC84 | 0.90 |
| UCC85 | 0.45 |
| UCF80 | 0.80 |
| UCH21 | 2.00 |
| UCH42 | 1.00 |
| UCH81 | 0.52 |
| UCL82 | 0.70 |
| UCL83 | 1.00 |
| UF41 | 0.70 |
| UF42 | 1.00 |
| UF80 | 0.40 |
| UF85 | 0.50 |
| UF89 | 0.52 |
| UL41 | 0.90 |
| UL46 | 1.00 |
| UL84 | 0.65 |
| UM80 | 1.00 |
| UR1C | 1.00 |
| UU5 | 1.15 |
| UU9 | 1.00 |
| UU12 | 0.45 |
| UY41 | 0.70 |
| UY42 | 0.70 |
| UY85 | 0.60 |
| U10 | 1.00 |
| U12/14 | 1.15 |
| U16 | 1.00 |
| U17 | 1.00 |
| U18/20 | 2.50 |
| U19 | 4.00 |

| | |
|---|---|
| U22 | 0.85 |
| U25 | 1.00 |
| U26 | 0.90 |
| U31 | 0.50 |
| U33 | 1.75 |
| U35 | 1.75 |
| U37 | 2.00 |
| U45 | 1.20 |
| U47 | 1.00 |
| U49 | 0.90 |
| U50 | 0.65 |
| U52 | 1.00 |
| U76 | 0.70 |
| U78 | 0.95 |
| U81 | 0.80 |
| U150 | 1.00 |
| U153 | 0.60 |
| U191 | 0.50 |
| U192 | 0.40 |
| U193 | 0.60 |
| U251 | 1.00 |
| U281 | 0.75 |
| U282 | 0.70 |
| U291 | 0.50 |
| U301 | 1.00 |
| U329 | 1.00 |
| U339 | 0.50 |
| U381 | 0.60 |
| U403 | 0.90 |
| U404 | 0.75 |
| U709 | 0.45 |
| U801 | 1.00 |
| U4020 | 1.00 |
| VLS492 | 9.50 |
| VP2 | 1.50 |
| VP4(5) | 2.00 |
| VP13C | 0.60 |
| VP23 | 0.65 |
| VP41 | 0.90 |
| VR105 | 0.50 |
| VR150 | 0.75 |
| VT61A | 0.75 |
| VU111 | 1.00 |
| VU120 | 1.00 |
| VU120A | 1.00 |
| VU133 | 1.00 |
| VX6020 | 1.00 |
| W76 | 0.50 |
| W81M | 1.20 |
| W107 | 1.00 |
| W719 | 0.45 |
| W729 | 1.20 |
| WD709 | 1.00 |
| XE3 | 0.60 |
| XFY12 | 0.60 |
| XH15 | 0.60 |
| XSG15 | 1.20 |
| X41 | 1.00 |
| X61 | 2.00 |
| X63 | 1.40 |
| X65 | 2.00 |
| X66 | 2.00 |
| X76M | 0.75 |
| X119 | 0.52 |
| X142 | 1.00 |
| X150 | 1.00 |
| X719 | 0.55 |

| | |
|---|---|
| Z145 | 0.67 |
| Z152 | 0.40 |
| Z329 | 0.70 |
| Z719 | 0.40 |
| Z729 | 0.52 |
| Z749 | 1.00 |
| Z759 | 6.50 |

**Transistors and Diodes**

| | |
|---|---|
| 1N1124A | 0.61 |
| 1N4744A | 0.16 |
| 1N4952 | 0.58 |
| 2N404 | 0.21 |
| 2N966 | 0.61 |
| 2N1756 | 0.58 |
| 2N2147 | 0.99 |
| 2N2297 | 0.26 |
| 2N2369 | 0.16 |
| 2N2613 | 0.45 |
| 2N3053 | 0.38 |
| 2N3121 | 2.90 |
| 2N3703 | 0.23 |
| 2N3709 | 0.23 |
| 2N3866 | 1.16 |
| 2N3988 | 0.58 |
| 2S323 | 0.58 |
| AA119 | 0.18 |
| AA120 | 0.18 |
| AA129 | 0.18 |
| AAZ13 | 0.21 |
| AC107 | 0.18 |
| AC113 | 0.30 |
| AC114 | 0.47 |
| AC126 | 0.14 |
| AC127 | 0.20 |
| AC128 | 0.26 |
| AC132 | 0.23 |
| AC154 | 0.30 |
| AC156 | 0.23 |
| AC157 | 0.30 |
| AC165 | 0.30 |
| AC166 | 0.30 |
| AC168 | 0.44 |
| AC169 | 0.38 |
| AC176 | 0.64 |
| AC177 | 0.32 |
| ACY17 | 0.30 |
| ACY18 | 0.23 |
| ACY19 | 0.23 |
| ACY20 | 0.30 |
| ACY21 | 0.30 |
| ACY22 | 0.18 |
| ACY28 | 0.21 |
| AD140 | 0.50 |
| AD161 | 0.53 |
| AD162 | 0.53 |
| AF102 | 1.04 |
| AF106 | 0.58 |
| AF114 | 0.30 |

| | |
|---|---|
| AF115 | 0.30 |
| AF117 | 0.23 |
| AF121 | 0.35 |
| AF124 | 0.36 |
| AF125 | 0.50 |
| AF139 | 0.76 |
| AF178 | 0.79 |
| AF180 | 0.56 |
| AF186 | 0.64 |
| AF239 | 0.44 |
| ASY27 | 0.50 |
| ASY28 | 0.38 |
| ASY29 | 0.58 |
| BA102 | 0.53 |
| BA115 | 0.16 |
| BA116 | 0.21 |
| BA129 | 0.14 |
| BA130 | 0.12 |
| BA148 | 0.20 |
| BA153 | 0.18 |
| BCY10 | 0.53 |
| BCY12 | 0.58 |
| BCY33 | 0.23 |
| BCY34 | 0.26 |
| BCY38 | 0.26 |
| BC107 | 0.14 |
| BC108 | 0.14 |
| BC109 | 0.14 |
| BC113 | 0.30 |
| BC115 | 0.18 |
| BC116 | 0.30 |
| BC118 | 0.26 |
| BF154 | 0.30 |
| BF158 | 0.21 |
| BF159 | 0.30 |
| BF163 | 0.23 |
| BF173 | 0.44 |
| BF180 | 0.35 |
| BF181 | 0.47 |
| BF185 | 0.47 |
| BFY50 | 0.26 |
| BFY51 | 0.23 |
| BFY52 | 0.23 |
| BTX34/400 | 2.31 |
| BY100 | 0.21 |
| BY101 | 0.18 |
| BY105 | 0.21 |
| BY114 | 0.21 |
| BY126 | 0.18 |
| BY127 | 0.21 |
| BYY23 | 1.16 |
| BYZ10 | 0.30 |
| BYZ11 | 0.30 |
| BYZ12 | 0.30 |
| BYZ13 | 0.30 |
| BYZ15 | 2.03 |
| CG12E | 0.23 |
| CG64H | 0.23 |

| | |
|---|---|
| FSY11A | 0.26 |
| FSY41A | 0.26 |
| GD4 | 0.38 |
| GD5 | 0.32 |
| GD6 | 0.32 |
| GD8 | 0.23 |
| GD9 | 0.23 |
| GD11 | 0.23 |
| GD12 | 0.23 |
| GD14 | 0.58 |
| GD15 | 0.47 |
| GD16 | 0.23 |
| GET119 | 0.30 |
| GET573 | 0.44 |
| GET587 | 0.50 |
| GET872 | 1.11 |
| GET873 | 0.18 |
| GET882 | 0.58 |
| GET887 | 0.26 |
| GET889 | 0.26 |
| GET896 | 0.26 |
| GET897 | 0.26 |
| GET898 | 0.26 |
| GEX113 | 0.21 |
| GEX36 | 0.58 |
| GEX45 | 0.38 |
| GEX55 | 0.87 |
| GT3 | 0.30 |
| M1 | 0.18 |
| MAT100 | 0.45 |
| MAT101 | 0.50 |
| MAT120 | 0.45 |
| OA9 | 0.14 |
| OA47 | 0.12 |
| OA70 | 0.18 |
| OA73 | 0.18 |
| OA79 | 0.11 |
| OA81 | 0.11 |
| OA85 | 0.11 |
| OA86 | 0.23 |
| OA90 | 0.14 |
| OA91 | 0.11 |
| OA95 | 0.11 |
| OA200 | 0.11 |
| OA202 | 0.12 |
| OC19 | 1.46 |
| OC22 | 0.44 |
| OC23 | 0.44 |
| OC24 | 0.44 |
| OC28 | 0.69 |
| OC29 | 0.73 |
| OC36 | 1.00 |
| OC38 | 0.50 |
| OC41 | 0.58 |
| OC42 | 0.73 |
| OC43 | 1.37 |
| OC44 | 0.12 |
| OC45 | 0.13 |
| OC65 | 1.31 |

| | |
|---|---|
| OC70 | 0.14 |
| OC71 | 0.13 |
| OC72 | 0.13 |
| OC74 | 0.26 |
| OC75 | 0.13 |
| OC76 | 0.18 |
| OC77 | 0.32 |
| OC78 | 0.18 |
| OC78D | 0.18 |
| OC79 | 0.47 |
| OC81 | 0.13 |
| OC81D | 0.13 |
| OC82 | 0.13 |
| OC82D | 0.13 |
| OC83 | 0.23 |
| OC84 | 0.28 |
| OC123 | 0.26 |
| OC140 | 1.11 |
| OC169 | 0.50 |
| OC171 | 0.40 |
| OC172 | 0.41 |
| OC201 | 1.00 |
| OC204 | 0.50 |
| OC206 | 1.05 |
| ORP12 | 0.61 |
| SFT237 | 0.50 |
| SM1036 | 0.58 |
| ST1276 | 0.58 |
| SX1/6 | 0.21 |
| U14706 | 0.30 |
| XZ30 | 0.30 |
| Y543 | 0.21 |
| Y728 | 0.21 |

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**MATCHED TRANSISTOR SETS**
LP15 (AC113, AC154, AC157, AA120). **61p** per pack
1/OC81D and 2/OC81, **50p.**
1/OC44 and 2/OC45, **50p.**
1/OC82D and 2/OC82, **56p.** Set of 3/OC83, **78p.**
1 watt Zeners, 2 4v 2 7v, 3v 3 6v, 4 3v, 4 7v 5 1v, 13v 15v, 16v, 18v, 20v, 24v, 30v, **12p each.**

All goods are unused and subject to the manufacturers' guarantee
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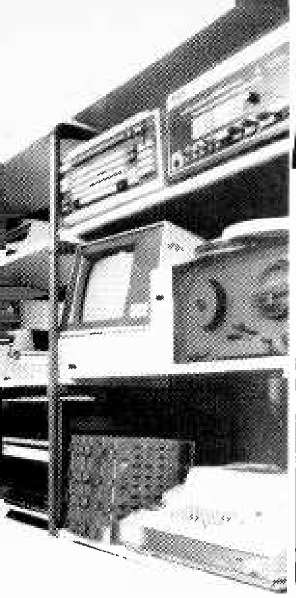
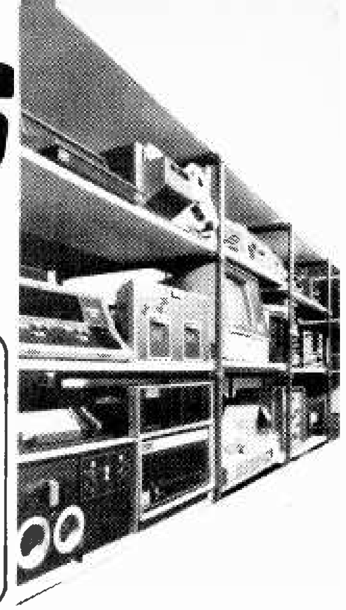
All prices subject to change without notice.
Special offer of EF50 valves, soiled but new and tested, £1 each.



# Electronic Brokers
## The Computer People



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*Special offer of Data Dynamics DD390 KSR Terminals, ASC11 Keyboard, Hard Copy, V 24 Interface, Modern Style Acoustic Cover*

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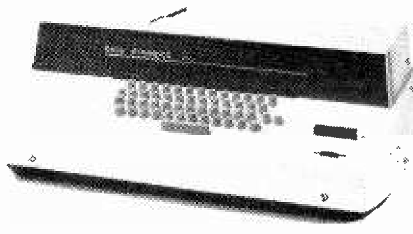

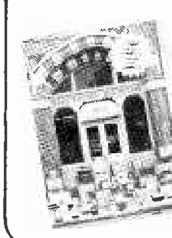

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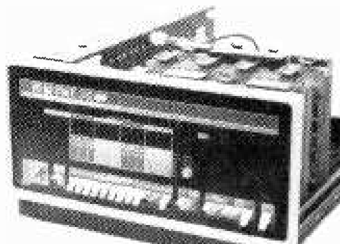

**LARGE NEW STOCKS OF DEC PDP MINIS**

**PDP8E Processors, 4K to 32K,** various configurations available prices from **£2500**
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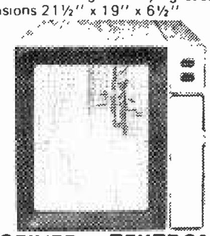
Model 725 KSR ASCII Keyboard Silent high speed operation up to 300 baud 5 x 7 dot matrix electronic printhead Full or half duplex operation Built in acoustic coupler Mounted in integral carrying case Gross weight 35lbs Dimensions 21½" x 19" x 6½"



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- ★ ASC11 Keyboard
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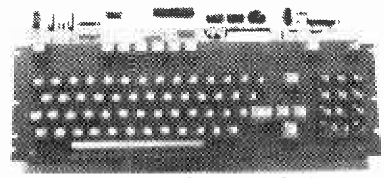
**IBM 731 and 735 INPUT/OUTPUT WRITERS**
10 pitch golfball, BCD or correspondence coding, 11in. or 15in. platen. Max. op. speed 15 cps PRICES FROM £275.00.

## Keyboards



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- ★ Standard TTL logic
- ★ Power requirements +5V @ 100mA and −12V @ 4mA
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- ★ negative strobe with 4 0 ms delay

Overall dimensions 16½ × 7¾ × 2", supplied complete with full technical data and circuit diagrams
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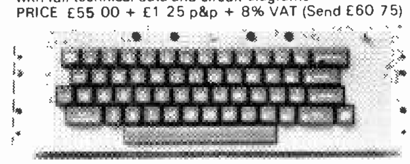

**55SW3-1** 54-station BCD-coded 4-bank alphanumeric keyboard. Hall-effect switches, input +5VDC negative logic and strobed output two-key rollover. Set in attractive panel incorporating 5 indicator lamps and on/off switch Dimensions 15½ × 5½ × 2½"
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Numerals 0-9 decimal point C K + − × ÷ = Mounted on PCB overall dimensions 5⅛ × 4⅝ × 1½"
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**World Leaders in CRT Terminals**

**★Teletype compatible ★12" Diagonal Screen ★TTY Format Keyboard ★64 ASCII Character Set ★5 x 7 Dot Matrix ★Switch-Selectable Transmission Rate up to 9600 baud ★Switch-Selectable Parity ★Standard CCITT V.24 Interface**

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**DISPLAYED APPOINTMENTS VACANT:** £7.50 per single col. centimetre (min. 3cm).
**LINE advertisements (run on):** £1.10 per line, minimum three lines.
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We offer a good salary and working conditions together with excellent promotion prospects which can lead to career development within the Company.

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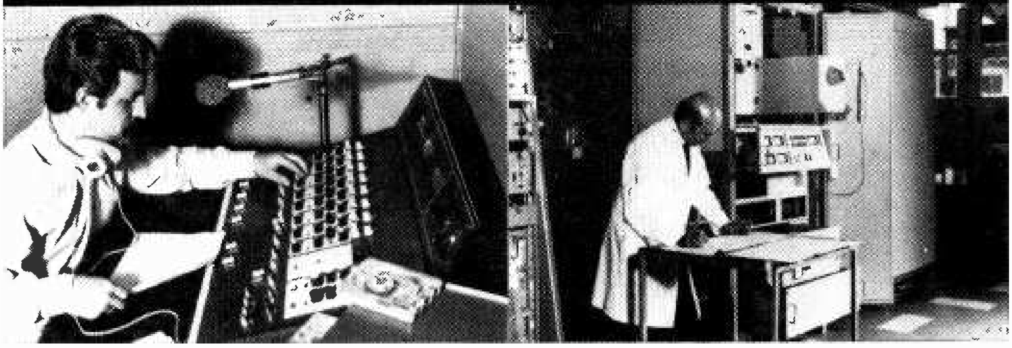

**Pye TVT Limited are major manufacturers of television and radio systems and equipment. Notable success in worldwide markets creates the need for additional Development Engineers to work in Cambridge:**

### Senior Development Engineer – Audio

We require an engineer to work in our modern Studio Equipment Development Laboratory on the design of circuitry for our audio equipment range. The successful candidate will exercise full responsibility for circuit design in a wide range of projects including audio mixing, assignment, communications and digital applications. The position calls for previous experience of audio circuit design, together with a desire to continue this design capability into new, "state of the art", economic products.

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Due to the continuing world wide success of our latest range of T.V. Transmitters and the expansion of the associated design area, we require Development Engineers for general circuit design, but with special reference to control logic and low level solid state drive stages.

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Benefits include those normally associated with a progressive company. Generous relocation assistance is available in approved cases.

**Please write or telephone for an application form to Dave Barnicoat, Personnel Officer, Pye TVT Limited, P.O. Box 41, Coldhams Lane, Cambridge CB1 3JU. Telephone Cambridge 45115**

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A current driving licence is essential and duties may include some travel both within the U.K. and abroad for periods up to several weeks.

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If you're thinking of a shore-based job, here's where you'll find interesting work, job security, good money, and the opportunity to enjoy all the comforts of home where you appreciate them most – at home!

The Post Office Maritime Service has vacancies at Portishead Radio and some of its other coast stations for qualified Radio Officers to undertake a wide variety of duties, from Morse and teleprinter operating to traffic circulation and radio telephone operating.

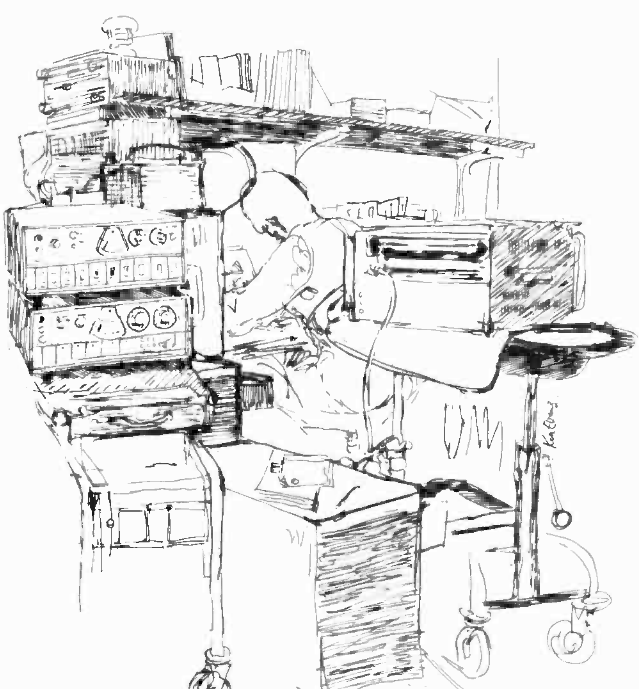
To apply, you must have a United Kingdom Maritime Radio Communication Operator's General Certificate or First Class Certificate of Proficiency in Radio-telegraphy or an equivalent certificate issued by a Commonwealth Administration or the Irish Republic. And, ideally, you should have some sea-going experience.

The starting pay at 25 or over works out at around £4093; after three years' service this figure rises to around £5093. (If you are between 19 and 24 your pay on entry will vary between approximately £3222 and £3732). Overtime is additional, and there is a good pension scheme, sick-pay benefits, at least 4 weeks' holiday a year, and excellent prospects of promotion to senior management.

For further information, please telephone Andree Trionfi on 01-432 4869 or write to her at the following address: ETE Maritime Radio Services Division (L690), ET17.1.2, Room 643, Union House, St. Martins-le-Grand, London EC1A 1AR.

Post Office Telecommunications

# Marconi Instruments



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Work situations range from fault finding on PCB's and components, to batch product testing of equipment that utilise very advanced techniques including microprocessors and the repair/calibration of all manner and types of test instruments.
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Further information may be obtained in confidence from John Prodger
**Marconi Instruments Limited,**
Longacres, St. Albans, Herts. tel: St. Albans, 59292

A GEC-MARCONI ELECTRONICS COMPANY

7782

mi

# RADIO TECHNICIANS

Government Communications Headquarters has vacancies for Radio Technicians. Applicants should be 19 or over.

**Standards** required call for a sound knowledge of the principles of electricity and radio, together with 2 years experience of using and maintaining radio and electronic test gear.

**Duties** cover highly skilled Telecommunications/electronic work, including the construction, installation, maintenance and testing of radio and radar telecommunications equipment and advanced computer an analytic machinery.

**Qualifications:** Candidates must hold either the City and Guilds Telecommunications Part I (Intermediate) Certificate or equivalent HM Forces qualification.

**Salary** scale from £2,230 at 19 to £2,905 at 25 (highest pay on entry), rising to £3,385 with opportunity for advancement to higher grades up to £3,780 with a few posts carrying still higher salaries. Pay supplements total between £443 and £522 per annum.

**Annual Leave** allowance is 4 weeks rising to 6 weeks after 27 years' service.

**Opportunities** for service overseas.

Candidates must be UK residents.

Further particulars and Application forms available from

**Recruitment Officer**
**Government Communications Headquarters**
**Oakley, Priors Road**
**CHELTENHAM, Glos GL52 5AJ**
**Tel. Cheltenham 21491 Ext. 2270**
**(STD 0242-21401)**

(7741)

## FOREIGN AND COMMONWEALTH OFFICE

**has a vacancy for an experienced**
**PRINTED CIRCUIT BOARD DESIGN**

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The works consists of the design and development leading to the manufacture of Printed Circuit Boards from prototype leading to batch production runs.

The successful applicant should have experience of the techniques involved in single-side boards, plated through-hole, flexible and micro-miniature circuitries. A knowledge of associated hardware would be advantageous.

Applicants should hold an ONC in Mechanical, Electrical or, preferably Electronic Engineering or an equivalent qualification.

Starting salary according to age, e.g. age 21 — £2425 per annum, age 25—£2785 per annum and age 27 or over — £2970. The maximum of the scale is £3450 per annum. In addition, all points on the salary scale attract Pay Supplements of £313.20 per annum and 5% of salary (minimum £10.88 per month — maximum £17.40 per month).

Please apply to:

**Recruitment Section**
**FOREIGN AND COMMONWEALTH OFFICE**
**Hanslope Park, Hanslope, Milton Keynes MK19 7BH**

(7756)

# Electronics Engineers

## for HF communication systems development.

Marconi Communication Systems are world leaders in the design development and manufacture of advanced communication systems and equipment. Electronics Engineers, at Senior and Section Leader levels, are now required to join teams working on a wide range of projects related to civil and naval defence contracts covering amplifiers, drives, receivers, frequency synthesisers and remote control equipment.

The continuing growth of the Company's activities in the HF field and the recent acquisition of £multi-million overseas contracts for this type of equipment means that there are excellent career opportunities available for both men and women at the Company's Chelmsford establishment.

Essential requirements are a degree or equivalent in electronics engineering together with knowledge of analogue or logic circuit design and ideally some HF experience.

Competitive salaries will be offered and there are first class company benefits including assistance with removal expenses where appropriate.

***Write with details of experience and qualifications to Gordon Short, Marconi Communication Systems Ltd., New Street, Chelmsford, Essex. Tel. Chelmsford 53221.***

(7790)

MARCONI COMMUNICATION SYSTEMS

*A GEC-Marconi Electronics Company*

## CHELSEA COLLEGE

**University of London**

## ELECTRONIC TECHNICIANS

**Grades 5 and 3**

required for interesting work in Departments of Electronics and Pharmacy Work includes electronics prototype design, development and construction and servicing and maintenance of electronic equipment.

Salaries (under review) Grade 5 £3377-£3856 per annum inclusive of London Allowance and Supplements, and Grade 3 £2930-£3276 per annum inclusive. Further information and application forms from **Mr. M. E. Cane (E.T.), Chelsea College, Pulton Place, London SW6 5PR.**

(7795)

**THE UNIVERSITY OF MANCHESTER**, Department of Physics. Electronics Technicians (2 posts). There are two vacancies in the Department of Physics for Electronics Technicians. The first post is an interesting one involving the development and construction of prototype apparatus and the maintenance of a wide range of electronics equipment. Applicants should have at least nine years' previous experience in electronics and possess an ONC or equivalent qualification. An HNC would be an advantage. Preference will be given to applicants with digital experience. Salary on scale rising from £2,889-£3,367 p.a. (under review). The second post requires similar experience and qualifications to that shown above but also carries supervisory responsibilities. This position is on a salary scale from £3,314-£3,950 p.a. (also under review). Applications should be made to the Superintendent, Department of Physics, Schuster Laboratory, Brunswick Street, Manchester M13 9PL. (7754

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7783

# UNIVERSITY OF ABERDEEN
## TELEVISION SERVICE
# TELEVISION ENGINEER

Applications are invited for the post of Television Engineer in the University's television service, which operates in colour to broadcast standards.

Applicants should be professional television engineers with experience of operations and maintenance of colour television origination and recording equipment. Work will be at the service's studio centre, the colour mobile unit and at medical school. Normal colour vision is a requirement for this post.

Salary on scale £2904-£4811, with appropriate placing. Six weeks' annual holiday.

Further particulars from the Secretary, the University, Aberdeen, with whom applications (2 copies) should be lodged by 12 January 1978.

7786

# SENIOR LABORATORY TECHNICIANS

## BBC Research Dept., Kingswood Warren, Tadworth, Surrey.

Duties include field strength survey measurements of existing VHF and UHF transmitters and assisting in the planning and testing of sites for new transmitters.

Although based at Kingswood successful candidates will be required to travel and work for periods anywhere in the U.K. – this will include working some weekends.

Candidates, male or female, should possess an H.N.C. or equivalent qualification and have knowledge of the use of radio frequencies as applied to the broadcasting bands. Ability to drive essential. Good opportunities for promotion to Engineering Technician.

Starting salary according to experience in the range £2,923 - £3,483 rising to £3,880 as a Senior Laboratory Technician, and ultimately to £4,792 as an Engineering Technician. Salaries quoted include pay supplements and an increase above these levels is also due to be implemented with effect from 1st October 1977. Pensionable post.

Write for application form to **Research Executive, BBC Research Department, Kingswood Warren, Tadworth, Surrey, KT20 6NP,** quoting reference 696/JME or telephone Mogador 2361

BBC

7744

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Applicants are required for interesting UNDERWATER PROJECTS, ROCKET PROJECTS and PROCESS CONTROL PROJECTS. They should have a knowledge of digital and analogue circuit techniques and will join small enthusiastic teams.

For the senior posts applicants should be qualified to degree or HNC standard; experience in working with aerodynamicists or hydrodynamicists would be an advantage. For the technicians vacancy applicants should have practical experience and preferably ONC or equivalent qualifications.

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Salary c £4,500.00p.

**Telephone Charles Cooper on 01-272 9212**

Or write to him at:

**CARDIAC RECORDERS LIMITED**
**34 Scarborough Road, Finsbury Park, LONDON N4**

7777

# Goodmans

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**Assistant Chief Engineer**

Applications are invited from experienced design engineers in the loudspeaker industry; they should have at least 8 years experience in the design of high fidelity speaker units and systems.

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Write in the first instance, giving age, qualifications, experience to date and present salary, to the Chief Engineer.

Candidates of either sex will be considered.

Applications to: Goodmans Loudspeakers Limited, Downley Road, Havant, Hampshire. PO9 2NL England
Telephone: Havant 6344

7740

**BROMPTON HOSPITAL**

# Senior Medical Electronics Technician

to undertake work involving maintaining, installing, and developing medical electronic equipment. A knowledge of ultrasonics and micro-computer based systems would be a distinct advantage.

Applicants should have a good general knowledge of electronics and be qualified to H.N.C. (Electrical and Electronic Engineering) standard or equivalent.

Salary will be on the scale £3,776-£4,708 according to experience.

Further information from Physicist in charge, Mr. R. B. Logan-Sinclair, Tel. 01-352 8121, Ext. 4252.

Application forms and job descriptions from Miss J. A. Jenks, Personnel Manager, Brompton Hospital, Fulham Road, London SW3 6HP. (Tel. as above, Ext. 4357).

# Classified

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If you want to put your knowledge and experience into practice, we'd like to see you. Contact John Davies, CDD Personnel, ICL, Wenlock Way, West Gorton, Manchester M12 5DR. Telephone 061-223 1301 extension 2748 or 2776. **(Reverse the charges.)** *Please quote reference WW1604.*

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**The Base:** Please contact Mrs. J. R. Feaver, Personnel Manager, Ampex Great Britain Limited, Acre Road, Reading, Berks. Telephone Reading 85200.

(7757)

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**The Company**

★ Sales throughout Europe of £1.5M
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Please contact:

**Beryl Homan at Vermont Research Limited**
**Cleeve Road**
**Leatherhead**
**Surrey**
**Telephone: Leatherhead 76221**

(7778)

## Telecommunications Engineering

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The vacancy is in the Telecommunications Division of the Central Computer Agency, London, which supplies a consultancy service to Government Departments on all technical aspects of the use and procurement of non-telephony telecommunications equipment and services.

The work is concerned with providing technical advice on the possible applications of audio and video teleconferencing, facsimile, closed circuit television, radio telephones and word processing. It includes liaison with manufacturers, product evaluation, assistance with procurement and the supervision of acceptance trials.

Candidates must have HNC in Electrical or Electronic Engineering, or an equivalent or higher qualification, and several years' relevant experience.

Starting salary between £4900 and £5700 depending on qualifications and experience. Promotion prospects. Non-contributory pension scheme.

Further details and an application form (to be returned by 11 January, 1978) write to Civil Service Commission, Alencon Link, Basingstoke, Hants, RG21 1JB, of telephone Basingstoke (0256 68551 (answering service operates outside office hours). **Please quote T/9607.**

**CENTRAL COMPUTER AGENCY**
**(Civil Service Department)**

(7759)

## UNIVERSITY OF BRADFORD

**Educational Development Service—Television Unit**

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Applications are invited for the post of Technician Grade 6 in the Television Unit of the University's Educational Development Service. The duties will include the operation and maintenance of a wide range of monochrome and colour video-recording equipment and the supervision of technical staff in the studio. Applicants should have a minimum of three years' experience in television and appropriate educational qualifications. Suitable training will be provided where necessary. Salary on scale £3314-£3950 p.a. Application forms and further particulars are available from the Personnel Office, University of Bradford, Richmond Road, Bradford 7, tel Bradford 33466, ext 252. Please quote ref. EDS/T6/R/WW

(7750)

**IMPERIAL COLLEGE, TECHNICAL STAFF,** Grade 5 electronics vacancy for a competent technician in a University computing department. Candidates should have ONC or City and Guilds Electrical Technicians Part 1 certificate or equivalent and have experience with construction and maintenance of computing equipment and peripherals. Salary in the range £3377-£3856 (Under review), inclusive of London weighting and permitted supplement. Five-day week: 9.00 to 17.30 hours: Four weeks paid annual leave plus additional days at Christmas and Easter. Please apply in writing with full details of qualifications and experience to Mr M. D. Cripps, Department of Computing and Control, Imperial College, London SW7 2B7, as soon as possible. (7794)

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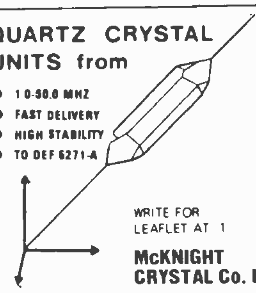

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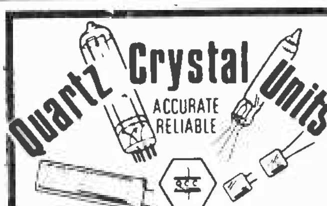


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| Size PC115 | For small components | 69p |
| Size SV130 | Use with copper bits and wires | £1.08p |
| Size AR140 | Metal repairs | 86p |
| Size AL150 | Aluminium | 76p |
| Size SS160 | Stainless Steel | £1.06p |

## Savbit Dispenser

Contains Ersin Multicore Savbit solder which increases life of copper bits by 10 times.

**Size5 58p**


## Solder Cream

For jointing most metals. Easy to use and ideal where solder wire cannot penetrate. Not suitable for electrical connections.

**Size7 99p**

# ...Bib keeps it playing

## Cassette Editing & Splicing Kit

Make editing simple with Bib splicer, tape cutters, tape piercer, splicing tape and tape winder/remover. Patent Pending Splicer.
British Pat. No. 1258280 (Method of Splicing)

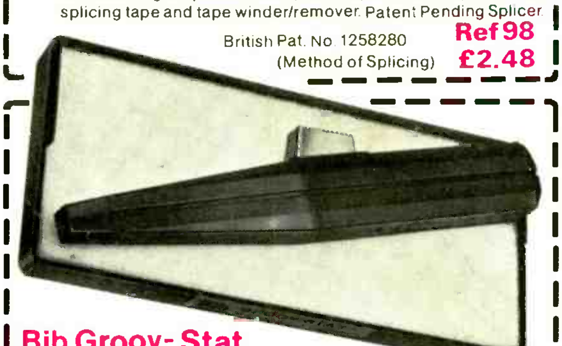
**Ref 98 £2.48**

## Universal Tape Head Maintenance Kit

Includes everything necessary for cleaning heads, capstan and pinchwheel on all types of recorders.

Patent Pending

**Ref 99 £2.48**



## Bib Groov-Stat Static Reducer

Neutralises in seconds the static charge that attracts harmful dust to record surfaces. Safe and simple to use.

**Ref 100A £5.98**

## ¼" Tape Care Kit

Combined editing/splicing/cleaning kit with splicer, tape, cutters, marker, cleaning fluid.

**Ref 111 £3.38**

## Bib Groov-Kleen

Supplied with two bases to suit all modern single play decks, the Bib Groov-Kleen cleans records while they play.

**Ref 2000S/P £3.48** Reg. Des. No. 967842.

Bib

*Send S.A.E. for free copy of colour catalogue detailing complete range.*

**Bib Hi-Fi Accessories Limited, Kelsey House, Wood Lane End, Hemel Hempstead, Herts., HP2 4RQ.**

*All prices shown are recommended retail, inc. VAT.*