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JULY 1978 40p

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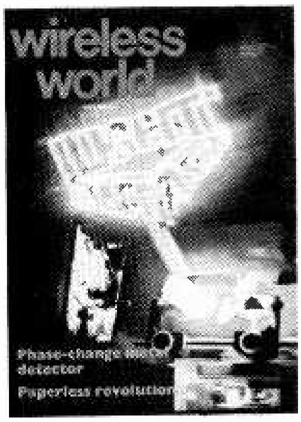

Front cover shows words traced by a deflected laser beam (photographed by Paul Brierley at the Royal Academy). Details inside.

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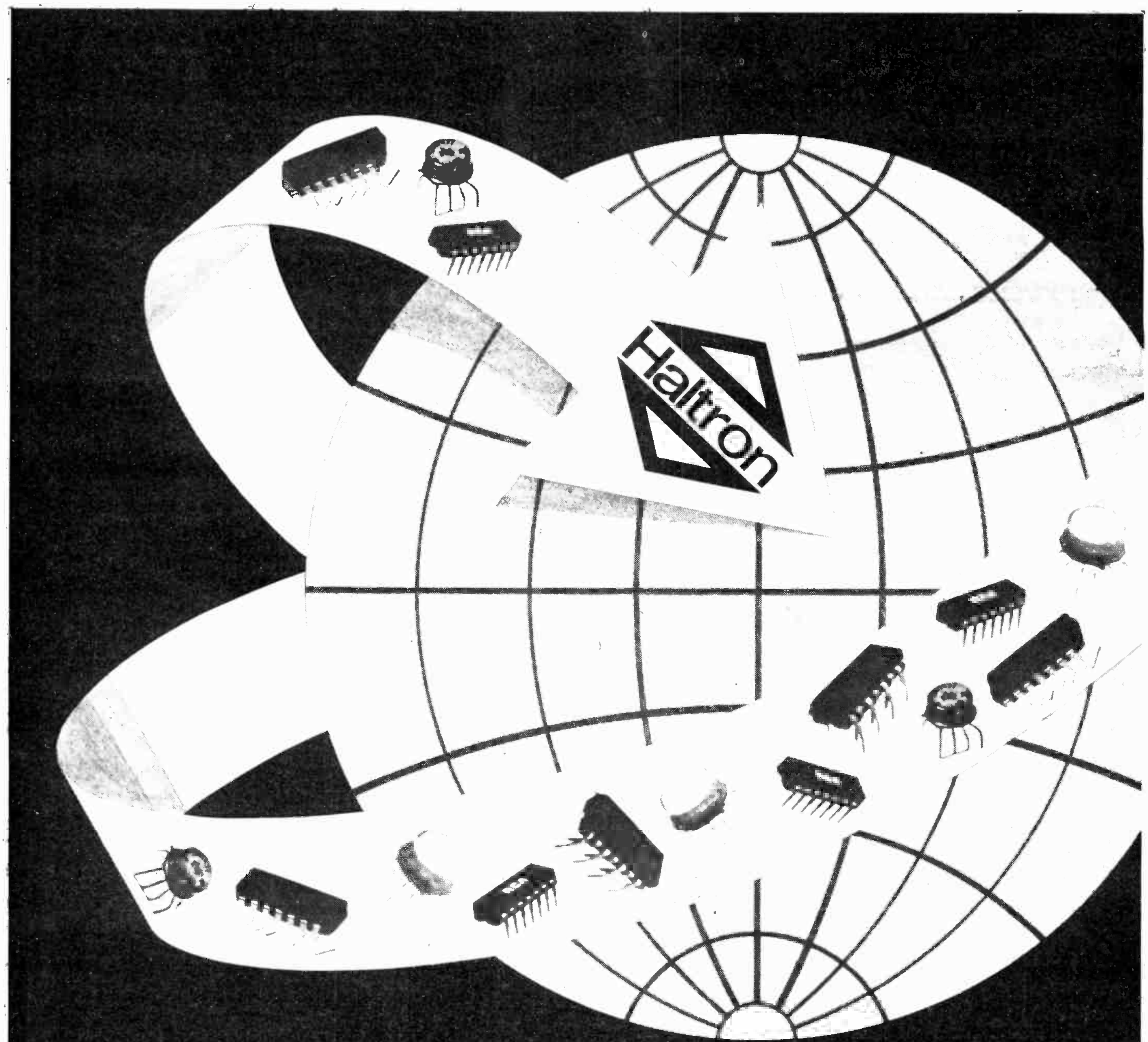
JULY 1978 vol 84 No 1511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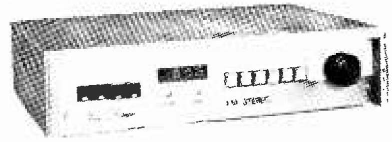
F.M. TUNERS, MODULES & UNITS by *Icon Design*

T3 **£149.00**

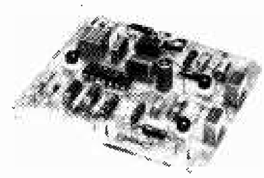


Six touch tuned pre-set stations plus manual tune, with digital frequency readout, combined with 1.8 micro-volt sensitivity and anti-birdy stereo make this one of the finest tuners available. Intelligent tuning indicator, a.f.c. and interstation mute included for easy operation by all the family. Two tone gold and brown front panel with teak veneer cabinet will blend with any surroundings.

M1 **£29.95**

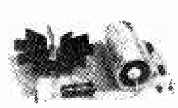
This module is the heart of the above tuner, giving a mono output with a.f.c., mute, and tuning indicator functions. Drift free tuning by 10 turn pot over the range 88 to 108 MHz. This module will not let you hear out-of-tune stations, and the fine tuning lamp is extinguished unless a station is received. The ideal basis for any High quality F.M. system.

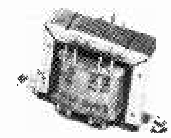
M2 **£8.36**



The ideal choice for adding stereo to the M1 module or any suitable mono receiver, this module has anti-birdy filters and pilot tone output filters, together with a phase-locked decoder for stable performance.

M4 **£6.93**





An integrated circuit regulator supplies all the power for the M1, M2 and M5, in addition to being short circuit proof and having automatic thermal shut-down, and ensuring hum free reception.

M5 **£17.54**

The M5(mk2) touch module adds 6 touch selected pre-set stations to the manual tuning already provided by the M1 module. Illuminated buttons indicate the channel selected, while remote control using a single contact push button steps the channels in an endless loop, including the manual control channel. Auto power-up channel selection may be set to any of the seven available channels. Remote inhibit and a lamp test facility are provided.

M6 **£44.40**

Using the optimum selection of discrete, E.C.L., T.T.L. and C-MOS technologies, this module will add the luxury of digital readout to the M1 module above, or any other LP1186 based receiver. The small (95 x 103mm) board contains all the logic, displays, and regulated power supply. Range is 60 to 99.9MHz, resolution 0.1KHz, and stability better than 40 p.p.m. per deg. C. It comes complete with mains transformer, polarised filter, and list of station frequencies.

★★ PLUS TWO NEW ONES ★★

M7 **£6.95**

This new module is a 4 way touch select switch having illuminated touch buttons, and C-MOS logic level outputs. Features pre-set power-up selection, and remote step facility. Multiple units may be cascaded to give 8, 12 or more channels of switching, and two modules may be paralleled to give full remote control from two or more locations. The outputs may be used to control logic etc., or to drive the new M8 channel selector opposite.

M8 **£4.95**

Controlled from single pole switches, or the M7 module, this unit will switch 4 mono or two stereo audio channels. Two M8 modules will therefore switch 4 stereo signals driven by one M7 touch switch, or other combinations may be controlled by multiple touch switches, providing a flexible system of audio selection and control. The ideal module for pre-amplifier source selection, avoiding long signal wires to and from control panels, and their associated hum and cross-talk problems.

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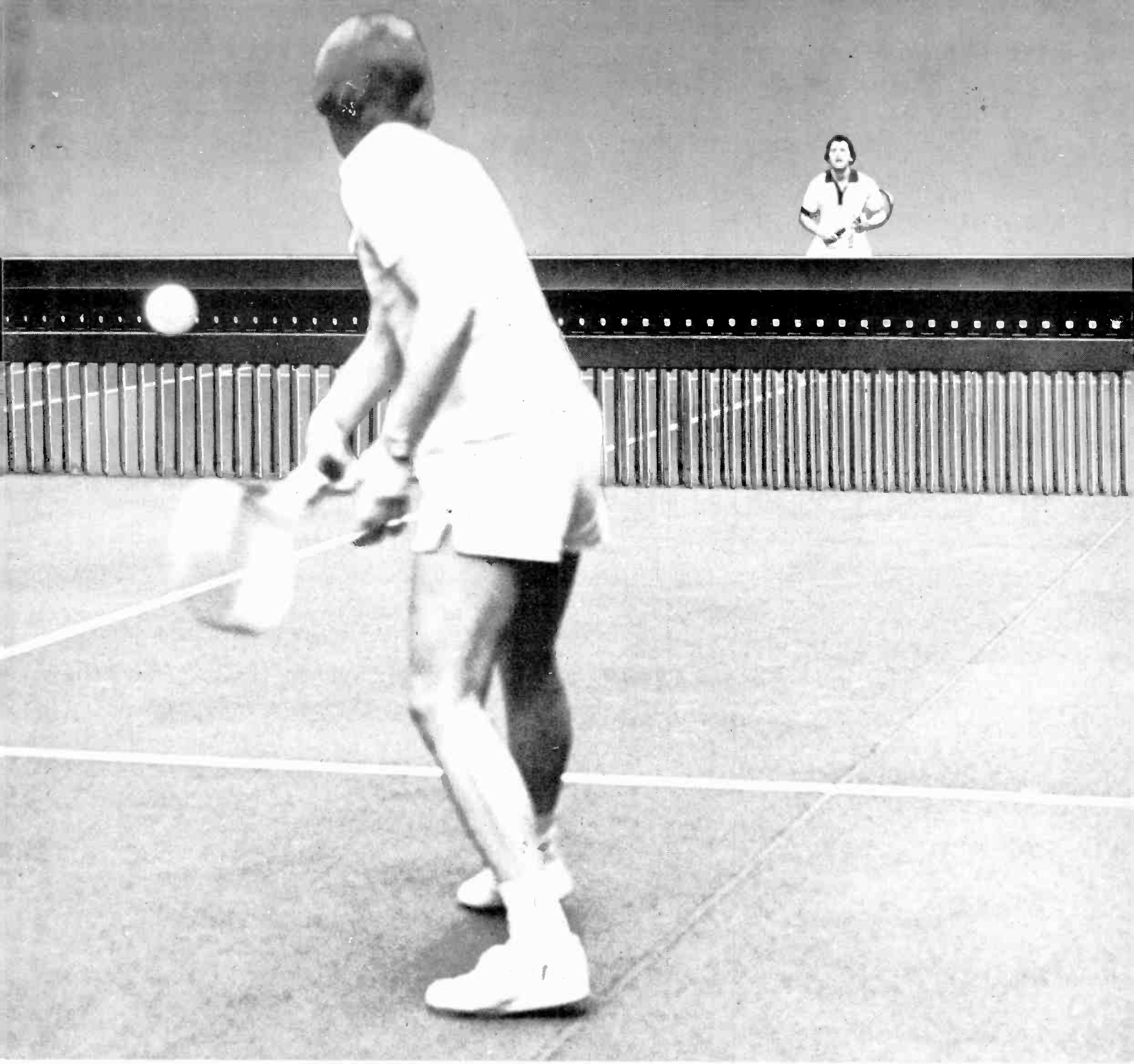

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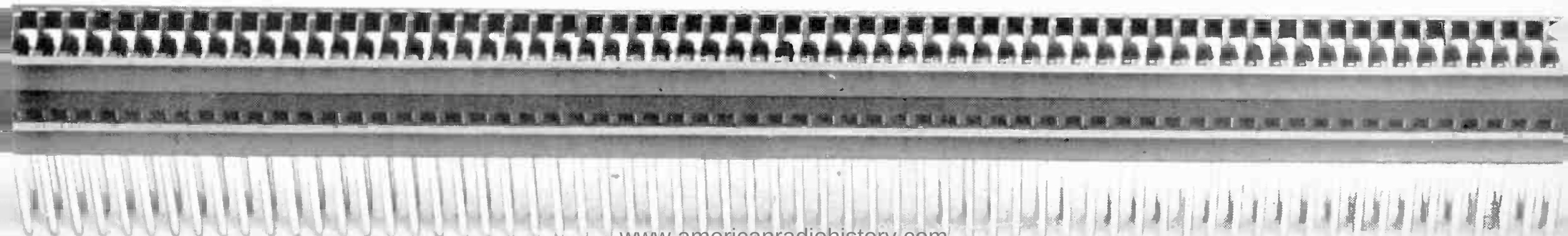

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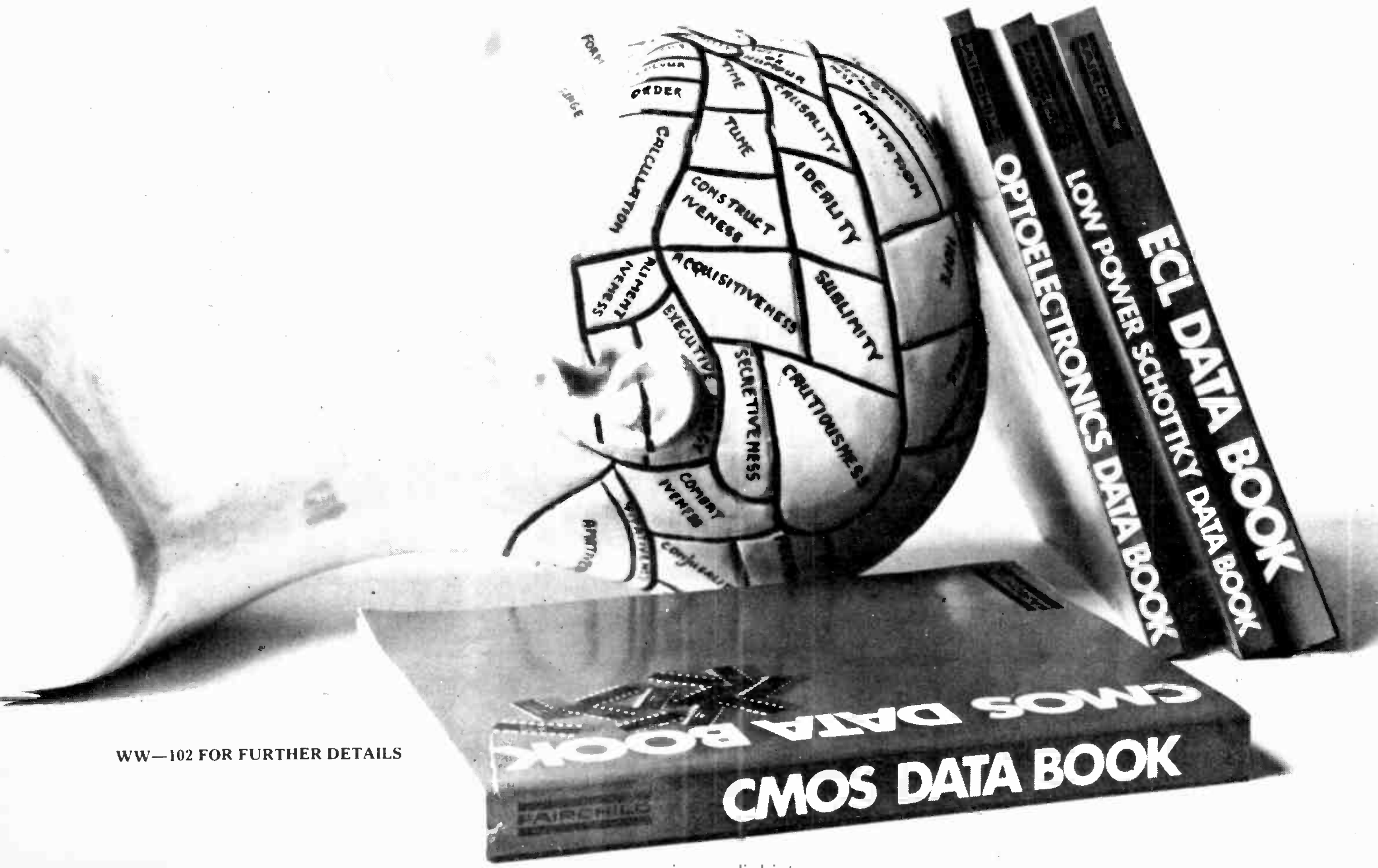

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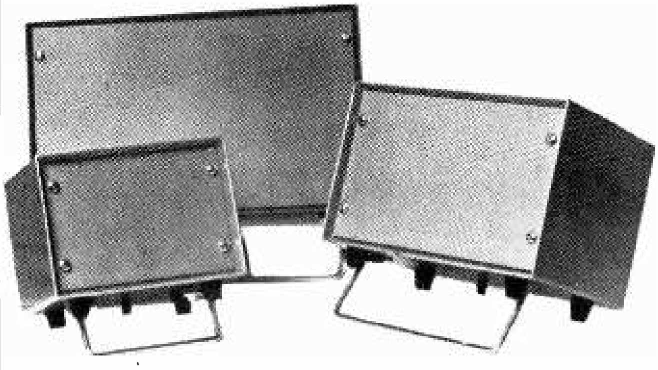
OLSON MINICASES



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25B	6½"	4½"	6¼"	5.45	6.05	1.20
26A	8¾"	5¾"	6¼"	7.15	7.75	1.20
26B	8¾"	5¾"	8¼"	7.50	8.10	1.20
27A	12¼"	7½"	5½"	7.85	8.55	1.20
27B	12¼"	7½"	8"	8.50	9.20	1.20
28A	14"	10½"	6½"	9.25	9.95	—
28B	14"	10½"	8½"	10.10	10.80	—
29A	10"	4"	6"	6.50	7.10	1.20
29B	10"	4"	8"	6.85	7.45	1.20
30A	12"	5"	6"	7.10	7.80	1.20
30B	12"	5"	8"	7.40	8.10	1.20
31A	14"	6"	6"	7.70	8.40	1.20
31B	14"	6"	8"	8.10	8.80	1.20
61	15½"	7½"	9½"	—	11.75	—
62	17½"	8½"	9½"	—	13.60	—
63	16½"	9½"	9½"	—	13.60	—
64	15½"	7½"	12½"	—	13.60	—
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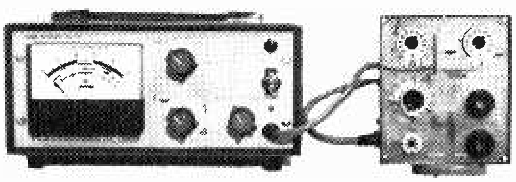

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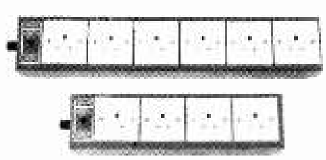

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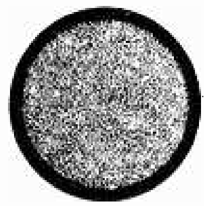

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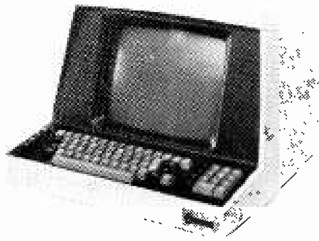

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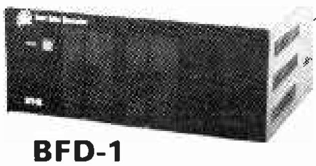

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...with the right contacts

In addition to the basic meter, a component jig, the CA4, is now available for rapid connection of components with axial, radial or pre-formed leads. The CA4 has built-in limits circuits for an automatic indication of 'Low,' 'Pass' or 'High' as each component is connected. Setting of the limits takes only a few seconds, no external equipment or standards being necessary.

These features, combined with the 0.25% accuracy over the wide measurement range, make the equipment equally valuable in Goods Inwards sections or design laboratories.

For more details fill in the coupon or contact your nearest distributor:

B424/CA4 New Simplicity in LCR Measurements

Tekelec-Airtronic, Cite des Bruyeres, Rue Carle-Vernet, 92310 Sevres, Paris, France, Tel: 027 75 35.
Keithley Instruments GmbH, Heiglhofstrasse 5, 8000 Munchen 70, West Germany. Tel: (089) 7144065.
G & P Electronics AG, Bernerstrasse-Nord 182, Ch-8064 Zurich, Switzerland, Tel: (01) 643231.
C N Rood BV, PO Box 42, 11-13 Cort van der Lindenstraat, Rijswijk ZH 2109, Holland, Tel: (70) 99 63 60.
Unitronics SA, Torre de Madrid, Princesa 1, Piso 12 Oficina 9, Madrid 8, Spain, Tel: 242 5204
Scandia Metric AB, Fack 171 19, Solna 1, Banvaktsvagen 20, Sweden, Tel: (08) 820 410.

Please send me details of the Wayne Kerr B424/CA4

Name ____________________

Company ____________________

Address ____________________

____________________ Tel: ____________________

Wayne Kerr

Wilmot Breeden Electronics Limited
442 Bath Road, Slough, Berkshire SL1 6BB
England

WW/7/78

WW — 079 FOR FURTHER DETAILS

In future, recording the present will be a thing of the past.

What's past is past. And said to be best forgotten.

But it's fundamental to the very existence of communications recording to be able to replay a selected portion of tape to find out what was said by who, to whom . . . and when. And 'when' can be vital.

Equally vital, particularly in emergencies when every second counts, is the ability to obtain such replay access rapidly, precisely, automatically. With absolute certainty—and without time-consuming multiple knob-twiddling aided by guesswork.

Racal-Thermionic has recognized this need and produced TIMESEARCH—designed specifically for its ICR range of multi-channel communications recorders—and providing just these facilities.

TIMESEARCH can generate a coded time reference signal of crystal accuracy and index it onto the tape. It can read and display that signal. It can search a tape at high speed for a pre-selected time signal and automatically initiate replay at that time.

In communications recording, the future becomes the present; the present becomes the past. And when you need to recall the past with precision, you need TIMESEARCH.

And for providing precise time signals every 10 seconds for recording onto magnetic tape: the International Timing Unit.

Racal-Thermionic the recording people

RACAL

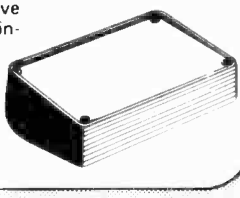
Racal-Thermionic Limited, Hardley Industrial Estate, Hythe, Southampton, SO4 6ZH, England. Telephone: 0703 843265. Telex 47600

WW—009 FOR FURTHER DETAILS

BIMCONSOLES
BIMBOXES
BIMBOARDS
BIMDRILLS
BIMDICATORS

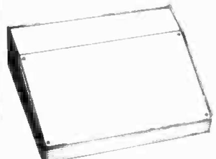
MINI DESK BIMCONSOLES

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) £2.12*
BIM1006 (215x130x75mm) £2.94*

LOW PROFILE BIMCONSOLES

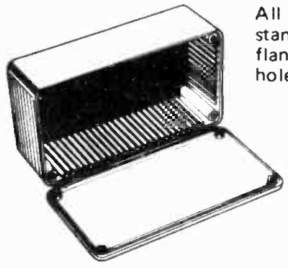


1mm Grey Aluminium panel sits recessed into front of console base, which is moulded in Orange, Blue, Black or Grey ABS and sits on 4 self adhesive rubber feet. Incorporating guides for holding 1.5mm thick pcb, the base also has stand-off bosses for supporting small sub-assemblies etc. and ventilation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

BIM6005 (143x105x55.5[31.5] mm) £2.32*
BIM6006 (143x170x55.5[31.5] mm) £3.08*
BIM6007 (214x170x82[31.5] mm) £4.12*

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).

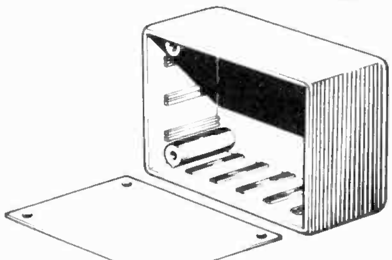
	ABS		Diecast	Hammertone	Natural
(100x50x25mm)	BIM2002/12	£0.95*	BIM5002/12	£1.20*	£0.97*
(112x62x31mm)	BIM2003/13	£1.05*	BIM5003/13	£1.50*	£1.20*
(120x65x40mm)	BIM2004/14	£1.15*	BIM5004/14	£1.86*	£1.49*
(150x80x50mm)	BIM2005/15	£1.30*	BIM5005/15	£2.38*	£1.91*
(190x110x60mm)	BIM2006/16	£2.04*	BIM5006/16	£3.41*	£2.85*

Also available in Grey Polystyrene (112x61x31mm) with no slots and self tapping screws BIM2007/17 £0.88*

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.

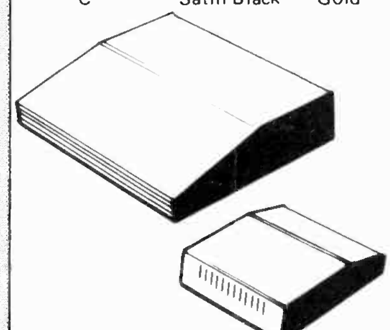
BIM 4003 (85x56x28.5mm) £1.24*
BIM 4004 (111x71x41.5mm) £1.56*
BIM 4005 (161x96x52.5mm) £2.08*



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



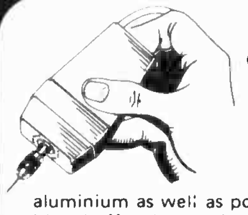
15° Sloping Panel

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*

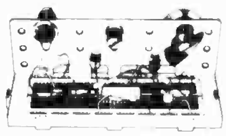
MAINS BIMDRILL

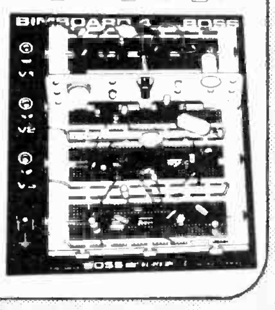


Operates directly from 220-240Vac and supplied with 2 metres long cable fitted with 2 pin DIN plug. Will drill brass, steel and aluminium as well as pcb's etc. Has integral biased-off switch and accepts tools with 1,2 and 3.2mm dia shanks £9.72*
Accessory Kit including 1mm, 2mm, .125" twist drills, 5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

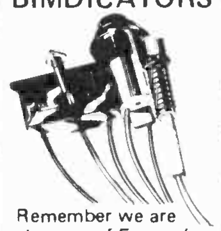
DIL COMPATIBLE BIMBOARDS

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



Remember we are also one of Europe's largest manufacturers of Filament, Neon and LED indicators. Send for our BIMDICATOR DATA

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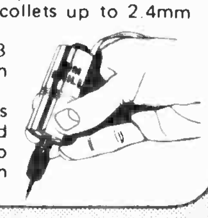
2 small but powerful 12V dc drills, easily held in hand or used with lathe/stand adaptor. Both drills have integral on/off switches and 1 metre long cable.
Mini Bimdrill with 2 collets up to 2.4mm capacity £7.56*
Major Bimdrill with 3 collets up to 3mm capacity £12.96*
Mains to 12 Volts adaptor, lathe,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



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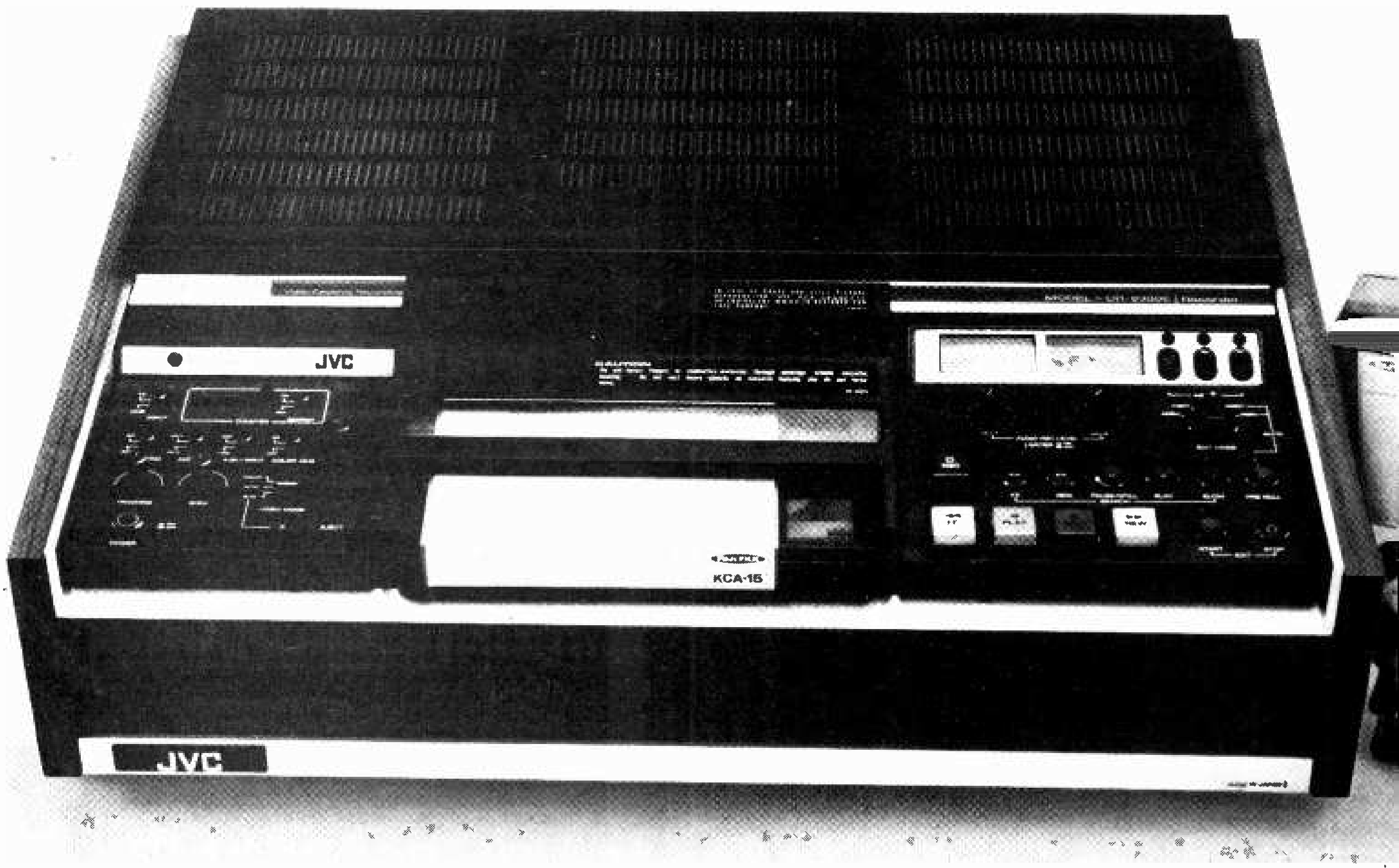
WW—026 FOR FURTHER DETAILS

The new, comprehensive JVC ¾" video cassette range

See-and believe



A pioneering electronics organisation with 51 years' experience of high-technology engineering, JVC has been developing and introducing new and better video products for 21 years.

Now, for the first time in Britain, you can choose from a new and comprehensive range of JVC ¾" U-format colour-plus-monochrome video cassette units, up to 38% smaller than directly competitive equipment.

From the compact portable CR-4400E for location work to the versatile CR-8300E for production studios, these easy-to-use models meet every video cassette recorder demand. They give you *exactly the same top-quality recording and playback throughout the range*. Price differences simply reflect the number of facilities available, not the performance.

The range. For those needing NTSC as well as PAL playback (perhaps for shipboard entertainment), JVC has the new CR-5060ED.

If you're looking for stop-action playback and PAL record/playback facilities, the new CR-6060E with its specially engineered still-frame system is the one for you. (Optional remote control available.)

PAL recording, plus PAL *and* NTSC playback, come together in the new CR-6060ED. Again, with optional remote control.

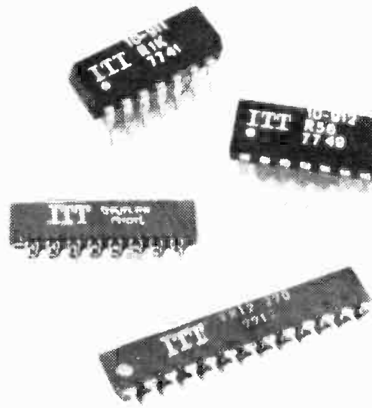
Full electronic editing facilities are built into the superb new CR-8300E, a PAL record/playback unit. For even more flexible editing, add the JVC RM83 editing suite.

Where you must have portable video equipment, able to record cassettes that can also be replayed by a mains cassette unit without an adaptor, it's got to be the new assembly-edit CR-4400E. This comes complete with built-in video/RF replay facilities. And, of course, there's a colour camera to match.

Use the inquiry service to get the literature from Bell & Howell and the name and address of an audio-visual centre where you can test for yourself the versatility of these new JVC units. Admire the outstanding picture quality each provides. Seeing is believing. You'll believe, as we do, that JVC U-format equipment is the best in the world.

WW—075 FOR FURTHER DETAILS

Thick Film resistor networks by ITT - of course



A wide range of low-cost Single-in-line and Dual-in-line resistor networks in standard circuit configurations are available from ITT on short delivery. Each resistor network is backed by many years' experience of thick film technology, and made to exacting specifications. Typical applications include pull-up resistors and line termination for TTL, ECL and CMOS logic.

S.I.L. units are ruggedly constructed in two basic package heights (8.55mm and 5mm) with 3 to 20 leads, giving designers the maximum flexibility to cater for various power-dissipation and board-density demands.

D.I.L. resistor networks from ITT are available in 14-pin and 16-pin transfer moulded packages.

In both styles resistor values are available up to 10MΩ with standard tolerances as close as 1%.

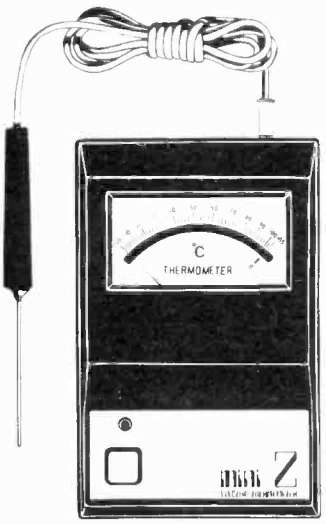
Custom designed networks are also available, offering a cost effective solution to many board-space problems. For more information on standard or non-standard ITT resistor networks, contact:

ITT Components Group Europe
RESISTOR DIVISION,
South Denes, Great Yarmouth, Norfolk NR30 3PX
Tel: 0493 56122. Telex: 97421.

Components ITT

WW—024 FOR FURTHER DETAILS

ELECTRONIC INDUSTRIAL THERMOMETER



THE MODERN WAY TO MEASURE TEMPERATURE

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

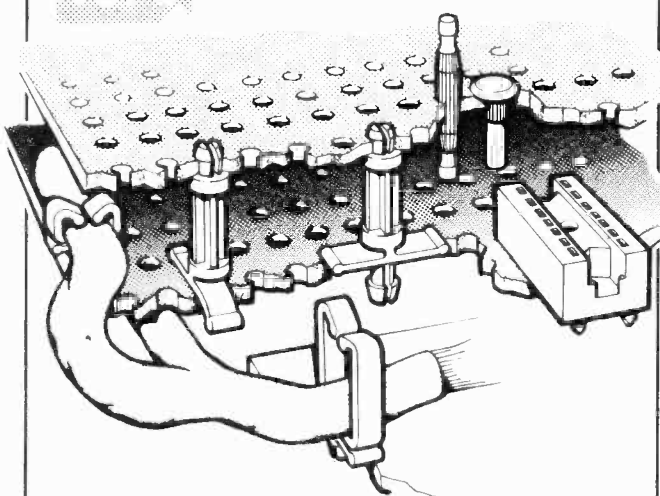
Model "Mini-Z 1" measures from—40° C to + 70° C. Price £30.00
Model "Mini-Z 2" measures from—5° C to + 105° C Price £30.00
Model "Mini-Z Hi" measures from + 100° C to 500° C £33.00
(VAT 8% EXTRA)

Write for further details to

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

WW—035 FOR FURTHER DETAILS

VERO



Our new 1978 catalogue lists circuit board access ones for all your projects — DIP sockets, pins standoffs, cable clips, hand tools. And we've got circuit boards, module systems, cases and boxes — everything you need to give your equipment the quality you demand. Send 25p to cover post and packing, and the catalogue's yours.

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WW—007 FOR FURTHER DETAILS

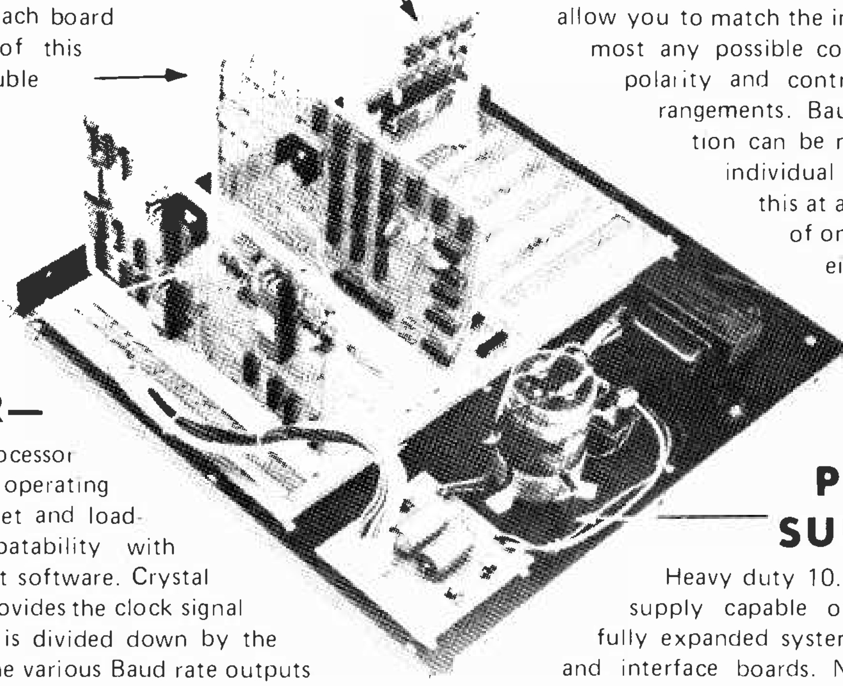
WHY SETTLE FOR LESS— THAN A 6800 SYSTEM

MEMORY—

All static memory with selected 2102 IC's allows processor to run at its maximum speed at all times. No refresh system is needed and no time is lost in memory refresh cycles. Each board holds 4,096 words of this proven reliable and trouble free memory. Cost—only £80.00 for each full 4K memory.

INTERFACE—

Serial control interface connects to any RS-232, or 20 Ma. TTY control terminal. Connectors provided for expansion of up to eight interfaces. Unique programmable interface circuits allow you to match the interface to almost any possible combination of polarity and control signal arrangements. Baud rate selection can be made on each individual interface. All this at a sensible cost of only £30.00 for either serial, or parallel type



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.

POWER SUPPLY—

Heavy duty 10.0 Amp power supply capable of powering a fully expanded system of memory and interface boards. Note 25 Amp rectifier bridge and 91,000 mfd computer grade filter capacitor.

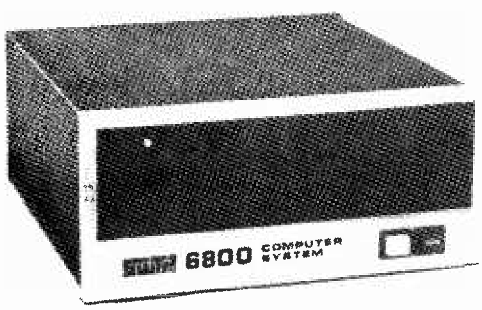
DOCUMENTATION—

Probably the most extensive and complete set of data available for any microprocessor system is supplied with our 6800 computer. This includes the Motorola programming manual, our own very complete assembly instructions, plus a notebook full of information that we have compiled on the system hardware and programming. This includes diagnostic programs, sample programs and even a Tic Tac Toe listing.

PRICE EFFECTIVE 1st OCTOBER, 1977

Mikbug® is a registered trademark of Motorola Inc.

SWTPC 6800
Computer System
with serial interface and 4,096 words of memory. **£275.00**
(Kit form only)



Prices quoted do not include VAT

Please send me details of your full range of computer equipment and software.

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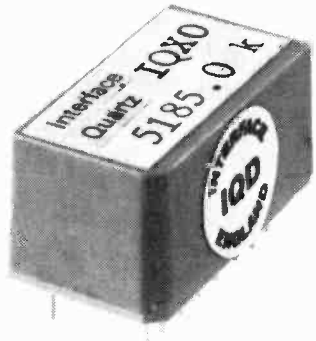

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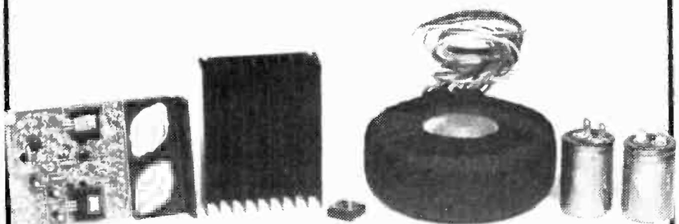
WW—048 FOR FURTHER DETAILS

TWO NEW SUPERMODULES: 170W INTO 4 OR 8 OHMS



By popular demand we have designed higher powered versions of our well known modules. The CE 1704 which gives 170W into 4 ohms and the CE 1708 which gives 170W into 8 ohms are physically similar to the orginal types and have the same combination of compatible performance features which makes CRIMSON amplification audibly superior to the competition and the only choice if you have an ear for music. We have also produced suitable power supplies which again use our superb TOROIDAL TRANSFORMERS only 50mm high, with a 120-240 primary and single bolt fixing.
Write of phone for more information and biased opinions.

POWER AMPLIFIER MODULES

	Home	Europe
CE 608 60W/8 ohms 35-0-35V	£16.30	£16.60
CE 1004 100W/4 phms 35-0-35V	£19.22	£19.30
CE 1008 100W/8 ohms 45-0-45V	£23.22	£23.00
CE 1704 170W/4 ohms 45-0-45V	£29.12	£28.46
CE 1708. 170W/8 0ohms 60-0-60V	£31.90	£31.04

TOROIDAL POWER SUPPLIES

	Home	Europe
CPS 1 for 2xCE or 1xCE 1004	£14.47	£18.40
CPS 2 for 2xCE 1004 or 2/4xCE 608	£16.82	£20.57
CPS 3 for 2xCE 1008 or 1xCE 1704	£17.66	£21.35
CPS 4 for 1xCE 1008	£15.31	£19.18
CPS 5 for 1 x CE 1708	£22.68	£26.50
CPS 6 for 2 x CE 1704 or 2 x CE 1708	£23.98	£27.70

HEATSINKS

	Home	Europe
Light Duty 50mm 2°C/W	£0.90	£1.30
Medium Power 100mm 1.4°C/W	£1.60	£2.40
Disco/Group 150mm 1.1°C/W	£2.30	£3.65

THERMAL CUT-OUTS
Recommended for improved reliability

	Home	Europe
70°C for use with free air heatsink	£1.60	£1.90
40°C for use with fan cooled heatsink	£1.60	£1.90

T.H.D.	:	Typically .01% any power. 1kHz. 8 ohms.
T.I.D.	:	Insignificant
Slew rate limit	:	25V/μS
S/N ratio	:	110dB
Freq. response	:	10Hz-35kHz. 3dB
Stability	:	Unconditional
Protection	:	Drives any load Safely
Sensitivity	:	775mV (250mV or 100mV on request)
Size	:	120 x 80 x 25mm

CRIMSON ELEKTRIK

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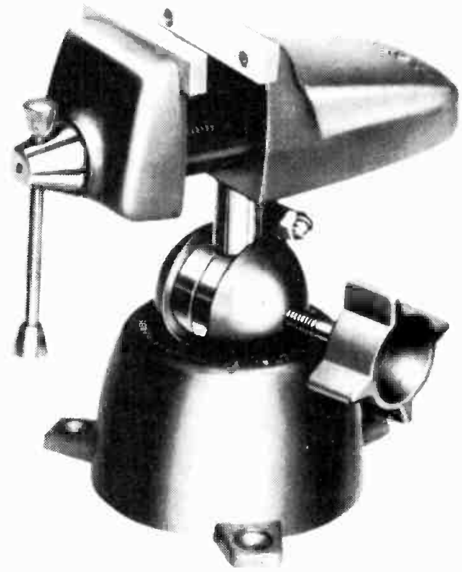
Home prices include V.A.T. & postage. C.O.D. 90p extra. £100 limit. Export no problem. European prices include carriage, insurance and handling, payment in **Sterling** by bank draft, P.O., International Giro or Money Order. Outside Europe, please write for specific quote by return. Send SAE or two International Reply Coupons for full literature. Favourable trade quantity price list on request. High quality pre-amp circuit 20p

WW—032 FOR FURTHER DETAILS

New from GREENWOOD



PANAVISE®

a precision vice that rotates a full 360 degrees-tilts 180 degrees from vertical to horizontal, and offers a choice of 3 bases, 3 heads, a bench clamp and a PCB holder.

We think it's like no other vice you've ever used. Its head rotates a full 360 degrees – and tilts 180 degrees from vertical to horizontal.

One conventional knob locks work in any desired position, firmly yet gently. You can choose a standard, low profile or vacuum base – a standard, low profile or wide opening head – a bench clamp mounting base – a printed circuit board holder and of course replacement jaws and pads if ever you need them.

Panavise is more than just a vice – it's a system.

Greenwood Electronics

Greenwood Electronics, Portman Road, Reading RG[illegible] 1NE
Telephone [illegible] Telex [illegible]

Obtainable also from our distributors:

Electroplan Ltd
P.O. Box 19, Orchard Road,
Royston, Herts SG8 5HH.

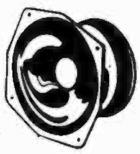
Toolrange Ltd
Upton Road, Reading RG3 4JA.

West Hyde Developments Ltd
Unit 9, Park Street Industrial Estate,
Aylesbury, Bucks HP20 1ET.

Special Products Distributors Ltd
81, Piccadilly, London, W1.

WW — 103 FOR FURTHER DETAILS

WILMSLOW AUDIO
The firm for Speakers



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Audax HD20B25J4	£10.95
Audax HD11 P25EBC	£6.95
Baker Superb	£22.50
Castle 8RS/DD	£11.95
Chartwell CEA205 8" bass, matched pairs only	pairs £59.90
Coles 4001	£6.25
Coles 3000	£6.25
Celestion HF1300 II	£8.25
Celestion HF2000	£9.75
Dalesford D20/105 4"	£10.95
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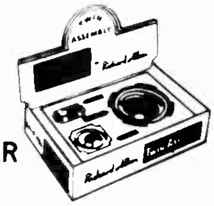

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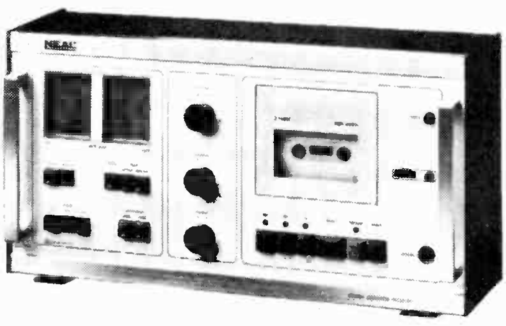

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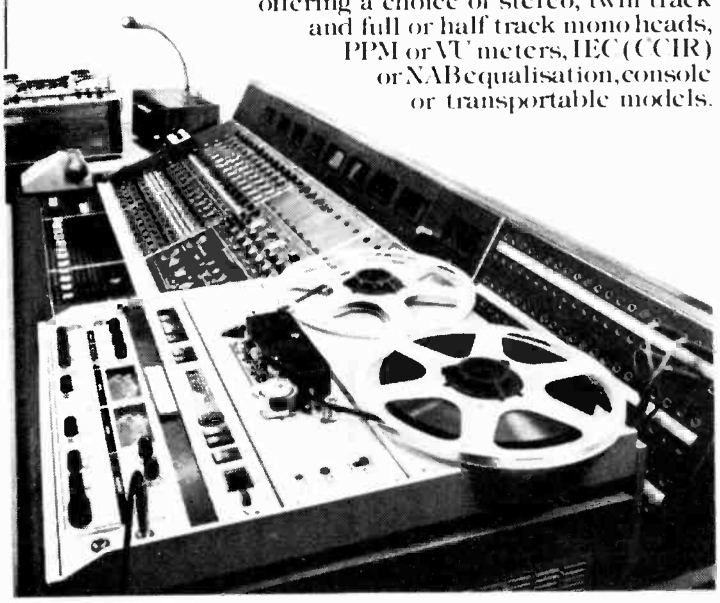

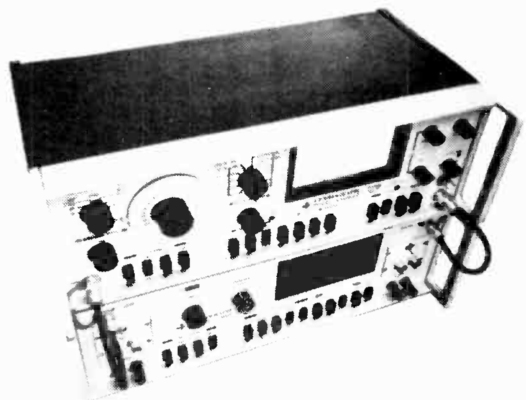

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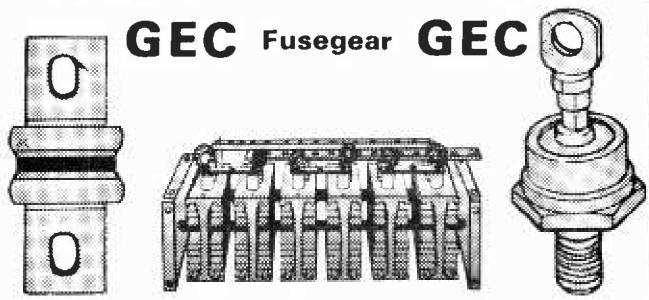

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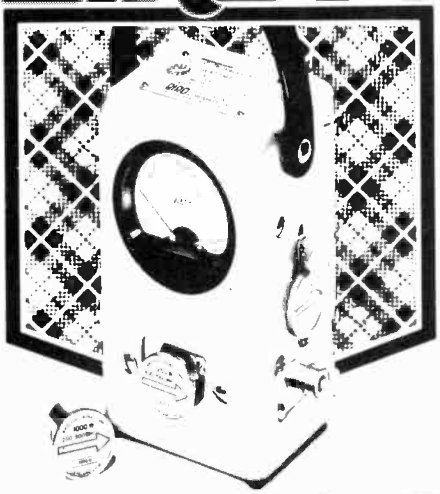

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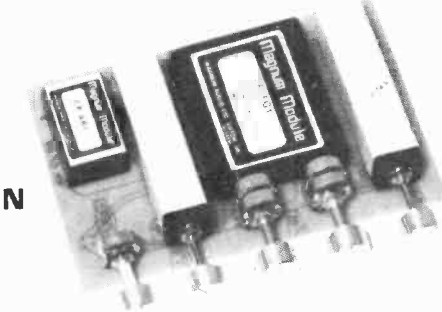

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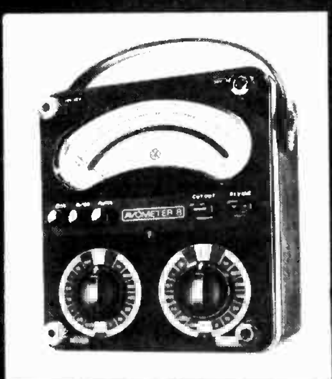

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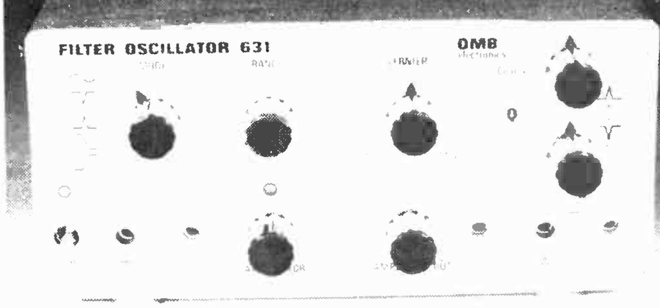

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In the beginning was the word

THE IDEA that information can be treated as a commodity and measured and processed in various ways quite regardless of any meaning it might have has long been accepted by electronics and communications, engineers. Now these same engineers are introducing the electronic embodiments of this idea to the wider world of industry and industrialized society, where it is being received with some bewilderment and dismay. In this issue A. E. Cawkell surveys the technology of electronic information systems and what is influencing their application to the world. Their purpose, of course, is to increase the effectiveness of communication and control. They work through machines and people and combinations of these. The trouble is that while the operation of the hardware and software is totally determined the human beings involved are unpredictable and may well produce reactions which the system designers had not bargained for.

The replacement of marks on paper by electrical states is not to be dismissed as a mere technicality. It is a metamorphosis which profoundly affects the positions and relationships of all the people caught up in it. First, electronics is so fast that the information in process cannot be grasped or seen like documents in transit. Secondly, the information is inscrutable: it is held in coded form in stores and can only be translated by permission with special equipment at certain times. Thirdly, the information is inaccessible: it is transmitted and processed within a fixed network which excludes human intervention. Fourthly, the operation of this network demands that the information shall be fed in and taken out in a form prescribed and directed by the system. People must adapt themselves to the environment of such systems and learn their language — to understand, for example, that a word (so far from St John's gospel) is a mere string of digits, an address a movable slot.

We do not yet understand the detailed consequences of these changes, but the overall effect is quite clear: an increase in the separation of industrial man from his own products and from those who co-operate with him in making them. In mass-production the shop-floor worker is already alienated. Now not only he, but also accountants, salespeople and all those service workers who are already accustomed to the idea of symbols standing for real objects and services, will be isolated from even the representations of reality. The National Computing Centre, in a recent case study, noted: "In the case of foremen and supervisors, for example, there was evidence that the introduction of a computer-based system can change roles in ways that may induce covertly hostile attitudes towards both the system and the management of the enterprise". A further result will be an increase in moral distancing – from remote consequences of one's acts.

Electronic information systems seem necessary for fast and accurate control of the complicated and interdependent processes of modern civilization. But as a result the new systems will become instruments of unprecedented power over individuals in the hands of industrialists, professional specialists and administrators. This could worsen the division in society between the well-educated managerial class, which understands and controls the systems, and the rest. We might even see a new instance of the Marxist principle that when new production technology comes into conflict with the existing social relations of production the conditions are set for social change.

The paperless revolution

Forces controlling the introduction of electronic information systems

by **A. E. Cawkell,** Institute for Scientific Information

The rate at which electronic information systems will take over from paper depends on various technological and social factors. This article looks first at developments in the technology and the rapid fall in the price of devices; also at input and output methods and the control, cost and future of communication channels. European and American politics are contrasted and the conditions for innovation described. Electronic information systems are expected to develop more quickly in non-domestic areas where the incentives and economics are more favourable. Social forces, such as unemployment, disruption of social activity, and fears about instrusion, secrecy, the control of information sources and "the machines taking over," (discussed next month) will slow down the introduction of the technology. Engineers should make it their business to understand the issues and publicise the accumulating evidence about trends in this revolution.

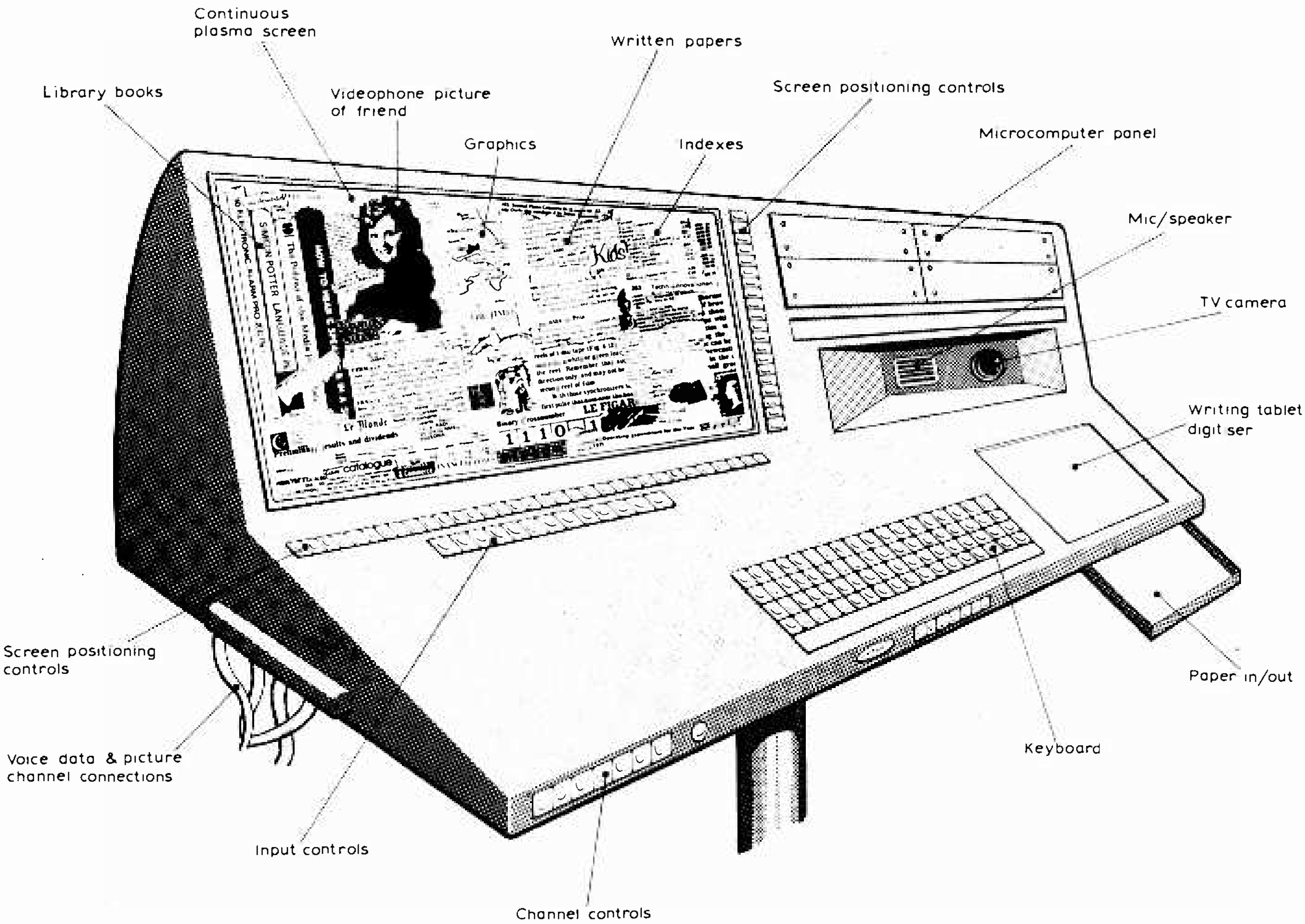
"The difference between Orwell's 1984 and a hypothetical participatory democracy lies in the question of who controls the sending and receiving of information."

E. B. PARKER

THE DRAWING on this page represents an information console as it may exist in any home, or with slight modifications, in any office or work-place in the year 2000. This all-purpose communication/information facility is based, in nearly every detail, on currently feasible technology. Many human activities involve information processing, and nearly all of them could be performed without leaving the console.

The "consumersole", an information console that could be in use in the home or at work by the end of the century.

This report is a review of the forces which will control the rate of widespread introduction of such a facility. Of course, all the systems shown in the drawing will not come into existence suddenly. Various devices and alternative channels will be introduced, improved, varied in price, etc. in an evolutionary way, not necessarily in the home first; the several channels shown may be eventually unified into, say, an all-satellite system — but these are details in the sweep of events. Factors controlling these events will be the technology and the vested interests tending to force a sometimes premature introduction of new devices. They will have to do with market forces which will encourage new developments; availability of communication channels and the politics of their control and pricing; resistance to change by those people likely to be displaced and organizations with an interest in preserving the status quo; and resistance by



an informed public and later by a better informed general public who will find it difficult to distinguish between beneficial and harmful changes. This resistance will be concentrated against developments which provoke profound social changes or those considered to be intrusive or of a "big brother" nature. Economic forces will be very important and the gap between information-rich and information-deprived people will probably widen. For instance it seems unlikely that the 30 million people in Cairo and Teheran will benefit much; neither city has a telephone directory; hotels in Athens are used by Cairo businessmen who fly there to place international calls[1].

New device technology

The basis for much of the new technology is the development of semiconductor chips and large scale integrated (l.s.i.) circuits. An assembly of these devices can enable extremely complex data processing and control functions to be reliably carried out at high speed while occupying a very small space and consuming little power. Basic material research and production know-how owe much to military and space exploration requirements.

Microprocessors are already being introduced into cars experimentally and will soon be used as a matter of course in domestic appliances. Do-it-yourself computer kits are available for a few hundred dollars and software — always the main problem — is catching up with new languages like Micro-Cobol.

Projections based on what has already happened in this field and in developments in storage devices can be made with some confidence. The first four- and eight-bit word microprocessors — the 4004 and 8008 — were introduced in 1972 by Intel; 16-bit microprocessors are now available. Developments in m.o.s. semiconductor devices and p-m.o.s./n-m.o.s. combinations known as c.m.o.s. (complementary metal oxide silicon) now seem to be of importance. Since 1960 minimum integrated circuit dimensions have halved every five years to about 4μm with correspondingly reduced capacitances and time-delays because of shorter circuit paths and interconnections; optical limits are being approached. At this rate, internal delays of 1 nanosecond and complexity increases of 2,000 times would be achieved in 15 years. The cost of including redundancy for greater reliability will drop; error correction for an 8-bit word requires 4 bits, but for a 64-bit word only 7 bits are needed. Arrays of 250,000 gates at 0.04cent per gate are foreseeable[2] (see Fig. 1 for a graphic representation).

The rate of development and cost reduction of storage has also been very rapid. In five years' time 250 Kbyte chips costing $100 may be available[3], but this forecast may be already out of date since 16K r.a.m. chips at $25 have just been announced.

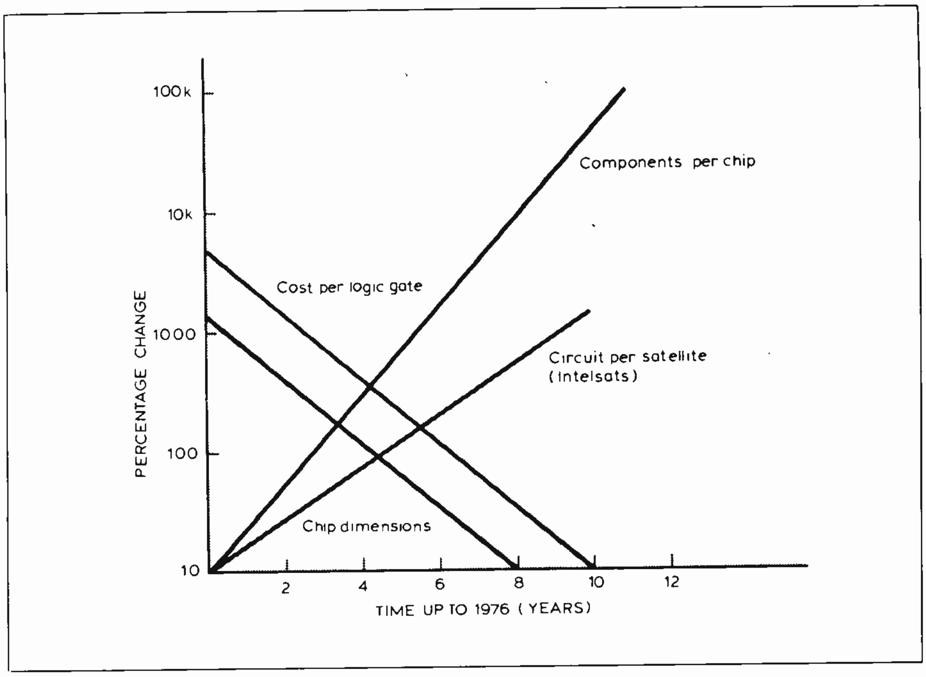


Fig. 1. *Rates of change in integrated circuit and other technology up to the year 1976.*

Work is in progress on a whole range of new storage technologies including charge-coupled devices (c.c.d.), magnetic bubbles, electron-beam accessed semiconductor memories, and optical memories [4]. Magnetic bubble memories first became available commercially in 1977 as a 92,000 bit storage chip; the 1978 quantity price is expected to be $75; these devices look like a powerful competitor for microcomputer storage, versus, say, the floppy disc, since they are more reliable and the cost per bit is about 0.08cent compared with about 0.3cent (1977) for the floppy[5].

Complete instruments embodying holographic storage have been described; one such has been designed for textual information storage and retrieval using film for holographically stored text with associated graphics stored on microfiche frames[6]. In another a terminal is available commercially, capable of retrieving information stored on a 4in × 6in film strip[7]. The film carries 200Mbit in the form of holograms. The information is read out by a laser which projects the image onto a photodetector array from which an electrical output is available to drive, say, a c.r.t. display.

The rate of progress is so fast that keeping up with current work and deciding which of the new companies will endure is extremely difficult, even although a number of new specialised journals have been introduced covering the various fields. Sufficient has been said in this rather brief review to convey the flavour of the technology.

Information input

The transfer of most non-verbal information starts with writing or typing; since many people cannot type, some ingenious ideas have been tried out to enhance the writing process. In one, digital codes are generated by writing with a magnetic stylus on a tablet within which a fine wire matrix is embedded[8]. Co-ordinates of induced e.m.fs formed by character patterns are read out. The wire pattern is arranged so that Gray not binary code is generated; for example, 11 not 1024 terminating connections are needed for a resolution of 1 in 1024, and since a 1-position error differs by only 1 bit from the desired position the effect of errors in the writing process is quite small. This idea illustrates one of many methods all having the same purpose — the second stage of the information transfer process — that is, the conversion of information from the human-generated form into a form suitable for machine processing or transmission. The commonest method of doing this is probably the direct generation of digital codes by keying as with Telex, Teletype machines, computer terminals etc; the codes are then stored on disc, tape, or other media by direct connection between keyboard and storage device, or by transmission and storage remotely on similar devices.

Since the paperless revolution is at an early stage, a huge fund of already keyed or typeset information exists as print on paper. Optical character recognition (o.c.r.) machines, usually requiring preferred fonts to make the machine's pattern recognition task easier, have been developed for converting print to digital codes. Advances in pattern recognition, typified in the Kurzweil reading machine[9], enable almost any printed text to be recognised. In this machine, scanning is carried out by a 500-element c.c.d. device, with a 2ms sampling period; a "split analysis" module isolates character entities, and a character is then recognised and transformed into the appropriate digital code by a "minimal in-variable property extraction" process, followed by a "disambiguator" module which makes a final decision; the phonemes formed by character sequences are determined by rule look-up associates with an exception dictionary; a syntax analyser adds prosody across sentences so that the emitted sounds will not emerge as a monotone; finally, control signals actuate a set of electronic synthesisers which generate speech sounds. The machine was developed to enable blind people to read a variety of printed material, and acceptable speech is generated.

This brief description of the Kurzweil machine has necessarily overlapped into another area of this subject — information output. However, this particular technology — speech communication with machines, in which intensive research has been carried out — certainly merits inclusion in this section.

It is important to distinguish between word recognition and speech-machine communication. Machine recognition of speech uttered by any person may or may not be achieved early in the next century; nevertheless there has already been some substantial progress. Speaker verification systems have been developed, to operate over the dial telephone system, which are capable of an identification accuracy of 91% on a set of 100 persons with several thousand impostors (Bell Telephone). Of more interest here is the state of the art of speech-machine communication. One current system uses adaptive differential pulse code modulation (a.d.p.c.m.) for carrying out a machine-prompted standardised-phrase dialogue — for instance in a flight booking system[10]. In the design of such a system decisions must be made about the size of the stored vocabulary which the machine will be required to recognise and the analysing resources which are needed to extract sufficient information from the speech to enable it to be correctly matched against the stored vocabulary. In the flight booking system a 24k bit/s rate is generated from the incoming speech, compared with a rate of about 60kbit/s normally used for good quality p.c.m. speech transmission. This is achieved by generating, say, 3 bits per quantized spech sample, with a sampling frequency of 8kHz. With a.d.p.c.m. the quantizer step size is continuously adjusted to follow changing speech characteristics. The codes generated are then matched against the stored vocabulary. In the flight booking system, the machine utters questions like "where would you like to fly to?" and recognises replies like "Washington" from a trained speaker. It will recognise dates, times, destinations, classes, number of seats required etc. Research continues into more sophisticated systems in which a detailed computer analysis of the characteristics of the actual speech is made — a requirement for comprehensive speech recognition[11, 12]. Quite recently a speech-recognising microcomputer, selling for $249, has been offfered in the USA by Speechlab[13]. It stores 64 different words, each word being stored as 64 bytes, and embodies the software for speech analysis and matching. 95% recognition accuracy is claimed after machine "training" by a particular speaker.

Information output

Again it is only possible to highlight here some current developments in order to show that most of the technology is available or being developed for the "information console" shown earlier.

There are two ways of composing textual information displays, although the distinction between them is blurred. A display can be built up character by character, or by words, sentences, etc, which are individually called up from computer store, processed, ordered, and displayed in some desired way. Alternatively the smallest available element can be a complete page — as in the viewdata system — although of course pages are received as a character by character bit-stream in this case; a microfiche image is another example based on a page-at-a time display.

The conception of an all-purpose information machine was put forward by Vannevar Bush in an often quoted 1945 article[14]. This machine — the "Memex" — would embody various input facilities, a large store, associative indexing of the stored information, and a comprehensive display system. Bush was of course well aware of cathode ray tube displays which received an enormous development effort during the war. Twenty-five years later he reviewed the situation and concluded "... a long time from now, I fear, will come the personal machine"[15]. Insofar as displays are concerned, Bush's remarks still hold good.

Although c.r.t. terminals have received enormous development and the electronics can be contained on a microprocessor chip[16] today's c.r.ts are not greatly different, at least in their capacity for displaying textual information. A good terminal — say a Tektronix 4006-1 — can display about 2600 characters at a time, assuming that the user knows what he wants. In reality, information requirements for forming successive sets of mental images often cannot be precisely specified in advance. A convenient arrangement is a very large display of ordered information, in anticipation of the general need, from which a specific selection can be made by using the extremely rapid scanning and information-processing power of the eye-brain. A set of pre-selected papers on a desk can present at least a quarter of a million characters; adjust the papers and a new set of a quarter of a million characters is presented. Two volumes of an index, opened to display four pages of 6 point characters — admittedly rather small — can alone present 180,000 characters at one time.

The contrast between the c.r.t. and the print-on-paper "windows" presenting 2600 characters and 100 times that number respectively, is very marked. What is needed is a window of the size represented by the papers, served by the full power of an on-line information retrieval system in which all the information likely to be needed is stored. High speed computer selection then replaces the laborious business of assembling the right collection of papers for each requirement. In a practical arrangement a screen would be required for the display of whole pages, notes, illustration, ordered lists etc. — at least 50,000 characters at a time — which could be called up from store, scanned, noted in a voice-controlled computer, re-arranged, etc. As with papers and indexes on a desk, the power of the eye-brain may then freely be utilised to scan and absorb what is required from a mass of material.

The screen would need to be at least 4ft × 2ft with light-pen or touch control of discrete areas enabling information in various formats to be displayed, re-positioned, expanded, contracted etc. This screen size would accommodate about 150 rows of 12-point characters; since about 12 lines or dots are needed to resolve a character satisfactorily, and allowing for space between rows, this screen would require at least 2400 × 5000 dots for matrix addressing. Facilities of this kind have been suggested in at least two cases, one using a conventional c.r.t.[17] and the other a so-called plasma display 8.5in square[18]. However, the "window" size in both cases is quite inadequate for the purpose and the requirements made above do not seem to have been recognised.

New display technology under development includes piezo-electric ceramic storage, magnetic particle, banks of l.e.ds or l.c.ds, electrophoretic and electroluminescent displays. Of the so-called "plasma" displays, a promising development is a 3ft square bank of neon-filled capillary tubes controlled by an electrode matrix. Resolution is at present 33 lines/inch[19]. The driving electronics is manageable, and a light-pen controlled cursor for area manipulations is described. A device of this kind coupled to a microprocessor controlled trackball/cursor facility[20], might, one day, be available at the right price for the "consumersole."

Small window displays are adequate for the more limited requirements of reading page-by-page sequences, look-ups in specific lists, display of information in response to specific questions demanding relatively short answers, and so on. Such displays could form a part of a larger panel, perhaps being projected onto it. Currently available displays are usually based on the cathode ray tube or on enlarged projections of a film image. Microfilm and microfiche (multi-image film cards) and associated equipment are of particular interest. Their advantage lies in cheap storage of an enormous quantity of information in a very small space; one application has been for archival storage, as in libraries. However, microforms of this type have never taken off, primarily because of user resistance to inconvenient microform reading equipment of poor quality. The low priced reader which can successfully compete with the convenience, portability, clarity, and resolution of print on paper is as yet unavailable[21]. A reader like the new book-size Izon machine, which incorporates 500 micro-lenses and a fibreoptics lighting system from a 12-volt lamp may be the answer[22].

A more recent development is the production of microform from machine-readable information (computer output microfilm — c.o.m.), as opposed to the photo-reduction of print on paper, and the introduction of computer controlled equipment for mechanically retrieving and projecting one frame out of tens of thousands carried on film strip or fiche cards. In the Marconi automated microfiche terminal[23] one hundred and twenty fiche cards, each containing 3500 size A4 page images are carried in a magazine — a total of 420,000 pages; magazines can be quickly changed. An indexing and fiche-selection programme is held in a minicomputer connected to the terminal and controlled by the terminal user with a keyboard. A desired fiche is selected and projected onto the terminal's screen in a few seconds after typing the appropriate indexing terms. A typical Marconi system consists of a number of terminals with locally updated fiche, each connected by telephone line to a common time-shared minicomputer which performs the selection operation for all terminals.

Stabletron[24], on the other hand, offers a system in which there is one central fiche-selecting machine with a time-shared mini beside it. Terminals, connected by lines to the central facility, consist of keyboard and a c.r.t. screen with local page storage. A user's commands are received by the machine and the desired image is despatched down the line, where it is stored locally and viewed at leisure on the terminal. Since the central facility embodies a queuing buffer and in any case takes only about 1.8 seconds to select a fiche and transmit its image, and most users spend most of the time reading or thinking, response time is normally quite adequate. An advantage of this system is that only one central up-date is needed, and since the system is television based, urgent up-dating may be achieved by overlaying part or all of a given fiche image with keyed characters inserted at the central facility. The disadvantage is that, unlike the Marconi, the terminal to central facility connection has to be a wideband channel, or a narrow-band channel with slow scan equipment at either end. Stabletron use a 15MHz 875-line system for transmission of small typeface. The facilities for quickly changing part of the fiche provided by Stabletron is reminiscent of another new development, computer input microfilm (c.i.m.) which enables film or fiche to be quickly changed. All material is stored in machine readable form and can be selectively viewed and modified from a c.r.t. terminal. New material is rephotographed and added to the file[25].

Turning from non-verbal to verbal machine-man communication, one sophisticated way of doing this was discussed earlier in connection with the Kurzweil machine. In general, the problem consists of applying digitally coded representations of speech to a speech synthesiser. For example in the commercially available Votrax multilingual synthesiser[26] one of 122 phonemes at one of 8 pitches and one of 4 durations is selected by a 12-bit command word. When fed with appropriate driving information — for example ASCII code at a rate as low as 300 bit/s — usable audio output is generated. The driving code is pulled from some external storage media, such as disc, by appropriate computer software. Less sophisticated microprocessor speech synthesisers for home computers requiring an appropriate microprocessor c.p.u. and storage[13], are already available in the U.S. for $400.

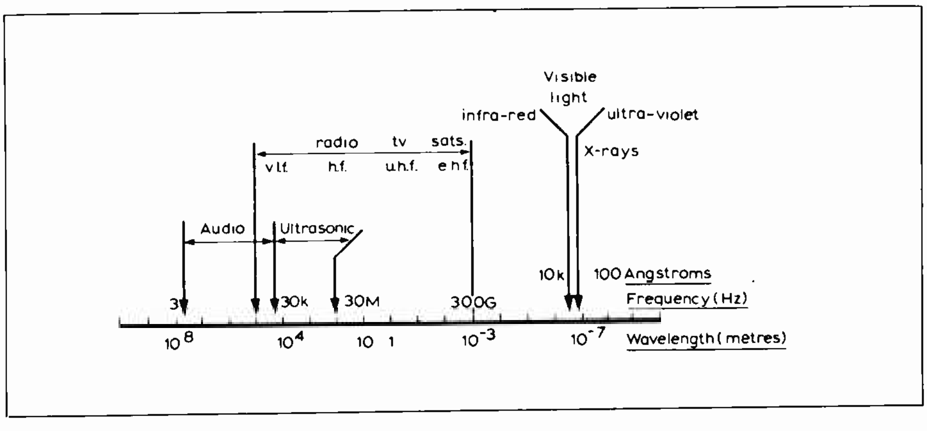
Communication channels—the politics

For communication at a distance, human-generated information is changed into a form suitable for transmission through a communication channel operating within the frequency bands shown on the spectrum in Fig. 2. To avoid chaos, national and international control has been organised for orderly usage of the available communication channels within the frequency bands which it is physically possible to use. More information demands more channels and technological developments have provided them — for example by satellite communication at e.h.f. — but there is a limit. Once it becomes feasible to use a channel the question arises, by whom should it be controlled and used? Because transmission of information is of such vital importance the politics of communication channel control is equally vital. I am referring here to the higher-order politics — for example governmental versus private control — rather than to the politics of channel allocation for broadcasting, radio communication, etc. which is agreed internationally through the International Telecommunication Union (ITU).

Telecommunications history started with telephone systems, organised in most countries as public services with the object of providing a universal service at minimum cost; heavy R & D costs and investment are involved in the setting up of plant with a working life of decades. Telephone organisations are usually large bureaucratic monopolies which change slowly. As radio communication developed, channel allocation in the electromagnetic spectrum was reasonably well managed, but conflict soon arose about public and private control of communications generally, including telephone voice and data transmission, radio and television broadcasting, cable television, computer communications and satellite networks. Ownership and government control is arranged on the basis of mutually exclusive applications, whereas in reality there are now no sharp divisions — for example computer data communications may be established along analogue telephone lines where ownership and tariffs are geared to universal voice communication requirements.

In this situation the contrast in the styles of change as betwen USA and Europe is very marked. The "... freedom of speech or of the press" referred to in the First Amendment in the US Constitution extends to broadcasting, cable etc. (Winters v. New York 1948, when it was held that one person's entertainment is another's doctrine). Furthermore, although the early activities of the Federal Communications Commission in broadcasting appeared

Fig. 2. *Spectrum of sound, ultrasound and electromagnetic waves, showing where various information transmission systems fit in.*



to be restrictive, its regulations were later considered to support the First Amendment by ensuring the expression of diverse views (e.g. NBC v. US, 1943). Freedom of choice issues do not arise in the same way in cable television (c.a.t.v.) — there is no shortage of channel space as in broadcasting — and the FCC's attempts to regulate c.a.t.v. have run into considerable criticism[27]. It has been suggested that c.a.t.v. is being strangled by regulations, and that the treatment of it should be similar to that of the press, which is free of restraint[28]. These issues are discussed openly in the US; frequent suits brought under the anti-trust laws, with lengthy discussion, confirm this generally open style (for example MCI's suit against AT&T, 1974).

Of particular interest here are the events following the 1934 Communications Act, passed in order to establish an integrated universal telephone network provided by controlled monopolies. As new devices became available for connection to the network, the public became frustrated by monopolistic inertia, which, in this respect, was broken in 1968. In that year an anti-trust suit was brought against AT&T, the largest US telephone company (it includes Bell R & D and Western Electric manufacturing associates). The FCC established a precedent for the connection of competitive devices to the telephone system by allowing connection of Carterphone equipment via acoustic or inductive coupling. In 1975 the principle was extended when the FCC ruled against preferential tariffs offered by the telephone companies when their own equipment was used[29].

Meanwhile communication technology was developing in the area of microwave and satellite communication, packet-switched networks etc., accompanied by the formation of new innovative companies. In 1968 MCI applied to the FCC to operate a microwave link using local telephone lines for distribution; the FCC agreed (with support in a later legal appeal "the Specialised Common Carrier" decision 1971), on the grounds that the public interest would best be served by communication innovations. In consequence of this a number of "Value Added Network Services" (VANS) now operate in the United States (or, to use the current jargon, Resale and Sharing Carriers). The FCC took the same viewpoint in 1972 with its "open skies" satellite communications policies. A rash of appeals followed and in 1976 (Docket 20097) the FCC produced rules which are an attempt to encourage innovative services. They do not permit the degree of "cream-skimming" which would affect the revenue of the telephone companies to the extent of endangering universal service.

During 1976/77 discussions started about reforming the 1934 Act; proposals are (at the time of writing) before Congress committees. Major issues include the effect of competitive equipment and private line services on the national telephone network, and whether groups, such as large businesss, are likely to benefit at the expense of low-income users[30]. These issues, particularly the last, are of course as relevant in Europe as in the US. While the US system of discussion before regulatory commissions, followed by appeals, court rulings etc, is laborious, costly, and time consuming, it seems to me that the outcome will be a relatively free flow of information. It should also be remembered that the flow of information generally is subject to the beneficial effect of the Freedom of Information Act.

I am unable to report comparable progress in Europe, or in the UK in particular. Here the climate is symbolised by the suffocating effect of the Official Secrets Act, passed on the nod after an half-hour debate in 1911 during a spy scare[31]. (In the US the 1973 Federal Advisory Committee Act requires that some 2,000 committees should meet in public.)

In the UK communications are provided by the Post Office (PO), a Corporation whose Board is accountable to the Secretary of State for Industry, a member of the government. The Secretary present the PO's annual report before parliament; although he has the right to issue directives he seldom does. "Without the stimulus of regular public hearings there is relatively little public debate, consequently the community of informed commentators who can act as advisers or write about policy is relatively small"[32]. The main discussion forum is, therefore, parliament, the supreme institution, whose supremacy is an expression of custom and is nowhere defined. This is certainly not the place to discuss the unwritten British constitution, but it is the place to discuss briefly the prospects for the free flow of information through electrical channels vis-a-vis the PO.

Post Office activities were reviewed in the "Carter Report" presented to the Secretary of State in 1975; separate corporations for postal and telecommunications services were recommended. In 1977 a government committee made proposals (the "Bullock Report") about Trade Union representation on boards, and proposals about the constitution of the PO's board have been made; in consequence the Carter proposals have been shelved. Attempts to extend the very limited liability of the Post Office have also failed.

(To be continued)

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Information systems conference

The sociological and psychological effects of computer based information systems will be the subject of a conference with mainly European and American contributors, "Computer Impact 78", to be held in Copenhagen, October 25-27. Details are available from: Spadille Congress Service, Sommervej 3, DK-3100 Hornbaek, Denmark.

Discriminative metal detector

A sensitive instrument which can differentiate between ferrous and non-ferrous metals by measuring a phase change

by **R. C. V. Macario,** B.Sc., Ph.D., M.I.E.E., University College of Swansea

This metal detector combines high sensitivity with the ability to differentiate between ferrous and non-ferrous metals. Unlike conventional detectors, a visual display by l.e.ds is used for producing a sense of phase change. Headphones can also be used to give a Geiger counter type of audio indication. The complete unit will operate for over eight hours from a small battery.

THE ARTICLE by D.E.O'N. Waddington in *Wireless World* April 1977 was interesting because it outlined the rules by which metal detection may be legally carried out, and also showed how the sensitivity of a search coil alters with size. The sensitivity was discussed in terms of change in resonant frequency from a nominal value, which was shown to be a few hertz for a small object.

However, it is well-known that a change in frequency between one oscillator such as that connected to the search coil f_S, and another similar reference oscillator f_R, can be measured by observing the relative phase shift between the two oscillator signals[1]. For example, if the frequency difference between f_S and f_R is Δf, then the phase shift, which will be observed between the two oscillators after a time ΔT, is given by $\Delta\phi = 360.\Delta T.\Delta f$ .....(1)
Therefore if $\Delta f = f_S - f_R = 1\text{Hz}$, a phase shift of 360° will take one second. This effect is illustrated in Fig. 1 where f_S changes at time T_0 to a frequency slightly greater than f_R. After a time ΔT there is a considerable phase shift $\Delta\phi$ between the two signals. Clearly, if the phase differences can be observed, then very small differences of frequency can be detected and a very sensitive frequency difference detector can be built.

An interesting feature of this system is that the sign of $\Delta\phi$ is equal to the sign of the increasing or decreasing frequency. A metal detector based on the phase measuring principle will therefore have the ability to indicate whether a hidden object within the vicinity of the search coil is intensifying the magnetic field, ferro-magnetic, or diluting the magnetic field, dia-magnetic. In theory, differentiation between, for example, buried iron or brass objects can be indicated. Because the dia-magnetic effects are usually small, search coil self-capacitance and sample eddy-currents can mask the self-inductive effects. Nevertheless, the potential to differentiate exists and some investigators may find a study of alternative search coils worthwhile.

In the author's prototype system as shown in Fig. 2, the search coil oscillator phase is compared with a similar reference oscillator. The phase difference is displayed by a line of l.e.ds arranged to indicate in which quadrant the phase difference exists, see Fig. 3. As the phase changes a different l.e.d. is turned on. The rate of change is dictated by equation (1). For a frequency difference of 1Hz the illuminated l.e.d. will move along the row in one second, sweeping from left to right for a ferromagnetic object, and from right to left for a diamagnetic object. As the search

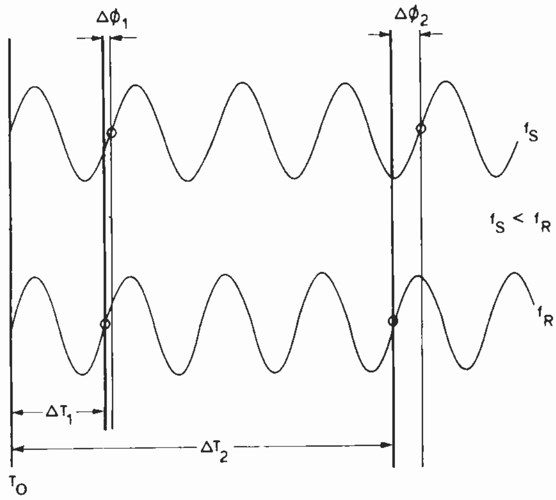


Fig. 1. *Oscillator waveforms showing phase difference changing with time.*

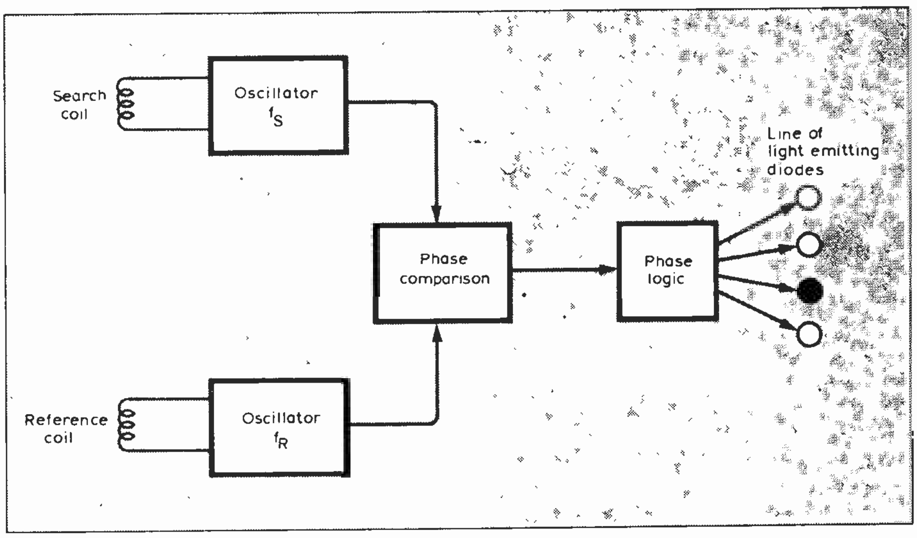


Fig. 2. *Basic detector arrangement.*

coil moves closer to the object the speed of sweep increases until all of the l.e.ds appear to be on.

Circuit design

Because the circuit uses c.m.o.s. i.cs throughout, the current consumption of around 5mA is almost entirely used by the l.e.d. which is on. The oscillator design shown in Fig. 4 is very suitable for this application because it is clearly defined by a coil inductance and an associated tuning capacitor, therefore f_S, or $f_R = 1/2\pi\sqrt{LC}$. The output is also conveniently squared-up to the c.m.o.s. logic level.

The unit uses the search coil and frequency of 120kHz proposed by Waddington in *Wireless World* April 1977. The coil consists of 45 turns of 26 s.w.g. wire wound around a circle of 6½in diameter. A circular wooden former is used to support the coil and the complete assembly is covered with tape, aluminium foil, tape, expanded polystyrene and a final layer of tape. The foil is connected to the screen together with one end of the coil. Other coils and allowable frequencies, however, are just as suitable. The reference oscillator needs a frequency of four times f_S, i.e. 480kHz. This is also very convenient because a simple i.f. coil can be used.

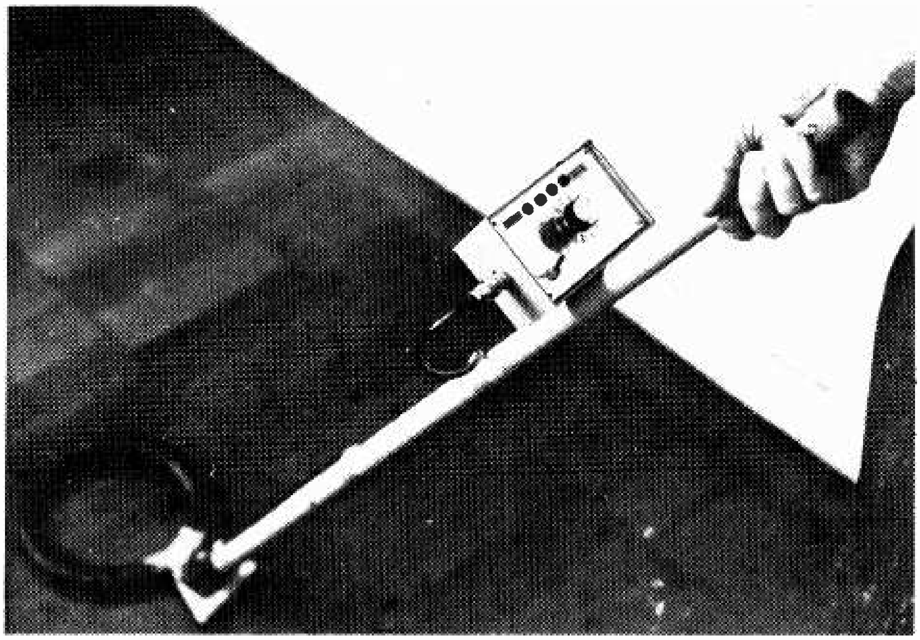
The circuitry for determining the phase difference between f_R and f_S uses two D type flip-flops as shown in Fig. 5. If f_S is applied to the two clock inputs, and the phase quadrant inputs of f_R are fed to the two D inputs, the input is only transferred to the output on a positive clock which produces the truth table below.

Phase quadrant f_R:f_S	**0-90°**	**90°-180°**	**180°-270°**	**270°-0**
Q_1	1	1	0	0
$\overline{Q}_1$	0	0	1	1
Q_2	1	0	0	1
$\overline{Q}_2$	0	1	1	0

The four outputs are then NANDed so that only one gate goes positive in each quadrant. The l.e.ds are arranged so that as the phase difference moves through the truth table, one device switches on after the other. To obtain the phase quadrature f_R signals, the well-known divide-by-four circuit shown in Fig. 6 is used. Another dual D-type flip-flop device is used to produce the outputs $f_R/4$ and $f_R/4 + 90°$ which is why f_R runs at $4f_S$.

The complete metal detector circuit is shown in Fig. 7. Five i.cs and four l.e.d. driver transistors perform all of the circuit operations. The signals are all square waves except at the oscillator coils where the frequencies f_S and $4f_R$ should be observed. The reference oscillator frequency can be tuned with a ferrite slug in the i.f. transformer coil L_2. The search coil is tuned by C_1 with the trimming capacitor in the mid position. When correctly tuned only one l.e.d. should be on which gives a stationary display except for the occasional hop. Adjusting C_{14}, or detecting an object, causes the light to run along the display in one direction or the other.

A suggested layout for the circuit is shown in Fig. 8. This printed circuit fits into an RS plastic box type 509-642 which measures 4½ × 2¾ × 2in together with all of the controls. The unit operates from a 9V PP3 battery which can be the rechargeable type. The



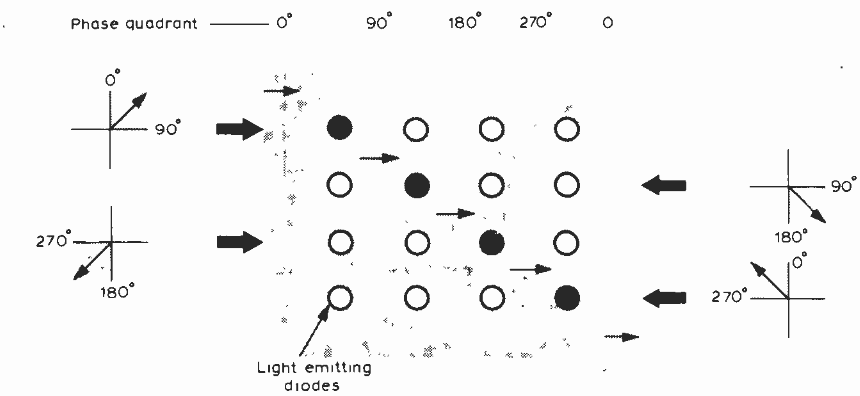


Fig. 3. *Line of l.e.ds indicating the four phase quadrants.*

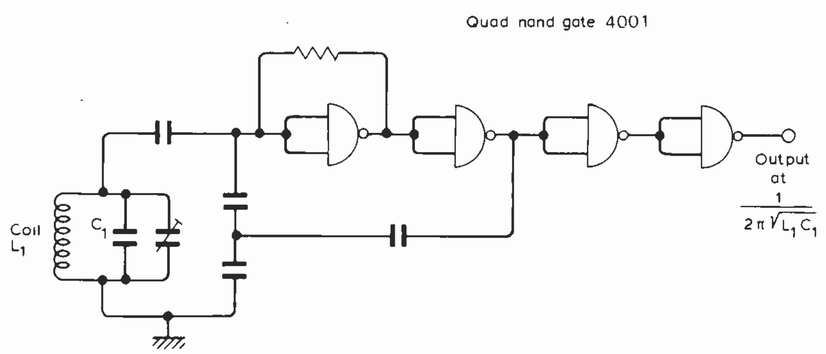


Fig. 4. *Basic l.c. oscillator using a quad NAND gate i.c.*

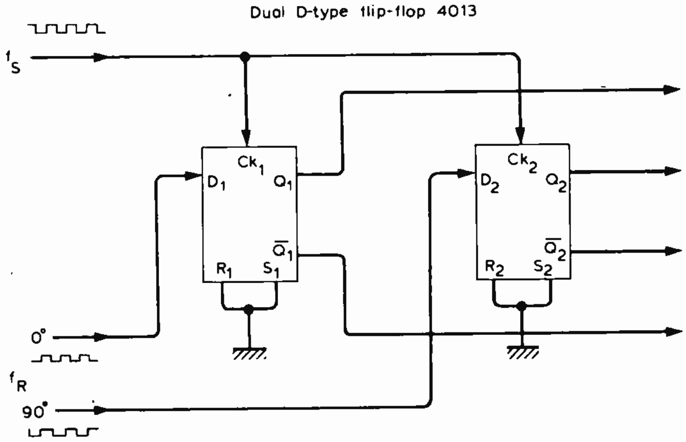


Fig. 5. *Phase quadrant comparison circuit*

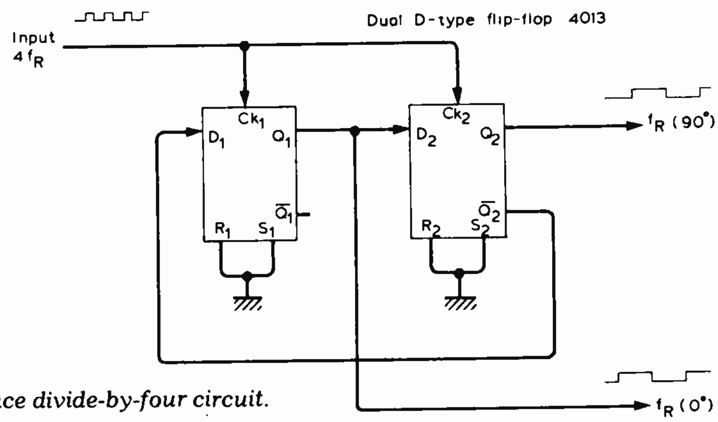


Fig. 6. *Reference divide-by-four circuit.*

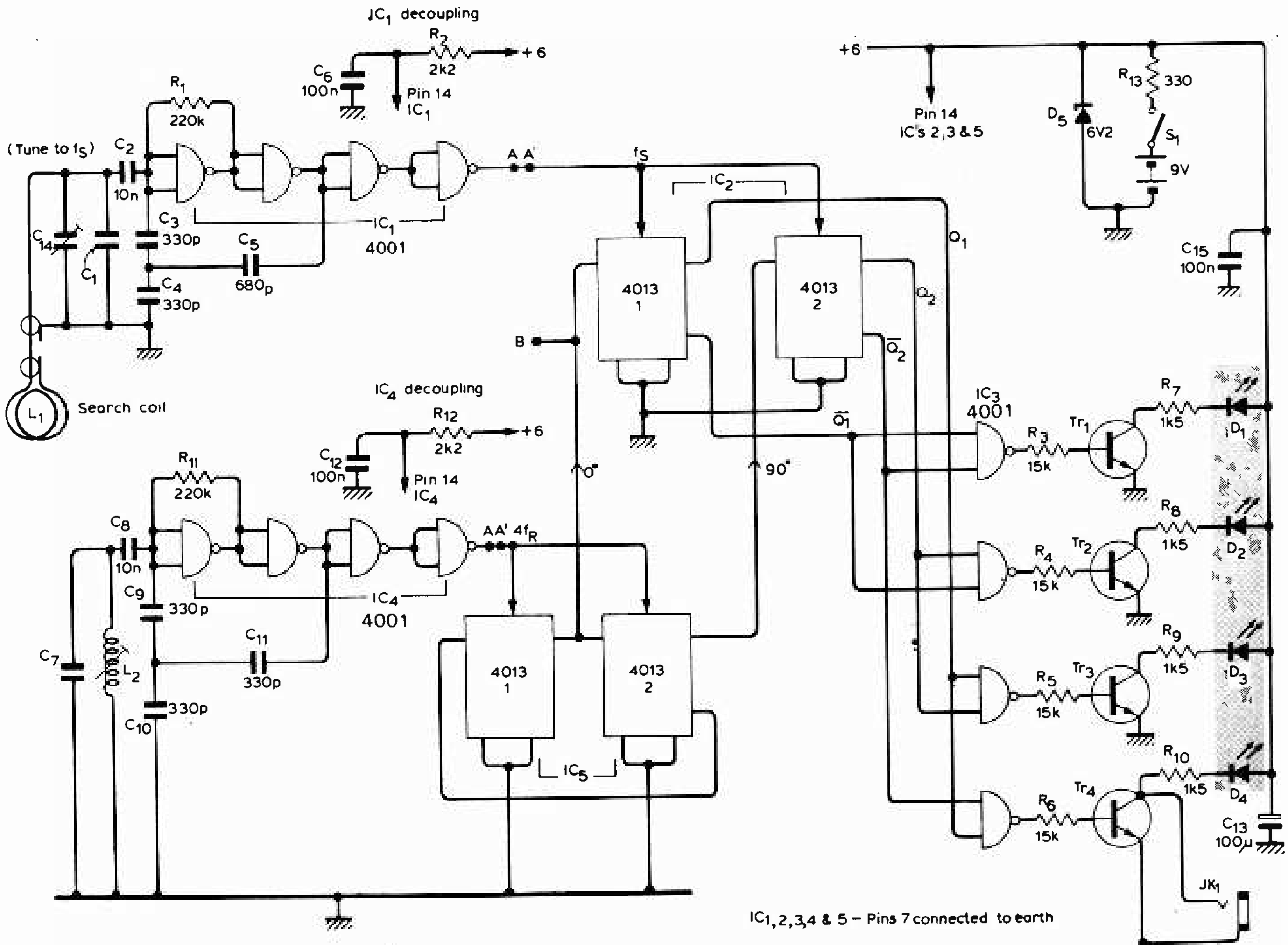


Fig. 7. *Full circuit for the detector.*

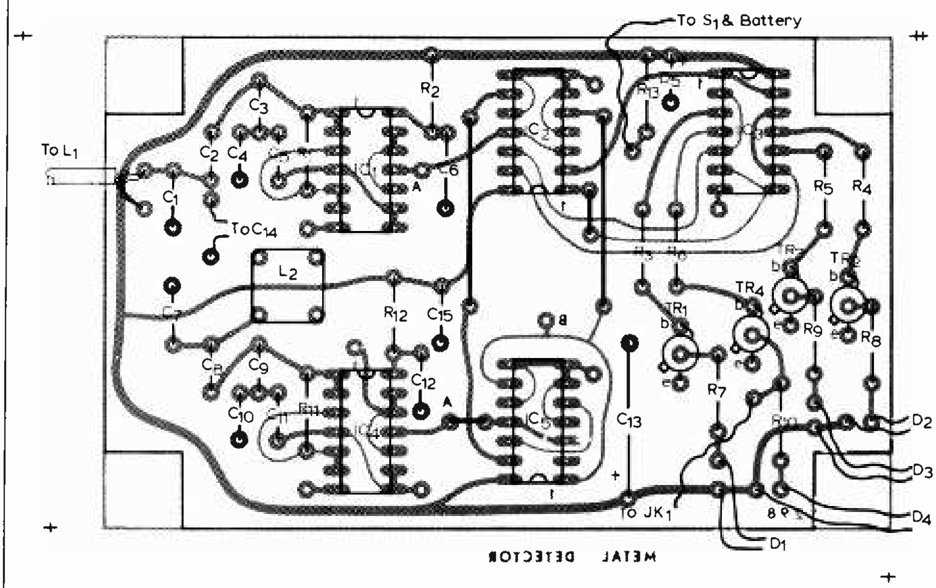


Fig. 8. *Printed circuit board layout and component overlay. A double sided board is used with the top copper layer forming a ground plane. All component leads connected to single pads are soldered to the top of the board. All other component connections are made on the underside of the board. The ground plane should be cleared with a small drill where necessary. Some additional pads have been provided on the layout to assist with the modification shown in Fig. 10.*

Printed circuit board

A double sided glass fibre p.c.b. for the metal detector will be available for £3.50 inclusive from M. R. Sagin at 23 Keyes Road, London, N.W.2.

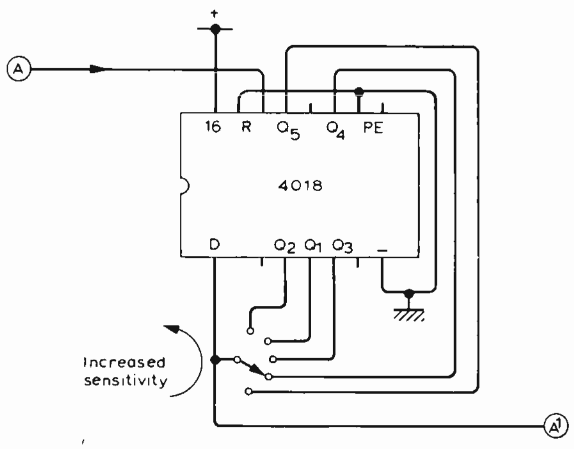


Fig. 9. *Divide-by-N circuit for variable sensitivity.*

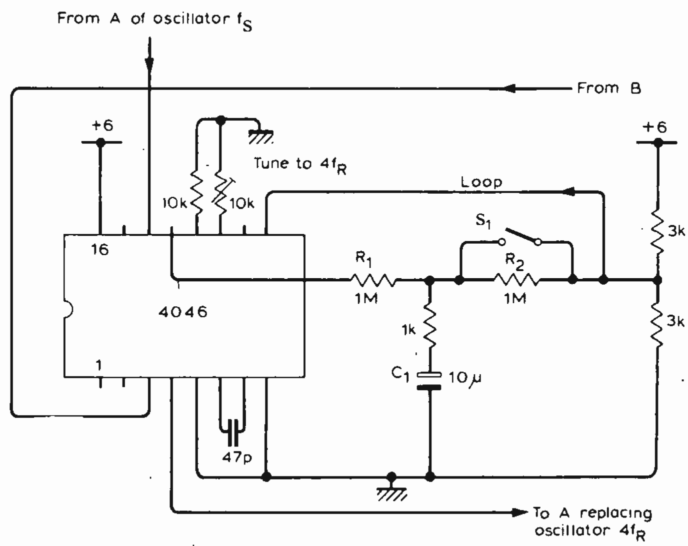


Fig. 10. *Voltage controlled oscillator This circuit replaces the f_R oscillator. The switch is a tune / operate control. When closed, C_{14} is adjusted for frequency balance, and when open the detector operates with a slow p.l.l. action. If the 4046 is mounted on the pcb in place of IC_4, the copper tracks should be cut where necessary.*

supply is regulated at 6V to reduce the tendency for f_R and f_S to lock.

Further considerations

The unit described is very sensitive to changing conditions around the search coil, and some form of sensitivity control is worth considering. The sensitivity is proportional to the frequency f_S, so a less sensitive version can be made by reducing the frequency of f_S and $4f_R$. One possibility is to reduce $4f_R$ to 120kHz and f_S to 30kHz, both of which are legal frequencies. A better method, however, is to divide f_S and f_R before comparison as shown in Fig. 9. Two identical divide-by-N circuits can be inserted between points A and A[1] of Fig. 7. With the switch connections shown, five sensitivity ranges can be selected from ½ to one-tenth of the full value.

Another characteristic which determines the sensitivity is temperature variation. Because the reference oscillator has to remain constant in frequency to within 1Hz, a frequency control is provided to compensate for small drifts. Although the problem is eased because both oscillators tend to drift in the same way, an interesting solution is to phase lock the two oscillators together. Fig. 10 shows a modification which can be made to the circuit shown in Fig. 7. A c.m.o.s. voltage controlled oscillator and phase detection device is used in place of the f_R oscillator. The v.c.o. section of the 4046 operates at $4f_R$, and the phase detection section compares f_S with the divide-by-four output of f_R to provide a control signal for the v.c.o. With this system the metal detector will always settle down and turn on the 0°-phase l.e.d. Moving the search coil past a buried metal object will cause the frequency f_S to change, but because f_R will then try and follow, a maximum indication may occur beyond the object. The choice of time constant can therefore depend on how fast the search coil is moved and is best determined by experimentation.

Because this metal detector has a visual display, headphones are not required. If the user prefers an audio indication and does not mind the loss of "directional" information for the type of magnetic material, a headphone can be connected across one of the l.e.ds which produces clicks rather like a Geiger counter.

Reference

1. Hewlett-Packard Application Note No. 52, 'Frequency and Time Standards,' 1962.

NEWS OF THE MONTH

UK proposals to WARC to be published — when final

THE HOME OFFICE has published a summary of its preparations for the World Administrative Radio Conference in Geneva next year. The 22 page booklet* is critical of the quality of the submissions received as a result of the Home Secretary's invitation to submit comments. "Many were concerned principally with or included matters of domestic frequency management which, upon examination, were found to have no implications for the WARC. Inevitably most contributions were concerned with particular sectional interests, and few made any attempt to identify or balance competing demands on the frequency spectrum. There was also a concentration on the table of allocations to the virtual exclusion of those technical, operational and administrative factors which, together with the table, will constitute the work of the WARC 1979." Nevertheless, the process of public consultation "has proved valuable". "It has made the Government more aware of the strength of interest in particular issues. It has provided an external source of ideas and proposals relevant to the WARC, all of which have been carefully considered before decisions were reached. Thus it has ensured that the work done has at least covered the right ground."

The statement notes that "some" of the 91 contributions, resulting from 104 specific invitations to submit comments, "evidenced much thought and hard work". It gives a broad outline of some of the proposals the Home Office has been able to accept or felt compelled to reject in its preliminary discussions with other PTTs before the WARC meets, as follows:

0 to 150 kHz
No major changes, but "several redundant radionavigation provisions" should be eliminated where they share with fixed and maritime services. To offset this, a broad band should be set aside for exclusively world wide radionavigation. Radio location and radionavigation will not be merged.

150 to 1605 kHz
The increasing interference with aeronautical beacons, which share frequencies with broadcasting from 255-285 kHz, has become "unacceptable in view of the safety of life service provided by the beacons". The Home Office's proposal is a classic illustration of the conflict between sound economics and common sense: the broadcasters should be allowed to drive out the aeronavigational beacons, which should be reallocated to space now used by the unoffending mobile maritime service. The latter should meet its requirements "by improved channel arrangements"(?) and a narrower distress and calling band. In addition, the broadcasters should get extra frequencies for their road traffic information service; the BBC had asked for 10kHz below the present medium wave radio band and it looks like they've got it.

1605-4000 kHz
In partial compensation for the above, the mobile maritime service, one of the most poorly regarded and administered in the spectrum, should have several exclusive allocations in this section. There should also be several exclusive narrow sub-bands for position-fixing systems. The requirements of the amateurs, who had asked for some of their shared frequencies in this band to be made exclusive, and the industrial, scientific and medical interests, who particularly wanted an exclusive allocation around 3.4 MHz, could not be met in full. Some amateur bands may be allocated, exclusively, and "the possibility of meeting the ISM requirement, but with a more restrictive tolerance than that requested, is being considered."

4-30 MHz
This section is one of the most congested, and may prove the one where the developing countries prove to have most determination to improve their allocations. Although the West may be able to accommodate the increasing requirements of h.f. broadcasting (now largely achieved by out-of-band assignments), h.f. maritime mobile, amateurs and ISM by replacing its fixed services by satellite services above 1 GHz, the developing countries are still heavily reliant on h.f. fixed services. The Home Office will propose enough increases in broadcasting allocations to eliminate out-of-band assignments and provide some extra "for growth", and increases in the maritime mobile allocations by widening the existing provisions at 4, 6, 8, 12, 16 and 22MHz and making new allotments at 18 and 25 MHz. They have allowed for the narrow radio astronomy assignments and part of the amateur radio allocations, but all these proposals depend on the attitude of the developing countries.

30-108 MHz
The Home Office accepts that the growth of the land mobile service is such that an additional 70-90MHz will be needed to accommodate the expected growth beyond 1985; the spectrum currently available to land mobile radio will be enough, say the Home Office, to meet its needs until then. The document summarises all the conflicting arguments over the reallocation of Bands I

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C.b communications likened to robbery, plunder and rape

AT THE end of April the House of Lords staged one of the longest debates yet on citizens' band — three columns in Hansard.

The noble Lords amply justified their reputation for maintaining a high level of debate, raising such matters as the inefficient use of radio frequencies, the vulnerability of communications in isolated areas, civil defence, and the freedom to communicate. Lord Wells-Pestell, for the Government, stonewalled all of them.

In reply to Lord Torphichen, Lord Wells-Pestell said that there were no plans to introduce c.b. in this country and it was a national matter unsuited to discussion by the WARC. Lord Tanlaw retorted that the answer was "depressing". Citizens' band frequencies that could be made available were "lying unused already in this country." C.b. could make a great contribution to civil defence in times of national emergency.

"My understanding is," replied the minister, "that there are not bands which are available. Some of the bands that the noble Lords may think available are used, I am informed, for important and essential Government purposes". He then recounted his horror at the possible misuses of c.b: traffic was once held up on an American motorway, he said. This was because "somebody using a citizens' band radio gave an instruction that it was dangerous to go along there." He did not say whether the instruction was justified.

Against Lord Wells-Pestell's dedication to the unimpeded flow of motor traffic Lord Tanlaw offered the news that 500 lives had been saved in the great blizzard through c.b. according to Ohio's chief of police.

Lord Harmar-Nicholls asked whether the Government frequencies were reserved unused or were being used. "Are they used for rehearsals or for practice in case an emergency arises, or are they just being left and not being used at all?" "I would not say," said Lord W-P, "they are used for 24 hours a day, but they are in fairly continuous use."

Lord Torpichen complained that in the recent snow farmers were reduced to making signs in the snow to attract helicopters, and the Earl of Cromartie jumped up to support him, to cries of "Order."

The Government replied: "I think we have seriously to consider the enormous disadvantages of having a vast army of people who can communicate with each other very easily . . ." Viscount St Davids asked, "Is the noble Lord aware that there is a point of liberty in this and that there ought to be freedom to communicate?"

"I do not think," said Lord W-P, "that society takes very kindly to people who feel that they have liberty to rob, plunder, rape and do all kinds of things."

First European communications satellite in orbit

THE REPLACEMENT for the Orbital Test Satellite (OTS) destroyed on September 13 last was launched at 22.59 GMT on May 11. It went into synchronous orbit on May 13 at 12.12 GMT before being manoeuvered to its position 35,900 km above Gabon (10°E) on May 24.

The launch had originally been planned for April 27 but was delayed because of technical problems with the Japanese communications satellite due to precede it and because of faulty cable connectors. The launcher was then re-examined because of a lightning strike. On May 3 the following day's launch was postponed because of "anomolies registered in the electrical ground support equipment at the launch site." Two days later it was again delayed for three more days because "part of the required redundancy in the launcher's first stage engine control circuitry was not working." A further delay resulted from a fault in the second stage inertial measuring unit.

OTS2 is Europe's first communications satellite. It is the forerunner of the European communications satellite (ECS) which will carry some European telephone, telex and tv traffic after the first ECS is launched at the end of 1981. The capacity of ECS will begin at 5,000 telephone circuits and rise to 20,000 in 1990. The four ECS satellites will be launched on Europe's own Ariane launcher rather than the presently troublesome McDonnell Douglas Thor-Delta rockets.

The payload of OTS2 developed by AEG-Telefunken and Selenia represents about a third of that of ECS. When OTS becomes fully operational in September it will have a capacity of one or two television channels and 2,000 to 5,000 telephone circuits, equivalent to about 6,000 telephone circuits in all. OTS2 operates at 11 to 14 GHz, among the first communications satellites to do so, because the normal 4 to 6 GHz satellite links would, in a regional service, be affected by radio interference. Although it is a regional satellite its coverage area includes Western Europe, the Middle East, North Africa, the Azores, Canary Isles, Madeira and Iceland.

The aims of OTS2 are: to demonstrate the performance and reliability in orbit of all the equipment on board; to carry out experiments on the transmission of radio waves through the atmosphere, frequency re-use and so on; and to provide adequate capacity for European traffic before the ECS programme is under way.

There will be two kinds of experiments: those requiring large earth stations with 15-19m aerials; and those with smaller, cheaper terminals. Four large stations at Fucino (near Rome), Bercenay-en-Othe (France), Goonhilly, and Usingen (near Frankfurt), will have special OTS2 aerials. Another 300 smaller terminals will be used by telecommunications authorities, universities and about 50 European institutes with aerials between 3 and 14m.

OTS2 will carry out propagation experiments at 11 and 14 GHz and other experiments concerned with new applications for communications satellites in Europe, including data transmission between small terminals, semidirect broadcasting of television programmes, and facsimile transmission of document and newspaper pages. The responsibility for carrying out the experiments will belong jointly to the European space agency and an organisation set up by the European conference of postal and telecommunications organisations (CEPT) called Interim Eutelsat.

The first OTS (see *WW* News November 1977 p.53) exploded 55s after takeoff. The cause was traced to a burn-through in one of the strap-on solid propellant Castor IV motors at the bottom of the first stage. The motor has since been modified by thickening of insulation. OTS2 was originally the back-up satellite for OTS1. □

Mr George Banner (left), area manager of the Post Office's earth stations, and Neil White, who will carry out the test transmissions with OTS2, in front of the newly-completed 19m aerial dish at Goonhilly. The aerial and equipment is made by Marconi Communications Systems with the support of the Department of Industry.

New frequency synthesiser techniques

PYE TELECOMMUNICATIONS appear to have moved closer to producing an easily-programmable single-channel frequency synthesiser. Delegates to a two-day symposium at Pye's new telecommunications headquarters at Cambridge in April were shown a demonstration of equipment which could be programmed to the assigned frequency in seconds using a device similar to a pocket calculator. Such synthesisers are about to be introduced into Pye products, but details of the technique are not yet available.

The growth in the development and use of frequency synthesisers — devices which are able to manufacture several frequencies by the mathematical manipulation of a reference frequency — is largely attributable to the growth in the citizens' band market. In the US a c.b. set needs to operate on any of 23, now 40, channels with a fair degree of accuracy. As the number of citizens' band sets in use increases the provision of a separate quartz crystal for generating each channel frequency in each set becomes impossible, and the frequencies are provided by the addition and subtraction of frequencies provided by a smaller number of crystals.

The techniques used have been well-suited to c.b. since the specification is not hard to meet and the frequency, 27 MHz, low. The synthesisers are not expensive to produce since the market is large enough to enable manufacturers to take advantage of l.s.i. In military applications, where the same techniques can be used in specialised equipment, cost is not an object since the customer is the tax-payer. The two-way private mobile radio market, however, is too small to benefit from l.s.i., each set is a special case, and the frequencies used make the need for better specifications imperative, with a consequent increase in cost. At the seminar Pye's Hugh Hamilton used the example of two components with the same frequency stability, one operating at v.h.f. and the other at u.h.f. If the frequency stability is ±0.001% then, when operating at 80MHz, this will represent a deviation of ±800Hz, well within the limits of a 12.5kHz channel. At 480MHz, however, which is a frequency around half way to the limit of the range covered by two-way mobile radio, the deviation would be ±4.8kHz, which would be unacceptable in the same channel width.

The greater accuracy needed for two-way mobile radio therefore drives up both costs and power consumption. Crystals have to be aged before use in the device and either operated in an oven when working, or temperature-compensated in a specially designed oscillator.

"By using mixing principles, harmonics, and division, and some ingenious mathematics, it is possible to use one reference frequency crystal to obtain all of the channels required. However, when another part of the spectrum coverage or channel spacing is needed an alternative process of mixing, harmonics and division may be identified, and these changes usually preclude a repeat of the original circuit or construction. Thus each design becomes an individual development. In the two-way radio application the number of variants would be excessive with this design approach." Few applications would provide a big enough market to justify the use of l.s.i.

As outlined in a paper presented at Communications '78, held in Birmingham, Philips Research Laboratories have been exploring synthesiser design using digital instead of the usual mixing and division techniques. Hamilton announced that they had now arrived at an i.c. design which used a programmable read-only memory and which would be suited to a wide range of applications. Unique requirements could be met merely by altering the p.r.o.m. programme.

The new single-loop design allows division ratios as high as 10^7 or 10^8, instead of the present upper limit of 10^3 or 10^4. It "permits a low close-in sideband noise level to be achieved. It is this close-in sideband noise which normally limits the overall performance of a conventional frequency synthesisers to a restricted division ratio." The design also provides higher loop-cutoff frequency, faster lock time and greatly reduced microphony, according to Hamilton's paper. Hamilton was invited to the USA to lecture on the technique.

Pye are hoping that future techniques will allow the use of plug-in p.r.o.ms so that the same equipment can be used in different applications. There is, however, the risk that the Home Office would not type approve such equipment unless the p.r.o.m. were inaccessible mechanically and electrically.

How accurate are audio reviews?

A RECENT issue of *Private Eye* carried a story alleging that *Hi Fi News* had "hurriedly concocted" a new review of the Bowers and Wilkins DM7 speaker when B & W threatened to withdraw advertising. As usual, *Private Eye* got it wrong. Minor adjustments were made to the April *Hi Fi News* review, as a result of a rather naive decision to send an advance copy to B & W's advertising agency, but these changes did little more than tone down what remained quite a critical report. A one-page advertisement for B & W did appear in the same issue, though for the DM5, not the DM7. The *Gramophone's* February issue, however, carried a highly favourable review of the same speakers by John Gilbert.

At least they are said to be the same speakers, but subscribers to both *Gramophone* and *Hi Fi News* may have been puzzled by certain differences between the two reports.

The *Gramophone* notes a "considerable" improvement in stereo imagery". Trevor Attewell of *HFN*, however, noted that, although the DM7 produced excellent images with simple sources, a full orchestra "gave more diffuse images, with a tendency for the size of individual instruments to be enlarged, especially in the bass."

The *Gramophone* said that "Speech, and particularly male speech, has a naturalness sadly lacking in many loudspeakers and one could easily be deceived into believing that one is hearing a live conversation." *Hi Fi News:* "Some speaking voices were virtually indistinguishable from the electrostatic version, while others acquire a hollowness, with more sibilance and bass loss. The effect was greater with 'fruitier' voices . . . ."

John Gilbert noted "seating positions are not so critical as with some other speakers," while Attewell thought, "the DM7 is more particular about correct positioning than many speakers".

There were, of course, substantial points of agreement between the two reviews. Nevertheless, even the published frequency response curves seemed to disagree. The *HFN* curves appeared to show a steep roll-off in the bass, while the *Gramophone* curves, though different from the curves published in B & W's specification, showed greater similarity to the B & W curves than those published by *HFN*.

We wondered whether the circumstances under which the measurements were made might help to explain the subjective points of disagreement. *Hi Fi News* told us that their frequency response curve and all the other measurements had been made by Trevor Attewell either at his home or at James Moir & Associates. The *HFN* curves had been measured in open air. Attewell added that, although he did consultancy work, all of it was concerned with pure electronics, none of it in the hi fi industry. He had not seen Gilbert's review until after he had written his own, and then only briefly.

The *Gramophone* review says, "An unusual opportunity enabled me to measure the performance of the DM7 speakers in the largest anechoic chamber in the UK." This is a reference to the chamber owned by the Department of the Environment's Building Research Establishment at Garston, near Watford. The hire rates are £75 a day plus VAT, and hirers have to provide their own measuring equipment. B & W are frequent users of Garston, and the DM7 specification notes that that is where all their measurements were taken.

John Gilbert told *Wireless World* that the "unusual opportunity" referred to was a reference to the fact that the *Gramophone* usually used the anechoic chamber at the North London Polytechnic, a facility no longer available to them.

The discrepancies might have arisen, he said, because the performance of a speaker depended so much on the room in which it was being assessed. He added that B & W had not seen the review before it was published.

But he told *Wireless World* that, on the occasion on which the measurements for the *Gramophone* review were made, the Garston chamber was hired for him by B & W, that measuring equipment was transported from B & K Laboratories to the chamber by B & W, and the B & W staff were there when the measurements were taken.

He said he had never been a consultant for B & W, but agreed that he had, on behalf of B & W, invited audio journalists to B & W functions by telephone. They had asked him to compile a list of people to invite, he said, because he knew a lot of people in the industry. He had phoned the journalists "at my own expense". It was not until April, some three months after the appearance of the *Gramophone* review, that John Gilbert became press officer for the Federation of British Audio, a trade group of 65 hi fi and audio manufacturers, among them B & W.

Before we went to press John Bowers of B & W told us that he did not see any difference between measurements taken during a session which had been booked by B & W and those John Gilbert could have taken on his own. The measurements had been taken, he said, by a B & W lab assistant under Mr Gilbert's direction. The equipment used had not been hired, he told us, it was standard B & K equipment owned by B & W and taken to Garston for the measurements.

● We feel that John Gilbert's review in the *Gramophone* should have stated the circumstances under which the measurements were taken, as he readily did to us on the telephone. This would have made his position as an independent reviewer abundantly clear.

● Hi-fi reviewers came in for more criticism at a recent product launch. Leak and Wharfedale manager Roger Fearn told journalists at a press conference to mark the launch of a

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PIONEERS

THE NAME of Professor Dr H. C. Manfred von Ardenne has been respected in electronic engineering circles for many years. His early work on cathode-ray tubes and television in the 1930s is well-known. Since 1959 he has been engaged in research into medical electronics and it was in this connexion that he was recently in London and paid a visit to the *Wireless World* offices. We had an interesting talk, during the course of which he mentioned that he had helped considerably in the development of British radar, since Sir Robert Watson-Watt had used several hundred of his cathode-ray tubes immediately before the war. Indeed, Watson-Watt was given to describing the c.r.t. as an Ardenne tube. Professor von Ardenne also told us that he had a magnetron-powered p.p.i. radar, very like H_2S, working before the war and had proposed production of the equipment to Reichsmarshal Goering. He was told, fortunately for us, that it was unnecessary to produce such devices, since the war would be quite short and would be won by the Germans without fancy bombing aids of that kind.

The work on which Professor von Ardenne is now engaged is of a much less bellicose nature and is directed towards the eradication of cancer. He was in London to read a paper to an audience of radiologists, describing his work in stopping the flow of blood through a cancer by selectively irradiating it with high-powered (8kW) 28MHz radiation and associated chemical treatment. Tests on animals have been successful and we will doubtless hear more about the technique.

He left us a photograph which shows himself and another famous television worker, Dr V. K. Zworykin, also equally well known for his medical researches. The picture was taken in 1972 at the International Congress of Medical Engineering, which was founded by Dr Zworykin.

Professor Dr H. C. Manfred von Ardenne (right) and Dr V. K. Zworykin.

BBC's digital plans

THE BBC have begun test transmissions of digitally encoded audio signals from Pontop Pyke, near Newcastle. The experiments are being conducted on 47 MHz in Band I using a four phase differential phase-shift-keying (p.s.k.) system to send the digital signals at a bit rate of 704 kbit/s. The BBC proposed the use of such a system in its evidence to the Annan Committee (*WW* News, August 1976 p 36). They suggested then a four phase p.s.k. system modulating the carrier and channels of 250 or 500 kHz width. Four phase p.s.k. does not require a high field strength to give good national coverage.

In general, the BBC will be keen to demonstrate the effectiveness of the system in order to keep its grip on Band I, currently used for 405-line television transmissions. It is not known how many 405 line sets are in use, and the BBC's lease on Band I is likely to be under increasing pressure after 1982 in the present climate of lobbying for changes in spectrum allocations.

The Annan Committee's report suggested that Bands I and III should be used for a fifth colour channel "but some frequencies in Band I might well be available for services other than broadcasting."

The BBC and IBA carried out joint tests on V.H.F. teletext transmissions in Bavaria, Germany, in April 1975. The tests were held in co-operation with the Institut fur Rundfunktechnik (IRT). The broadcasters are also considering the transmission of teletext pages on channels totally reserved for teltext.

The BBC's digital broadcasting experiments are an indication of their reluctance to attempt to re-engineer Band I, which suffers from sporadic E interference, for television. The plan is that all four radio channels could be multiplexed all over the country on the same signal. The idea's main drawback is that everyone would have to buy totally new types of receiver.

The ability to send digitally-encoded sound signals is a spin-off from the work on teletext. No transmitter can send out square wave pulses, but engineers have learned a great deal from teletext about the shaping of broadcast pulses and the avoidance of inter-symbol interference, wherein the pulses merge into one another.

In the present experiments the BBC are using the same coding and demodulating equipment as that used by BBC outside broadcasts in December 1977 to send live stereo concerts from Cardiff and Lancaster over a microwave link to Post Office circuits to London. As well as objective measurements, the BBC say they are carrying out subjective tests on the quality of the transmissions of two audio signals.

They describe the experiments as the initial phase of an investigation into the reception of digital signals under various listening conditions, such as with a whip aerial in a car, a fixed dipole at home or a ferrite rod inside the receiver, which could provide an efficient aerial for v.h.f. portables. "It is hoped," said a BBC statement, "to answer questions on how effective digital transmissions might be when used for a very high grade sound programme service, or for a reliable alternative to the present medium-wave service which has a rather variable night time range caused by overcrowding of the band. Indeed, several signals or types of signal, including new data services, could be made up into a common package using the time-division multiplexing facility afforded by digital operation." Digital signals could also be used for low-capacity links distributing stereo programmes to v.h.f. transmitters in remote areas.

● The BBC decided on standards for digital links some months ago, but their announcement drew a rapid counterblast from the IBA.

The BBC settled on a modified near-instantaneous companding and multiplexing (n.i.c.a.m.) method for sound transmission along the 2048 kbit/s links the Post Office is to introduce from this year. A statement was issued at the end of October last year.

The full n.i.c.a.m. system (*WW* June 1975, p.248) was first used for a live transmission from the Edinburgh Festival in 1976. It can transmit up to six sound channels along the 2048 kbit/s link but the Corporation were looking for a way to take advantage of the opportunity to use fewer channels and allow the Post Office to send telephone calls down the link at the same time. Sound signals rarely need to be transmitted six at a time, and the broadcaster can send his signals in any convenient multiple of 64 kbit/s provided the 128 kbit/s the Post Office needs for framing and signalling the telephone calls in the other channels are left alone. This meant the BBC had to find a way of transmitting the data at a little less than n times the 64kbit/s bit rate.

Engineers therefore carried out subjective tests to decide which of the many digital sound coding systems now proposed will give adequate sound quality and fit conveniently into a whole number of 64 kbit/s telephone channels. Among the systems tested were n.i.c.a.m, a French variant of n.i.c.a.m, an Italian system based on the 'A-law' characteristic used for telephony, and two more variants on n.i.c.a.m. "specially devised with partial access in mind." The statement said the 13 bit linear p.c.m. system now used for radio distribution was also included as a basis for comparison. The best system in their view was one of the modified n.i.c.a.m. systems, which the BBC will now use on all appropriate distribution networks. With a sampling frequency of 32kHz the signal required 320kbit/s with 3kbit/s for scaling the rest of the information, additional bits for framing, signalling, justification and error correction. The total bit rate is 384kbit/s, corresponding to six telephone channels.

The BBC added cryptically that the new system had other applications than sending signals down the 2048kbit/s links, "and in some of these applications the error rate could be high," hence the need for comprehensive error checking.

The IBA's statement, issued a week later, said their view was that "it is still too early to state categorically that any particular system has emerged as optimum or that systems can be interfaced simply, since some degradation of performance quality occurs in practice when this is done." The subject had been discussed by the appropriate working party of the European Broadcasting Union, which reduced the choice of two systems: the French near-instantaneous companding technique, and an Italian one based on the "A-law". The EBU had referred the matter to the CCIR, which was studying the systems with the aim of achieving an international standard. "It is preferable to continue to seek, and endeavour to expedite, international agreement for a system that will be suitable for both international and national distribution links." No decision appears to have been made yet by the CCIR.

The BBC seem to be taking the view that the choice can be made before the European Broadcasting Union has agreed on an international standard, and that if the choice the EBU makes is different from that already made by the BBC then the two systems can easily be matched up. The IBA's view is that the choice should be made on the basis of an agreed standard, with all countries using the same system nationally and across national boundaries. Any attempt to match dissimilar systems will, in their view, cause a deterioration in quality which will outweigh any individual advantages the BBC or anyone else may attribute to a system chosen by one country alone. The IBA believe the BBC has made the decision hastily; since the European discussions are now drawing to a close. It is noteworthy that the IBA came out with their strongly-worded statement even though their need for international or even national high quality sound distribution links is a great deal less than that of the BBC.

One point that does spring to mind, however, is that not much of out programming originates from overseas anyway. The initial ambitious prospectus for Eurovision has deteriorated to a confinement to football matches, "It's a Knockout" and, worst of all, the Eurovision Song Contest. The most desirable international linking system might well be an open circuit, at that rate.

"Longest optical fibre link"

THE ALBERTA Government, Canada, is to install "the longest, highest capacity optical fibre communications link proposed to date." Laser light will carry telephone signals along a 32-mile bundle of fibres between Calgary and Cheadle in the south-west of the province. Work will begin on the $6.6 million contract this year, for completion in the autumn of 1979. The system, to be built by the Harris Corporation, will transmit 274 million bits/over six optical fibre pairs encased in a sheath half an inch in diameter. It will be able to handle 20,160 phone calls at once, and could also transmit tv or computer data.

Harris claim several advantages for optical fibres over copper conductors, among them large capacity, immunity to interference, possibly lower cost, and resistance to moisture and temperature changes. They expect the glass fibre cable to last 20 to 30 years, instead of the normal five to seven years.

A similar view on fibre-optics was offered at a recent symposium in Amsterdam organised by Arthur D. Little and attended by 150 telecommunications executives from Europe, the US, the Middle East and Asia. Cambridge Consultants managing director Richard Cutting presented the view that "long before the year 2000 practical cables will be readily and cheaply available with attenuations better than the best copper cables available in 1978.

"Apart from reducing the dependence on copper for cable links, the very high bandwidth capability of a fibre-optic link will bring a considerable reduction in cable dimensions and hence ease the problem of distributing urban cabling in underground ducts." □

Colour receiver design

Remote control and designing for reliability and stability

by **Erik Albert Jensen,** Bang and Olufsen, Struer, Denmark

During development of a new range of colour receivers, one of the major aims has been to keep power consumption as low as possible. Low power consumption means low dissipation inside the set, giving low working temperatures and leading to a marked improvement in reliability.
Television receivers using ultrasonic signals for remote control have often been plagued with problems of random switching, alteration of volume or picture adjustments. This happens because ultrasonic frequencies can be generated in the room by many sources, for example a bunch of keys and other transient sounds. The solution has been to lengthen reaction times, and to use very high working levels from the remote unit, with relatively insensitive receivers.
A patented, automatic cut-off control circuit ensures that colour reproduction does not deteriorate with gradual changes in the cut-off points of the picture tube.

ONE OF THE PROBLEMS with the reproduction of colour on the traditional colour receiver is that the three-gun picture tube is extremely sensitive to drift in the cut-off points. Incorrect balance of the cut-off points results in a constant back-ground shade of some colour, most easily recognised on a black and white picture, but also affecting colour pictures.

The cut-off point of the electron guns occurs when the electrode voltages result in an electron beam which is so weak that the corresponding tint on the screen just becomes undetectable. For the correct reproduction of colour it is important to adjust the cut-off points of all three guns to occur at the same point. The cut-off points are set by adjusting one of the electrode voltages, normally the acceleration voltage of g_2.

Experience shows that the cut-off point drifts in normal use. The cause is not only ageing of the components in the receiver but, most importantly, ageing of the picture tube itself. Any error in the cut-off point can be corrected by a service engineer.

Automatic cut-off control

In order to eliminate the visual effects due to drift, Bang and Olufsen introduced automatic cut-off control in the Beovision 4000 receiver in 1973. This generation of receivers had RGB control-grid drive, so that the three cathodes were free to be coupled individually to the separate automatic cut-off control circuits.

In the new Beovision 4402 generation, automatic cut-off control is integrated in a RGB video amplifier for cathode drive. Thus, the receiver has conventional video drive, measuring the cut-off point of the electron gun and adjusting the direct bias voltage to the correct cut-off point on one electrode only, the cathode. This is less expensive, more elegant and more efficient than the system used earlier.

Video amplifier. A simplified diagram of the principal elements of the video amplifier is shown in Fig. 1. Tr_8 and Tr_1 are fed with R-Y and Y signals respectively, from low-impedance sources. The signals are added across R_{81}, so that the video content of the output of Tr_1 is the required R signal.

During the field fly-back period, the low end of C_{48} is fixed at 24V, while the high end is charged to the output voltage of the video amplifier via R_{86}, with a time constant appreciably lower than the fly back time. The output voltage of the video amplifier is partly set by the actual bias from C_{47}, but also by a reference level, coupled to give field blanking of the Y channel. The voltage across C_{48} at the end of the blanking period is therefore

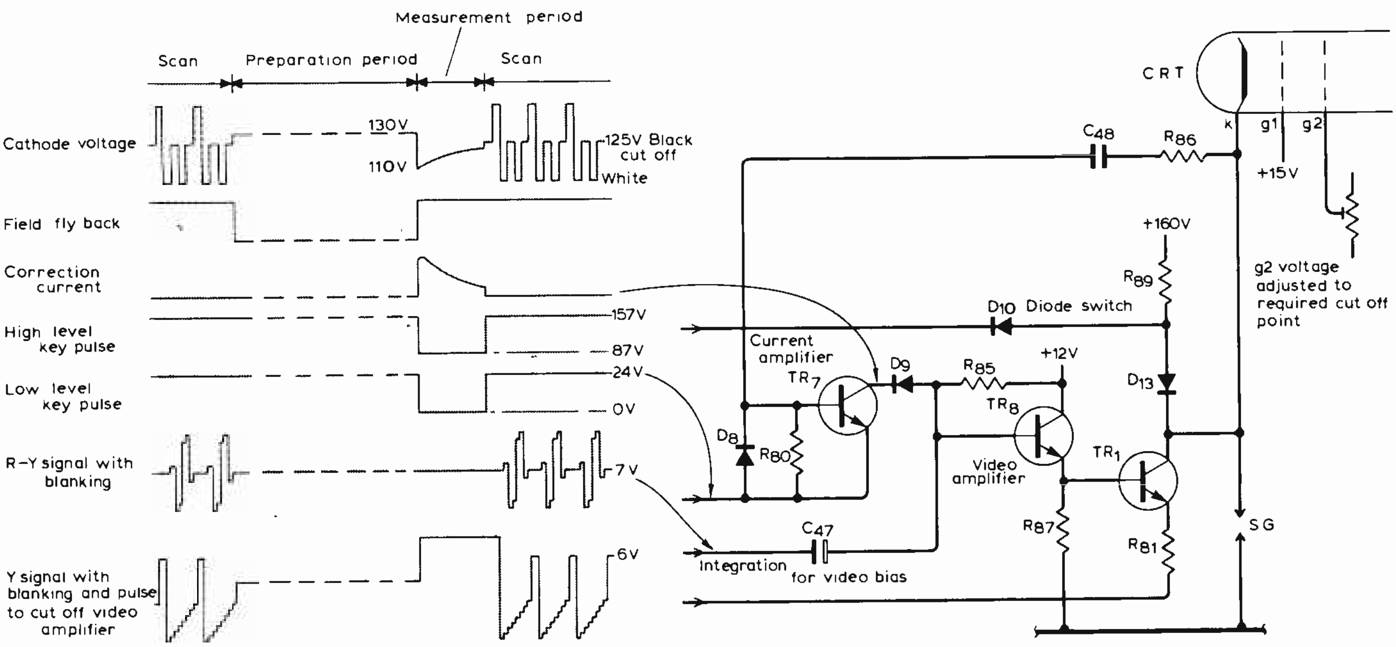


Fig. 1. Automatic cut-off control of the red gun, with waveforms.

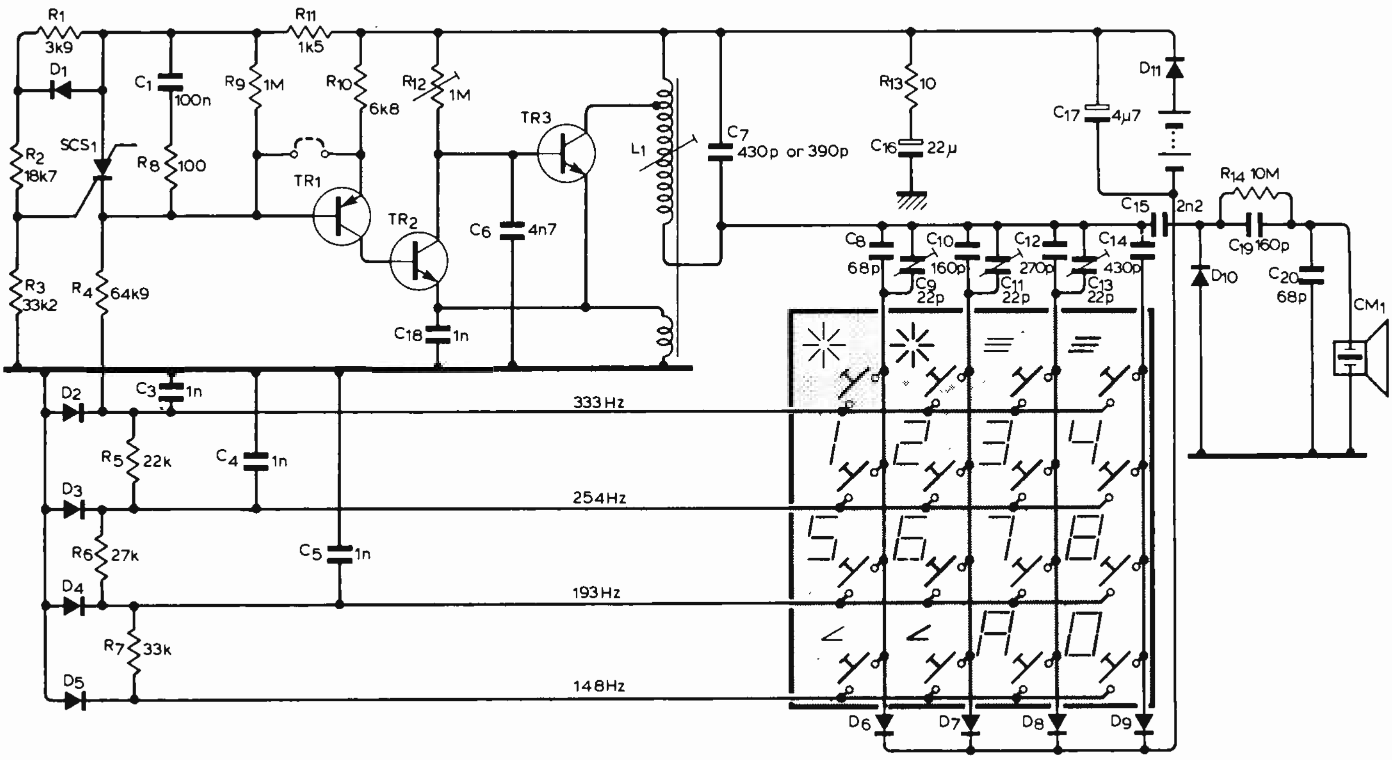


Fig. 2. Circuit diagram of the ultrasonic remote-control transmitter.

representative of the bias voltage of the video amplifier, approximately 130V, and is for all practical purposes independent of the video content of the signal.

The circuit is now prepared to measure the conditions of the red electron gun in the region of the cut-off point. The picture tube is blanked during field fly back, the three g_2 voltages being adjusted to give a cathode voltage of approximately 125V at cut-off, giving a margin of 5V for field blanking. The measurement period lasts 0.2 ms, and occurs immediately after field fly back. Coupling to the video amplifier is replaced and the measuring amplifier Tr_7 is activated so that any cathode current is led to Tr_7, and amplified. The amplified measuring current is bled from C_{47}, to correct the d.c. working point of the video amplifiers.

Current in R_{89} is bled via D_{10} to the generator for the 70V key pulse, while a positive pulse in the Y channel cuts off Tr_1, to deactivate the video amplifier. The key pulse of 24V, via Tr_7, C_{48} and R_{86}, pulls the cathode voltage on the picture tube in a negative direction, during the transition from blanking to measurement period. This introduces a beam current in the picture tube, which is led from the cathode, via R_{86} and C_{48}, to the base of Tr_7. Since the measurement period occurs immediately after the field fly-back period, where the electron beam is deflected to strike the picture tube above the picture area, measurement has no visible effect.

With the automatic cut-off control in balance the measurement currents of the three electron guns are around 8µA, in a practical case. These currents can be adjusted by means of resistors between the case and emitter of the current amplifier Tr_7. Thus, the three cut-off points may be adjusted to the best possible colour reproduction, and the automatic cut-off control will maintain correct colour rendering.

The automatic cut-off circuit is able to compensate for errors of the order of 15V on the cathode (±50V on grid2), without visible effects on the picture.

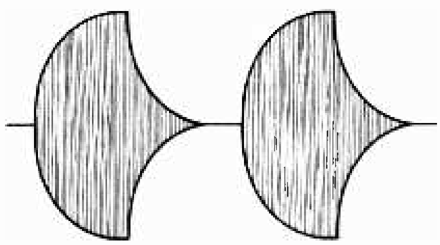


Fig. 3. Ultrasonic signal modulated by the tone oscillator.

Remote control

The remote control system works on the same basic principle as most similar systems in use today, the working medium being ultrasound. At this point, however, the similarity ends. In the traditional system, commands are transmitted as discrete frequencies adjacent to each other. Such systems are extremely sensitive to noise which has components in the frequency range used. Sensitivity to noise can be reduced by introducing a delay on the receiving end of the ultrasonic signal, and by making the receiving system of low sensitivity, with a corresponding increase in the transmitted signal (up to 110dB s.p.l.). Another method is to use some form of code in the transmitted signal, but both methods introduce longer reaction time in operation, and the delay increases with the amount of security against random operation required.

In 1974, Bang and Olufsen introduced the two-tone matrix modulation system, which has extremely low sensitivity to random noise, with a reaction time to an instruction from the remote control of less than 50 ms.

Transmitter. Fig. 2 shows the circuit diagram for the remote control unit. The 16 orders that be given are arranged in a matrix of four ultrasonic frequencies and four modulation frequencies. A single switch activates both oscillators, current from the battery being led through diodes D_2 to D_5 and D_6 to D_9 to select particular frequencies. The l.f. oscillator generates a sawtooth wave built up around the silicon controlled switch SCS_1, its frequency determined by C_1 and resistors R_4 to R_7. Oscillator frequency for the circuit shown is for all practical purposes independent of battery voltage.

The ultrasonic oscillator directly feeds the transmitter transducer and its frequency is determined by L_1C_7 and capacitors C_8 to C_{14} in conjunction with Tr_3. The ultrasonic oscillator is blocked by the modulation oscillator for half the time period by transistors Tr_1 and Tr_2. Thus the l.f. signal is modulated on the h.f. signal, and the resultant transmitted signal is shown in Fig. 3. Most of the power in the remote control unit is used while the ultrasonic signal is being generated, so keeping the ultrasonic transmission

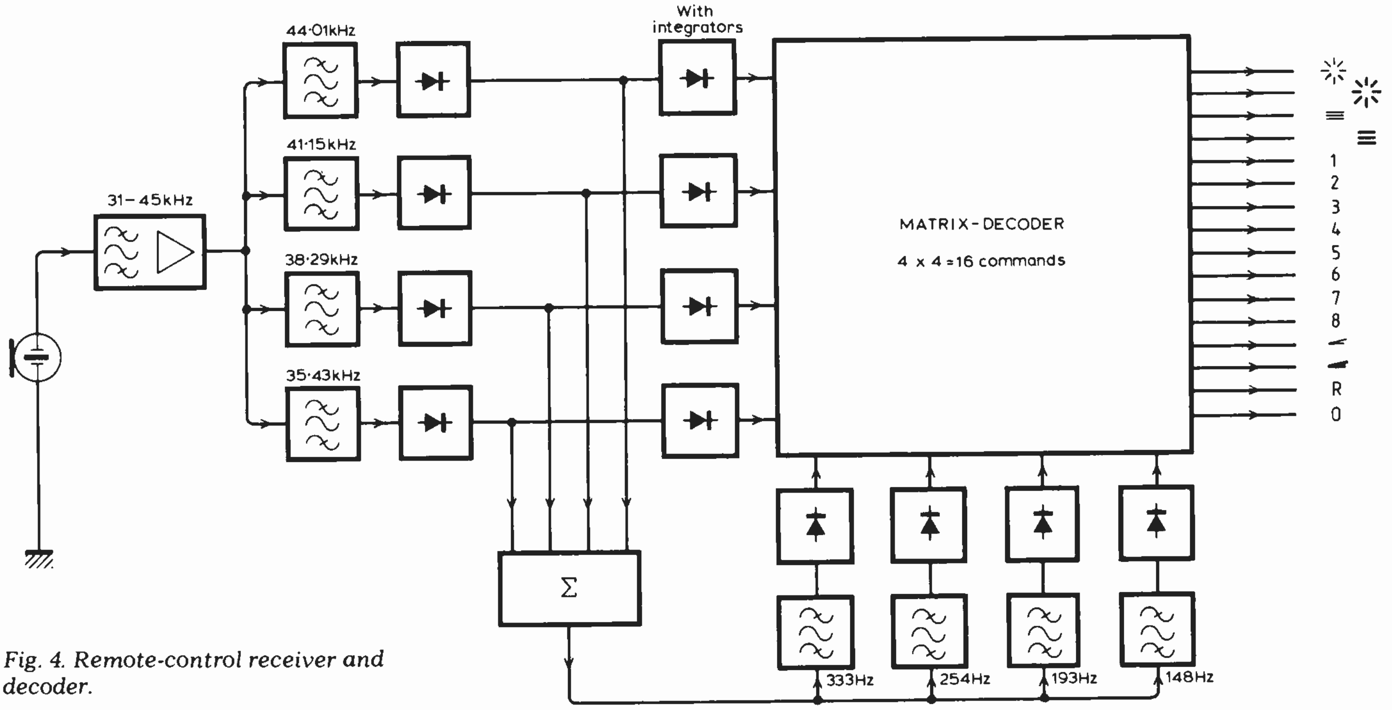


Fig. 4. Remote-control receiver and decoder.

time to less than half the total results in comparatively low current consumption from the built-in dry batteries (about 5mA).

Receiver. The two tone matrix system allows the transmission of 16 different commands arranged in a 4×4 matrix of l.f. and h.f. signals. Fig. 4 shows a block diagram of the circuit of the signal receiver. After necessary amplification, the modulated ultrasonic signal is decoded in two stages. After the stage consisting of filters and detectors for the four high and the four low frequencies, the commands are represented by l.f. and h.f. signals in the 4×4 matrix. In the stage consisting of 16 AND gates built around diodes and resistors, the 4×4 matrix is decoded to one of the 16 possible commands. The bandwidths of the filters are sufficiently narrow for frequencies half-way between those specified to be rejected by the decoder. Frequencies used for other products in the range are chosen so that no combination of tones can be mistaken as a positive command for a television receiver, or vice versa. Thus, a colour receiver and remotely-controlled audio equipment can be used in the same room with no danger of false operation of either.

Reliability

In recent years, reliability and long-term stability of colour television components have improved to an extent where the need for regular service adjustments has been considerably reduced. This trend is particularly welcome at a time of rising service costs. The inclusion of the automatic cut-off control is a further step in the same direction.

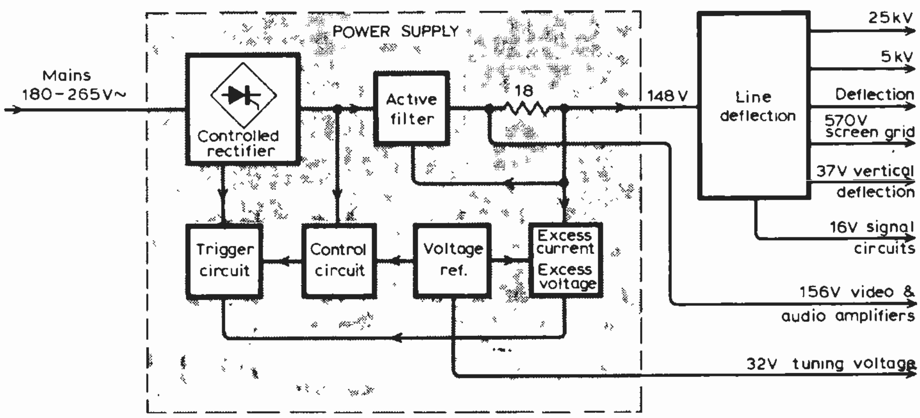


Fig. 5. Power supply block diagram.

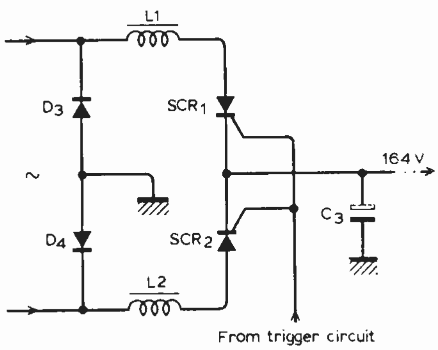


Fig. 6. Controlled rectifier.

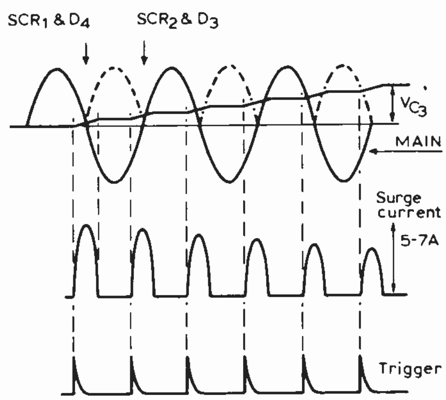


Fig. 7. Principle of surge-current limiting.

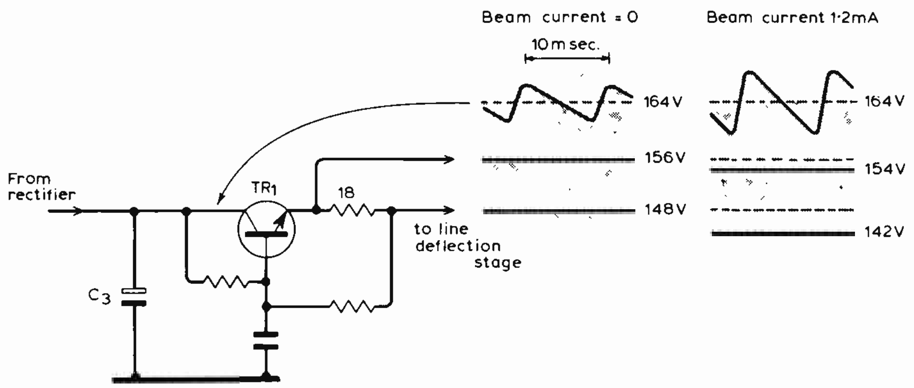


Fig. 8. Active filter.

As the need for adjustments is reduced, it becomes more and more attractive to reduce the risks of a fault occurring in the receiver. One of the factors which has a major influence on reliability is the ambient temperature inside the set. Amongst other reasons, lower temperatures lead to less ageing of components, adding to their life expectancy.

One of the most obvious ways to lower the working temperature is to reduce waste heat generated, due to power losses within the set, resulting in a reduction in the total power consumption of the set. In general, it would be true to say that the lower the power consumption of a receiver, the lower will be the internal working temperature. The largest power saving is in the power supply, which must be explained in some detail.

The power supply is of the s.c.r. type, which delivers stabilized voltage to the line-deflection and high-voltage generators of 148V at zero beam current and 141V at 1.2mA. The voltage drop is intentional, to compensate for variations in picture size with beam current, which cannot be removed cheaply by other means. The stabilized voltages, and therefore picture size, are constant for mains voltage between 180 and 265V. Fig. 5 shows a block diagram of the power supply. The line deflection block is included to show the connexions to the high-voltage supply, and voltage sources of the vertical deflection and signal circuits.

There are two details in the function of the controlled rectifier which help to reduce power consumption. Full-wave rectification gives a lower ripple voltage across C_3, for the same capacitance. With only half the ripple voltage to cope with, power loss in smoothing is reduced. A surge resistor will normally be necessary to limit charging current through the semiconductors to C_3, when the receiver is switched on. By using choke L_1 in Fig. 6, and the controlled rectifier to limit surge current, 8-10W continuous power loss in the surge resistor is saved. The surge current is limited to 5-7A, by triggering SCR_1 and SCR_2 late in the sine wave of the mains voltage, as seen in Fig. 7.

Stabilization is designed to maintain voltage across C_3 constant. The active filter used, besides reducing ripple voltage on C_3 from 5-8 Vpp to less than 0.1V, also serves to ensure the dependence on the beam current of the supply voltage to the line deflection circuits. The principle diagram for the active filter is shown in Fig. 8. The voltage drop across Tr_1 is determined by the voltage drop across R_{18} and the voltage divider to the base of Tr_1. The voltage drop across R_{18} is directly proportional to the line deflection current requirement, which in turn is determined by beam-current requirements. The two cases, with zero beam current or 1.2mA, also show that the voltage drop across Tr_1 is not larger than that needed for smoothing, and protection against saturation, giving the minimum load on Tr1. □

Viewdata journal

A quarterly journal for people interested in the rapidly developing use of the television screen as a comprehensive information service, especially the viewdata technique, is to be launched later this year by our publishers, IPC Electrical Electronic Press. To be called *Viewdata and TV User*, it will have in the first issue feature articles by experts explaining what Prestel (the Post Office's viewdata system) can do for domestic, business and professional users. It will explain how viewdata works and how the layman can use the system to the best advantage. The first issue will also describe teletext, showing how this service differs from viewdata, and will contain the first of a series on other tv screened information services. Video games and home video "film" making will be covered in later issues.

Each issue will contain an updated official Post Office Prestel (viewdata) directory for users of the service. All users will receive the magazine, which will also be available to other people for a subscription of £2, including postage, or 40p per copy.

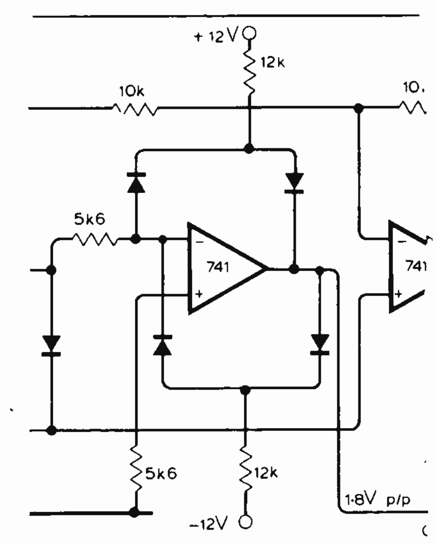
Mobile radio users' conference

A co-ordinated effort to assert the needs of mobile radio users and impress them on the Government, the equipment makers and the public will be made at a conference "The Freedom of the Air" to be held at Bristol University on 18-19 July. It will be the first ever conference of the Mobile Radio Users' Association and is sponsored by *Wireless World* and *Electronics Weekly*. Sessions will cover present-day mobile radio usage, requirements of specific groups, administration of mobile radio and future developments. Speakers will include Frank Lawson (Post Office head of marketing), Hugh Taylor (Home Office head of licensing), Walter Stevenson (Motorola), Graham West (Pye Telecommunications), Norman Cohen (London Transport) and Malcolm Sinclair (Sinclair Communications).

The number of delegates is limited to 120, so it is advisable to apply early. An inclusive charge of £24 per head covers conference papers, accommodation in single rooms and all meals. Write to: MRUA Conference Secretary, c/o Greater Manchester T.E., 2 Devonshire Street North, Manchester, M12 6JS.

Stereo power and phase meter — corrections

Regrettably, several errors occurred during preparation of this article. The circuit diagram in Fig. 5 on page 65 of the May issue should show the zero-crossing detector as in the accompanying diagram. In Fig. 6 both



electrolytic capacitors across the meter should have their connexions taken to earth and in Fig. 7 the feed to the 5V regulator should come directly from the rectifier output.

Apologies for the errors to readers and to Mr Hodgson.

Valves versus transistors

The results of a comparison among three different amplifiers

by **James Moir,** F.I.E.E. James Moir and Associates

What follows is the result of a series of listening tests commissioned by the Acoustical Manufacturing Company ("Quad"). The intention of the tests was to investigate claims that valve amplifiers sound better than transistor amplifiers.

IN recent years a cult has arisen in which the members worship valve amplifiers, claiming that amplifiers employing transistors are incapable of achieving the same high standard of sound quality that is obtainable from amplifiers using valves. The reasons for the claimed superiority of valved designs are never set out in detail, nor is there any attempt to prove the claims, but instead they appear to be based on the bottomless argument that *absolute* contradiction of their claims is not possible, so by a process of accelerated inference a remote possibility becomes converted to an absolute certainty. It is to be expected that a valve amplifier costing, say £1000, will have a better performance than a transistorised model costing £100, but it appears to the writer that the claims go beyond this and that it is being suggested that all present designs of transistorised amplifiers include some ingredient 'X' that, being beyond any possible measurement, automatically ensures that it is impossible to duplicate the performance of a valve amplifier with any unit employing transistors.

The discussion that follows describes one attempt at the professional level to discover whether there is in fact any basic difference in the performance of a group of valve and transistor amplifiers, all of them recognised as being at the top of their class at the time they were in production. Ingredient 'X' being, by definition, impossible to measure, any attempt at assessing the performance of the amplifiers by objective techniques would have been unconvincing and was therefore discarded, leaving listening tests as the only alternative likely to be acceptable to members of the cult. However it was decided that if listening tests did reveal any significant difference in the sound quality, then the subjective judgement would be followed by a determined attempt to segregate the cause of the observed quality differences by objective means. Listening test techniques that are completely free from any criticism are not easy to arrange. There is a IEC Publication No. 543 covering the ground in a rather vague manner and a more recent IEC document 29B/WG5 providing a more detailed discussion of the subject. This is more specific in its suggestions and will presumably appear as a British Standard in due course. Where this document was applicable to the tests described, it was followed as far as possible.

In designing a listening test it appears reasonable to try to ensure that all the other elements in the reproducing system are at least an order better in performance than the element being submitted to a subjective judgement, although this is manifestly difficult to ensure when the components being judged are amplifiers of the highest class. If it is assumed that the non-linear distortions are at least a rough guide to the sound quality that can be obtained, then it is impossible to ensure that the recordings and loudspeakers that must be employed in any subjective assessment have a performance that is at all comparable to that of the best current amplifiers. Broadly speaking the situation is as follows.

There are power amplifiers on the market having distortions that are at least 90dB below their rated power output. The best current loudspeaker designs have distortions around 40dB down, professional tape recordings are perhaps 30 to 40 dB down, while the best current disc recordings have distortions that are no better than 25 dB below maximum output. Amplifiers have the additional advantage of having a large amount of headroom allowing the amplifier to be worked well below its overload point without compromising the system signal-to-noise ratio. In consequence the working distortions are much lower than are indicated by a quotation of the distortion content at full power output.

It is not the purpose of the present contribution to discuss all the distortions that exist in a reproducer system, but, assessed on the basis of the amplitude dependent components, it is reasonable to suggest that the best amplifiers have distortion products that are at least 40 to 50 dB lower than in the other elements in a hi-fi sound system. Thus it is a major weakness of a subjective assessment that the programme material and the equipment that must be used for the evaluation has a performance that is far far worse than the amplifiers being evaluated.

The amplifiers employed for the listening tests were all the products of one manufacturer, Acoustical Manufacturing Co. Ltd, (Quad in other words), who commissioned the tests. It seems likely in any case that most people would agree that their amplifiers have been in the top class for very many years, right back to the time when valved types were the only models available. In addition, using the products of one manufacturer seems essential if comparison with other manufacturers' products and design skills is to be avoided. Quad II amplifiers were the valve model used and the performance was compared with that of the type 303, their first transistor design, and with their model 405, the present current dumping transistor design.

Choosing the programme material for a listening comparison is a very difficult problem when the products being judged are 'state-of-the-art' amplifiers. About forty programme samples on 15 i.p.s. tape were available from four of the best-known studios in the country, with some additional material from several other sources. All were original recordings or first generation copies of original recordings made on machines of the highest professional standard. These samples had been provided as the best examples of current recording practice in the particular studio, but these samples were further distilled by careful listening comparisons until we were left with four selections that were considered to be outstanding in respect of frequency response, low distortion and acoustic clarity. The examples of programme finally used consisted of a concert orchestra, a light orchestral section, a group of male singers and finally a 'pop' group, all thought to be broadly representative of the type of music played at home by the average enthusiast.

The tapes were replayed on a Studer A80 recorder, the signal output being applied directly to the three amplifiers through resistive potentiometers to achieve the same output voltage from each of the power amplifiers. Preamplifiers were not necessary and were not used. A double-beam 'scope was installed to monitor the output signal from the amplifier to ensure that over-

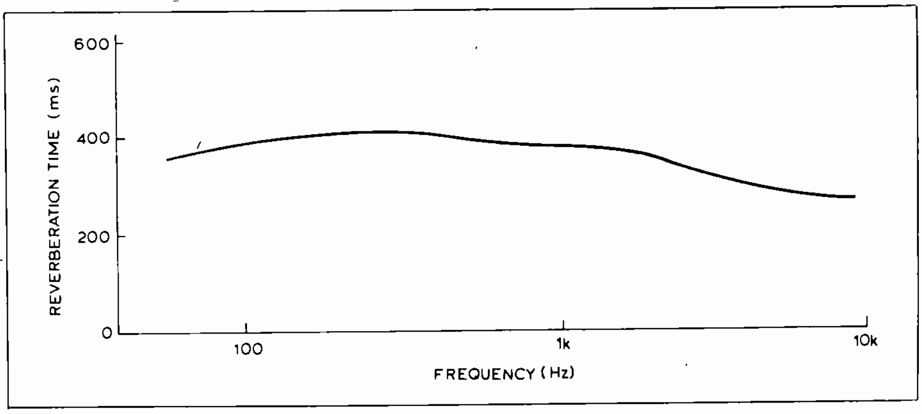


Fig. 1. *Listening room reverberation time response.*

loading did not appear even on instantaneous peaks of very short duration.

Yamaha Type NS 1000 loudspeakers were employed, the choice being that of one of the cult members as a condition of his participation in the tests.

The cult members that were invited to take part in the tests accepted but subsequently withdrew from the listening group, but by that time considerable effort had been devoted to determining the effect of the speaker impedence on the frequency response of each of the amplifiers and by then there was inadequate time available to investigate the performance of any substitute speaker system.

The output from the amplifiers being compared was switched to the loudspeakers by relays with gold-plated contacts to avoid any suggestion that contact-resistance or rectifying-action at the contacts was in any way responsible for the findings. These relays were operated through a switching system that allowed a randomised selection of any pair of amplifiers to be connected to the loudspeakers. At the same time the switching system operated a series of lamps that indicated the number of the particular test to the listening panel. Separate A and B lamps were employed to indicate which of the two amplifiers being compared was connected to the loudspeaker, although the panel had no means of knowing the types of amplifier in use in any particular comparison; all the technical equipment was operated in an adjacent room. In a large number of the comparisons the same amplifier was used in both the 'A' and 'B' positions.

The listening panel were all well known and experienced listeners. They were seated in two rows at a distance of approximately 4.0 metres from the two loudspeakers, but they were free to interchange seating positions as often as they wished. The test was conducted in a typically-furnished lounge having the measured reverberation time/frequency relation shown in Fig. 1 and an ambient noise level around 22dBA in the absence of the panel, rising to 28 dBA at the quietest moments when the panel in a form suitable for statistical training run before judging commenced, the loudness level was adjusted to that thought reasonable by the panel, the level being continuously monitored by the double-beam crt across the speaker line to ensure that this level was maintained through the series of tests.

It is probably impossible to assemble a reproducing system that is absolutely beyond all criticism but the system used had a 'state-of-the-art' performance that was far beyond the facilities of any ordinary enthusiast.

Each item in the musical programme was presented to the panel as two 30s repeats, separated by an interval of one or two seconds during which the amplifiers were switched. This was followed by an interval of about 15-20s before the second piece of music was presented in the same general format.

Obtaining the opinion of a listening panel in a form suitable for statistical analysis requires some careful consideration, for it is not as simple as might appear at first thought. When three identical amplifiers are compared, then if a sufficiently large number of opinions are taken, each amplifier will get one-third of the votes in much the same way as an unbiassed penny will come up heads on 50% of the throws, but only if there are a large number of attempts. Thus a large number of independent quality judgements are required if the result is to be even moderately conclusive. If a small number of judgements are made, any one of the three amplifiers is likely to find favour by sheer chance, in much the same way as the neutral penny tossed three times will confirm that it is weight-biassed because heads will come up twice as often as tails.

To judge the amplifier performance, each of the four pieces of music was played twenty-four times to a panel of six judges, their opinion on the performance of each pair of amplifiers being given after hearing each of the four pieces on music on each of two amplifiers. After each of the four pieces of music, the panel members were asked to record their opinion on that particular pair if amplifiers in the form:—

1. I prefer A.
2. I prefer B.
3. I have no preference.

If a preference was expressed the panel members were asked to indicate their reasons for that preference. It was thought just possible that an expressed preference might be connected in some way with the particular seating position, so each panel member was also asked to mark his position on a small seating plan on the score sheet.

To avoid listening fatigue there were gaps in the comparison process after twelve judgements had been made, with longer gaps after twenty-four judgements. Lunch was taken in the interval between the first and second groups of twelve judgements, a whole day being devoted to the comparisons. Every possible effort was made to ensure that the test conditions were as free from criticism as could be achieved, but it would be too optimistic to believe that the arrangements were beyond all criticism.

Table 1.

PAIRED COMPARISON TEST RESULTS

Comparison	Quad II/405			Quad II/303			Quad 303/405			Same Amplifier	
	Prefer II	Prefer 405	No. Pref.	Prefer II	Prefer 303	No. Pref.	Prefer 303	Prefer 405	No. Pref.	Preference	No Preference
Listener a	5	4	15	7	6	11	5	6	13	11	13
Listener b	2	2	20	1	3	20	4	3	17	3	21
Listener c	3	6	15	5	3	16	4	1	19	7	17
Listener d	4	9	11	2	4	18	7	4	13	8	16
Listener e	2	3	19	2	2	20	3	1	20	3	21
Listener f	8	7	9	8	10	6	7	4	13	14	10
Group results	24	31	89	25	28	91	30	19	95	46	98

When statistically analysed using the 50% Probability Test none of these results indicates either on a group basis, or an individual basis, that there are any audible differences among the performance of the three amplifier.

A summary of the listening panel's scoring is given in Table 1. Each panel member had 24 opinions to record on each paired comparison and the Table indicates his views.

The data collected is sufficient to allow two of the many standard statistical tests to be applied to determine how far the result obtained is likely to be due to sheer chance (luck) rather than to any real difference in the performance of the three amplifiers. There are several statistical tests that can be used for this purpose, but two that appeared particularly applicable have been applied. The 50% probability test applied to a paired comparison of samples thought to be identical reveals how far the consensus opinion is due to sheer chance and how far it is due to a real difference between the amplifier being compared.

As a second test of the validity of the listening panel's opinion the Chi-square test was applied to their scoring. Both tests confirm that the residual preferences expressed by the panel were no more than would be achieved by sheer chance (guesswork is the crude term). The analysis is not reproduced in detail but one simple and easy-to-understand result is worth quoting.

There were a large number of 'no preference' votes, sufficient to allow them to be separated into a 'no preference' group when a single amplifier was used in both the A and B positions and a second group of 'no preference' votes when two different amplifiers were being compared. The percentage of 'no preference' votes when one amplifier was being compared with itself was 68%, while the number of 'no preference' votes when two different amplifiers were being compared was 64%. The panel judgements amplifiers indicated that they did not prefer any one amplifier to either of the other types and that there are no consistent audible differences between any of the amplifiers being compared.

It is worth commenting that during a trial run some days before the test described, a different expert panel and different programme material were used, but the result did not differ in any significant respect from those obtained in the 'official' test. There was no indication of a consistent preference for any one type of amplifier either by any individual member of the panel, or by the panel as a group, or by the comined result of two separate group tests.

The test was primarily aimed at discovering whether there were any real differences in the sound quality that could be achieved from valve and transistor amplifiers, but there were other incidental differences between the designs that reflect the developments in technology that have taken place since the appearance of the valve design around 1960. The valve design necessarily employed an iron-cored output transformer, whereas the 303 includes a series capacitor of 2000μF, while the 405 amplifier has the loudspeaker directly-coupled to the output transistor. Separate power supplies are used in the Quad II but a common power supply is used for both channels in the 303. Protection circuits of different designs are used in both the 303 and 405. The 405 includes a circuit that provides a sharp cut-off below a frequency of 20Hz whereas the Quad II falls away more slowly below 20Hz.

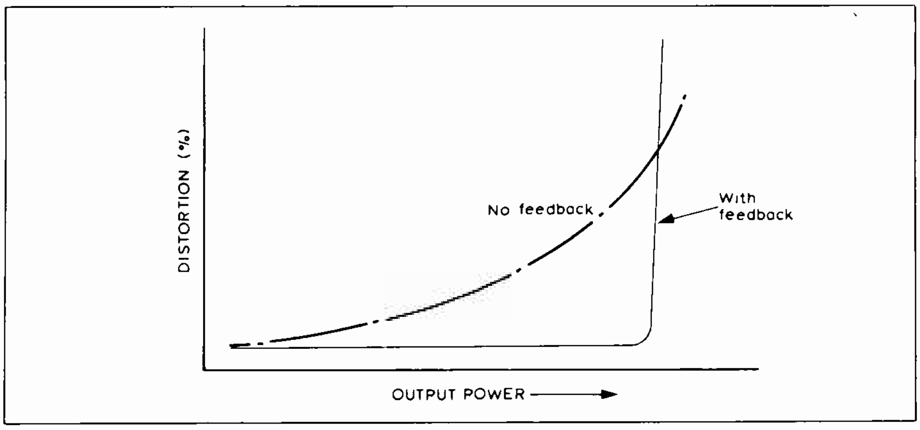


Fig. 2. *Output power against percentage distortion characteristics for amplifiers with and without feedback.*

The comparison also includes amplifier designs completed before t.i.d. (transient intermodulation distortion) became a misunderstood explanation for every subjectively-assessed difference in amplifier performance. All of these differences have at some time been claimed to be responsible for large difference in sound quality, but it will be appreciated that the comparison tests quoted show that in the hands of a skilled designer none of these factors appears to be of real importance.

It seems reasonable to conclude that if a dozen expert listeners working for a day with the best available equipment and the best obtainable programme material cannot find any significant difference between the amplifier types, then it is highly unlikely that such differences as are inherent in designs that span more than twenty years will be of any significance to any user.

Finally it is worth considering how far the findings are reasonable from an engineering point of view. Insofar as the understood distortions in any of the three amplifiers are far lower than in any part of the record-replay system, the findings are logical and are what might be expected. The residual amplifier distortions are likely to have been masked by the much greater distortions in the recording/replay elements, even though these were representative of the best current professional practice.

The absence of preference for any one type of amplifier is exactly what an engineer might expect, so it is reasonable to ask why other published listening tests and reviews appear to show differences so large that one expert was able to speak of the type 405 amplifier as producing '100 watts of squawking sound'. This aspect is worthy of some comment.

It has been stressed that the amplifiers were all operated within their power ratings and this may be one possible key to the difference between findings of this listening panel and of others that have been published. An amplifier which employs a relatively small amount of feedback overloads in an entirely different way to an amplifier having a large amount of negative feedback, a result indicated by Fig. 2. Negative feedback can reduce amplifier distortions by a large factor, but only below the point at which the distortion without feedback is less than a few per cent. Above this power the overall distortion is greatly *increased* by the application of negative feedback.

In consequence an amplifier design employing a small amount of feedback will approach its rated distortion limit rather slowly, the overall distortion increasing gradually as the input signal is increased. In contrast an amplifier employing a large amount of feedback will exhibit much lower amounts of distortion at output powers below the rated value, but the distortion will increase very rapidly above this 'overload' value.

The difference is well illustrated by the distortion/power output curves of Fig. 2. In practice it is almost impossible to specify with any real accuracy the distortion content of an amplifier employing large amounts of negative feedback at output power levels near, or above, the overload point. Beyond this point the distortion increases so rapidly that small changes ($\pm$1% etc.) in mains supply voltage or signal input voltage may increase or decrease the measured distortion by four or five times without there being any significant increase in the power output.

Above its overload point, every amplifier type exhibits its own particular overload characteristics depending on the cause of the distortion. Slew-rate limiting, transient intermodulation distortion, dynamic intermodulation distortions, amplitude compression, mains frequency modulation and the well-understood distortions due to curvature in the overall transfer characteristics will all introduce their own characteristic acoustic effects.

However it is unreasonable to operate any amplifier above its claimed power output. If the amplifier has to be overloaded to achieve an adequately loud signal then a more efficient loudspeaker or a more powerful amplifier should be substituted.

Differences in the acoustic performance of an amplifier can also be induced by applying test signals that are outside the designed frequency band of the amplifier. In a misguided attempt to assess the transient performance of an amplifier short square wave dc pulses or short pulses of sinusoidal tone are often applied to an amplifier, but it is easy to show that such short pulses contain components up to a frequency in the region of 80 to 100kHz. For example a pulse 10μs long will have a first zero in its amplitude response at 100kHz and the amplitude of components at 80kHz will be only a few dB lower than the maximum. In most amplifiers this is well outside the designed frequency range and overloading is easily produced by signals that would be far from overloading the amplifier if they were of the same amplitude but inside the designed frequency pass band.

Finally some comment about the pitfalls that are possible when connecting up the components in any hi-fi system. Fig. 3 shows the same units having their earthing connections set out in different ways that are superficially identical. Yet in practice there may be large differences in the performance of the system in respect of sound quality depending on just where the earthing wire is connected to the circuit earth bus or the chassis. An assembly in which two or more amplifiers are connected to the same earthing system and the same loudspeaker will almost certainly not achieve their catalogue performance unless some considerable expertise is employed in assembling and testing the completed system.

The writer took no part in reaching the judgements discussed, but it is his firm personal opinion that no 'X' ingredient, nor any 'black magic' is necessary to explain the results. As Mr. Peter Walker has commented, "If an engineer finds that a couple of measurements appear to contradict Ohm's Law he does not immediately rush into print with his findings, he looks again at the measuring technique employed."

This comment should be taken to heart by all those reviewers who are so eager to print comment that flatly contradicts all reason. They might, with advantage, look at the experience of a Canadian journal.[1] Their reviewing panel listened to half a dozen amplifiers, all in the top class and found large differences in sound quality. Doubting the findings, they set out to investigate the reasons for this. After having eliminated all the little problems that they were able to unearth, a repeat of the listening test revealed that all the quality differences had vanished. It is a mundane explanation perhaps, and one that is without journalistic appeal, but then the truth is often less sensational than pseudo-science or witchcraft.

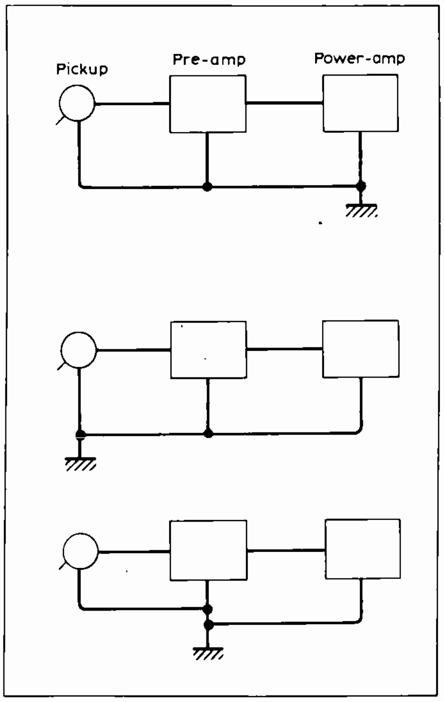


Fig. 3. *Nominally-equivalent earthing arrangements.*

Reference and further reading

1. Six Amplifiers, How Did They Compare? Ian G. Masters, Audio Scene, May 1977.
2. Audible Amplifier Distortion is not a Mystery, P. Baxandall, Wireless World, Nov. 1977.
3. Rational Amplifier Testing, P. Walker, Hi-Fi News, July 1977.
4. Can You Hear Any Difference? Adrian Hope, Hi-Fi News, June 1978.

How accurate are audio reviews? *From p. 67*

new range of Wharfedale speakers that British hi fi customers had bought more of their XP speakers than any other brand in the past ten years, in spite of no press coverage or adverse reviews. The four large comparative reviews of bookshelf speakers that had appeared in the previous four months had grouped up to 16 loudspeakers, not one of them a Wharfedale, yet 20% of readers, he asserted, would be buying a Wharfedale product. At least five competitors had appeared in three out of four reviews.

"When the Wharfedale Denton or Linton products have been reviewed there has been virtually no consideration of the price the consumer will pay. A recent letter in the hi fi magazine had a customer asking advice on the purchase of a pair of Dentons, to which the magazine said there were a lot better products on the market and proceeded to list some which would cost the consumer between 30% and 100% more than the Denton, hardly fair advice."

"We have survived this approach for some years, but we are naturally concerned about the eventual impact of what we consider to be slightly unfair journalism. Particularly with the increasing competition from Japanese loudspeakers, who have the weight of advertising expenditure to overcome any type of press coverage."

Reviewers should take price into account, he said. Later he told *Wireless World* that he also questioned the usual method of reviewing, by comparing the tested equipment with a reference monitor. "It's a bit like comparing a Cortina to a Jensen: you are always going to find areas of performance that are not quite up to the standard of the Jensen, whereas a Cortina would normally be measured against standards expected of that category of car." □

Electronics well-represented in Queen's awards

THE FOLLOWING firms are among those listed in the latest Queen's awards to industry: Brookdeal Electronics, for technical achievement in signal recovery; General Instrument Microelectronics, for exports; International Aeradio, for exports; Marconi Avionics, for exports; Racal Dana, for technological achievement in programmable synthesised signal generators.

Three audio companies were represented. Electrosonic won an export award for audio visual and lighting equipment. The Acoustical Manufacturing Company won a technology award for their Quad current dumping amplifier, and Bowers & Wilkins won an award for exporting almost 90% of production. □

Disaster avoided

Over 300 mobile radio users attended Pye's two-day symposium, (see other news items, this issue) including some from the Ministry of Defence, the Home Office, police forces, area health authorities, fire brigades and water authorities. The symposium was a triumph over adversity. Pye employees at first said they would picket the week's events as a protest against their £1 million cost. No sooner had they been persuaded not to do so than the giant marquees in which the symposium was to be held, set up on fields next to the Cam river, were flooded by three feet of water, this only days before the opening. The same employees won the eternal gratitude of Pye executives by working day and night to clean up the mess. They did, so effectively that delegates had to be shown photos of the inundated marquees to believe what had happened.

LETTERS TO THE EDITOR

MICROWAVE HYBRID INTEGRATED CIRCUITS

I write regarding the very interesting article by Drs Davies and Newton, "Microwave hybrid integrated circuit technology" in the February issue. Review articles with this kind of flavour seem an ideal choice for this journal with its wide professional readership.

It is especially important, I feel, that the mainly "non microwave" engineers who read Davies's and Newton's article do not in fact get "the wrong end of the stick" on anything – if this can possibly be avoided. To this end I should like to offer the following comments on certain aspects of the article.

1. In the article summary, m.i.c. have been made at frequencies *well* above 40 GHz.[1,2]
2. Gunn diodes are still very useful (and conveniently) made in waveguide – and a smaller waveguide (than standard) is used so that the higher-Q and higher stability can be achieved by operating near cut off. Also impedance "matching" is hardly a problem since the device only has to be correctly located with respect to a short-circuit.
3. Dispersion in microstrip is very significant at frequencies even *well below* 12GHz – sometimes down to 3 or 4GHz.[3] The paper referred to here quotes very reliable formulas for *alumina* as well as sapphire.
4. In the table, the dielectric constant of "alumina" can vary greatly over the approximate range: $8.5 \leq \epsilon_r \leq 10.2$. A value of 9.6 is typical of thick-film substrates (not often used at microwave frequencies). 10.1 is often the case for thin-film substrates.[3] The permittivities of sapphire are 9.4 and 11.6[4], and *not* the values given.
5. Sapphire is *not* employed because of its high dielectric constant (only marginally greater than alumina). It is used because of its surface finish, repeatibility and transparency etc.[5]
6. It is difficult to see how coupling the X-band oscillator to a (relatively low-Q) microstrip resonator provides . . . "the necessary temperature stability." Perhaps the authors can enlighten me on that point.

Notwithstanding these comments, the article is certainly wide-ranging and informative. I am especially interested in the "low-cost" parametric amplifier of Fig. 8, and would be grateful if the authors could supply any further information on this item.

T. C. Edwards
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Bundoora
Victoria
Australia

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1. Schneider, M.V., Bernard Glance and Bodtmann, W.F. "Microwave and millimetre wave hybrid integrated circuits for radio systems." *Bell System Technical Journal*. July-August 1969, pp. 1703-1726.
2. Oxley, T.H. "Microwave integrated circuit techniques." *GEC Journal of Science and Technology*, vol. 43, No. 1, 1976, pp. 21-31.
3. Edwards, T.C. and Owens, R.P. "2-18GHz dispersion measurements on 10-100Ω microstrip lines on sapphire." *IEEE Trans MTT-24*, No. 8, Aug 1976, pp. 505-513.
4. Owens, R. P., Aitken, J.E. and Edwards, T.C. "Quasistatic characteristics of microstrip in an anisotropic sapphire substrate. *IEEE Trans. MTT-24*, No. 8, Aug 1976, pp. 499-505.
5. Ladbroke, P.H. "Some effects of field perturbation upon cavity-resonance and dispersion measurements on MIC dielectrics." *IEEE Trans. MTT-25*, No. 11, Nov 1977, pp. 892-893.

The authors reply:
With reference to the items in our article discussed by Mr Edwards we would like to make the following comments.

1. Microwave integrated circuits have been made at frequencies well above 40GHz (90GHz in reference 2 of Mr Edwards' letter) but the losses due to radiation from discontinuities (especially from connectors) and surface waves make open microstrip unattractive for use at frequencies much above Q-band. At these frequencies alternative circuit structures such as coplanar waveguide, trapped inverted microstrip (TIM), suspended microstrip etc, which do not radiate as much energy offer improved unloaded Q-factors.
2. We agree that waveguides are still widely used in constructing, for example, Gunn oscillators. Furthermore, the solid-state devices can be conveniently resonated by an appropriately positioned short-circuit and the correct resistive termination can be provided by adjustment of the output circuit. See for example the Q-band Gunn oscillator used as the pump for the X-band paramp. Even so our point in the article was to emphasise the *integration* capabilities of microstrip circuits which applies throughout the microwave spectrum.

With regard to the matching problem, we believe it is much easier to match semiconductor devices (Gunn diode, mixer diode, impatt, trapatt etc.) to a given circuit load impedance if the stray series inductance and shunt capacitance associated with the encapsulation are removed. Then any series and parallel resonance effects (to which the usual encapsulations are prone in C and X band) are eliminated. The spurious resonant frequency of the stray reactances surrounding an unencapsulated diode occur well above 12GHz.
3. There is no doubt that dispersion effects occur at lower microwave frequencies but note that in the design of many circuits below 4GHz, e.g. trapatt oscillators, dispersion effects are often negligible.
4. Our experience in the design of narrow band thin film directional filters is that a value of $\epsilon_r = 9.6$ for M.R.C. Superstrate gives excellent agreement between predicted and experimental results. A value of 10.1 would certainly be noticed in our designs. (It is probable that Mr Edwards is referring to Allsimag 800 for which the permittivity is 10.1). The values of ϵ_r for sapphire which we quote are not too different from Mr Edwards's values. A 1% difference is not going to introduce a significant design error in, say, a bandpass coupled line filter compared to the tolerance involved in the technological process for making the circuit.
5. We agree with this comment.
6. It was not within the scope of the article to discuss the details of the stability of the microstrip Gunn oscillator. However a detailed account is given in reference 6 of our article. Basically, the Gunn oscillator is locked to a capacitively coupled microstrip line to give a basic temperature stability of 1 MHz/°C. With a thermistor compensation technique this value was reduced to 0.3 MHz/°C over the temperature range −10° to +50° which was sufficient for the application.

We thank Mr Edwards for his interesting comments.

R. Davies and B. H. Newton

NEGATIVE FEEDBACK AND HARMONICS

I read the article "Distortion in low-noise amplifiers" by Eric F. Taylor in the August and September 1977 issues with great interest. I would like to correct one error which perpetuates a common misconception. I quote from the August article: ". . . the effect of negative feedback has been to reduce the coefficients of the terms of the power series representing the non-linearity by a factor $(1 + A\beta)$ compared with the open-loop configuration." It is not even approximately true that all harmonics are reduced by the same factor; the proof given is incorrect.

In Appendix 1 of the August article, the non-linear gain, A, of an amplifier without feedback is expanded in a power series

$$A = A_0 + A'v + A''v^2/2 + \ldots,$$

where v is the input voltage in appropriate units, A_0 is the gain for an infinitesimal signal, and A', A'', ... are the successive derivatives dA/dv, d^2A/dv^2, etc. Following the article, we obtain the 2nd order term for an amplifier with feedback:

$$A_f'' = A''/(1 + A\beta)^2 - 2(A')^2/(1 + A\beta)^3$$

In the original article it is stated that the second term on the right-hand side can be neglected, and this statement is implicitly generalized for higher order terms. The gain is reduced by a factor $(1 + A\beta)$, so that the (erroneous) conclusion is that all distortion components are reduced relative to the fundamental by a factor $(1 + A\beta)$ when feedback is applied.

We shall assume $A\beta >> 1$, which simplifies the algebra; the gist of the argument is valid for any $A\beta$. The ratio of the neglected term to the retained term is, with the above approximation,

$$-2(A')^2/AA''$$

We ask the vital question: is $(A')^2$ really very much smaller than AA'', justifying the approximation? The answer is no; I will give some heuristic arguments here, and will deal rigorously with the common-emitter amplifier in an Appendix.

Let us consider an amplifier with constant transconductance, g_m, and variable load, R. The gain will be $A = g_m R$, which can be expanded in a power series as before. If we now increase R without changing the input voltage, we expect the relative distortion to remain constant (if it increases, the argument is reinforced; only a decrease in distortion can invalidate this discussion). In other words we expect the absolute distortion components (voltages, not ratios) to increase by at least the same factor as the gain; in mathematical terms, we expect the derivatives to be approximately proportional to

A_0. This argument shows that a more appropriate power series is

$A = A_0(1+pv+qv^2+\ldots)$,

where $p = A'/A_0$, $q = A''/2A_0$, etc. The new coefficients are now a true measure of linearity, being independent of the gain. The 2nd harmonic distortion is essentially given by p, the 3rd by q, etc. The ratio discussed above is equal to $-p^2/q$, which is clearly only negligible if the square of the 2nd harmonic component (relative to the fundamental) is much less than the 3rd harmonic. This is normally not so, and the term neglected by the author of the article is not small, invalidating the proof. We conclude that negative feedback does not normally reduce all haromics by a factor $(1+A\beta)$. I state without proof (exercise for the reader!) that higher harmonics may be (and in general will be) reduced by a smaller factor. I conjecture that under certain circumstances some harmonics could conceivably be enhanced relative to the fundamental – unpleasant high harmonics, of course (Murphy's law).

Roughly speaking, the effect of feedback is to convert a given distortion component into a $(1+A\beta)$ times smaller component of the same order, plus terms of higher order. The higher order terms will add (algebraically) with the higher order components already present. It is not difficult, although tedious, to calculate the effect of feedback on a given transfer function. The results are thought-provoking. An interesting hypothetical example was given by M. G. Scroggie in his "Essays in Electronics" (out of print, but not out of date); the effect of 40dB of negative feedback was to convert 20% of pure second harmonic distortion into a set of distortion components giving a higher weighted total harmonic distortion. The application of feedback to a non-linear amplifer can be compared with hammering out dents from a metal sheet: a large, smooth dent tends to become a mountain range of nasty small dents.

I will not delve deeply here into the audible aspect of distortion, but will simply point out that feedback reduces the magnitude but increases the order of distortion, and should not be used blindly.

M. G. Salem
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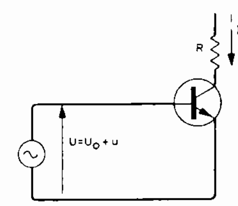
Appendix

Consider a common-emitter amplifier with no resistance in the base-emitter circuit. The



instantaneous collector current, I, is given approximately by

$I = I_s e^U$

where I_s is a constant, and $U = qV/kT$, with V = base-emitter voltage, q = electron charge, k = Boltzmann's constant, T = absolute temperature. We have $q/kT = 40$ at room temperature. Normally both I and U have a steady component (I_0, U_0) and a time-varying (signal) component (i, u). In terms of these components

$I = I_0 + i = I_s e^{U_0} e^u = I_0 e^u$,

and thus

$i/I_0 = e^u - 1 = u + \frac{1}{2}u^2 + 1/6u^3 + \ldots$

The gain is:

$A = A_0(1 = \frac{1}{2}u + 1/6u^2 + \ldots)$,

where $A_o = I_p Rq/kT \approx 40 I_o R$.

We have for small u: $A' = A_o/2$, $A'' = A_o/3$, etc. The ratio $-2(A)^2/AA''$ is thus $-3/2$; the neglected term is actually larger in magnitude than the retained term. In this particular instance the neglected term decreases the magnitude of the distortion; this is fortuitous, and higher harmonics are, in general, enhanced in magnitude by the term neglected in the August article. We have $A'' = A_o/3$, $A''_f(\text{uncorrected}) = 1/(3\beta A_o)$, A_f (corrected) $= -1/(6\beta^2 A_0)$.

PICKUP-ARM DESIGN

Mr Randhawa, in his first article on this subject in your March issue, comments "One of the first problems faced by pickup arm designers was tracking error......"

It will continue to be a problem while ever designers try to make a curved line fit a straight one.

I see no reason why the cutting head *must* follow a straight line. Why cannot it be fixed on the end of a radius arm? The cutting head would then follow a curve, and without any difficulties or abstruse calculations the pickup head would follow exactly the same curve.

There is probably a best compromise for the length of the radius and the amount of overhang beyond the centre of the disc; there might even be an actual indisputable best. In any case it could be standardised, and no more trouble.

F. Holloway
Rayleigh
Essex

Editor's note: We understand from recording engineers that what Mr Holloway suggests is in fact possible but difficult to achieve. There is perhaps an argument here for concentrating difficulty and cost of mechanical design once and for all in the recording equipment rather than allowing it to be distributed forevermore as a permanent problem in the manufacture of reproducing equipment.

AUDIO EQUIPMENT REVIEWS

Paul Messenger (Letters, June) said that *Hi Fi Choice* "should try to provide comprehensive and comparable data on a significant proportion of the available products in whatever category ... to enable the reader to make his own choice according to his particular need." A modest enough claim one might think, but in the newly published *Loudspeakers* we read (p.10) "What we're saying is this; we can point you towards the best hi-fi system in the world. The best turntable, the best amplifier, the best cartridge, the best tape deck, the best loudspeakers." Since Mr Messenger has actually invited discussion of *Loudspeakers* by readers of *Wireless World* perhaps the following observations will be of interest.

The strength of the publication seems to lie in the technical introduction (p.31-38) and in some, if not much, of the conclusion (p.169-173). Insights are to be found, and pertinent comments are made about 'characteristic forward response' in particular, and about coloration. Having admitted this it must then be said that "the most comprehensive guide to buying loudspeakers ever published" is very weak.

There are three principal areas of weakness that invalidate the entire report. First, procedures for test are not properly correlated; second, the marking procedure in listener-panel evaluation cannot provide satisfactory sample material for the statistical procedures employed; and, thirdly, there are serious inconsistencies in the presentation of the evaluations.

No integrated response measurements are given for the 'sound window' – the virtual listening rectangle prescribed by the included angles 20° vertical and 60° horizontal for each speaker. Instead the traditional on-axis sine-wave drive response curves at 1 and 2 metres are quoted in all cases. Unexplained anomalies between subjective comment and frequency response measurements abound – p.57, 75, 81, 85.

We are told that the reference for evaluation is "provided by the mean standards of the group as a whole" (p.169). This apparent tautology simply means that the average is a statistic not a loudspeaker, and we are brought to the heart of the problem. The testing was done in an average-size listening room that happened to agree in essential characteristics with the IEC recommended test room. Live versus recorded tests were made using voice and instruments. This is notoriously difficult (as Colloms himself admits) but quite misleading as a general comparative test procedure simply because amplitude mis-matching between live sound and the recordings inevitably occurs. A difference of only a fraction of a decibel will affect assessment of fidelity. Also the human voice changes subtly but significantly from day to day and recording should be updated accordingly.

Anyway the results were analysed to achieve an average. The listening panel of six – "a mixture of trained and untrained ears" (p.19) – "was asked to give a numerical mark to each loudspeaker, an evaluation of its general impact, and errors or attributes of frequency balance . . . marks were used to denote judgements like clarity, accuracy, too much or too little treble, too much or too little mid-range . . . to identify (again with numerical marks) the coloration they could hear". (p.20). An attempt was made at standardisation on colorations as bumps or resonances in certain frequency bands. Each classification – 'tube', 'chesty', 'cup-like', 'sharp', 'fizzy' etc – is given a numerical mark. Then, we are assured, "it is possible to run a statistical analysis of what the panel hears and thinks of what it has heard". p.20.

A strange contrast appears throughout the book between the results obtained on the live versus recorded test and the stereo sessions where high quality recordings were replayed (p.46, 50, 53 etc). No explanation is offered.

The absence of pulse tests is quite unforgiveable when so much attention now is being paid to phase accuracy and time domain behaviour by loudspeaker designers and manufacturers. It is partly explained by a disregard of phase phenomena in favour of a new slim-speaker theory of stereo accuracy (p.171) which seems to emerge from the statistics. However, the book is also luminous with revelations on such things as plastic cone drive units with some degree of "quack" on the upper mid voice band (p.74).

The third criticism mentioned was that of inconsistencies in the presentation of evaluations. Loudspeakers that previously had been favourably reviewed by Martin Colloms were very positively presented again (p.50, 58, 60, 94), the identity of such speakers emerging noticeably better than others that appear as shadowy and intangible as the statistics quoted to delineate them. Each report had a comment from Tony Faulkner which is a little less statistical than the main panel result since it is a solo performance. At times he contradicts the panel (p.77, 85, 95, 133). Also, in the summary a recommended speaker is said to have "fine distortion and stereo imaging" (p.175) whereas TF comments "I scored this speaker above average in all respects except stereo image, which I found slightly overwide and out of focus" (p.150). Similar inconsistencies abound with respect to wording (and apparent censoriousness) on matters of sensitivity, low frequency performance, and value for money.

It is my belief that loudspeaker evaluation cannot be done to any worthwhile purpose in a piecemeal, dissecting and comparative manner. Loudspeakers will always have individual character in so far as they are mass market contenders, and the 'average' speaker that emerges from the text of *Loudspeakers* is a pure fiction. I certainly hope that the lessons will be learnt.

John Greenbank
Tangent Acoustics Ltd
Bar Hill
Cambridge

DEFENDING THE NRDC

There is no need for me to respond to Mr Catt's biased complaint of his treatment by NRDC published in your May issue (letters), since that organisation could undoubtedly present their view of his case with greater commercial and financial sobriety of expression than Mr Catt displays. When Mr Catt attempts, however, by tortuous illogicality and irrelevancy to involve me with your readers in his personal affairs and through this channel denigrate in advance the report of the Government Committee which I am privileged to chair, he cannot be allowed the luxury of public expression of his spite without reply.

Strangely, Mr Catt was one of the first of the many to write to me on 21 December last just after formation of the Committee asking to be allowed to give evidence. For somebody who lacks confidence in the activities of the Committee this would seem rather an odd action.

Although it is no part of the purpose of my Committee to comment on NRDC, Mr Catt may care to have my personal views. I believe that the concept of NRDC is essentially sound and that the help they provide in developing and exploiting inventions from all sources can play an increasingly important role in advancing innovation in this country's industries and services. During the period 1963-73 when I served on the Board of the Corporation, we had our share of both successes and failures. Not all inventors were always right, but not all were always wronged and I suspect that this pattern will continue. If NRDC's track record can be improved I am sure that nobody would be happier than the present Board of NRDC. Where they have made mistakes of judgement, I am equally certain they would in so far as they can be recognised wish to correct them; whilst Mr Catt clearly believes that in his own case this has not happened perhaps NRDC would not, even with hindsight, have acted differently.

Finally, I find Mr Catt lacks a sense of proportion as well as abusing the English language. If Mr Catt believes that the NRDC with its limited investment over the past 28 years is "doing more damage to the economy than shop stewards in the car or shipbuilding industries," he will believe anything, and to consider NRDC as "cancer" which is a destructive growth, can hardly be supported on the past record of NRDC.

Monty Finniston
Committee of Inquiry into the Engineering Profession
London SW1

OPEN LETTER TO FINNISTON

My son completed grammar school with ten 'O' levels and three 'A' levels, the latter in physics and mathematics with A, B, A grades. Last year he left university with B.Sc (Hons) to his credit. Fifteen to twenty years ago he would have proceeded to a science or engineering based profession. In fact, he has taken articles with an international firm of accountants and is working for chartered accountant, not chartered engineer, status.

It is relevant, to the current Inquiry into the Engineering Profession, to ask why not engineering? No doubt the vicissitudes of my own career have been observed. I have discussed the matter with my son and his contemporaries and there can be no doubt that the lack of a coherent, and recognised, career structure within the profession coupled with the transparent career assurances of the engineering employer is responsible for this lack of interest. Too, the run-down of job prospects with the advent of integrated circuits (*WW* April 1978 — "Mixer") has been observed. Also, the first job of one of his friends, an electronics graduate, with one of our large companies was a hack job of ONC technician level, and responsible to an unqualified time server having no conception of graduate aspirations. This graduate is now in technical marketing. Heigh ho!

For myself, at the age of fifty-one, I feel like Kipling's time expired soldier. "Me! Wot 'as" made major contributions to the radar industry of this country. "Me! Wot 'as" contributed to the technical press and to institution affairs. "Me! Wot 'as..." but the list is so long.

The fact is that the undoubted shrinking of the electronics industry (an unfashionable statement) coupled with social and pay policies acts to discount experience. Young graduates are recruited as short term industrial fodder, bright eyed and bushy tailed with digital technology, having little knowledge of fundamentals, least of all radio techniques, no knowledge of the impedance of a copper conductor or of circuit transit time. As a pointer, Honeywell have recently dropped their high speed CML based computer for lack of ability to cope with the problems of high speed transmission, a lack of fundamental electromagnetic theory (*Computing*, March 16, 1978).

Our industry, sadly, is managed by narrow and small-minded people, themselves working in slots and unwilling to depart from a rigid job specification, unable to appreciate that an experienced engineer has a breadth of knowledge transcending the limits of a job label. One of our companies has, as a senior general manager, a legal type whose problem solving approach is to decide on the answer and then to gather data in justification. Another has a recruiting policy that requires a recruit, irrespective of experience, to start at the bottom of the salary grade. Only in-house experience is recognised.

To the young electronics engineer I would say be wary, do not succumb to the Myth of Management, broaden your knowledge and seek excellence within a marketable speciality, do not communicate your special knowledge, for the game is personal survival and knowledge is power. This is at variance with normal engineering instinct, certainly with mine, but is offered seriously in the current climate. And do not forget that you will be fifty, one day.

Chartered Engineer A.M.B.I.M.
(name and address supplied)

HI-FI IMPORTS

Earlier this year a great deal of publicity was given both in your magazine (January 1978 issue) and in the national press to the campaign by Mr Jack Akerman, managing director of the Philips subsidiary Mullard, to keep any further development by Japanese manufacturers out of the UK. The forecast of the ensuing unemployment among British manufacturers, should Hitachi commence operations, was sufficient for the government to send them on their way. Since this action numerous British workers have found themselves out of work from the closure of tv production plants without, it seems, any help from the Japanese.

Now the Philips group and its sister organization, Pye Ltd, have launched two new ranges of hi-fi equipment, into what is already a market overloaded with similar products. One might expect that the manufacturer of these products would provide much needed employment for the workers of the UK, or perhaps on the Continent. No such luck. They are assembled in the Philips plant — in Japan! I leave you to draw your own conclusions.

Michael Hutchinson
Kings Lynn
Norfolk

REACTANCE

The drinking driver is such a serious cause of death and suffering on our roads that it is not a source of surprise that electronic cobblers sometimes leave their lasts and want to join in the discussions [*Sidebands, April 1978 issue – Ed.*].

Reaction time, allied with accuracy, has been a subject studied many times over and can be very useful in certain experiments, but it is only a very small part of the overall problem. Many experimenters have demonstrated what we would all expect to happen. Typically, a group of sober mature people are tested with a skill resembling driving a motor vehicle and then the group are given increasing quantities of alcohol. Not surprisingly, as the group gets drunker their performance gets worse.

Because the extraordinarily diverse collection of human attributes such as social consciousness and intelligence which tend to make a driver safe on the roads far outweigh reaction time, one tends to relegate the latter to a small part in laboratory experiments.

When a person is arrested, the police and the police surgeon have to concern themselves with a number of possible circumstances. Of course the "drunk-in-charge" driver and "breathalyser" driver are common enough with no complications, but some of the complicating factors are: driving under the influence of drugs, the presence of concomitant illness and injury or the presence of a disability or mental illness.

Let me quote the kind of case which illustrates. A young man is arrested for driving with high blood alcohol concentration and the circumstances leading up to his arrest are as follows. It is alleged that the driver has taken and driven away a motor vehicle without the owner's consent and has had an accident with the vehicle. He has, so the police say, hit a pedestrian on a pedestrian crossing, the pedestrian having suffered serious injuries. The driver, in swerving the car after the accident, has run into a lamp-post and, because he was not wearing a seat belt, has a severe nose bleed, many small scratches and a bump on his head. The police surgeon discovers during his comprehensive medical examination that the subject is a sufferer from epilepsy and should not hold a driving licence.

What possible valid results could come of attempting to test such a subject for reaction time? Multiple factors could have degraded his mind when considering the results of such a test: alcohol; drugs properly prescribed; drugs improperly taken; head injury; emotional factors because of the circumstances leading up to his arrest.

If every case was straightforward and uncomplicated life would be so much easier for the courts, the police and the police surgeon, but these cases are full of pitfalls.

David V. Foster, G3KQR
(Police Surgeon and Deputy Coroner)
Tolworth
Surrey

DIRECT PERCEPTION OF RADIO WAVES

I would like to comment on the subject of direct perception of radio waves (Letters, December, February, March and May).

There has been well documented research into this and related phenomena. In his book "Electromagnetic fields and life" A. S. Presman of Moscow University* describes how A. Frey investigated sound sensations due to radio waves. Briefly, pulse-modulated r.f. will produce, in people exposed to it, buzzing or whistling noises. The sounds are similar to that of noise with the same envelope as the pulses, with all frequencies below 5kHz cut off. It is suggested that this "radiosound" effect, as it is called, is perceived in the auditory nerves, and in the auditory zone of the cerebal cortex.

The field of biological effects of r.f. seems a relatively unresearched one when compared to other fields, yet appears to have enormous possibilities. The same book describes many experiments that have been undertaken, mainly in the USSR, with applications that range from increasing crop yields (simultaneously retarding weed growth) to bionics, medicine, behavioural control of animals and fish and possibly even telepathy.

As much of the described research seems to use pulsed r.f. for its effects, I wonder if the "Kiev buzzsaw" transmissions that regularly blot out much of the short-wave spectrum are in fact not just a form of radar, as is generally accepted, but something more sinister.

P. J. Quinn
Romford
Essex

* Translated by F. L. Sinclair. English language edition by Plenum Press, New York and London, 1970m.

RECORDINGS OF WIRELESS TRANSMISSIONS

With reference to Mr E. S. Walker's letter in the April issue, I have an Edison "Voicewriter" Dictaphone which records and plays back from discs similar to those of Mr Walker's. The discs are 7.05in diameter, the central hole is 1.5in diameter, and the thickness 1/64 inch. The groove modulation is transverse, not vertical.

I believe my machine is *circa* 1950.

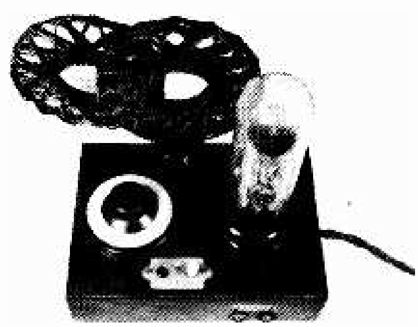
J. C. W. Waghorn
Crawley
West Sussex

INTEGRATED CIRCUIT OF THE 1920s

I was most interested in the letter by Mr T. R. Thompson in the November 1977 issue.

The accompanying photograph is of a complete radio using the 3NF valve. It is not, however, in an operational condition due to the glass pip having been broken (for which any information on how to evacuate and reseal the valve would be appreciated). The supply wires have the appropriate values on them, and it would be interesting to have the radio operating once again.

The history is not known, but similar early wireless equipment, such as crystal detectors, iron filing coherers and other early valves, such as Marconi's W.T. Co. Ltd 2VPF, Ediswan 68530X, were used in experiments around the 1900s by the Midland Railway Company.



My thanks to British Rail for allowing me to publish this information.

N. Gresty
Chief Signal and Telecommunications Engineer's Laboratory
British Railways
Crewe

T. R. Thompson asks for information on the Loewe valve (November Letters). In the early 1930s, I used to make specialised radio items particularly for commercial broadcasting stations. One item was a condenser microphone, a cheap version for hams, and a fully adjustable one for the stations. Because of its very low output, the microphones were supplied with the Loewe tube which could be wired up as a three-stage RC amplifier. Many years later, Radio 2UE retired the microphone and the station's chief engineer and founder, Mr Murray Stevenson, returned it to me as a memento. However, the tube was missing.

P. Levenspiel, VK2TX
Wyong, N.S.W.
Australia

MICROCOMPUTER SIMPLIFICATION

The growing popularity of microprocessors for use in microcomputer systems is very evident from the articles and advertisements in your magazine. When using these computers the most frequently employed high level language is BASIC, though ALGOL60, FORTRAN and COBOL compilers are rapidly becoming available. The majority of the computers sold include some form of ASCII keyboard with possibly a separate numeric keypad as well. In using any high level language the most commonly used groups of characters are those making up the languages' commands, such as LET, GOTO, OR and the mathematical operators *, + / — and =. It would make sense if these groups of letters could be available at the touch of a key. Thus instead of keying in several letters (or a single letter holding the shift key down) one deft action would input the required string of letters. This would save time and reduce errors. If the letter codes were stored in a r.o.m. then, on changing to another language, a new r.o.m. could simply be substituted for the old one.

Having spent many hours typing in commands at a v.d.u. keyboard, I feel a time saving innovation like this would be very welcome.

M. J. Shepherd
Wadham College
Oxford

CAMPBELL SWINTON

We are endeavouring to gather together material for a biography of the Scottish electrical engineer and broadcasting pioneer A. A. Campbell Swinton (1863-1930) and would be grateful for any information to which your readers might have access.

Ian Mowatt and George Cooper, Department of Humanities, Glasgow College of Technology, Cowcaddens Road, Glasgow G4 0BA.

Logic design — 14

Action/status interfaces

by B. Holdsworth* and D. Zissos† *Chelsea College, University of London
†Dept of Computing Science, University of Calgary, Canada

The two-wire interface is explained from first principles and clear cut step-by-step methods for the design and implementation of interfaces for action-status equipment are described. For the sake of clarity simple equipment such as paper tape readers, tape punches and printers are used to demonstrate the design steps. It must, however, be stressed that the design steps apply to all types of digital equipment irrespective of their complexity.

THE DESIGN PHILOSOPHY adopted is one that allows the inexperienced user to produce sound and reliable interfaces simply, while at the same time providing the specialist with tools to improve his technique in dealing with more sophisticated assemblies.

Conventional interfaces

A block diagram of a conventional interface between two devices is shown in Fig. 1. The function of the interface logic is to co-ordinate the activities of the two devices by monitoring their status signals k, m, x and z and generating in the correct sequence the appropriate command signals l, n, w and y.

Any devices, unless they are identical, require a dissimilar set of command signals and a different interface logic configuration will be needed for each data channel, a fact which has contributed greatly to the complexity of interfaces. This has resulted in a great deal of the design effort in recent years being directed towards the development of standard interfaces. A number of such interfaces have been produced, notably the CAMAC interface and more recently the Hewlett-Packard Interface Bus. Several other universal interface schemes are currently under consideration by standards-making organisations[1]. However, for relatively small dedicated systems the above solutions appear to be unnecessarily complex, particularly when compared with the two-wire interface discussed next.

Two-wire interface

The two-wire interface was developed by Zissos, Duncan and Collins[2,3] and is an alternative approach to the problem. It is based on the fact that interface logic is not required between two devices that are triggered into action, as shown in Fig. 2. That a pair of action/status devices do not require synchronising logic can be shown by considering the step-by-step design of the logic block shown in Fig. 3, which is used to interface devices 1 and 2. Each device has two terminals, a status terminal r and an action terminal a. On the leading edge of a pulse 'a' the device is triggered into action. While the zero device is busy, r=0, and when it has fully responded (i.e. it becomes ready), r changes to 1. Activation of the device is not possible when r=0. The interface will be designed to ensure that only one of the two devices is activated at any time. This mode of operation, commonly referred to as the *handshake system*, avoids the need for timing signals.

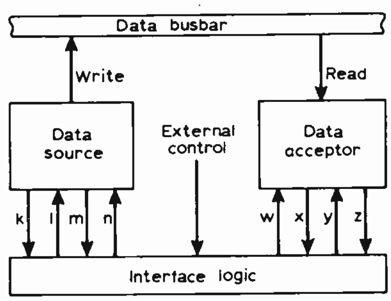


Fig. 1. Conventional interface.

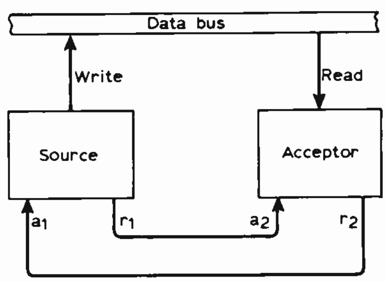


Fig. 2. Two-wire interface.

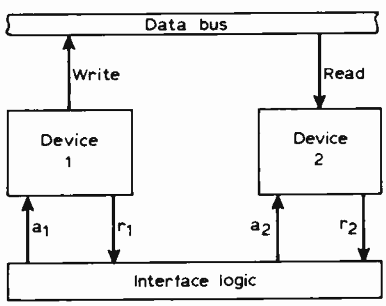


Fig. 3. Interface logic.

A suitable state diagram for the interface and the corresponding time diagrams are shown in Figs. 4(a) and 4(b), where t_1 and t_2 are the response times of devices 1 and 2. External control signals have been omitted for the sake of clarity, but will be introduced later.

The step-by-step operation of the system may be described as follows. Assume that device 1 is active ($r_1=0$) and device 2 is dormant or free ($r_2=1$). This corresponds to state S_1 in Fig. 4(a). When device 1 has fully responded, its status signal r_1 changes to 1, thus initiating the S_1-S_0 transition. On assuming state S_0, action signal a_2 changes from 0 to 1, thus activating device 2, whereupon r_2 changes to 0, causing the circuit to move to state S_2. The change of the action signal a_1 from 1 in state S_0 to 0 in state S_2 has no effect

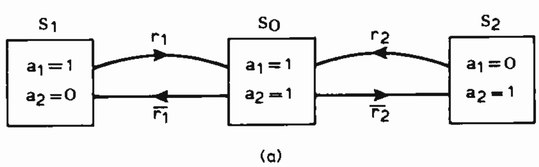
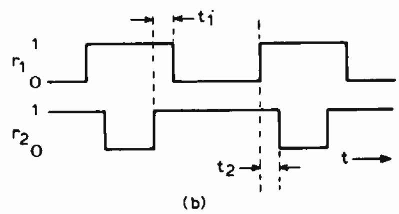


Fig. 4. State diagram (a) and timing diagram (b) for interface.



on device 1, since the devices are triggered on the leading edge of the action pulses, that is, by a 0 to 1 transition. When device 2 has completed its response, status signal r_2 changes to 1, moving the circuit from its current state S_2 to state S_0. On assuming S_0 the second time, device 1 is triggered into action, causing the circuit to move to state S_1. As with signal a_1, the change in signal a_2 from 1 to 0 does not affect device 2. When device 1 has fully responded, r_1 changes to 1 resulting in the S_1—S_0 transition and the cycle repeats itself.

Translating the state diagram into the state table shown in Fig. 5(a) and applying Caldwell's merging rules described earlier in this series[4], it can be seen that its three rows can be merged into the single row shown in Fig. 5(b).

By direct reference to the reduced state table,

$$a_1 = r_1r_2 + r_1r_2 + (r_1r_2) = r_2$$
$$a_2 = r_1r_2 + r_1r_2 + (r_1r_2) = r_1$$

Note that $r_1r_2 = 0$ because the two devices are never active together. Since optional product r_1r_2 has not been used in deriving the final expression of a_1 and a_2, $a_1 = a_2 = 0$ in the first square of the reduced table.

The implementation of the above logic equations, shown in Fig. 2, proves that synchronizing logic is not needed for data transfers between a pair of action/status devices.

Clearly all interfaces must be provided with turn-on arrangements for starting the transfer of data between the two devices, and also turn-off arrangements for terminating the transfer of data. These two modes will be designated as 'go' and 'no-go' and they are indicated by G= 1, G = 0 respectively, where G will be referred to as the go/no-go signal.

In order that information is not lost, it is necessary that data transfer which started with a read operation ends with a write operation and vice-versa. If it is decided that the data transfers will always start with a read operation and end with a write operation, the corresponding interface equations are:

$$a_1 = r_2$$
and
$$a_2 = Gr_1$$

Their implementation is shown in Fig. 6(a). Data transfers are started by setting the go/no-go flip-flop and are terminated by resetting it. One method of implementing this is to apply two successive pulses on the clock terminal of a T flip-flop as shown in Fig. 6(b). If the designer wishes to reverse the read/write cycle, then the above equations are rewritten:

$$a_1 = Gr_2$$
$$a_2 = r_1$$

Front-end logic

Most devices in practice require a sequence of command signals to operate them and do not therefore immediately fit the action/status model. Such devices can be readily modified and turned into action/status devices by the inclusion of some simple circuitry called the front-end logic. This is basically a sequential circuit that generates, on the receipt of a single action pulse, the correct sequence of command signals required to operate the device, as shown schematically in Fig. 7. In addition, the front-end logic generates the status signal r. The design of the front-end logic in this diagram follows the established procedures which have been described in previous articles in this series.

The main difficulty likely to be experienced in designing the front-end logic for a device lies in the interpretation of command and status signals. Such an exercise, however, provides the

r_1r_2	00	01	11	10
S_0		S_1 $a_1=1$ $a_2=0$	S_0 $a_1=1$ $a_2=1$	S_2 $a_1=0$ $a_2=1$
S_1		S_1 $a_1=1$ $a_2=0$	S_0 $a_1=1$ $a_2=1$	
S_2			S_0 $a_1=1$ $a_2=1$	S_2 $a_1=0$ $a_2=1$

(a)

r_1r_2	00	01	11	10
S_{012}	S_{012} $a_1=0$ $a_2=0$	S_{012} $a_1=1$ $a_2=0$	S_{012} $a_1=1$ $a_2=1$	S_{012} $a_1=0$ $a_2=1$

(b)

Fig. 5. State table for interface (a) and reduced table (b).

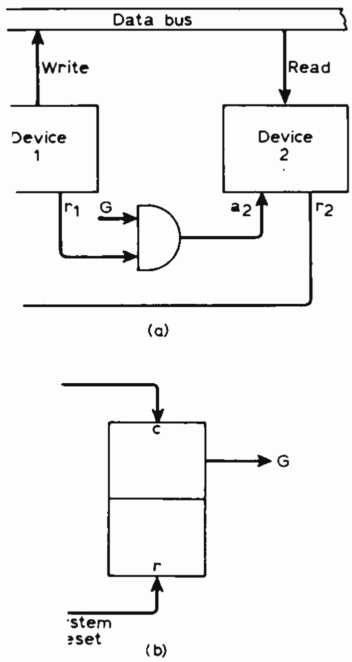


Fig. 6. Two-wire interface (a) and go/no-go generator (b).

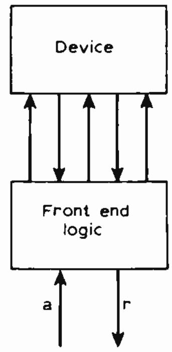


Fig. 7. Arrangement of front-end logic.

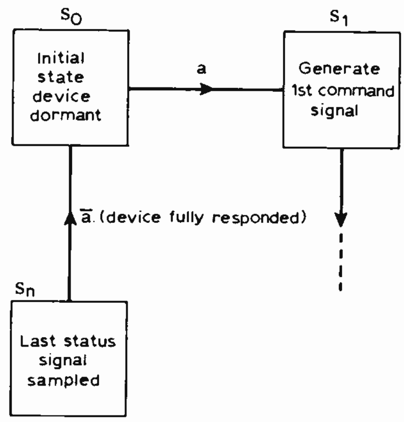


Fig. 8. General state diagram of front-end logic of action/status device.

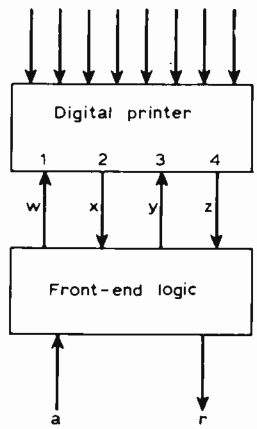


Fig. 9. Block diagram of digital printer.

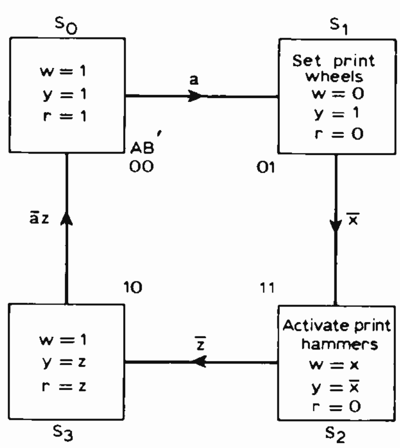
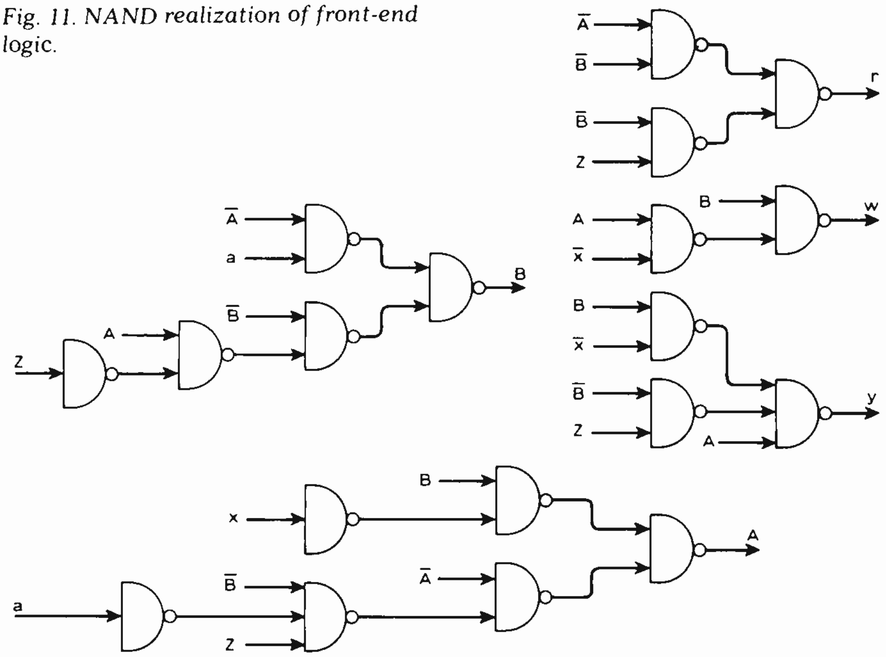


Fig. 10. Internal state diagram for front-end logic of Fig. 9.

Fig. 11. NAND realization of front-end logic.



logic designer with a clear understanding of the operational features and idiosyncracies of the devices to be used.

In order that the input drive requirements of all devices equipped with front-end logic are identical, the action pulse is not used as an input signal to the device, but it is used simply to initiate a transition from S_0, its initial state, to its next state S_1, shown in the state diagram of Fig. 8. In state S_1 the first command signal is generated and the corresponding status signals are monitored. When the device has fully responded to the first command signal, the next command signal in the sequence is generated and the process is continued until the device has fully responded to the complete sequence of command signals.

State S_0 is re-entered with signal $\bar{a}$. This ensures that the front-end logic responds to the leading edge of the action pulse and allows the device to free-run, by connecting its ready or status signal to its action terminal.

The design of a particular front-end logic will now be demonstrated by means of an example.

Example. Design the front-end logic of the digital printer, shown in Fig. 9, whose terminal characteristics are listed below.

Terminal 1: A ground on this terminal ($w = 0$) positions the print wheels according to the input data.

Terminal 2: While the print wheels are being positioned the status signal x on this terminal is at 0 and changes to 1 when the wheels are correctly positioned.

Terminal 3: Grounding ($y = 0$) terminal 3 causes the print hammers to strike and the paper to advance to its next line position.

Terminal 4: While the print hammers are being activated and the paper is advancing $z = 0$, otherwise $z = 1$.

In this example a, x and z are input signals and w, y and r are outputs. A suitable state diagram for the required front-end logic of the printer is shown in Fig. 10.

In S_0, x and z are monitored by the front-end logic. If they are both 1 the printer is ready and the status signal $r = 1$. When the action signal a changes from 0 to 1 the circuit makes a transition from S_0 to S_1 and on entering that state the status signal r is turned off. In state S_1, $w = 0$, and this is a command signal telling the print wheels to move. As soon as they do so, the status signal on x becomes 0 and a transition is made from S_1 to S_2. The wheels carry on moving until the specified position has been reached when x goes to 1 and $y = x = 0$. This is the condition for activating the print hammers and advancing the paper to its next position, and results in the status signal z becoming 0, thus initiating the transition from S_2 to S_3. The circuit remains in this state until printing has been completed, the paper has advanced, and the action signal a has returned to zero, when it returns to the initial state S_0.

From the state diagram

Turn-on set of $A = B\bar{x}$

Turn-on set of $B = \bar{A}a$

Turn-off set of $A = \bar{B}\bar{a}\bar{z}$

Turn-off set of $B = A\bar{z}$

$A = B\bar{x} + A(B + a + \bar{z})$

$B = \bar{A}a + B(\bar{A} + z)$

$w = S_0 + S_2x + S_3 = \bar{B} + A\bar{x}$

$y = S_0 + S_1 + S_3z + S_2x =$

$A\bar{B} + \bar{A}B + A\bar{B}z + AB\bar{x}$

$r = S_0 + S_3z = A\bar{B} + A\bar{B}z = A\bar{B} + \bar{B}z$

The NAND circuit implementation of the front-end logic is shown in Fig. 11.

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1. "Universal Process Interfaces," R. Merritt, *Instrumentation Technology*, August 1976.
2. "Logic Free Data Channels," D. Zissos, F. G. Duncan and T. J. Collins, *Electronics Letters*, Vol. 10, No. 17, August 1974.
3. "Logic Free Data Channels," T. J. Collins, M.Sc.Thesis, Univeristy of Calgary, 1974.
4. Logic design—3. B. Holdsworth and D. Zissos, *Wireless World*, March 1977.

To be continued

Laser projection

This month's front cover shows the words "light fantastic" written by an argon-ion laser beam. A scanning technique has been developed from the simple mirror deflection systems used to produce geometric patterns and symbols in laser light shows. Although the principle is quite simple – X and Y galvanometer movements with mirrors to deflect a light beam rather like the XY plates of an oscilloscope – there are some difficult problems associated with the fast scanning that is necessary for long or complex motifs.

At present the frequency limit of a galvanometer movement loaded with a small mirror is around 20kHz. In a practical system this value falls to around 8kHz because a more rugged mirror has to be used to cope with the heat generated by a large 20 to 30W continuous wave laser. Another difficulty with laser scanning is the continuous beam, which can be considered as a pen that cannot leave the paper. For alphanumerics, the characters can be joined together with a line like longhand writing. For other symbols where this is not desirable, the beam can be speeded up to make the line faint.

Because of the enormous costs of high powered lasers and the ancillary equipment, very few people are developing this technology. John Woolf, an entrepreneur already well known for his activities with "The Who" rock group and, more recently, Holoco, a company dedicated to research and development in holography, has pioneered laser projection in the UK. A new company called Laser Command has been formed to offer a laser projection service such as an advertising scheme planned for Piccadilly Circus in London. For this venue an argon and a krypton laser will project their beams 120 metres onto a 27 × 8 metre screen.

Due to the complexity of the galvanometer drive electronics, a computer based system has been developed to control the laser programme. This package, designed by Integrex Ltd., uses a Z80 microprocessor and a floppy disc store which loads data into a large r.a.m. The XY information is turned into galvanometer drive voltages by d-to-a converters, while other instructions such as enlarge, turn, change motif, also stored on the disc, are used to control the programme.

After the Piccadilly installation has been completed, John Woolf has plans to light up several other sites in the UK and Europe.

If this venture is a success and the initial investment of around £400,000 is recouped, future developments may include the projection of holograms, and animated pictures using laser beams. The possibilities are almost limitless when the financial budgets of advertising agencies are considered together with the amount of street advertising space currently in use.

Time coded transmission

Details of the additional slow code

SINCE publication of the time code clock design, August, September, October 1976 and June, July 1977, a "slow code" has been added to the 60kHz transmission from MSF Rugby. Fig. 1 shows the original fast code which takes 330ms from the minute marker. The new code starts at second number 17 and extends to second 59. A logic 0 is denoted by the carrier break of 100ms, and a logic 1 is donated by a carrier break of 200ms. Parity bits and a BST bit are denoted by carrier breaks of 100ms but displaced by 200ms from the start of the seconds interval as shown in Fig. 2. A minute identifier sequence of 01111110 is always transmitted from second 52 to 59 which enables a positive identification of the minute to be made. The transmitted data is based on the civil time scale currently in use where BST = UTC + 1 hour. As can be seen from the diagram, year, month, day-of-month, day-of-week (Sunday is 0), hour and minute are transmitted and this information corresponds to the next minute marker.

The graph in Fig. 3 shows an estimated field strength trace from Rugby. The power supplied to the antenna is about 120kW but due to losses in the system the e.r.p. is approximately 50kW. Although the useful range is around 1000mls, reports of signal reception have come from as far as Newfoundland.

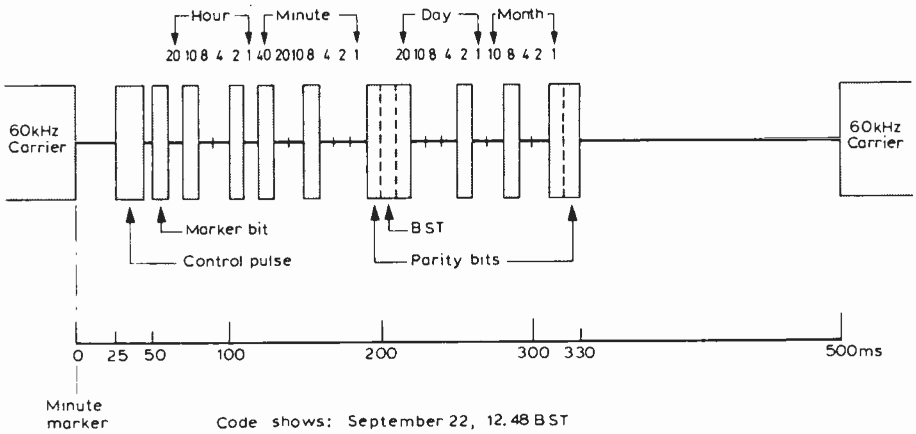


Fig 1

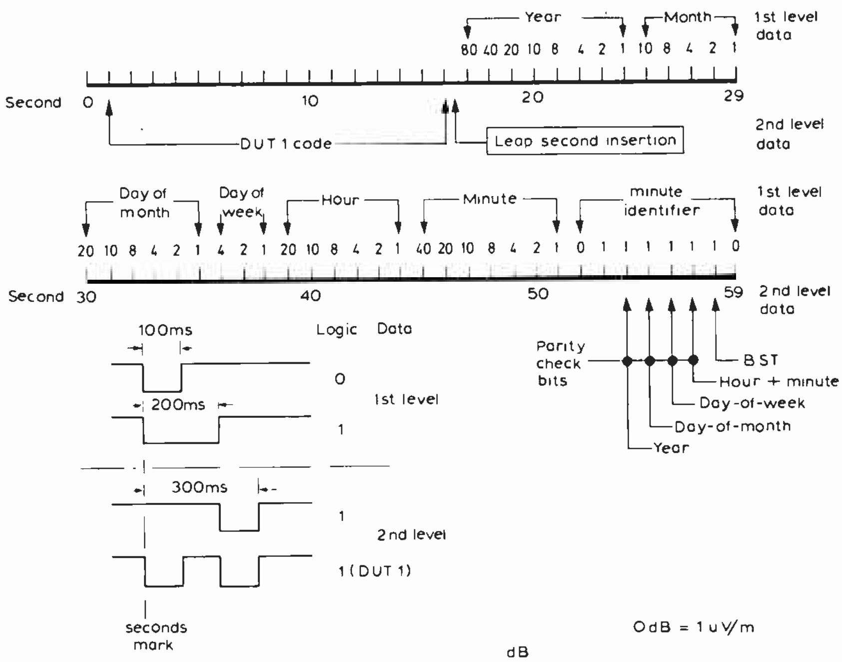


Fig 2

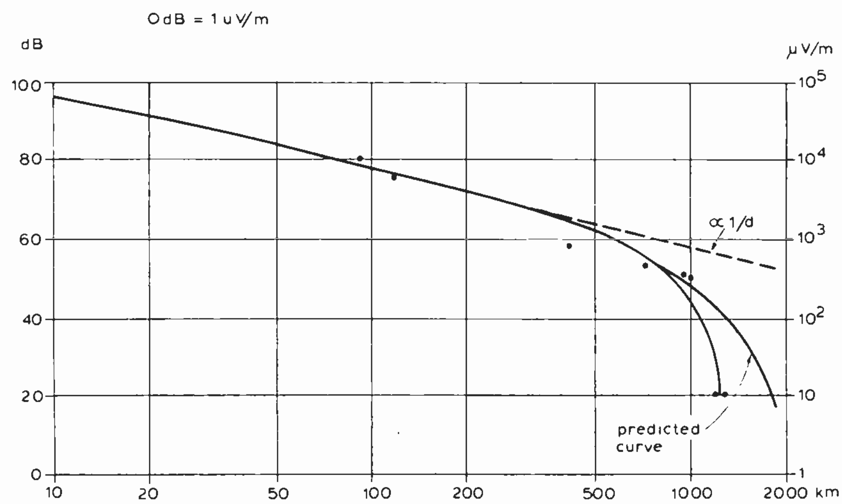


Fig 3

continued from page 47

and III, but is able to reach no conclusions: "At this stage it is too early to say what the future of Bands I and III will be since a decision on the United Kingdom position has still to be taken. However, whatever position the United Kingdom adopts it has to be recognised that many European countries may want to retain broadcasting in these bands and that the international consensus of views at the 1979 WARC will determine the outcome . . . If the v.h.f. television bands were to be given up in the United Kingdom, the availability of the bands for our mobile services would be severely restricted if the broadcasting services of neighbouring countries did not also surrender the bands." There is likely to be pressure to increase the broadcasting Band II up to 104MHz, but not up to 108MHz.

108-470MHz
No action. "Criticisms have been made that there is wasteful use of the band 108-136MHz occupied by the aeronautical services, and of the band 225-400MHz which is reserved mainly for defence purposes. These criticisms do not appear well-founded." Aeronautical channels were already being reduced to 25kHz and could not be reduced further. "Regarding the defence band, a thorough examination is being made but with the continued national importance of the requirement, together with the interrelationship with European countries, there would appear to be little prospect of satisfying any of the land mobile requirements identified [above] at this part of the spectrum."

470-960MHz
No change. Any proposals would be concerned with the long term, in frequencies above 854MHz.

960-2700MHz
The amateurs should be allowed extra space for their amateur satellite sub-band, and keep their existing allocations. Maritime mobile satellite and radionavigation satellite allocations ought to be increased but "overwhelming pressure from other services" prevents an increase for aeronautical mobile satellite services. Frequencies for the development of coded response secondary maritime radar should be found slightly lower in the spectrum. Tropospheric scatter systems should be kept clear of satellite broadcasting frequencies, but the 1.9-2.3GHz band should cater for foreseen tropo requirements to the end of the century. Few changes will be required for electronic newsgathering links.

The paper notes that no contributions were received on space research in this part of the spectrum. Provision would be made for this, as well as for "passive space research and earth exploration satellites in radio astronomy bands, taking advantage of their sharing compatibility, and to increase and strengthen the radio astronomy provisions". It also says "considerable attention is being given" to satellites beaming solar power to earth by microwave.

2700-10500MHz
Two sub-bands at 4 and 6GHz for fixed satellite feeder links to maritime mobile satellites, and an amateur satellite allocation, but within the existing amateur band at 10GHz. Amateurs may lose some frequencies in this section. The Home Office seeks to limit deep space research in this section to allow "other research activities nearer the earth" which are not specified. In general, there is no proposal to increase the allocation for radar, or give ISM any extra frequencies.

10.5-15.4GHz
Fixed satellite allocations should be increased, particularly for Intelsat. 1GHz in each direction of transmission should be available within the section. Broadcasting satellite feeder links are being considered near 11GHz. Other changes include allocations for passive earth exploration satellites and space research services in radio astronomy bands.

15.4-38GHz
Improved allocations for the fixed satellite services to provide feeder links for broadcast satellites, and extra intersatellite allocations to meet growing Intelsat requirements. Passive space research and earth exploration satellite allocations will be provided in some radio astronomy bands. The replanning of the band for likely future developments should take account of the need for transportable television links and outside broadcasts.

38-275GHz
Intersatellite services should share with such terrestrial applications as intra-urban links. High atmospheric attenuation should allow for considerable frequency re-use. Allocations include fixed and mobile satellite services, one band for the broadcasting satellite service, terrestrial communications, and amateur and amateur satellite services. Allocations are proposed up to 135GHz, but above that there would be quiet bands, and there would be no allocations above 275GHz.

The Home Office paper says that the geographical dimension of the table, wherein the world is split into three regions, and its frequency dimension is a construction which "has stood the test of time and should continue". As we noted in April (p.51) the developing countries are likely to attack this assumption.

The introduction to the paper seems keen to defuse any controversy over the proposals for land mobile radio. It says that operational provisions for the various mobile radio services will be revised by further conferences to be held late in 1981 or early 1982. The frequency table does not distinguish among various classes of radio user, such as civil or military, or among the different elements within the same service, such as between controlling equipment in base stations and that in the mobiles, or between paging and message handling. The task of selecting and assigning such classes and uses belongs to each national administration. In a footnote, the paper says, "A number of the contributors who commented on the land mobile service made detailed technical comments concerning recommended channel spacing, methods of working, etc. These matters are for national consideration after the conference."

It is a matter of great rejoicing that the Home Office have published anything at all. While they are to be congratulated there are still some reasons for concern. The first, simple point is that we are no nearer learning what the Home Office has in mind for the UK. That, at least, should be public knowledge with or without WARC 1979. The second point is that the sources of information remain almost entirely anonymous. It seems quite unsatisfactory to accept the views of those who are not prepared to say who they are or why they express those views.

Worse, though, is the Home Office's eagerness to be on the winning side. We do not expect our representatives to put forward proposals that have no hope of success, but neither do we elect Home Office ministers to act as honest brokers at international meetings. That is the job of the Foreign and Commonwealth Office. The Home Office should be pressing as hard as it can for proposals on which the British people have previously agreed. Instead the document constantly refers to gaining the support of other countries, particularly those in Europe, for the Home Office's proposals before the WARC has even met. It is after this consultation process that the Home Office intends to publish its submission, passing it off as that of the United Kingdom.

The most glaring example of this absurdity is the absence of any proposal at all for the re-engineering of Bands I and III. In this case the Home Office is unwilling to follow the logical course and insist that those bands be cleared for more efficient use, preferring instead to wait and see what the Europeans decide. We can be absolutely certain that those countries will not choose the same approach; if they did no decision would be reached at all.

Yet the Home Office's apparent concern for European unity collapses when the small ISM interests ask for an extra provision at 433MHz to bring them into line with some European countries; their case, say the HO with peerless pomposity, "has not so far been sufficiently substantiated". Inside Waterloo Bridge House, it would seem, the only sound to be heard is the faint rustle of ties being straightened for the 1980 New Year Honours ceremony at Buckingham Palace.

* *Preparation for the World Administrative Radio Conference 1979, published by the Home Office Radio Regulatory Department. The publication is the result of a decision by the Home Secretary, announced in the Commons on May 10.*

News in brief

The technical sessions at the seventh **International Broadcasting Convention** at Wembley from September 25 to 28 will cover the following topics. microprocessors and minicomputers in broadcasting; point to point transmission; video signal origination and processing; transmitters and transposers; video and audio recording and storage; transmitting antennae; satellites in broadcasting; teletext broadcasting systems; stereo and quadraphonic sound systems; teletext sub-titling systems; new broadcasting systems; future possibilities in radio receiver design. All papers will be available to delegates on registration.

Breadboard '78, an exhibition of "kits and bits for the home electronics enthusiast", will be held at Seymour Hall, London W1 from November 21-25. Two thirds of the available space had been sold by the beginning of May.

Ritro Electronics and Surrey Electromaterials are holding two seminars on anti-static materials, at Maidenhead on July 3 and Bristol on July 5. Details from Ritro at Maidenhead.

The IEE have published papers from conferences on maritime aeronautical satellite communication and navigation, and communications equipment and systems, conference publications 160 and 162 respectively.

The Telemobiloscope

An Edwardian radar

by **V. J. Phillips** Ph.D., B.Sc(Eng)

University College, Swansea

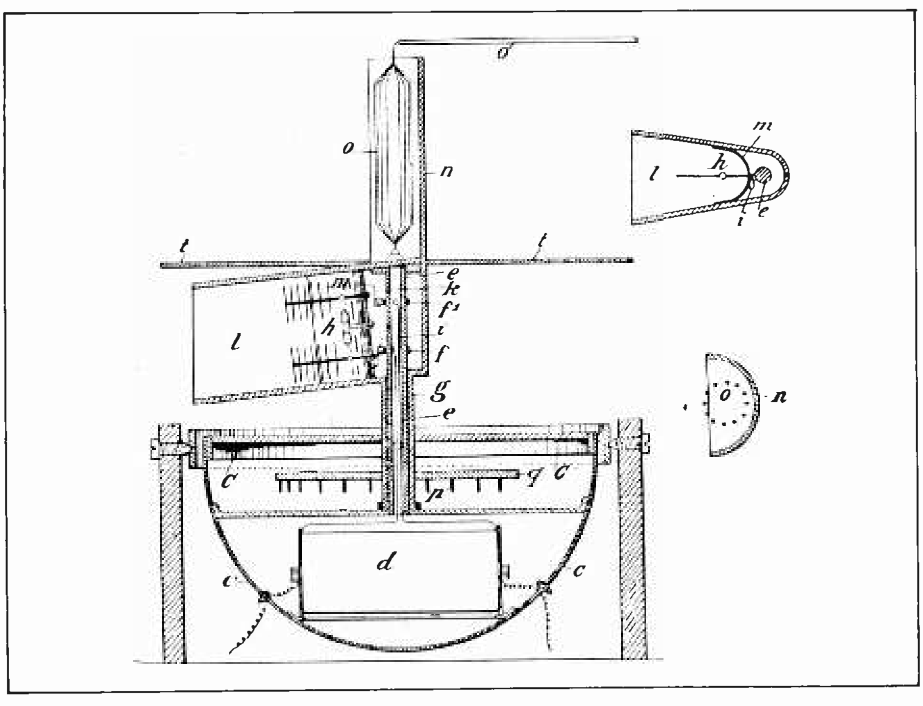
If one were to ask the proverbial man-in-the-street when radar was invented, and by whom, he would probably reply that it came into being sometime around the date of the second world war, and was the work of Watson-Watt and his colleagues. In the sense of producing a reliable operational device this answer would indeed be correct, but the average person is usually most surprised to learn that the first working demonstration of radar seems to have been given in 1904 by one Christian Hülsmeyer of Düsseldorf. His device was not known by that name of course but was called the Telemobiloscope. This article outlines the invention and relates it to other early devices.

MANY of the text-books on radar refer to the fact that Heinrich Hertz had demonstrated during the course of his classic experiments (1886-8) that metallic objects reflect radio waves. Some mention that related techniques were being used during the 1920s to measure the height of the ionosphere by reflection of radio waves, either by phase-shift measurements on the received signal or by pulse techniques. Naturally these experiments had nothing to do with navigation or the avoidance of collisions at sea.

The chance observation in 1922 of Taylor and Young, who noticed that the movement of ships on the Potomac river caused phase-shifts in radio signals received nearby, usually gets a mention, as do the words of Marconi who, during the course of a lecture to the Institute of Radio Engineers, in New York in June 1922 said:

> "It seems to me that it should be possible to design apparatus by means of which a ship could radiate or project a divergent beam of rays in any desired direction which rays, if coming across a metallic object such as another steamer or ship would be reflected back to a receiver screened from the local transmitter on the sending ship and thereby reveal the presence of the other ship in fog or thick weather. One further advantage of such an arrangement would be that it would be able to give warning of the presence and bearing of ships even should these ships be unprovided with any kind of radio."

Fig. 1. *Hülsmeyer's first patent. Parts identified by letters are described in the text.*



The general impression usually given is that the germ of the idea appeared in the 1920s but that nothing much was done about it until the following decade. Very few books mention the earlier work of Hülsmeyer*.

The matter was brought to my notice by a short note in the *Electrical Magazine* of 1904[1] which is a report of

> "apparatus brought out by Mr Hülsmeyer of Düsseldorf and demonstrated to the North German Lloyd. The new invention is based on the principles of wireless telegraphy and is intended for viewing ships and metallic objects at sea. In wireless telegraphy the transmitter and receiver are used separately on different ships, but are both on the same ship with the telemobiloscope. The electric waves, not being able to reach directly the receiver, must be reflected by metallic objects on the sea (that is ships) so as to arrive at the receiver on a broken path. The advantage afforded by this invention is mainly that ships fitted with the transmitter and receiver will be able to view any other ship devoid of these apparatus. It will even be possible to inform the captain on the bridge in the case of distances ranging from 3 to 5 km of the position of an approaching ship to enable him, when luminous and fog signals fail, to alter his vessel on the right course so as to avoid accidents in time. Experiments made so far on small instruments designed for shorter distances have given every satisfaction."

Hülsmeyer was granted British Patent No. 13,170 on his apparatus in 1904, and in the same year he was granted a further patent, No. 25,608, embodying certain improvements on the original device. The drawing of his first patent is reproduced here in Fig. 1. An induction coil *d* contained in the hemispherical bowl C generates a high voltage which is fed up inside the hollow shaft *e* to two slip rings *f* and *f'*. Two brushes *k* and *i* bearing upon these rings convey the voltage to a Hertzian spark transmitter. This appears to be of the type which is often known as a Righi spark gap, consisting of four balls, the inner two being enclosed in oil which has the effect of quenching the spark after a short time. Two rods, with

* The Encyclopaedia Britannica and the book "Radar System Engineering" by L. N. Ridenour (McGraw Hill 1947) are two exceptions.

cross-pieces, are fixed to the outer balls. The capacitor formed by the gap and rods is charged by the coil and when the voltage is sufficiently large a spark occurs which effectively causes it to be discharged through the inductance associated with the rods. The result is a damped oscillatory flow of charge, the associated electric and magnetic fields causing the emission of a pulse of r.f. By means of a reflector *m* and a shaped tube or funnel *l* these radiations are emitted in one direction only. The reflector and funnel are also shown in plan view in the small drawing at the top of Fig. 1. In the words of one of Hülsmeyer's patents it forms

> "a projector which throws the electric waves in the form of a cylindrical bundle."

The funnel *l* is mounted on the outer tube g which enables it to be turned to point in any desired direction. Above this spark transmitter, and screened from it by the metal plate *t*, is the receiving aerial o. A semi-circular screen *n* rotates with the transmitting funnel so that the aerial is affected only by signals arriving from the appropriate direction. It also screens it from unwanted interfering signals from other directions.

The whole arrangement is mounted in gimbals to combat the motion of the ship. The receiving aerial is connected by wire o′ to a coherer-type receiver. For those readers who may not be familiar with the coherer it is illustrated in Fig. 2. It was found in many different forms but essentially it consisted of a mass of metal filings lying between two metal plugs, the whole being contained in a glass tube. Normally the mass of filings exhibits a very high electrical resistance but when a voltage such as that induced in the aerial is applied across the plugs the resistance drops very markedly. This change in resistance can be sensed by connecting a battery, in series with a galvanometer or telephone receiver, across the device. The coherer remains in this low-resistance condition until it is mechanically disturbed and so it was customary to provide an automatic tapper to shake it back to the high resistance condition and prepare it for the reception of another pulse of voltage from the aerial.

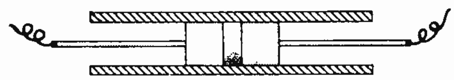


Fig. 2. *Basis of the coherer, which was used as a detector in the radar.*

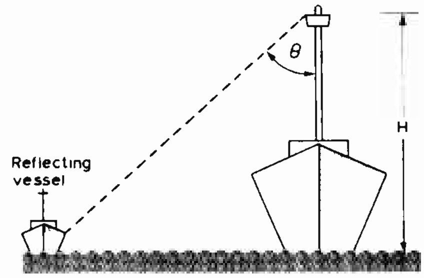
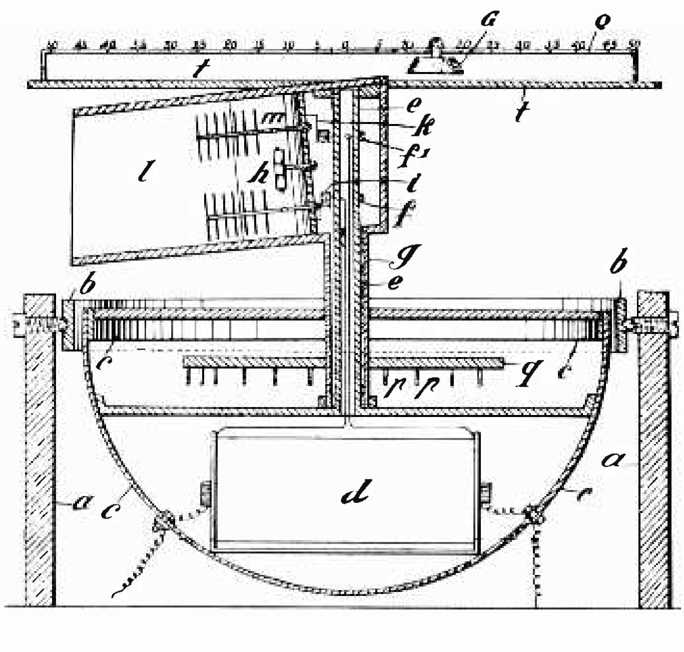


Fig. 3. *Trigonometrical principle of estimating the distance of a reflecting vessel. H is the height of the radar aerial.*

It was suggested in Hülsmeyer's specification that in operation the whole apparatus would be rotated slowly in a stepwise manner by a clockwork or electric motor acting on cogwheel *q*. When a signal was received this gave an indication of the direction of the reflecting vessel. As a further convenience it was suggested that the officer who would be sitting in his cabin listening to the signals might be provided with a remote indication of the direction in which the transmitter was pointing at any time.

Fig. 4. *Hülsmeyer's first modification, to allow the transmission to be beamed at any vertical angle.*



The apparatus described so far is only able to indicate the direction from which the signal is coming. In his second patent Hülsmeyer suggested making use of the fact that if the height *H* of the aerial is known together with the vertical angle θ (see Fig. 3) from which the reflections are arriving, then it is a matter of simple trigonometry to determine the distance of the reflecting vessel. Two devices are described in this patent, the first (shown in Fig. 4) being a simple modification of the previous apparatus. A horizontal rod Q is mounted on the screening plate *t*. A weight G can be moved along this rod, causing the whole transmitter to tilt in the gimbals. The transmission can then be beamed at any vertical angle θ and, if desired, the rod can be calibrated directly in terms of distance. It is not really clear from the patent whether the receiving aerial is also on tilt, or whether it is mounted separately. The weight is moved until the received signal is greatest and then the distance may be read off the rod directly.

The second modification is rather more complicated, and is shown in Fig. 5. Two lenses, *R* and *S*, are mounted in the transmitter tube. (There is nothing in the patent on how these lenses are constructed or on what material they are made of.) The tops of the lenses are connected to the threaded pieces *U* and *V* which project through a slot and engage with the threaded rod *V*. The bottoms of the lenses are connected by the bar *X*. Rod *Z* sliding in guide *Y* is connected to the centre of *X*. As the screw thread turns the lenses will be tilted but will still remain parallel to each other. The radiations, it is stated, will then be emitted at a vertical angle which may be varied. When the lenses are not required they may be parked in the position shown in dotted lines, presumably by pushing in the rod *Z*.

The limitations imposed upon this invention by the technology of the day are very apparent here. Quite apart from the vagueness about the construction and action of the lenses in Fig. 5, how was one to determine the vertical angle of the maximum signal? The coherer was really only capable of giving a simple yes/no indication. Under carefully controlled laboratory conditions it was sometimes possible to obtain a quantitative measure of the strength of the signal from the resistance in the cohered state, but such an indication was far too unreliable to be of any use operationally in an environment such as that aboard ship. Many writers on the subject of coherers, the present author included[2], testify to the extreme sensitivity of the device to the slightest mechanical vibration. Some workers with them[3] were reduced to making their measurements at dead of night to avoid disturbance from people walking about the building. What hope was there aboard ship with the engines thumping away and the whole vessel bouncing up and down on the waves?

Again, how was one to ensure that the height H in Fig. 3 remained constant, since the ship would be moving vertically up and down on the swell in addition to the other motions which the gimbals attempted to counteract. Perhaps one ought not to be too pessimistic here when one remembers that in a thick fog the sea is often calm.

Anyhow, whether from indifference on the part of the maritime community or simply from the limitations of the technology, the idea never caught on and, if you will pardon the phrase in the circumstances, seemed simply to sink from sight. Let us acknowledge, however, that if the report in *The Electrical Magazine* is to be believed the device seems to have worked to some extent. It must, therefore, be counted as the first attempt to use the phenomenon of reflection in a practical way for purposes of navigation. One is tempted to say that it must also be considered as the first *pulsed* radar since the emission was in the form of short damped pulses of r.f. Perhaps this is overstating the case, though, as no attempt was made to time the arrival of reflections as in the subsequent development of radar proper. I wonder whether it is just possible that, seventy-odd years later, there might be someone who has some first-hand knowledge of these trials or might perhaps remember a colleague reminiscing about them?

As a footnote to this story it is perhaps of interest to mention that a patent was granted to John Logie Baird (none other) in 1928[4] for a method of "seeing in darkness by utilising radiation outside the visible spectrum". His proposal is illustrated in Fig. 6. Object 6 is "illuminated" by radiation from the spark transmitter 2. The scene is then viewed by one of his normal television scanning discs 8, a radio aerial 10 being substituted for the photo-cell used when illumination was by visible light. A detector 12 is followed by various amplifiers which vary the brightness of lamp 20. The disc 22 then reconstructs the image as in his television receiver.

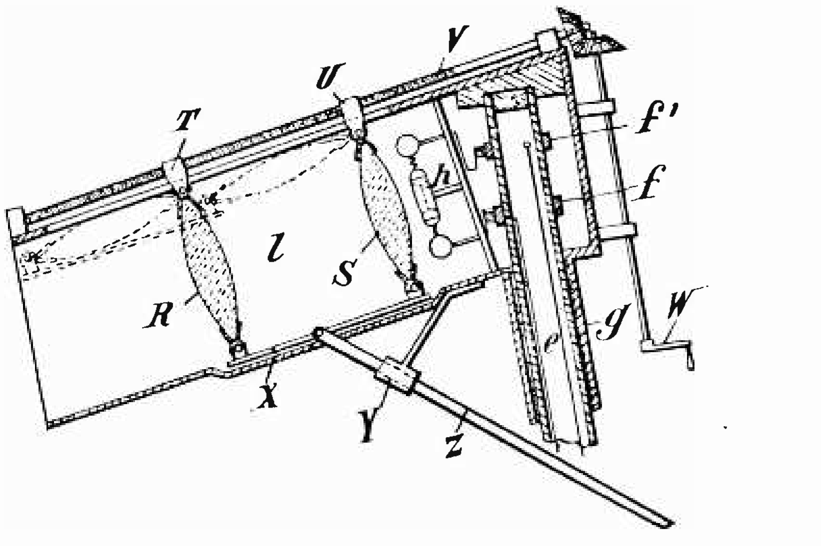


Fig. 5. *Second modification, for tilting lenses to vary the vertical angle of the transmission.*

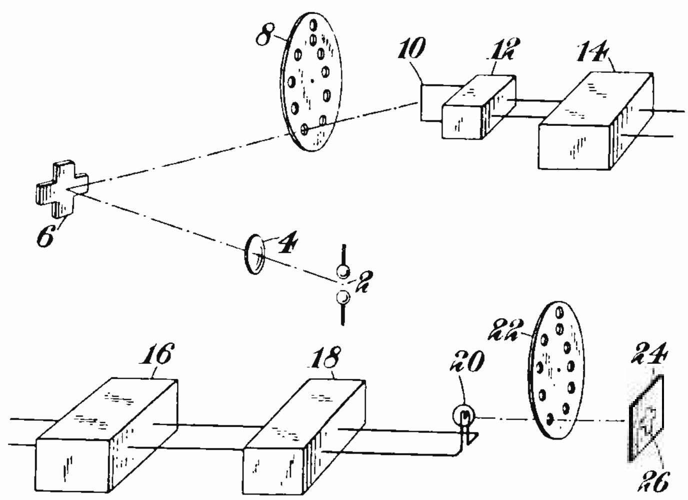


Fig. 6. *Baird's patented proposal for "seeing in darkness."*

Two further points are of interest here. The first is that Baird was also granted an almost identical patent[5] which proposed using infra-red radiation for illuminating the object. The second point is that the transmitter shown is a simple Hertzian spark gap, although by that time generators of continuous r.f. were readily available. It is difficult to see how a simple spark transmitter which essentially produced pulses of r.f. would be compatible with a continuously rotating scanning device.

In view of all the controversy which has recently surrounded the work of Baird one is very reluctant to stick one's neck out too far, but let me just say that I know of no practical demonstration of this apparatus having been given, and from the details in the patent I would be most surprised if it ever worked. □

Acknowledgement

The patent drawings are reproduced by permission of the Controller of Her Majesty's Stationery Office.

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2. Phillips, V. J., "Some filings-coherer experiments," I.E.E. Weekend meeting on the History of Electrical Engineering, Manchester, July 1975.

3. Taylor, A. H., "The coherer – a review," *Physical Review* (New York) vol.16 No. 4, April 1903, p.199.

4. British Patent No. 292,185.

5. British Patent No. 288,882.

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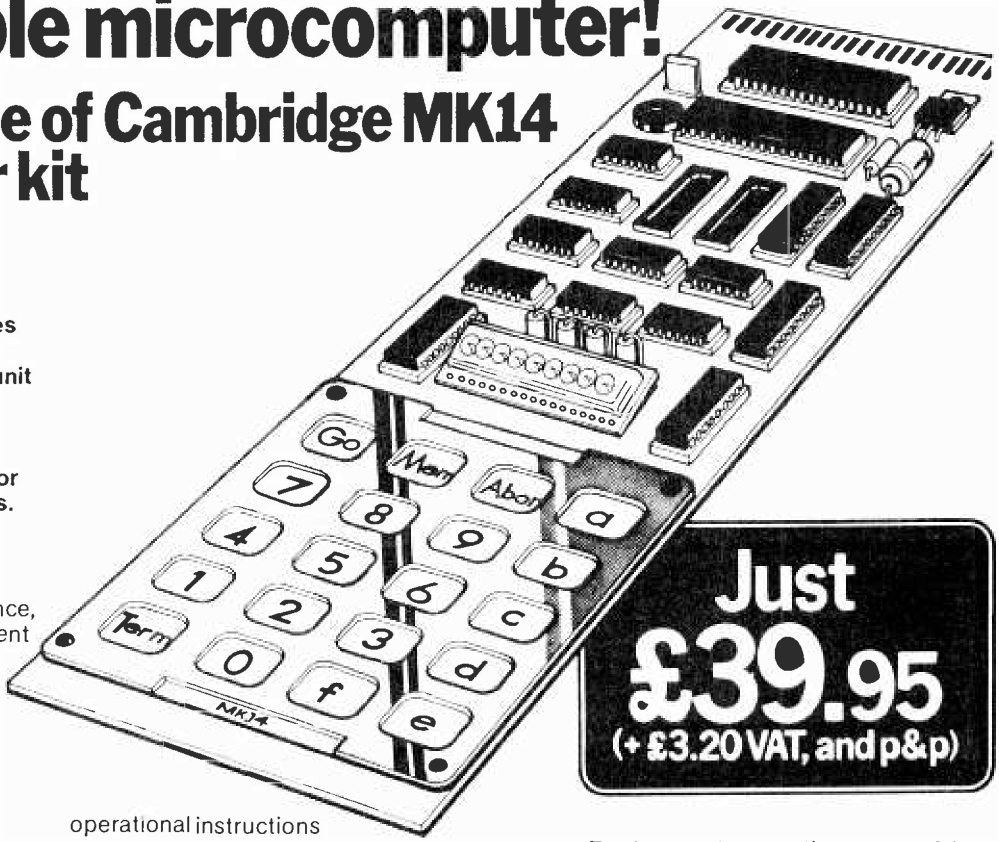

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CIRCUIT IDEAS

High quality stereo decoder

THE HA 1196 is a relatively unknown stereo decoder IC which can offer a performance beyond the capabilities of the transmitted signal.

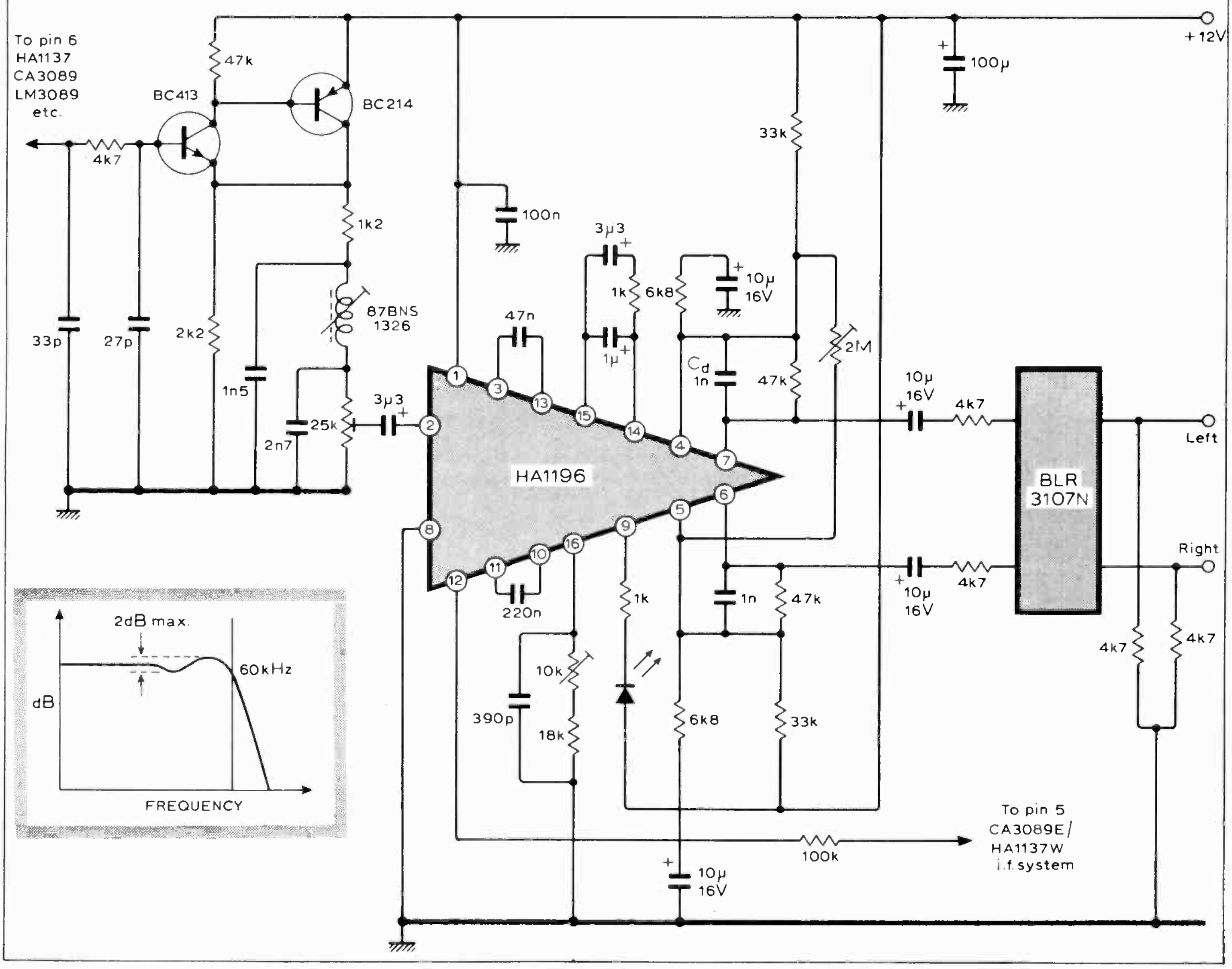
In this application a 60kHz low-pass filter is formed around a coil/capacitor pi-network so that virtually no phase error is created. The filter characteristic may be trimmed for optimum performance with the core of the coil.

The input to the "birdy" filter, whose characteristic is shown in the graph, is driven directly from a CA3089E type of output. Input level to the HA1196 is set with the 25kΩ preset to about 200mV which is optimum for an average deviation level of 40kHz. A stereo/mono switch on the chip at pin 12 is designed to operate from the muting output of a CA3089E/HA1137W. When the device is fully unmuted with a carrier present, the muting output goes low, and thus switches the HA1196 to stereo automatically.

For alignment, insert a known stereo transmission, set the input level to 200mV, and adjust the v.c.o. potentiometer until the l.e.d. lights. The stereo separation control, which in fact compensates for phase errors introduced by i.fs, should initially be set at maximum, and slowly reduced until optimum separation is achieved. In the absence of a stereo generator, Radio 3 provides suitable test tones after the evening broadcasts.

The de-emphasis shown is for 50μs. For 75μs, capacitor Cd should be 1500pF. The best method of adjusting the low-pass filter is to tune for best separation or best stereo channel balance while listening to a test tone. A correctly adjusted decoder offers a separation approaching 60dB, a t.h.d. figure of 0.15% at 10kHz, and a signal-to-noise ratio of 80dB.

W. S. Poel,
Ambit International,
Brentwood, Essex.



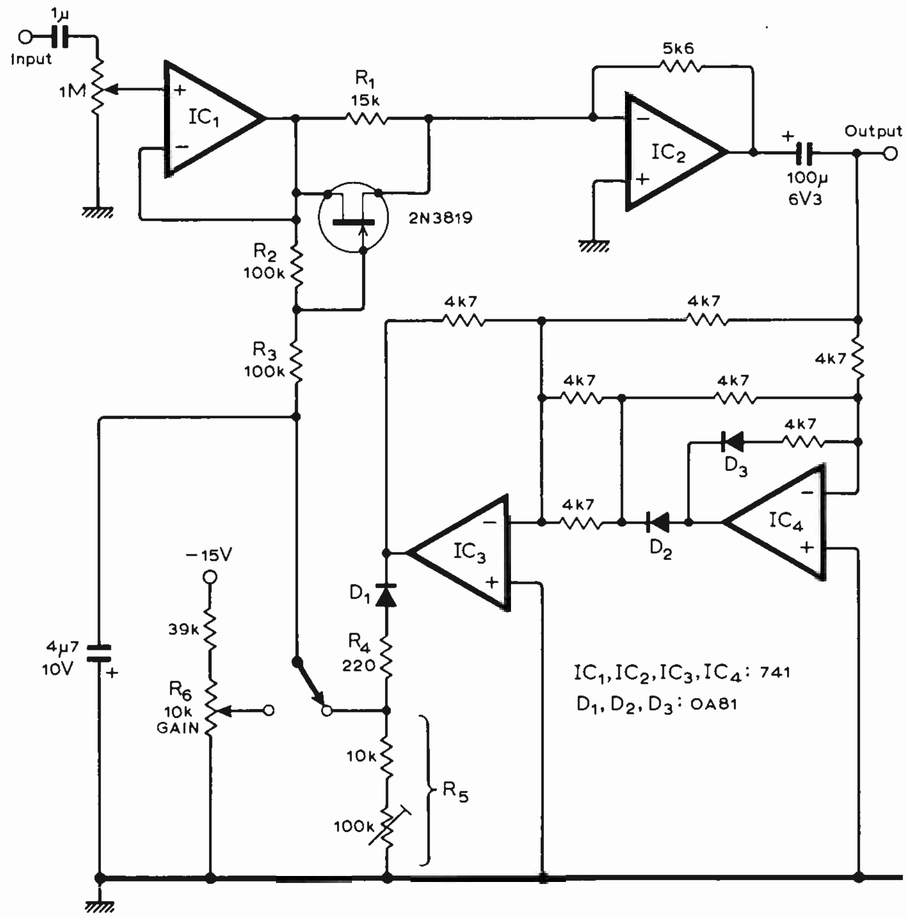
Audio compressor

GAIN of the single stage virtual earth amplifier IC_1 is determined by the drain-source resistance of the f.e.t. Resistors R_1, R_2 and R_3 linearise the f.e.ts V-I characteristic. A control voltage is derived from the output signal by using a precision rectifier and peak detector. Attack and decay times are adjustable by resistors R_4 and R_5, and with the values shown give time constants of 1 and 517ms respectively.

The two way switch allows the compressor to act as a conventional amplifier by applying a fixed control voltage which may be varied with a potentiometer for a gain control.

In the compress mode, a 29dB change in the input signal level produces a 9dB change in the output.

L. Mayes,
Ipswich,
Suffolk.



Low voltage d.c.-to-d.c. converter

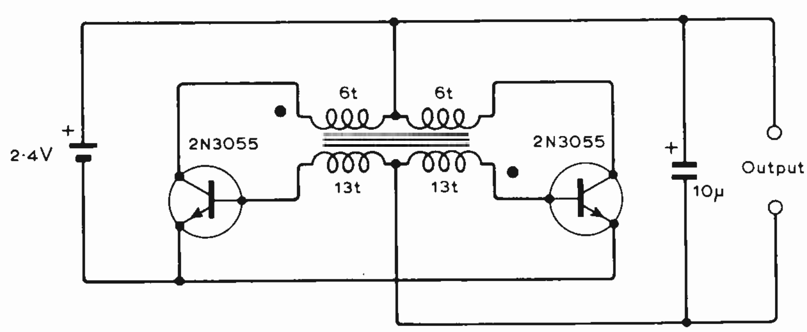
A CONVERTER operating from 2 or 3V is not easily made efficient because the voltage drop across the switching device in the on state can be a large fraction of the supply voltage. With a bipolar transistor as the switching device, V_{CEsat} can be made tolerable by providing a large base current, but this normally leads to extra loss in the base drive circuit. It is possible, however, to place the load in series with the transistor base-emitter junction so that the load acts as a high current base drive circuit and the transistor acts as a rectifier for load current. Both functions are performed without any extra power dissipation. The circuit shows this principle applied to an otherwise conventional self-oscillating converter, with the saving of two diodes. The usual separate base driver winding on the transformer is eliminated, which leaves space for thicker primary and secondary windings. Also, the base current is large and varies with loading. These two factors provide good regulation and high efficiency over a wide range of load currents.

An added advantage of this circuit is that the oscillation ceases if the load is open circuit, which reduces battery drain to a few microamps. The converter can therefore be controlled by a switch in series with the output. The prototype circuit, supplied from 2 nickel-cadmium cells, delivered 1A at 6V with an efficiency of 75 to 80%. The oscillation frequency was about 10kHz.

It is possible to modify the circuit by changing the transformer windings. If an audible whistle is undesirable, the frequency can be increased by reducing the number of primary turns. This will, however, reduce efficiency because commutation will take a larger fraction of the time, and the peak I_c will be higher. The output voltage can be raised by increasing the number of secondary turns. Above about 10V, diodes must be used to protect the base-emitter junctions against reverse breakdown.

A wide range of transistors can be used but they should be selected for low V_{CEsat} at the design current, and the BV_{EBO} must be adequate for the design output voltage.

F. Ainscow,
Winchester,
Hants.



Transformer core: FX2239

Sound-to-light unit

THIS circuit uses zero-voltage switching to achieve interference-free proportional control of a lamp intensity from a sound source. Both inputs to the AND gate IC_{15} must be high for the triac to turn on. One of these inputs comes from the zero-crossing detector IC_1, Tr_1 and IC_2 which produces a 100Hz series of positive-going pulses. Transistor Tr_1 and the 7413 invert the waveform twice to make it t.t.l. compatible. The other input to the AND gate comes from the filter/rectifier/comparator circuit. The negative-going output of IC_{13} provides a signal for the non-inverting input of the comparator IC_{14}.

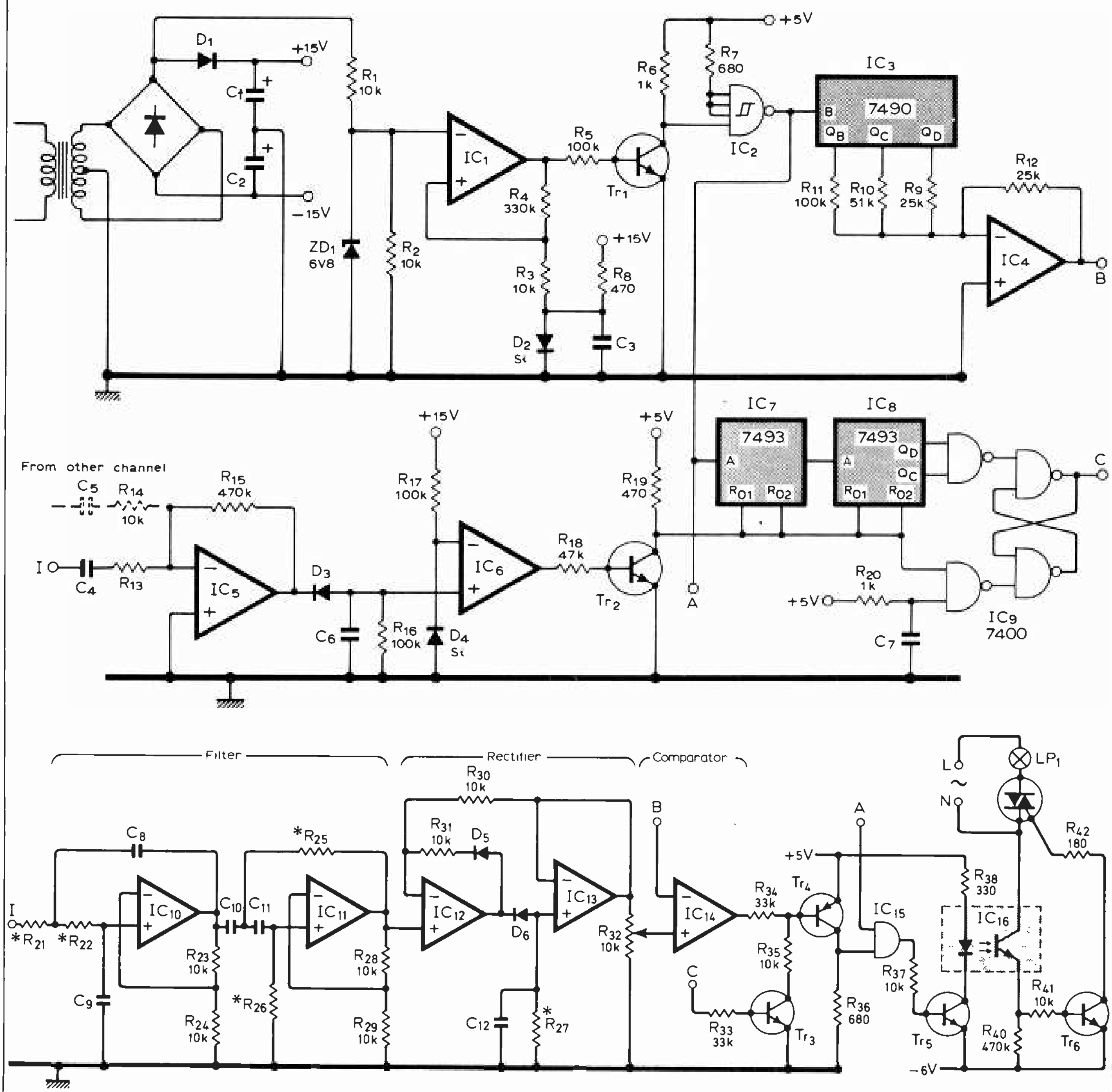
The inverting input of IC_{14} is fed from a d-to-a converter IC_4, which produces a stepped ramp waveform from the outputs of the counter. The B input of IC_3 is used so that it counts to five before internally resetting. Therefore, the lamp has five possible brightness levels.

Op-amps IC_5 and IC_6 detect when the audio input falls below about 10mV. When this happens IC_7, IC_8 and IC_9 are released from their reset state and the two 4-bit counters start to count the 100Hz waveform. They are again reset when the audio input next passes the 10mV level. If the input remains below this level for more than 2s, output C of IC_9 is set, Tr_3 is saturated and the triac is turned on until the audio signal exceeds 10mV again. Therefore, the lamp will automatically turn on after the music has stopped. The resistor values listed below are for filters in a three channel system, but more channels can be used if required. The audio input at point I should preferably have a peak value of around 6 to 10V.

All i.c.s are 741s or equivalent except where stated otherwise. All diodes are 1N4148 types except for D_1 which must be a higher current type. Capacitors C_1 and C_2 are electrolytic types and all others are 100nF polyester. The transistors can be any general purpose n-p-n or p-n-p devices as necessary.

	bass	middle	treble
R_{21}, R_{22}	12k	3k3	820
R_{25}, R_{26}	56k	12k	3k3
R_{27}	1M	220k	56k

Andrew R. Ward,
Bath, Somerset.



Audio power amplifier design — 4

More on feedback stability

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

The May article ended by discussing Bode's ideal loop-gain attenuation characteristic, which maintains full loop gain up to a certain frequency and then attenuates the gain as rapdily as possible consistently with not exceeding an excess phase shift of 150°. This ideal characteristic cannot normally be realized in practice, and the present article deals with some more realistic techniques.

THE 33dB/decade (10dB/octave) attenuation rate of Bode's ideal characteristic, which must be produced by minimum-phase-shift networks, is assumed to continue to indefinitely high frequencies. In practical multistage amplifiers this cannot be achieved, for the attenuation rate at very high frequencies is determined by unavoidable shunt capacitances and by transistor characteristics. Thus in the absence of circuit elements added for controlling the loop-gain attenuation, it will typically be as shown by curve 1 in Fig. 1. With suitable elements added within the forward path of the amplifier circuit, a close approximation to the Bode Ideal characteristic may be obtained up to a certain high frequency, but above this frequency, as shown by the full-line curve 2, the response inevitably follows curve 1. However, provided the 33dB/decade slope is continued for a sufficient number of dB, marked *x*, below unit loop gain, the resultant phase margin will not be very significantly reduced below 30°. Bode showed that in these practical cirumstances, the desired 30° margin can be retained, together with the advantage of starting the loop-gain attattenuation at a somewhat higher frequency, by adopting the characteristic shown in curve 3. The flat portion between P and Q delays the onset of further phase lag until the loop again is well below unity. This and related topics are discussed in much greater detail in Bode's book[1]. It should be noted that the definitions of phase and gain margins used by Bode are different from those illustrated in Fig. 7 of my May 1978 article. Bode takes the phase margin as applying at a loop gain which is below unity by the quoted gain-margin figure, usually 9dB. The definition I have given is also in widespread use[2,3,4] and seems more convenient for practical purposes.

It is very rare in the practical design of feedback amplifiers, either for audio or for other purposes, for any great effort to be made to follow accurately the Bode or other similar precepts for achieving full feedback up to the maximum possible frequency. Designs of this type tend to be complex and expensive, containing LCR networks to give the rapid drop in loop gain below the point A in Fig. 1, and the flat between points P and Q, together with staggered transitional-lag networks to give a close approximation to the 33dB/decade slope. Such designs have sometimes been used in critical Post Office repeater amplifier circuits.

The simplest stabilization technique is always to put in one dominant lag to attenuate the loop gain at 20dB/decade (6dB/octave), starting from a corner

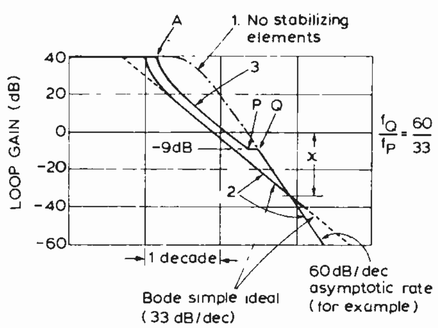


Fig. 1. *Bode simple and modified loop-gain-attenuation characteristics. See text.*

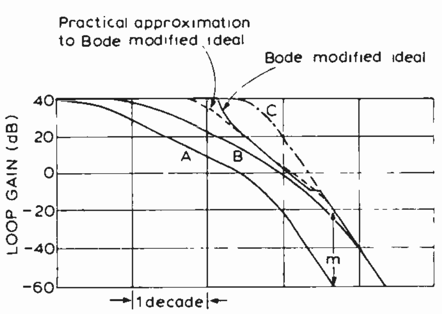


Fig. 2. *Dominant lag loop-gain-attenuation characteristics compared with Bode modified ideal. See text.*

frequency which is sufficiently low to ensure that the loop gain is reduced to unity before the other lags inevitably present at high frequencies have produced too much further phase lag. In a multistage amplifier, the dominant lag is most straightforwardly introduced simply by putting a sufficiently large capacitor across the first stage collector load. This will produce a loop gain characteristic such as that represented by curve A in Fig. 2. The technique is in all respects sub-optimum, and it is important to note that the curve remains below curve C, obtained without any stabilizing elements, even at very high frequencies. This is the inevitable result of using any type of shunt stabilizing network, in the forward path of the amplifier, whose impedance becomes that of a capacitor at very high frequencies. The ultimate high-frequency asymptote position is lowered by *m* decibels, as shown in Fig. 2, where:

$$m = 20 \log \frac{\textit{total shunt capacitance}}{\textit{original shunt capacitance}}$$

The introduction of any network which acts as a three-terminal potential-divider at very high frequencies will have a similar effect.

Clearly, if we wish to attenuate the loop gain in a simple 20dB/decade manner, starting at the highest possible frequency, a characteristic such as that represented by curve B in Fig. 2 must be aimed at. The simplest way to achieve this is to put a series combination of *C* and *R* across the first stage collector load. The transitional lag introduced by these elements is arranged to "flatten out" in the frequency region where the other lags come in, thus maintaining a fairly uniform rate of loop gain attenuation.

So far a single overall feedback loop has been assumed, with stabilization by means of added passive loop-gain-attenuating circuits within the forward path of the amplifier. Most modern amplifiers, however, incorporate local feedback loops as well as the main overall loop. Nyquist's criterion, in the simple form already given, is applicable to such multiple-loop amplifers only if the circuit remains stable when the overall feedback loop is broken. However, it is possible, for example, to make amplifiers in which internal positive feedback is employed to enhance the gain of part of the forward path, and such amplifiers may be unstable when the overall feedback loop is broken. An extension of Nyquist's criterion to cover such cases is described in Bode's book[1], but in many years of circuit design work involving diverse applications of feedback, I have never had to make use of this more elaborate criterion. This is because:

(a) Nearly all practical multiple-loop feedback systems employ only quite tame and stable local feedback loops.

(b) Even if the amplifier is unstable with the overall loop broken at the β-network, it is sometimes possible to break the loop at a different place, within the amplifier's forward path, leaving a stable system.

Thus, in all normal circumstances, one merely uses the closed-loop response of each internal local-feedback "sub-amplifier" as an element contributing to the total forward-path response of the complete amplifier, arranging matters so that the ordinary Nyquist stability criterion is satisfied for the overall loop.

The advantages of using local feedback, rather than purely passive networks, to tailor the internal responses of a feed-back amplifier, are often very great. One reason is that the local feedback, if applied in enlightened ways, can be exploited, like overall feedback, to reduce non-linearity distortion. Another reason is that local feedback provides a means for modifying the input and output impedances of individual stages so that they may be connected together with little interaction[5,6]. These matters will be considered in greater detail in later articles.

Stabilizing elements in the feedback arm

It has been implied so far that β is frequency-independent and that all modification of the loop-gain-attenuation characteristic to secure good stability is done in the forward path of the amplifier. There are usually advantages, however, in including one or more stabilizing elements in the feedback arm, but just what constitutes an optimum design depends upon many factors, and particularly upon the application for which the amplifier is being designed.

In feedback amplifiers for some non-audio purposes, the aim is to achieve the widest possible bandwidth of flat response, and in such cases the β-arm must have a flat response up to about the unity-loop-gain frequency. Even then it is often advantageous to add a capacitor of quite small value across the feedback resistor as shown in Fig. 3(a), sufficient to cause a little phase advance around the unity-loop-gain frequency and a reduction in the rate of attenuation of loop gain at frequencies above this. This will improve the phase margin and give a better-damped step response.

In an audio amplifier, on the other hand, if other conditions permit, there is no reason why C in Fig.3(a) should not be made much larger, giving a substantial reduction in the bandwidth of the amplifier above audio frequencies. The use of a more complex double-phase-advance network as show in Fig. 3(b) is also a possibility. In general, if the very lowest distortion up to the highest possible frequency is the requirement, the forward gain should be attenuated as little as possible and the required gradualness of loop-gain attenuation achieved as far as can be managed by arranging for the value of β to increase with rising frequency. Such designs are liable to have a very high frequency of unity loop gain, however, and it is necessary to take particular care over layout and the effects of tolerances in transistor parameters.

A feature of audio amplifiers stabilized on the Fig. 3(a) basis, with a substantial value of C, is that the step response becomes quite rounded. If, at the same time, the stability margins are rather small, the total step response is liable to be of the type shown in Fig. 4.

Very often the rapidly-increasing rate of attenuation of the forward gain at very high frequencies, with an accompanying large phase lag, prevents the possibility of carrying the technique of stabilization by manipulating the β-network very far, but from a distortion point of view it has everything in its favour.

Circles of constant gain rise

The gain of a feedback amplifier is:

$$\frac{V_{out}}{V_{in}} = \frac{A}{1-A\beta}$$

which may be written as:

$$\frac{V_{out}}{V_{in}} = (1/\beta) \times \frac{A\beta}{1-A\beta} \qquad \ldots(1)$$

Consider now the part of a Nyquist diagram shown in Fig. 5. It is clear that for points on the Nyquist curve in the region of the point (1, 0), the $A\beta$ phasor OP becomes much longer than the

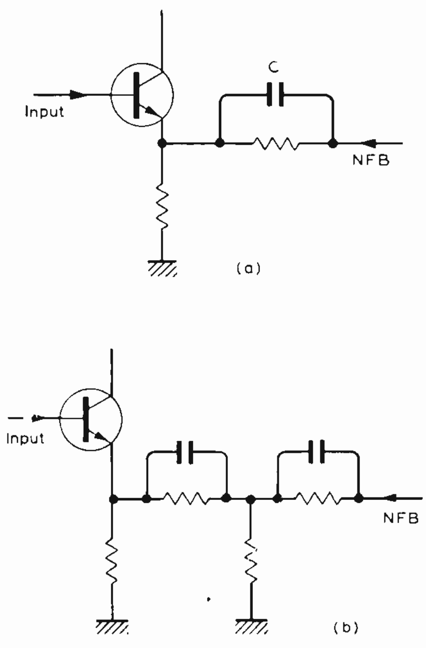


Fig. 3. *Stabilizing arrangements in the feedback arm of an amplifier. In non-audio amplifiers a low value capacitor C, in (a), can be added to improve the phase margin and give a better damped step response. In audio amplifiers C may be much larger, giving a substantial reduction in the bandwidth of the amplifier above audio frequencies. Arrangement (b) is a double-phase-advance network.*

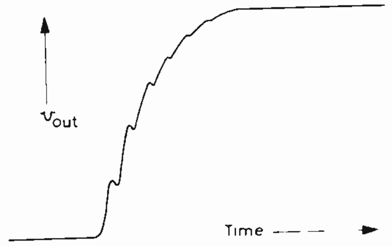


Fig 4. *Typical total step response for an audio amplifier having an arrangement as in Fig. 3 (a), with a substantial value of C, and a small stability margin.*

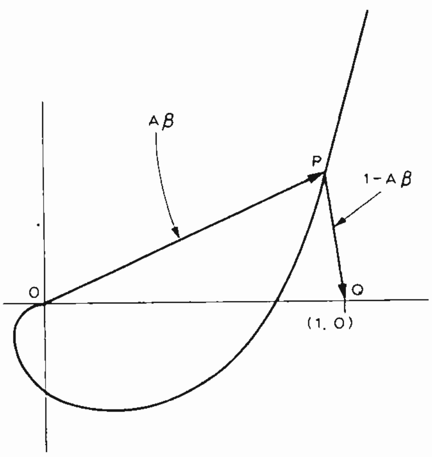


Fig. 5. *Nyquist diagram illustrating that, for points on the curve in the region of (1, 0), the phasor OP becomes much longer than the phasor PQ, so that the gain with feedback considerably exceeds 1/β and as the frequency increases the gain rises to a peak value and then falls off.*

($1-A\beta$) phasor PQ, so that, from (1), the gain with feedback then considerably exceeds $1/\beta$. Thus as the frequency increases and the point P moves down from the top of the Nyquist curve, the gain rises to a peak value and then falls off.

One may draw a set of curves on such a Nyquist diagram, each curve being for a constant ratio of OP to PQ. The simplest of these is a straight line through the point (½, 0), and if P lies anywhere on this line, OP = PQ and the gain with feedback is then exactly $1/\beta$.

Consider now the curve for OP = 2PQ, i.e. a 6dB gain rise above $1/\beta$. To determine this curve is a typical school geometry problem—"what is the locus of a point P such that OP = 2PQ everywhere on the curve?". The locus turns out to be a circle, centre (4/3, 0) and radius 2/3. For other ratios of OP to PQ, the locii are all circles of various radii and centre positions, as shown in Fig. 6. Note that the radial scale in this diagram is a linear one, not a decibel scale as sometimes used. This is quite satisfactory since only a small part of the complete Nyquist diagram has to be drawn.

Given the loop gain and phase information for an amplifier, the relevant part of its Nyquist diagram may be quickly sketched in on Fig. 6, and the magnitude of the high-frequency peak thereby deduced. For the Nyquist diagram shown in broken line as an example, the closed-loop response will be +3dB with respect to $1/\beta$ at f_1, will reach a maximum of +9dB at f_2, and will be −6dB at f_3, etc. If the β-network does not have a flat response at these frequencies, due allowance must be made for this in deducing the overall closed-loop response, since the diagram only gives response variations with respect to $1/\beta$.

Mere inspection of the Fig. 6 circles gives one a pretty shrewd idea of the sort of phase margins to aim at for various types of amplifier application, bearing in mind that the step response is in practice fairly closely related to the degree of high-frequency response peaking — see Fig. 2 of the May 1978 article.

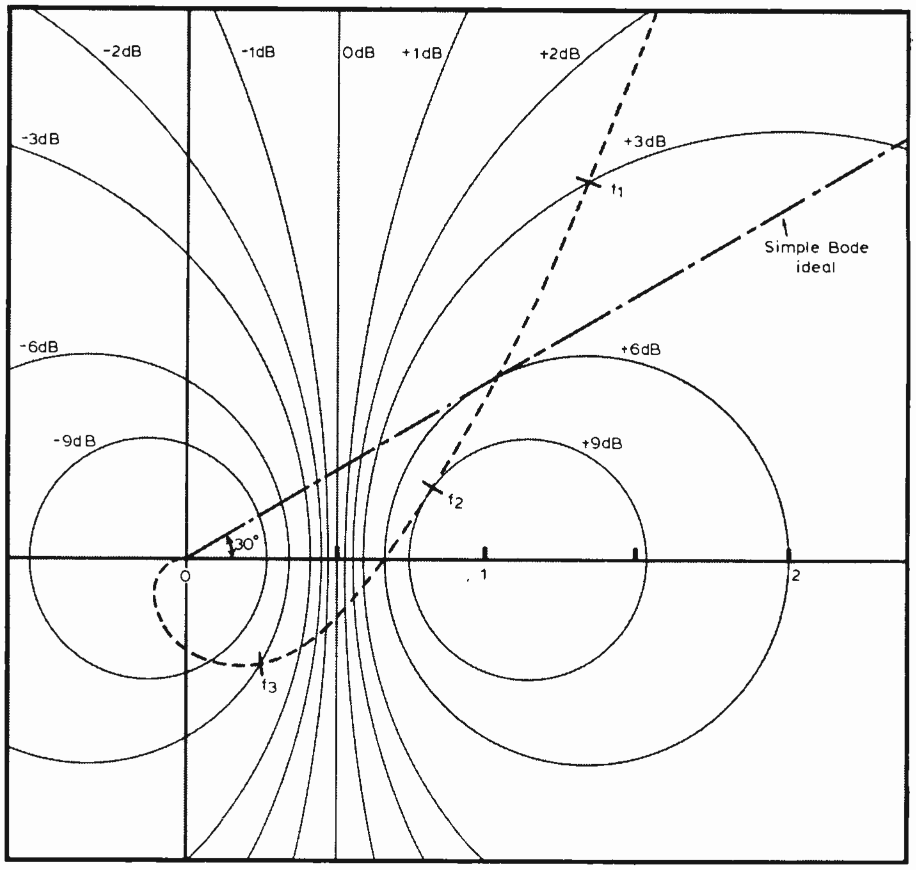


Fig. 6. *Nyquist diagram with circles of constant gain change with respect to $1/\beta$.*

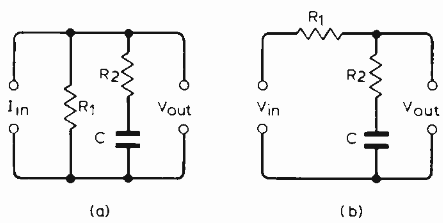


Fig.7. *Transitional lag circuits. Both circuits are equivalent and give no phase lag at zero or infinite frequencies, but contribute a phase lag which reaches a maximum value at the geometric mean of the two 'corner' frequencies. See text.*

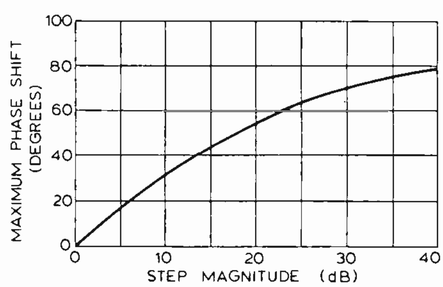


Fig. 8. *Characteristic for simple transitional lag or lead circuits.*

Maximum phase shift for transitional-lag circuit

In controlling the rate of attenuation of loop gain in feedback amplifiers, frequent use is made of transitional-lag circuits having one or other of the configurations shown in Fig. 7. The circuits are, of course, equivalent, since the combination of R_1 and I_{in} in Fig. 7(a) may be replaced by a voltage source $I_{in}R_1$ acting in series with R_1. The circuits give no phase lag at zero or infinite frequencies, but contribute a phase lag which reaches a maximum value at the geometric mean of the two corner frequencies given in the table on page 44 of the March 1978 issue. The larger the ratio of R_1 to R_2 the larger is the step in attenuation between very low and very high frequencies and the more nearly does the maximum phase lag approach 90°. Fig. 8 gives the relationship between the step magnitude in decibels and the maximum phase shift, and has been found useful for some design purposes. The graph may also be applied to the corresponding phase-lead networks sometimes used in the low-frequency stabilization of a.c.-coupled amplifiers.

Amplifier with only two lags

A particularly simple case is that of an amplifier having only two significant lags, of time-constants T_1 and T_2, in the forward path, and a frequency-independent β-network. If the low-frequency loop gain is large, then, to avoid a large high-frequency peak in the closed-loop response, T_1 and T_2 must be made very unequal, so that most of the loop-gain attenuation is done by the larger time constant without too much additional phase lag from the smaller one. A set of universal curves for this situation, calculated many years ago and recently rechecked, is given in Fig. 9. Knowing the low-frequency loop gain, the required ratio of time constants to give a specified magnitude of high-frequency peak in the response may be immediately obtained. As with Fig. 8, this data may also be applied to the corresponding low-frequency problem in an amplifier having two a.c.-

coupling time constants in the forward path.

Addition of small time constants

In many practical cases where a feedback amplifier is stabilized by the dominant lag technique, there will be one large lag plus several significant smaller lags. These smaller lags can often be satisfactorily considered as approximately equivalent to one lag of time constant equal to the sum of the individual small time constants. Some calculations relating to this are presented in graphical form in Fig. 10. It will be seen that provided the total lag introduced by the small time constants does not exceed about 40°, there is no great error in the calculated phase angle if they are taken as equivalent to a single lag of time constant equal to their sum. This procedure is very satisfactory for amplifiers having large phase margins such as 50°, and is a useful guide to approximate values, as a basis for experimentation, even when smaller phase margins are used. In this way the information of Fig. 9 may be used to some extent even when there are actually more than two time constants.

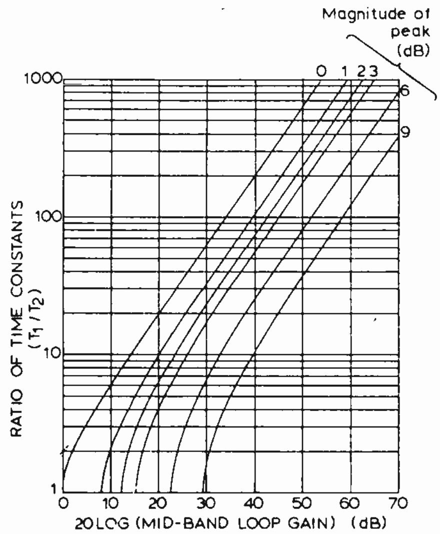


Fig.9. *Curves relating to amplifier with only two lags, or leads, in forward path, and a frequency-independent β-network.*

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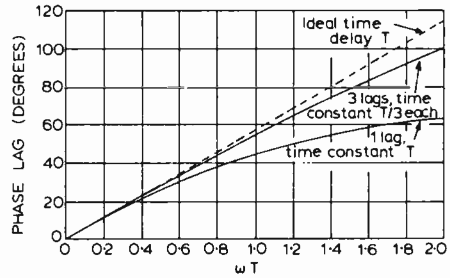

Fig. 10. *Phase lag characteristics.*

WHOSE LASER?

FROM THE USA comes news of the grant to Gordon Gould of a patent on laser technology and an impressive climb in share price of Refac Technology Corporation, the company with which Gould is associated. The climb in share prices was hardly surprising, bearing in mind the claim bandied around, namely that the new Gould patent on lasers could cover more than half of all the lasers now being used and manufactured in the United States and abroad. If this were true Refac and Gould would without doubt be in a highly enviable and lucrative position. A cold and closer look at the overall situation however, suggests that the recent grant to Gould of USA patent 4,053,845 may be more valuable as p.r. than as a legal weapon.

Although Einstein is credited with the idea behind the laser and Theodore Maiman of Hughes made the first to actually work, it was Arthur Schawlow and Charles Townes of Bell Labs, New York who first proposed the technology for a workable laser. They also patented their proposals; USA patent 2,929,922 was applied for in July 1958 and granted in March 1960. The patent described itself as relating to masers, and listed a large number of metal vapours (including sodium, potassium and rubidium) as suitable for "optical pumping" to generate a beam of coherent monochromatic light, itself amplified by further pumping in a generally similar second device. The inventors instanced infra-red, visible and ultra-violet wave lengths and claimed the broad concept of modulating the generated beam while amplifying it, for the purposes of communication. The pumping chambers have reflective ends and transparent sides, Schawlow and Townes drawing the analogy between optical pumping and microwave cavity amplification. This patent has now expired (having run its natural legal life) and what it described and claimed is now in the public domain. What then was left for Refac and Gould to claim as novel over Schawlow and Townes? Not very much, it would seem from a comparative reading of the various documents. Schawlow and Townes variously claimed a maser generator, an amplifier, a modulated amplifier and a communications system incorporating a generator, modulated amplifier and remote detector. All the Gould claims relate to a light amplifier *per se*. Moreover, the US Patent Office was quite clearly not anxious to allow even these limited claims over prior documents such as the Schawlow patent. The Gould patent was finally granted in October 1977 but dates back to an application made in April 1959! Gould was therefore negotiating with the US Patent Office for *eighteen years* before his patent application was allowed.

An indication of how drastically the original 1959 Gould application was limited to satisfy the US Patent Office examination can be had from a comparison with the series of seven very lengthy British patents which in 1964 were granted in the UK (to TRG Inc. with Gould as inventor) and relying on the same April 1959 priority. British patents 953721-953727 inclusive together contain nineteen different system drawings whereas the US case contains only seven. Moreover the string of British applications variously claimed monopoly on a maser, an apparatus for intensifying light, a heat generating apparatus and an apparatus for illuminating a reflecting body by stimulated emission light and producing an electrical signal in response. A light communication system capable of carrying over a hundred tv channels each of 6MHz bandwidth is also described.

The string of British patents have now all expired, mainly through "natural causes". The relatively rapid acceptance of the British patents, compared with the eighteen-year battle for the US counterpart, is not in itself significant. British patent office examination has (at least until now) been generally less stringent than that encountered in the USA. It is however, significant – or at least interesting – that the Official Register of the British Patent Office shows no record of any infringement action on any one of the seven patents during their lifetime and no licence granted to any rival laser manufacturer or supplier. This poses an obvious question. If the single relatively limited US Gould patent is as important as Refac and the US Stock Exchange appear to believe, how is it that no licences were granted and no court actions brought on any of the seven, and more far-reaching, British equivalents during their legal working life? **Adrian Hope** □

Users must press for more p.m.r. spectrum

"THE TIME might now be approaching when we can no longer economically satisfy the mobile radio users' needs by further channel splitting or fairly simple technical innovation," according to Joe Whelan of Pye Telecommunications' Mobile Radio Management Group. Speaking on WARC 1979 at the Pye seminar he said the use of mobile radio had grown by 10½% a year for 20 years, but the spectrum allocation had not grown with it. However, manufacturers had been able to get round this by design improvements enabling users to operate in less spectrum and users had been willing to replace their equipment at "rather frequent intervals". Those days, said Whelan, may be over.

"These services need more space and, hopefully, someone at WARC will stand up

continued on page 85

Case for cellular mobile radio "not yet proved"

THE BEST USE of private mobile radio could be achieved by narrower channel-widths, not digital techniques, according to a paper presented at the Pye symposium.

Rodney Gibson and Rick Mitchell of Philips Research Laboratories said that the spread spectrum technique, where several users operate simultaneously in the same frequency range, each signal being identified by a coded digital carrier rather than by time or frequency division, would be "a disaster" with the wide signal ranges found in normal mobile radio use. "The problem with this technique is that the signals cannot be perfectly separated unless the carrier codes are all synchronised to much greater accuracy than is possible in mobile radio. Without this synchronisation each transmission produces noise-like interference on all the others and, even with careful control of relative signal levels, unsynchronised spread spectrum systems provide very inefficient use of the spectrum." The technique would provide fewer available channels than with current frequency multiplex techniques.

Their assessment of various techniques was based on the assumption that a signal should take up the smallest range of frequencies over the smallest geographical area for the smallest length of time if the spectrum were to be properly used. They concluded that narrower channels would make the best use of the spectrum. "The result showed that either a.m. or f.m. could probably be developed to give adequate performance at 6.25kHz channel spacing . . . S.s.b. is feasible for v.h.f. working at 5kHz channel spacing and the performance will at least equal that of current 12.5kHz equipment."

On digital techniques the authors noted that for adequate speech quality the digital encoders currently available needed a bit rate of 10-16 kbits/s, requiring channel spacings of about 25kHz. Digital speech at these bit rates should only be used where its other advantage, that of privacy, outweighs the extra use of the spectrum. Nevertheless, speech encoding could become an attractive use of the spectrum if adequate quality could be provided at 2400 bits/s, using 5kHz channelling.

"It is sometimes claimed that broad channels of 25kHz or even 50kHz can be just as spectrally efficient as narrow ones because the strong capture effect of wide deviation f.m. allows better rejection of co-channel interference and therefore more efficient re-use. However, the gain in re-use often cannot be realised . . . because multipath fading severely reduces the capture effect, the local terrain often dictates coverage areas, and the demand for radio channels is usually concentrated in big cities and a high proportion of permissible re-use areas fall in regions of low population." There was little sense, the authors said, in reducing the number of channels in central London to make channels available in East Anglia. "By contrast two frequency simplex working is a technique in which the apparent reduction in bandwidth efficiency really does pay off in increased use of simultaneous transmissions within the same coverage area." The frequency separation between receivers and transmitters allowed so much extra freedom in frequency allocation that it more than offset the apparent waste of using two frequencies for the same channel.

The cellular schemes that had been proposed against the day when every car would have a radiotelephone had not yet proved their case for such an ordered network, "still less is it proved for the more relaxed conditions of ordinary mobile operations.

In the cellular system (see WW June '77, p.40) an area is divided into small hexagonal cells, each served by three low power transmitters on the boundary of each cell. Mobiles transmit only with their own cell's base station, and land-lines carry the signal from one cell to another to give coverage over a wide area. "The mobiles all have diversity reception to minimise the effects of multipath propagation and the use of three transmitters per cell helps to even out the signal received in different parts of the cell." The capacity of the system can be increased by making the cells smaller, though this would increase the number of base stations needed. Cellular systems would probably work well only in flat terrain, where vehicles were equally-spaced throughout the cellular array. There would be additional problems caused by the progression of mobiles from one cell to another. The authors say that p.m.r. uses spectrum most efficiently where there are narrow channels, where low transmitter power and directional aerials are used, where channel sharing is adopted, and where there is an incentive to keep transmissions short. In the latter case, routine messages could be transmitted by data saying, for example, "I have a job for you", leaving speech channels better used. □

Will the dish antenna replace the chimney pot?

HOMES of the future should have satellite aerials built into them, according to Dr. G. J. Phillips of the BBC Research Department, who hoped that the result would be more attractive than chimney pots had been on houses in the past. He was speaking about antenna requirements for satellite television broadcasting at a joint meeting of the British Aerial Standards Council (BASC — See "Inferior tv antennas dominate the market") and the Radio Industries Club (RIC) in May..

Although the UK still has the fourth television channel to develop before turning to satellite broadcasting, Germany and the Scandinavian countries foresee themselves finding applications within the next decade.

A plan for the use of the 11.7 to 12.5GHz band for satellite broadcasting was drawn up by the Geneva Broadcasting Satellite Conference in 1977 and, with only a few exceptions, each country in Europe and Africa was assigned five wide-band channels suitable for the present 625-line television standard, but using f.m. for transmission. The plan provides for sufficient transmitter power to allow individual home reception with a microwave receiving dish no more than 80 or 90cm in diameter. This antenna would not have to be mounted high above the ground provided there was a line-of-sight view to the satellite at an elevation angle of 25 degrees—the UK satellite position being 31° West.

An antenna of this kind, of course, must be rigidly mounted to maintain a pointing accuracy of the order of half a degree and, as stated by the Vice Chairman of BASC, Mr A. N. V. Pedersen, "rigging will be an exact science requiring advanced training." The significance of this is that rigging standards must change dramatically when satellites begin transmission in the '80s or '90s because, according to Mr Pedersen*, "rigging standards are abysmally low (in the UK) compared with West Germany."

In addition, because of an attenuation problem with feeders, the antenna must incorporate a frequency changer so that signals in the down lead are about 1000MHz. To remove one of the variables in mounting and aligning the antenna, circular polorization can be used but this must have good rejection of signals of the opposite circular polarization.

Yet another problem will be that of interference due to harmonics radiating from microwave ovens — the science of which has been given the name "radio gastronomy". To reduce this interference the antenna will also require a good sidelobe performance.

Both the BBC and the IBA are studying this type of broadcasting system and tests are being carried out with the European Space Agency's communcation satellite, OTS-2, which was launched on May 11 and was placed into geostationary orbit on May 24. □

*Mr Pedersen is also Chairman of the Radio Industries Club, marketing director for Antiference Ltd. and a director of Antenna Specialists (UK) Ltd.

Tory government would break up Post Office monopoly

ONE OF the earliest pieces of legislation sought by an incoming Conservative government would be to release the supply of telecommunications equipment from the Post Office monopoly. Private enterprise would be allowed to supply equipment to link the home, the office and the factory with the telecommunications network, according to Sir Keith Joseph in an interview with *Computer Weekly*. Sir Keith, who is head of the Conservative Party Centre for Policy Studies, said that although there would be some other legislation that would take priority, and although the Conservatives would aim to legislate rather less than recent governments, action to free as much of the whole spectrum of Post Office activity as possible from monopolistic control would be one of a new Conservative administration's first acts.

The Party was still discussing whether this should also apply to the postal service, which is likely to develop into electronic mail, where letters are sent by display or printing terminals attached to the telecommunications network.

He said that although he was no enthusiast of the Government's committees and sector working parties within the National Economic Development Office, they should not be "lightly abolished." □

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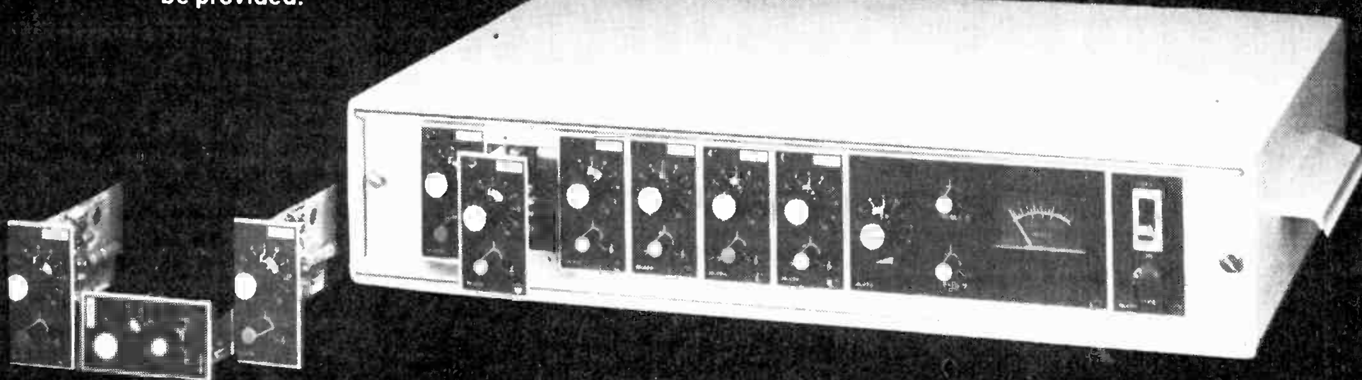

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Current dumping — does it really work?

2—Measurements

by **J. Vanderkooy** and **S. P. Lipshitz** University of Waterloo, Ontario

This article (part 1 appeared in the June issue) shows theoretically that the current dumping principle is quite sound. Whether it should be called feedforward error correction in the feedback loop is perhaps still open to debate. In several respects the distortion reduction appears due to a passive bridge balance. Dumper beta variation results in distortion, fortunately very low, which cannot be balanced out in present circuits, and readers are challenged to produce a circuit which nulls out such current distortion as well.

Measurements show that the amplifier performs very well, and analyses of the distortion oscillograms and wave analyser measurements show that, qualitatively, much of this data can be understood. We both heartily agree that the current dumping principle as embodied in the Quad 405 amplifier has significantly advanced the state of the art in class B power amplifier design.

IN ATTEMPTING TO MAKE distortion measurements on a Quad 405 amplifier (SN1861), we found no oscillator with sufficiently low distortion was available to us. After a number of modifications, we employed a Heathkit IG-18 whose distortion finally measured out at $<0.002\%$ at audio frequencies around 1kHz. We found that the Hewlett-Packard 302 wave analyzer, when fed a full scale signal, produced internal distortions or intermodulation with internal noise such that distortion components lower than 0.005% were difficult to measure. Accordingly, we employed a switchable passive twin-tee notch filter to remove the fundamental to the wave analyzer in all our measurements.

Correction factors for the twin-tee filter were applied to the measured harmonics to give total harmonic distortion, which excludes the wide-band amplifier noise. While making measurements we found it very interesting to observe with an oscilloscope the twin-tee filter output, having the fundamental largely removed. The noise of the Quad 405 is considerably higher than that of the Quad 303 power amplifier, probably because of the integrated operational amplifier used in the 405. This noise interfered with the oscilloscope display and in several instances we found it useful to place a capacitor across C_6 of the amplifier circuit.

The most important point we wished to check was the operation of the distortion nulling bridge. We did this firstly by observing the distortion signal with the amplifier as supplied, and also with Z_4 (the 3μH inductor L_2) shorted. This is easy to do and not very upsetting to the amplifier's stability. Fig. 4 shows a photograph of the distortion output after the twin-tee for four cases. Starting from the top, (a) is the resultant at 1.32kHz for 1Vrms output into a 10-ohm load, amplifier as supplied; (b) is the same with Z_4 shorted; (c) the same as (a) but with signal frequency of 13.2kHz; and (d) the same as (c) but with Z_4 shorted. Notice that the twin-tee allows some fundamental residue to remain in (a) and (b). The traces clearly show the beneficial effect of the bridge element Z_4, especially at high frequencies, as one might expect. They also clearly answer Mr Bennett's objections (ref. 2, part 1): vastly larger amounts of negative feedback would be required to achieve as low a distortion as can be achieved by inserting Z_4 and balancing the bridge.

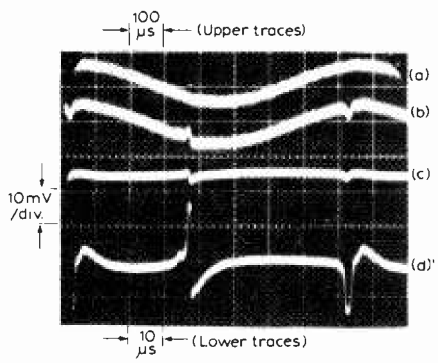


Fig. 4. *Oscillogram illustrating residual distortion voltage at output of twin-tee filter at 1.32kHz (top two traces) and 13.2kHz (bottom two). In each case the lower trace shows the effect of shorting the inductor Z_4. (Output 1V r.m.s. into 10Ω.)*

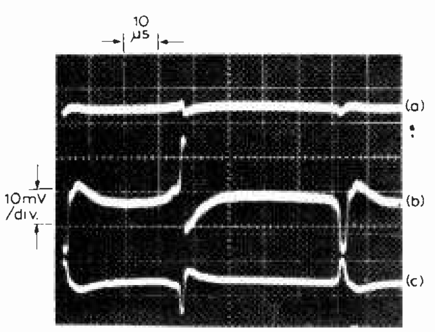


Fig. 5. *Oscillogram illustrating the effect of unbalancing the bridge in both directions. Upper trace is with amplifier as supplied; middle trace with bridge unbalanced in one direction (Z_4 shorted), and lower trace with bridge unbalanced in opposite direction (Z_1 shunted). All at 13.2kHz, 1V r.m.s. output across 10Ω.*

The fact that the amplitude of the notch distortion in Fig. 4 increases visibly with frequency and consists in large measure of sharp spikes, suggests very strongly that this remaining distortion is due to residual bridge unbalance. This is as predicted by our analysis, and is further reinforced by Fig. 6 (see later). The spikes are roughly constant for output levels from 1.5 to 10Vrms; to understand this feature even qualitatively requires a more complete treatment of crossover distortion than we can give here.

It is worth remarking that for outputs less than about 200mVrms the notches disappear completely, as the dumpers remain off and the amplifier operates in pure class A. Hence at very low power, crossover distortion is totally absent. As the output signal amplitude is increased beyond about 10Vrms (at 13.2kHz), the peak-to-peak notch amplitude rises, until at 25Vrms output it has risen by a factor of four from 5 to 20mV pk-pk. This strongly suggests that this effect is due to β variation in the dumpers, as our theory predicts that this contribution should rise in amplitude with output level. We have not, however, been able to correctly predict the magnitude of this effect from our equations. It may well be that the slow dumper transistors have a region near crossover where $\beta \approx 0$ or $\beta < 0$ after a quick turnoff.

Finally, each spike in trace (d) in Fig. 4 is in fact composed of two spikes of vastly different amplitudes. It would appear that the smaller spike is caused by the switching of the upper (single) dumper, while the larger spike is contributed by the lower dumper pair (with its higher speed).

Fig. 5 shows that the amplifier as supplied has a bridge roughly in balance. All traces are at 13.2kHz with 1Vrms out across 10 ohms; horizontal scale 10μs/division, vertical scale 10mV/division; twin-tee in circuit. The upper trace shows the amplifier as supplied. The middle trace shows the effect of shorting Z_4, the inductor L_2. This unbalances the bridge in one direction. The lower trace is produced by restoring Z_4 and resistively shunting Z_1 (the 500Ω resistor) to unbalance the bridge in the opposite direction. Comparing traces, the bridge as supplied is reasonably well balanced, perhaps within 10%, which is to be expected with four 5% components.

The remaining glitches in the distortion waveform suggest that the bridge is not perfectly balanced, or that some other distortion mechanism such as dumper β variation may be occurring. Fig. 6 shows the results of several attempts to achieve better bridge balance. The signal frequency is 13.2kHz, horizontal scale 10μs/division, vertical scale 5mV/division. The upper trace shows the twin-tee output for the amplifier as supplied. The middle trace shows the best balance that can be achieved by shunting Z_1 (the 500Ω resistor) with a resistance which for our amplifier was about 5kΩ. The lower trace is the result when Z_1 is shunted by two resistors in series, with their junction going via a 100μH inductor to ground.

This was an attempt to balance the bridge, taking into account the effect of C_9(330pF), R_{19}(3.3kΩ) and the collector capacitance of Tr_3. Although one may think that such effects should be negligible because Tr_3 has a β of say 100, any collector current due to capacitance goes through an active base and is

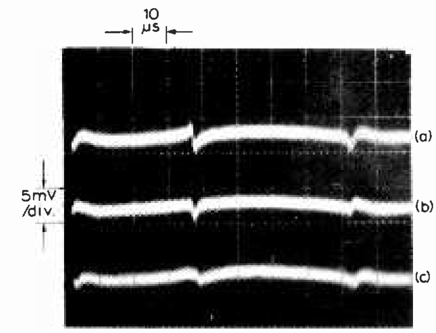


Fig. 6. *Oscillogram illustrating attempts at achieving perfect bridge balance. Upper trace is twin-tee output of amplifier as supplied, middle trace shows best balance achieved by resistively shunting Z_1, and lower trace is best balance with complex shunt. All at 13Hz, 1V r.m.s. across 10Ω.*

multiplied by β. (A recent Quad 405 circuit shows C_9 and C_{11} replaced by a single capacitor, a configuration we have not analysed). The slightly better appearance of the lower trace indicates some success on our part, but the problem is complex and subtle. There may also be an effect due to the separation of Z_1 and Z_2, these being fed back to opposite ends of Tr_2, the input transistor. The distortion signals fed back through Z_1 and Z_2 will not be quite right, due to the different impedances at opposite ends of Tr_2. We believe that this effect can be seen in Figs 4 and 5 with Z_4 shorted. The large spikes are followed by an exponentially decreasing waveform with a time constant of about 5μs. If one estimates the impedance at the collector of Tr_2 (the input transistor, triple input, and the current source Tr_1) at about 50kΩ, the 120pF capacitor (Z_1) gives a time constant with this impedance of 6μs. No other time constant seems near to this value, indicating that an effective bridge unbalance may have resulted from the separation of Z_1 and Z_2. The only other possible cause could be a slow dumper turnoff.

Several other features tend to influence the bridge and the dumper β variation. Although C_{10} bootstraps R_{30}(560 Ω), this resistor now forms a shunt across the dumper stage from bases to emitters. This will influence the effective β for the dumpers in the crossover region (there will be a small current region for which $\beta<0$, using a d.c. analysis). As the dumpers are slow, an a.c. analysis is almost impossible, and they may well be the cause of much of the residual distortion. Because of the bootstrap capacitor C_{10}, R_{31} (also 560 Ω) now forms a load to an a.c. ground (the negative rail), which tends to unbalance the bridge. Our calculations show that this has an almost negligible effect at audio frequencies, because the relevant ratio turns out to be the conductance of R_{31} relative to that of Z_4. (The presence of the loading effect of R_{31} slightly changes the bridge balance condition $B = 0$ by, in effect, modifying β very slightly. The possibility of achieving a balance is not affected.)

Another source of distortion in the Quad 405 amplifier is the non-linearity in the modulation of β of Tr_2 (the input transistor following the operational amplifier) due to collector voltage variations. This transistor has a collector-to-emitter voltage which is modulated by 180/680ths of the output voltage, due to the feedback resistors. Suppose that the *non-linearity* of the collector current with voltage variation is 1% of the quiescent current of about 6mA. Using a simple diode model for Tr_2 we can easily show that such non-linearity of β with voltage results in a distortion of around 0.001% at full output level. Such distortion is mainly second harmonic and will become negligible at low power levels.

Harmonic distortion measurements with Quad 405 bridge balanced as accurately as possible

Fundamental		n^{th} order harmonic distortion (%)																
		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	t.h.d. (%)
1.32 kHz	signal generator	.0011	.0004	N	N	N	N	N	N	N	.0001	N	N	N	N	N	N	.0012
	Quad 405, $1V_{rms}$, best resistive balance	.0051	.0072	.0058	N	.0042	N	.0024	.002	N	.0021	N	N	N	N	N	N	.012
	Quad 405, $1V_{rms}$, Z_4 shorted	.017	.016	.022	.0049	.021	.005	.016	.012	.0089	.014	.0021	.013	.0031	.01	.0062	.0072	.051
	Quad 405, $10V_{rms}$, best resistive balance	.004	.0005	.0007	.0007	.0004	.0005	N	.0004	N	.0003	N	.0003	N	N	N	N	.0042
	Quad 405, $10V_{rms}$, Z_4 shorted	.0046	.0014	.001	.0023	.0009	.0023	.0009	.0022	.0009	.0021	.0011	.002	.0011	.002	.0011	.002	.0079
13.2 kHz	signal generator	.0081	.0004	N														.0081
	Quad 405, $1V_{rms}$, best resistive balance	.012	.0063	.0039														.014
	Quad 405, $1V_{rms}$, Z_4 shorted	.14	.14	.18														.27
	Quad 405, $10V_{rms}$, best resistive balance	.011	.0034	.0023														.012
	Quad 405, $10V_{rms}$, Z_4 shorted	.017	.027	.0015														.032

N denotes signal below noise: wave analyzer bandwith 2Hz

To gain some insight into the magnitude of the remaining distortion components in the Quad 405, it may be instructive to quote some figures. The table gives harmonic distortion measurements (of harmonics up to 50kHz) made as outlined earlier, with the Quad 405 bridge resistively balanced as accurately as possible, as in Fig. 6, trace (b).

Clearly, the low-order harmonics excepted, the measured residuals are of a very low amplitude indeed, and are frequently barely above the residual noise. Particularly impressive is the absence of measurable high-order harmonics, even at low powers. The enormously beneficial effect of Z_4, already evident from the oscillograms, is again emphasized by these numbers. Much of the residual second and third harmonic distortion may be due to the class A stage, as this stage sets a limit on the ultimate performance of the whole amplifier. The contribution due to the input operational amplifier (which is outside the overall a.c. feedback loop) should also not be ignored.

About part 1*. In connection with our reference to Peter Baxandall's letter, page 38, Mr Baxandall has recently justified his approach quite clearly to us. We hope he will expand his elegant argument in his own series of articles. The second term in the last equation of the middle column on page 39 should have a minus sign between v_i and e_o. The word relaxed should have been used at the foot of column two, page 38, intead of "related."

**Script originally received October 1976.*

Additional reading

Quadi-complimentary, *Elektor* 8, December 1975, pp. 1220-2.
Quadi-complimentary complemented. *Elektor* 21, January 1977, pp. 1-39.
Letters to the editor, *Wireless World* vol. 82, November 1976, pp. 52/3.
Letters to the editor, *Wireless World* vol. 83, April 1977, p. 76.
Letters to the editor, *Wireless World* vol. 83, June 1977, p. 49.

Having a keen interest in electronics and audio, **John Vanderkooy** has contributed a number of articles in these fields. He is an assistant professor in the Department of Physics at the University of Waterloo, having previously spent two years on post-doctoral research at the University of Cambridge. John graduated from McMaster University, Hamilton, Ontario with a B.Eng. degree in engineering physics in 1963 and a Ph.D. in physics four years later.

With a long interest in audio and electronics, **Stanley Lipshitz** has recently begun investigating some of the mathematical problems associated therewith. He's an assistant professor in the Department of Applied Mathematics at the University of Waterloo. Before that he obtained his first degree in mathematics, applied mathematics and physics from the University of Natal, Durban, in 1964, an M.Sc. degree in applied mathematics from the University of South Africa, Pretoria, and the Ph.D. degree in mathematics from the University of the Witwatersrand, Johannesburg in 1970.

continued from page 79

and say so." It was essential that the conference recognise the true value of mobile radio to the world community. A study of the spectrum would show that, despite the now massive use of mobile radio, "a surprisingly small amount of frequency space is allocated for the use of a very significant list of users." Many public and private undertakings all over the world would suffer considerable inconvenience, reduction in efficiency and increased costs if they were to lose their radios, yet all of them are to some extent at risk during the WARC.

- Successful competitors might take their allocations.
- Equipment might cost more because of changing technology.
- Spectrum might be leased, perhaps to the highest bidder.
- Restriction on non-priority users might reduce freedom to use or expand existing allocations.

Pressure will come from the developing countries which might cause disharmony at the conference, and from well-entrenched user groups. "It can be anticipated that all countries will give first priority to defence needs, and will also consider broadcasting and telecommunications to be essential services. One can perhaps be forgiven for feeling that not all defence services are defensive, and that not all broadcasting is essential but, whilst many would agree, such sentiments are unlikely to be allowed to affect the outcome."

"Additional radio spectrum for mobile radio use can be made available only by other users conceding some of the space at present occupied or reserved by them. Is it not time for the needs of defence or broadcasting users to be more thoroughly scrutinised and should they not be made to respond in the same manner as mobile radio to pressures for better utilisation of bandwidth simply through the discipline of restricted allocation?"

Inferior television antennas dominate the market

WILL THE poor quality antennas, which make up about half of the UK television antenna market, be adequate for teletext, the fourth tv channel and data communications, which are on the way?

That was one of the questions being asked at a meeting of the British Aerial Standards Council (BASC) and the Radio Industries Club (RIC). Chairman of BASC, and Managing Director of Wolsey Electronics, Mr A. C. F. Leadbitter, said that even now there are many antennas in the television broadcasting field that do not function adequately.

"These antennas could be just a collection of rods with little or no attention being paid to dimensions or optimisation for the required frequency bands," he said.

In his view, these low-grade products were the result of smaller manufacturers, with little or no expertise, producing antennas which, although competitively-priced, do no justice to either the quality of the transmissions or the receivers installed.

Of the other 50% of the present UK market, 25% are set tops and only 25% are good quality antennas or fringe types. Clearly, consumers should be more aware than they are about technical standards when selecting their receiving antennas. One suggestion by Mr Leadbitter was that, with the mass market being dominated by rental organisations, the antenna installation is often contracted-out to the cheapest installer, who in turn is forced to use the cheapest materials.

It is thought that there is no guarantee that the low-grade antennas will have sufficient bandwidths for the fourth channel and may give mediocre performance.

In the field of digital communications and teletext the situation is expected to be much worse, with close-space reflections seriously affecting the received information. In surveys carried out by the IBA, some existing domestic installations, in three areas of the UK, were compared against a reference — a vehicle equipped with a standard, domestic ten-element u.h.f. antenna mounted at 10m with a 15m length of standard domestic feeder. The results of the surveys showed that the standard ten-element test antenna often shows a significant improvement over the average domestic installation.

On the subject of satellite transmissions, which will require a high standard of technical know-how, BASC feel that it may not be within the capabilities of many of the smaller manufacturers.

BASC was reformed in 1973 by the leading UK antenna manufacturers to try to improve the technical standards of domestic receiving antennas. In an attempt to promote the highest possible level of both mechanical and electrical excellence in their antennas, these manufacturers, through the technical committee of BASC, have prepared a technical standard for the design and manufacture of receiving antennas. This standard, which was first published in 1975, is currently being introduced into the BSI and IEC regulations.

Any manufacturer wishing to obtain full membership of BASC must themselves maintain a high technical standard because they must demonstrate that their electrical and mechanical design, test and quality control capabilities meet the minimum standards laid down by BASC. In addition, they must possess the appropriate equipment and facilities and employ suitably-qualified engineers. At present BASC has only five full members.

WORLD OF AMATEUR RADIO

"Revolutionise" amateur radio?

The amateur satellite organization, Amsat (Amsat Phase III, PO Box 27, Washington DC, 20044, USA), in appealing for funds to help further their interesting and laudable Phase III project to put an amateur satellite into geostationary orbit may unwittingly raise a few hackles in the process. For they have as their tag line the phrase "help to revolutionize amateur radio communications". Few amateurs will quarrel with the concept of providing a new band comparable to 14MHz "a resource usable by hundreds of stations at a time". But what is questionable is whether the hobby will in the long term benefit from reliable, 24-hour, consistent dx operation. When it becomes as straightforward to talk to the West Coast of America as telephoning across town, will the hobby suddenly lose its appeal? This is perhaps what is at the root of the long-lasting pro- and anti-repeater controversy that has already done so much harm to the hobby.

Then again, I recently received a letter from someone who has held an amateur licence for more than four decades, as well as spending a lifetime in professional radio communications. He questions the current interest in amateur h.f. radio teleprinting and even more the now-permitted high-speed data transmissions at 600 and 1200 bauds, or above, on v.h.f. He asks where amateurs will get all the traffic that needs shifting in such a hurry or the paper to print it all out on. Who, he asks, will take the trouble to receive and digest great spurts of data?

"I just cannot think what the appeal of r.t.t.y. is to amateurs when those of us who used it for real traffic knew from the beginning what a poor system of synchronism 'stop/start' is when applied to ionospheric-reflected signals" he adds provocatively.

Clearly one can see the attractions of communicating by speech or c.w. at speeds well suited to an individual operator, or even occasionally sending images by s.s.t.v. or facsimile. But the idea of spending hours preparing to send a two-minute burst of data or linking up two home computers seems a curious way of improving the hobby. Though I suspect that to say so is to invite the label reactionary!

Czech summer of 1968

Traditionally, amateur radio steers well clear of international politics but just occasionally, willy-nilly, the lines get crossed. There was for instance the Hungarian business of 1956 when several Hungarian amateur stations could be heard desperately trying to get messages through to broadcasting stations in West Germany. But the most unusual — and to all who listened one of the most moving — episodes occurred ten years ago during the later stages of that Czech summer which culminated in the military intervention of Russia. Yet little has ever appeared in print of what took place.

For several days during August 1968 a number of apparently "official" Czech mobile stations using callsigns such as OK5CSSR and OK9CSSR operated on the amateur bands sending out streams of highly political messages in support of Dubcek and a "democratic socialist republic" and containing such phrases as "go home Russian army" and "we want no Soviet politics and pressure in our lives". The messages were often dramatic and moving in their appeals for moral support. Using the QRR (Amateur SOS) procedure one of the last messages heard on 14MHz was "Please moral help for us in your countries. Now I am moving to 3.5MHz for our democratic service. 73 to all good hams of the world. The situation here very bad."

Soon afterwards the CSSR stations went off the air. Whether, as appeared to be the case, the activity had been officially planned, co-ordinated and encouraged, or whether it was simply some Czech amateurs who took matters into their own hands has never been revealed. One day the full story of those CSSR "amateurs" may perhaps become known.

A new "Guide"

Like many other would-be amateurs, the very first publication I ever read devoted entirely to amateur radio was a pre-war edition of "A Guide to Amateur Radio" published by the RSGB. Over 20 years later, in 1958, I took over responsibility for the contents at a time when there were still less than 10,000 amateurs in the UK and little activity other than on c.w. and a.m. (A3). Just how much the hobby has changed since then has been very evident during the preparation of the latest (17th) edition and in fact the entire publication has had to be re-set and expanded. The changes have not been technical only; it has been necessary to take into account the new syllabus and style of the Radio Amateur's Examination to be introduced in May 1979. The 120-page limp cover edition is available from RSGB, 35 Doughty Street, London WC1 (£1.71 including post and packing) For those with very long memories, the concept of a low-cost guide to the hobby originated with a publication called "What is amateur radio?" as early as 1932, and several of the amateurs mentioned in that original publication are still active.

Here and there

Television dx enthusiasts have long discovered that favourable tropospheric paths exist quite often between the UK and Spain, but it was only in September 1977 that the first 432MHz contact was made (G3AUS and EA1AM). More recently, during March 1978, GJ8ORH and GJ8KMU both in Jersey were included among several UK amateurs to work Spanish stations on 144MHz and 432MHz.

Several papers and demonstrations are being given by radio amateurs at the three-day IERE conference on radio receivers and associated systems at Southampton University, July 11-14.

According to *CQ-TV*, A. H. Turner, one of several amateur tv stations active in the Luton/Dunstable area, has made colour transmissions and is also active on the 23cm band. Most activity in the UK is on the 70cm band and a weekly "activity period" for amateur tv stations in the North London, Watford, Cambridgeshire, Northamptonshire and Buckinghamshire area has been proposed (contact John Wood, G3YQC, 54 Elkington Road, Yelvertoft, Northampton, telephone 0788-823250).

A 144MHz transequatorial mode contact has been made over a distance of 5972km between ZE2JV in Rhodesia and 5B4WR in Cyprus.

In brief

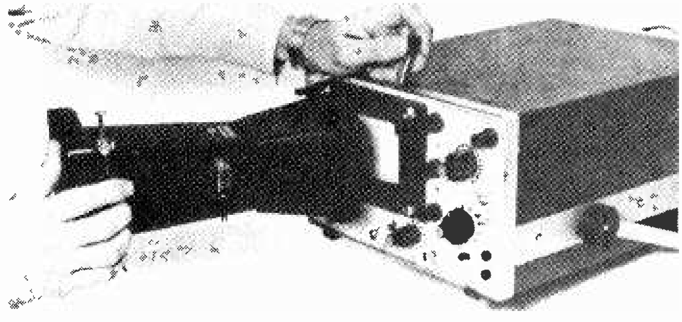
British nationals holding an amateur licence issued by any administration with which the UK has a reciprocal licensing agreement can now obtain a UK licence without taking the UK examinations . . . The conditions governing the use of crystal control by British maritime mobile stations have been relaxed . . . . ITU callsign prefixes now include J4A to J4Z for Greece and J5A to J5Z for Republic of Guinea-Bissau . . . . The Home Office is now prepared to issue GB8 "special event" permits for operation on bands open to Class B operators . . . . The French REF balloon-borne v.h.f. activities have been resumed again this summer . . . The 21st Jamboree-on-the-Air, the amateur radio event organised by the Scouts, is to be held on October 21-22 . . . . The special expedition to Clipperton Islands made 29,069 contacts, an average of 187 per hour.

PAT HAWKER, G3VA

NEW PRODUCTS

Oscilloscope camera

The Shackman 7000 oscilloscope camera is claimed to be half the price of comparable existing equipment and is available with a choice of mounting systems. This camera has been introduced as an up-dated replacement to the CR-9, which was manufactured by Shackman Instruments Ltd for Polaroid in the late '60s. Its lens has been improved (now f3.5 instead of f5.6) and it has eight shutter speeds starting at 1s. According to the makers, the 7000 weighs less than 24 ounces and produces 83 × 108mm prints, with virtually no picture distortion, in just 30s. The camera needs no focussing and the exposures can be controlled to take account of the brightness of the display and the type of phosphor used. The lens has a 70mm focal length and includes aperture control down to f32. Speeds on the self-cocking shutter may be adjusted down to 1/125th second and a 'B' control, for time exposures, and an 'X' contact, for event triggering, are included. The shutter is activated by cable release. The camera takes quick-loading, Polaroid, black-and-white 8-exposure film packs of the type 107C 3000ASA or, where extra prints are required, the type 665 75ASA pos./neg. A range of ten hoods are available and the camera can be fitted to any one of over 60 adaptors, enabling it to be used with over 27 different makes of oscilloscope. Price is from £130 to £160. Shackman Instruments Ltd, Mineral Lane, Chesham, Bucks HP5 1NU.
WW 301



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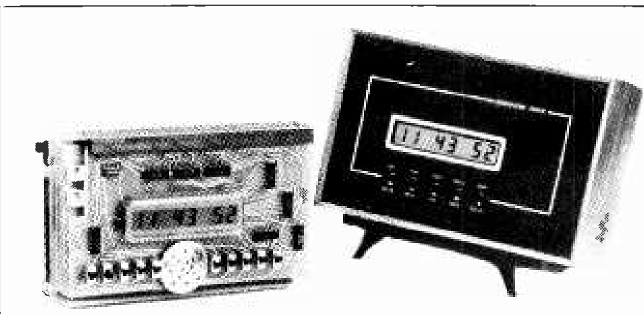


WW 302

Radio code clock

The Radiocode clock, which automatically receives a 60kHz transmission from Rugby MSF and decodes all of the time and date information, is claimed to provide the most authoritative portable and self-contained time source available. A liquid crystal display shows either hours, minutes and seconds or day, month and year. Because the unit has a crystal backup, the clock will continue to operate even if the transmission stops during a maintenance period. The instrument can also be supplied with an alarm/timer module which enables the clock to control other equipment at certain times for precise periods. No initial or subsequent adjustments are required because the clock sets itself and accounts for leap seconds, leap years, and BST. Internal standard batteries allow a year's continuous use even with a built-in sounder operating. The estimated range is around 1000 miles, and the receiver delay, after compensation, is quoted as 5ms. For use on the Continent, the clock has an add-on-hour facility. Alternatively, a modified version can be supplied which receives a similar signal from the DCF 77 transmitter at Mainflingen, West Germany. This allows the clock to be used in eastern Europe where the MSF transmission may be weak. Various optional outputs are also available, enabling the clock to be used with a complementary record/replay unit. This interface allows the "time" to be recorded on one track of a conventional tape machine. On replay the recorded time is displayed by the clock. If very low frequency signals or d.c. levels are to be recorded on the other tracks of the tape recorder, an additional f.m. interface unit can be supplied. For applications which require an accuracy of around 1μs, details of an NPL system using a Radiocode clock and television sync pulses can be supplied. Prices for standard clocks range from £275 to £365. Circuit Services, 6 Elmbridge Drive, Ruislip, Middlesex HA4 7XB.
WW 302

Seven-segment display

A seven-segment l.e.d. display, introduced by Highland Electronics Ltd, has a rectangular presentation measuring 24 × 18mm and mounts in a 16mm diameter round hole. The 31D, as it is called, includes a memory and a decimal point and operates from a 5V d.c. source. It accepts a b.c.d. negative input and displays 16 characters: figures 0 to 9 and letters A to F. Highland Electronics Limited, Highland House, 8 Old Steine, Brighton, East Sussex BN1 1EJ.
WW 303

WW 303

Microwave isolators

A range of X-band microwave isolators, in waveguide 16 (WR90, R100), has been designed and manufactured by Nore Microwave Ltd. Characteristics include bandwidths up to 500MHz, an operating temperature range of −40 to +85°C and isolation, at the centre frequency, in excess of 40dB. A typical 100MHz-bandwidth unit has a v.s.w.r. of 1.15:1, an insertion loss of 0.4dB and a power handling capability of 10W. Since they weigh only 50g, and are packed into only one half-inch of wavelength, they are particularly suited to severe military and airborne environment conditions. Nore Microwave Limited, 36 Towerfield Road, Shoeburyness, Southend-on-Sea, Essex SS3 9QT.
WW 304

Serial data analyser

The model 1640A analyser is claimed by its makers, Hewlett-Packard, to make the troubleshooting of data communication networks easy. A keyboard enables a range of functions to be selected to alleviate the need for programming by the user. When used passively, the analyser can be connected to an RS232C (V24) interface and monitor to record both transmit and receive data. When used actively, it can simulate a computer, modem or terminal and can interact with the network to which it is connected. In its 'copy' mode of operation, instead of having to enter complex format sequences via the keyboard, the analyser can simply monitor the format changes between the c.p.u. and the terminal, and then automatically transfer either the receive or transmit data into the analyser's transmit message buffer. The data can then be edited prior

to transmission by the analyser. This feature reduces the need for the user to be intimately familiar with the network format and practically eliminates the possibility of human error during message composition. Hewlett-Packard Limited, King Street Lane, Winnersh, Wokingham, Berkshire RG11 5AR.
WW 305


WW 305

Driver-amplifier i.c.

The ICL8063 is a driver-amplifier which will interface low level signals from operational amplifiers directly with power transistors. It is capable of providing up to 100mA of drive current in this mode. A useful feature of the device is that it has built-in regulators which may be used to provide supply rails for other devices in the system. The ICL8063 is fully short-circuit protected. Intersil Incorporated, 8 Tessa Road, Reading, Berkshire RG1 8NS.
WW 306

Low-cost function generator

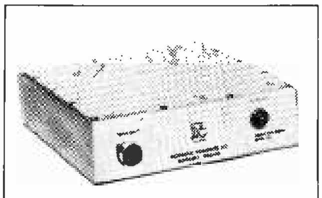
The FG601, from Feedback Instruments Limited, is an all-purpose function generator which is claimed to provide users with facilities normally only found on much more expensive instruments. It produces sine, square and triangular waveforms, as well as t.t.l. pulses, at frequencies between 0.001Hz and 1MHz, in nine overlapping ranges. The output level is variable up to 20V pk-to-pk, while switched attenuators are provided for control of low level signals. A direct voltage offset of up to ±10V may be superimposed on the output and an oscillator control voltage input is provided for sweeping of up to two decades of frequency. Price is about £250. Electroplan Limited, P.O. Box 19, Orchard Road, Royston, Herts SG8 5HH.
WW 307

Attenuation meter for optical fibres

The Fibre-Link 3140 has been designed to measure the attenuation in optical fibre links using the insertion loss method. Its built-in light source is a visible red l.e.d., with Fibre-Link 3100 computing hardware, but alternative external sources may be powered from the controlled and metered "external emitter power supply" terminals. In addition, accessories for alternative couplings can be supplied to meet customers' special requirements. The instrument, which is suitable for loss measurements in fibres, couplings and assemblies under both laboratory and production conditions, operates from either 120V or 240V and incorporates a stabilized power supply. Price is £392 ex UK works. Lee Green Precision Industries Limited, Grotes Place, Blackheath, London SE3 ORA.
WW 308

Multi-crystal r.f. sources

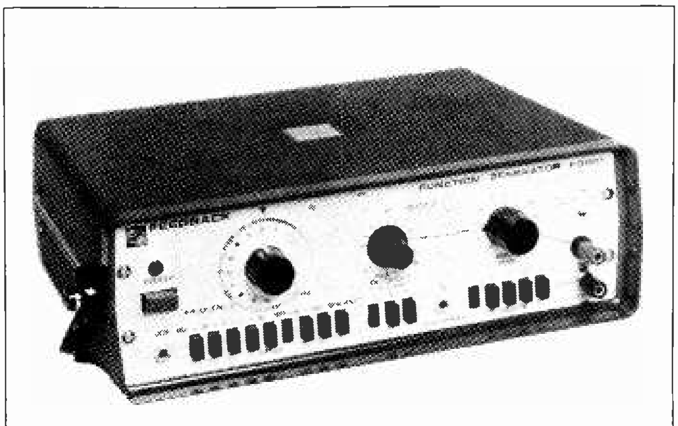
The ML12000 series of very-low-noise, r.f. signal sources can now be supplied to give up to ten switch-selectable, fixed output frequencies — contained within a 2% bandwidth — over the total range of 1 to 11GHz. Each unit comprises a low-noise, crystal-controlled oscillator and amplifier, driving a high efficiency varactor-type frequency multiplier to achieve the specified output frequency. Standard models include


WW 309

the ML12024, delivering 80mW at up to ten frequencies in a 2% band between 1.7 and 3.2GHz; the ML12025 with an output of 1W at three frequencies between 2.4 and 2.6GHz; the ML12055 and 12491 with 10mW outputs and ten frequencies between 5.1 and 5.7GHz, and 9.4 and 10.3GHz respectively; and the ML12100, which can deliver 100mW at three frequencies between 9.4 and 10.3GHz. All of the units have a frequency stability of better than 50 p.p.m. from −20° to +50°C and are designed for coaxial operation, via a 3mm SMA connector, with an integral isolator allowing operation with load v.s.w.rs up to 3:1. Microwave Associates Limited, Dunstable, Bedfordshire LU5 4SX.
WW 309

Microprocessor system for v.d.us

Scrumpi 3 is a small business computer system for o.e.m. applications and d.i.y. enthusiasts. It is based on a S6/MP11 n.m.o.s. microprocessor and has video and u.h.f. outputs for 32 × 8 character v.d.us. It also has a 20-key keyboard allowing 64 ASCII-code inputs, a 1K p.r.o.m. plus a 1K socket, a 128-byte r.a.m. plus a 1K socket and u.a.r.t. and teleprinter interfaces. Optional extras include a mini-cassette transport and interface and a 50mm v.d.u. monitor. Bywood Electronics, 68 Ebberns Road, Hemel Hempstead, Herts.
WW 310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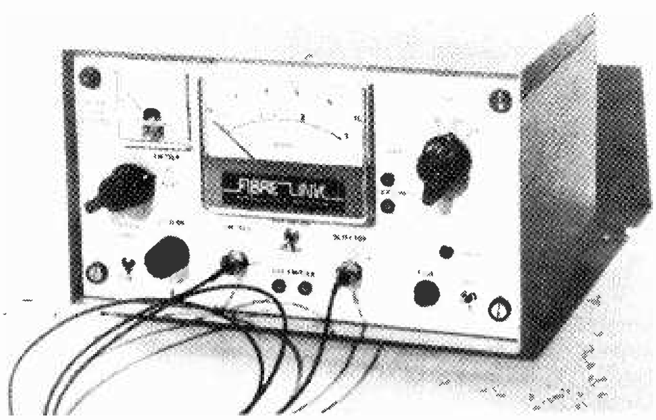
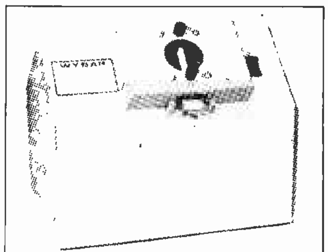


WW 308

Lead forming machine

The model WLF-300, from Eraser International Ltd, is designed to straighten the leads of d.i.l. components for 0.3in lead spacing. By straightening the leads of a component in this way, the com-


WW 311

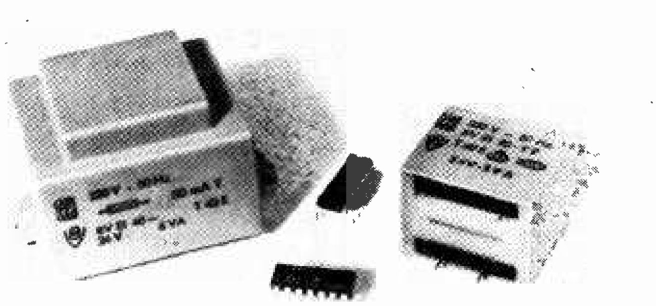
ponent is more easily inserted into a p.c.b., and damage to plated-through holes or the leads themselves is eliminated. The forming machine, which is electrically-operated, is fully automatic and is adjustable for components with different body thicknesses. Setting-up time is minimal and production rates are in excess of 40,000 pieces per hour. The WLF-300 weighs 20lb and measures 11x12x10in.

Eraser International Limited, 2/3 Hampton Court Parade, East Molesey, Surrey KT8 9HB.
WW 311

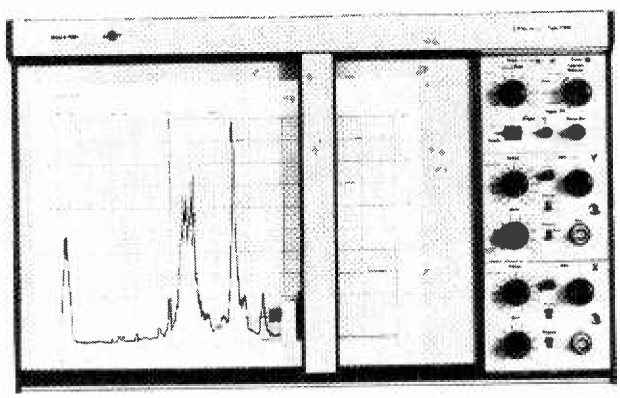
Radio pager with visual backup

A digital radio-paging receiver, from Multitone Electric Co. Ltd, provides a visual display as well as eight tone call-codes. The f.m. receiver, known as the RB151, has call memory and silent-alert facilities, an out-of-range warning facility and the ability to receive group alert calls. Up to four pagers may be called every second, enabling the requirements of large and busy systems to be met. In one mode, the visual facility is a single-digit number, from one to eight, on a large l.e.d. display. This number is associated with its own tone signal. In a second mode, the display can show any number up to 9999 as a sequence of single digits which can be used, for

example, to inform the called person of a telephone number, or the degree of urgency of a call. According to Multitone, the RB151 receiver can be used to convey more information than any other pager on the market and the programming and re-programming of the receiver – to meet almost any requirement – can be done speedily by unskilled personnel. All of these facilities are made possible by the use of c.m.o.s. and bi-polar custom-designed integrated circuits. Multitone Electric Company Limited, 6-28 Underwood Street, London N1 7JT.
WW 312



WW 313



WW 314

P.c.b. mains transformers

A range of p.c.b.-mounting mains transformers, claimed to offer cost savings to bulk buyers, includes open and encapsulated-construction models, of both the power and isolation type. The power ratings are in the range 1 to 125VA, with a large number of the models at the smaller end of the range being quoted as short-circuit proof. The transformers, which are made by Eichoff-Werke, all comply with VDE and DIN specifications and can therefore be used in double-insulated electrical equipment. Typical specifications for the smaller versions could be: 240V primary, 2.4 to 24V secondary for about 1.5VA power, and measuring 25.5 × 27 × 32mm (h × w × l). For bulk orders, special designs with dual secondary outputs and short-circuit-proof operation can usually be supplied. Prices for the smaller versions start at £1.20. Selig Electro-Magnetics Limited, 2 Powis Gardens, London NW11 8HY.
WW 313

X-Y recorder

An X-Y recorder, introduced by B & K Laboratories Ltd, is designated as the Type 2308 and is claimed to have a slewing speed of 1000mm/s. It is designed for fast, accurate recording of linear d.c. characteristics and it can handle rapidly changing voltages without difficulty, it is claimed. Despite the fast slewing speed, overshoot is less than 1% and the error is only 0.2%. The recorder provides 15 calibrated sensitivity ranges from 0.02 to 1000mV/mm and nine calibrated sweep rates from 0.2 to 100mm/s. Paper sizes up to A4 can be accommodated on the 2308 and the writing area is 185 × 270mm. The recorder which has an input impedance of 1MΩ, has floating and grounded input modes with high common-mode rejection and reversible polarity. B & K Laboratories Limited, Cross Lances Road, Hounslow, TW3 2AE.
WW 314

U.h.f. amplifier

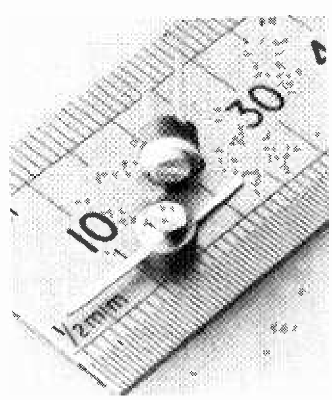
A u.h.f. amplifier, designated the CM7043, has been designed specifically for serving a second tv receiver in instances where

WW 315

only a single outlet or aerial is available. The CM7043, which has a bandwidth from 470 to 860MHz, requires a 220/240V alternating supply and has a maximum output of 16mV (24dBmV). Other specifications include a typical gain of 4dB — to each outlet — and a noise figure of 6dB. Labgear Limited, Abbey Walk, Cambridge CB1 2RQ.
WW 315

Light-emitting diodes

Two red l.e.d.s, types MIL30 and MIL50, have typical minimum light intensities of 0.5mcd at 20mA and are available in a choice of sizes, lens effects and mounting configurations. The diodes are gallium-arsenide-phosphide types in plastic encapsulations and the choice of lens effects includes diffused, clear, transparent and diffused/clear types. Type MIL30 is a 3mm l.e.d. and type MIL50 is a 5mm l.e.d. Both diodes are available with plastic adaptor clips for panel mounting, and are suitable for p.c.b. mounting with wire-wrap leads. Specifications include maximum forward currents of 70mA, maximum reverse voltages of 5V, a spectral half-bandwidth of 40nm, and a peak wavelength of 660nm at 20mA. Micro Electronics Limited, York House, Empire Way, Wembley, Middlesex.
WW 316



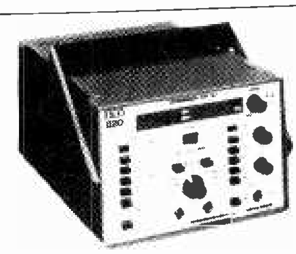
WW 317

Trimmer capacitor

New developments in ceramic technology have enabled the CD5 series of 5mm miniature ceramic-disc trimmers, from Oxley Developments Company Ltd, to be extended to include a high capacitance value of up to 40pF. This trimmer, type CD5/40, has a minimum capacitance of 4pF and is particularly suitable for crystal pulling in quartz-controlled circuits. The CD5 series is BS9000-approved in the capacitance range 0.9–2.0pF to 3.5–25pF. Other recent developments in the CD5 series have been the introduction of horizontal- and back-adjustment configurations. The CD5/40 has a Q value at 1MHz of greater than 200 and a self-resonant frequency of greater than 750MHz. Oxley Developments Company Limited, Ulverston, Cumbria LA12 9QG.
WW 317

Audio frequency test set

On show for the first time in the UK at the Communications '78 exhibition was a test set for measuring transmission levels, frequencies, noise and weighted noise of audio frequency channels and systems. The test set, designated the TTI 1120, has a built-in microprocessor and memory which, in addition to controlling measurements and transmit functions, automati-



WW 318

cally test all major instrument components. This diagnostic routine takes only 12s and the results are shown in word form on an alphanumeric display. A low-distortion precision oscillator acts as the signal source, and this may either be tuned in the bands 50Hz to 4kHz and 1kHz to 20kHz or used in a fixed push-button mode at predetermined frequencies. Level is auto-ranging from −50 to +10.5dBm, noise readings are from −90 to +10dBm, and the frequency range is 50Hz to 20kHz. The Model TTI 1120 is a battery-powered set weighing only 14lb, but a second set, the model TTI 1122, is also available for mains operation. Both sets are manufactured to CCITT specifications and are available from Wandel & Goltermann (UK) Limited, 40-48 High Street, Acton, London W.3.
WW 318

SIDEBANDS by Mixer

If it's Radio 3, this must be Thursday

They tell me you can now buy a tuner which you can programme to switch to any station at any time on any day for a week or more ahead. Well, I can't tell you how happy I am to know that. You realize what it means, of course? No? It means that Friday evenings will be properly occupied from now on.

Can't you just see it? You arrive home after the legendary hard day at the office, and after you've kissed the wife, kicked the cat and got Coronation Street safely out of the way, you settle down with *Radio Times* and calculator for an enjoyable evening's programming. I dare say the choices may sometimes be a little on the agonizing side — in our ménage the decisions are fairly clearly defined between pop and music, although one can imagine this not always being so. But having made the decisions and commanded the wireless to do the right thing at the right time, that's it. No more worries until next Friday.

Mind you, you've got to stick to it. None of these spur-of-the-moment idiocies like wanting to listen to the Archers instead of that fascinating talk on Radio Three entitled "The private life of the dung-beetle." One will have to be very firm with people wanting to go off to bed early or expressing a desire for an hour's quiet read. All back-sliders of that kind are asking for the ultimate penalty — a ten-minute closed-loop sound recording of a Kenny Everett commercial.

Smoothese

All those who are accustomed to hearing and speaking Double Dutch might as well switch off for a couple of minutes, because I'm about to go on again about plain English. My intention is to initiate an on-going elucidation situation, but I doubt very much that I shall do any such thing.

Actually, I was just reflecting that not only is ordinary English maltreated in the most cavalier way to make new, technological words, but these new words themselves are often used in a way that wasn't originally intended. Look at 'software,' for example, Years ago, we used the word 'hardware' in a jocular sense, meaning the equipment itself rather than its circuit diagram. It has always been the fashion to use homely words in our industry — perhaps to show that we are so familiar with the subject that we needn't use the technical description. Then, along came computers and 'software' was used not to mean a circuit diagram, but all the paper associated with the use of a computer. It is now the respectable antonym for a word that was originally used in a slang way. There's another one — "state-of-the-art." No self-respecting PR or marketing man can afford to ignore a buzz-word like that. I remember it being used by our chief engineer back in the '50s, when he would stalk into the lab. and say "Right, what's the state of the art this morning, then?" Presumably, he really meant to ask how the work was going and why were we just sitting there? How it became an adjective, complete with hyphens, I just don't know.

Marketing in its broader sense, meaning sales, market research, press and public relations and the rest, has done its share of debasing the language (*the* language? I wonder if they do it in French and German, as well?) and every time I read one of the publications concerned more with commerce than technique I come across another word I don't understand. Some time ago I kept seeing references to turkey contracts, or I thought I did, but now I know that I was misreading the word 'turnkey.' Well, at least I don't have to wonder why people are spending millions on turkeys any more, but I'm a bit at sea again, because the Concise Oxford says a turnkey is a person in charge of prison keys. I reckon a turnkey contract is one where the vendor has been nicked for laying about him with bribes and finishes up in Brixton.

I was going on to have a go at 'interface' and a passing crack at "hopefully" and "orientated," but I've said enough. It's an on-going deterioration situation, but I've run out of software, so a termination condition is mandatory.

Panic button

Six months of my life. Gone, just like that, in vain expectation. I began to listen to the latest form of mass sado-masochism, the 'phone-in radio programme, last year and ever since I've been waiting with breath well bated for the first naughty word to come resounding through the ether.

Each time the presenter has put down a caller or has cut him off short in the customary loutish way, I've been expecting a faint, pathetic cry of "Oh, knickers", or perhaps something a little more trenchant, to disturb the ordered calm of the studio. I've offered the odd exhortation myself, but it's not the same as hearing it broadcast. I remember my brother-in-law, who operates microphones and things on a film unit, telling me that when they approach a 'man-in-the-street' for his opinion on Mrs Thatcher and ask him if he has a comment, they sometimes get the reply "Yes, I have. – off!" Now, that would be really something. I wouldn't mind paying the licence fee at all, for that.

But it seems that I am the last person in the country to realize that the phone-in presenters have a delay unit with a 'delete expletive' button, so that they can bowdlerize the conversation and, of course, my brother-in-law's tape never sees the light of day at all. I think it's disgraceful, personally — a shameful curtailment of the public's right to be as offensive to the presenter as he is to them. But I don't care — I've stopped listening, now.

No, really?

I heard an interview on the radio the other morning, in the course of which a delightful nun was asked how her order conducted its financial affairs. She thought about it for a bit and said "We don't worry much about money — it doesn't pay." The quote of the week, and it set me off trying to remember quotes from people I have known in the electronics industry. Like the member of the guided weapons trials team at Hatfield who, when their round had missed the target, said "Well, they're expensive, you know — we can't have them colliding with every bit of tin up there."

Or the chap who wanted to show me just how one of our colleagues had collected an 800V shock. "The twit leaned on it like this" he said; whereupon he screamed and went out like a light. Then there was the American reporter who complained, about 60 years ago, that he couldn't get Guglielmo Marconi to give him an interview. "Mr Marconi is a very uncommunicative man," he said, in what must be the canard of the century.

I well remember reading a description of an f.m. carrier deviation monitor in which the writer claimed "The inherent a.m. noise is better than —80dB; and, in fact, with the instrument switched off it is unmeasurable." It is unfair to take remarks like that out of context because, believe it or not, it did make sense when read with the full description, but it stuck in my memory and I couldn't resist it.

Relative

There was a young spaceman called Farr
who went there and back to a starr
and when he came down
just outside Kentish Town
an elderly gent called him "Parr!"

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:

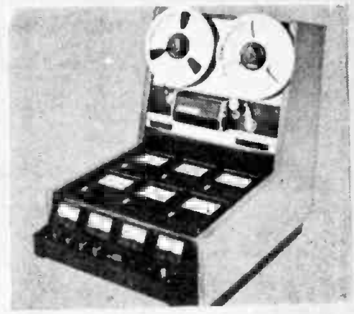
- **Location.** In Central London - easy parking.
- **Delivery.** Large stockholding covering 500 versions for immediate delivery.
- **Servicing** By ITA factory trained staff. Quickest turnaround time. Machines supplied or rebuilt for special requirements.
- **Pricing.** Check our prices - you will 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

1-7 Harewood Avenue, Marylebone Road, London NW1. Tel: 01-724 2497.
Telex: 21879.

THE NEWBEAR COMPUTING STORE

PETITEVID VDU KIT £85

- ★ 110 to 1200 band V24
- ★ 64ch x 16 line, scrolling
- ★ All on 8 x 4 pcb

Needs TV set, UHF modulator and ASCII keyboard

BOOKS

p&p 50p unless otherwise stated

Computer designs. 77-68 a 6800 Microcomputer	£7.50
Spare diagram set for 77-68	£1.50
WB-1 a TTL Microcomputer	£6.50
Spare diagram set for WB-1	£1.00
Zilog. Z-80 Technical Manual	£4.00
Z 80 PIO Technical Manual	£2.50
Motorola. Understanding Microprocessors (30p p&p)	£2.75
M6800 Microprocessor Programming Manual	£4.50
M6800 Microprocessor Applications Manual (£1 p&p)	£9.50
M.O.S. Technology. KIM 1 User Manual	£5.00
6500 Programming Manual	£5.00
6500 Hardware Manual	£5.00
Adam Osbourne. Introduction to Microcomputers	
Vol 0 Beginners Book	£5.95
Vol 1 Basic Concepts	£5.95
Vol 2 Some Real Products (£1 p&p)	£11.95
8080 Programming for Logic Design	£5.95
6800 Programming for Logic Design	£5.95
Some Common Basic Programs	£9.95
Payroll with Cost Accounting in Basic	£9.95
Sybex. Microprocessors Rodnay Zaks	£8.00
Microprocessor Interfacing Techniques C207	£8.00
Some Common Basic Programs P 10	£8.00
Scelbi. 8080 Software Gourmet Guide Cookbook	£7.95
6800 Software Gourmet Guide Cookbook	£7.95
The Scelbi Byte Primer (£1 p&p)	£9.95
What to Do After your Kit Return	£7.00
(PCC First book of Computer Games)	
PCC Reference on Home Computers	£4.95
Instant Basic	£4.95
Your Home Computer	£4.95
My Computer Likes Me	£1.65
Games with a Pocket calculator	£1.75
Games Tricks & Puzzles for a hand calculator	£2.45
Best of Creative Computing Vol 1	£6.95
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Hobby Computers are here	£3.99

Our range of books is constantly expanding. Please write for latest list plus full range of 6800 and Z 80 software

Hardware Components Section

MEMORIES

2102 1	·£1.25	4027 (250ns)	£4.50
2102L 1	·£1.35	2114 (450ns)	£10.00
2112	£3.04	4116 (250ns)	£29.50
2513	£6.50	2708 (450ns)	£10.50

MOTOROLA MICROCOMPUTING ICs

MC6800P	£12.00	SWARBUG	£16.00
MC6820P	£6.20	MC6830L7	£11.33
MC6850P	£6.74	MC8602P	£2.88
MC6810AP	£3.61	MC14536P	£3.69
		MC3459	£2.00

ZILOG MICROPROCESSORS

Z-80 CPU 2 5MHz	£15.50	Z 80A CPU	£20.50
Z-80 PIO PS	£10.00	Z 80A P10	£11.55
Z 80 CTC PS	£10.00	Z 80A CTC	£11.55

MICROPROCESSORS

SC/MP Mk II £10.30 6502 £14.93 2650 £17.50

INTERFACING ICs / BUFFERS

SFF96364	£16.20	VDU		
MC1488P	£1.40		81LS95	£1.30
MC1489P	£1.40		81LS96	£1.30
75150P	£1.30	For V24	81LS97	£1.30
75150N	£1.20	RS232C	81LS98	£1.30
75154	£2.50		8T26	£1.84
4N33	£1.95		8T95	£1.60
AY-5-1013	£5.40		8T97	£1.60
5402		£4.50	74367	£1.30

LOW POWER SCHOTTKY TTL PRICE LIST

74LS00	.18	74LS30	.26	74LS109	.38
74LS01	.21	74LS32	.24	74LS112	.38
74LS02	.21	74LS33	.40	74LS113	.38
74LS03	.21	74LS37	.30	74LS114	.38
74LS04	.26	74LS38	.30	74LS125	.50
74LS05	.26	74LS40	.27	74LS126	.50
74LS08	.21	74LS42	.88	74LS132	.85
74LS09	.21	74LS47	.96	74LS136	.38
74LS10	.21	74LS48	.96	74LS138	.65
74LS11	.26	74LS51	.21	74LS139	.65
74LS12	.21	74LS54	.21	74LS151	.96
74LS13	.55	74LS55	.21	74LS153	.58
74LS14	£1.26	74LS73	.34	74LS154	£1.45
74LS15	.21	74LS74	.38	74LS155	£1.05
74LS20	.21	74LS75	.55	74LS156	£1.05
74LS21	.26	74LS76	.34	74LS157	.60
74LS22	.21	74LS78	.34	74LS158	.65
74LS26	.31	74LS83	£1.05	74LS160	£1.22
74LS27	.21	74LS86	.38	etc	
74LS28	.40	74LS107	.38		

CONNECTORS & SOCKETS

Subminiature D Type

9 way plug	.58	25 way plug	.92
9 way socket	.68	25 way socket	£1.50
9 way cover	.74	25 way cover	.85
15 way plug	.74	37 way plug	£2.10
15 way socket	£1.09	37 way socket	£3.11
15 way cover	.83	37 way cover	£1.19

BEAR BAGS (Kits)

1 177 68 components and edge connectors	£49.50
2 77 68 Led s and switches	£14.95
3 77 68 Power Supply	£17.95
4 77 68 19 5a Rack and Backplane	£27.70
5 77 68 4K Ram P C B and components	£75.00
6 77 68 Mon 1 P C B and components	£50.70
7 4K Ram Exorciser P C B and components	£71.50
8 8K Ram Exorciser P C B and components	£160.00
9 Petitevid V D U Kit	£85.00
10 Kansas City Cassette Interface	£18.95
11 U H F modulator	£4.50

Available direct from us or from your local Bear Bag Stockist (dealer enquiries welcome)

77 68 Corner
(The 6800 Microprocessor that works!)

77 68 Manual (PP50p) £7.50

Veroboard 8 x 8 £4.10

PRINTED CIRCUIT BOARDS

CPU	£10.00
4K RAM	£10.00
Soft Monitor	£10.00
V D U Keyboard interface	T.B.A.
ROM Monitor	T.B.A.
Veroboard 8 x 8	£4.10
Veroboard backplane 8 x 17	£4.30
Hexadecimal Keyboards	£11.25
FND 500 7 segment display	£1.05
Decoder chip	£2.45
ASCII Keyboard (unencoded)*	£27.50
Keyboard assembled and tested*	£86.00
Keyboard case*	£20.33
1 50 P&P	

Goods are normally shipped within 24 hours, subject to availability. Barclaycard & Access. VAT at 8% for Hardware Components. 30p postage and packing unless otherwise stated. Cheques to be made out to "The Newbear Computing Store". Send for an up-to-date catalogue to The Newbear Computing Store 7 Bone Lane Newbury Tel 0635 49223. Callers welcome Monday to Saturday 9 00 a m -5 30 p m. The Newbear Computing Store is a division of Newbury Laboratories Ltd

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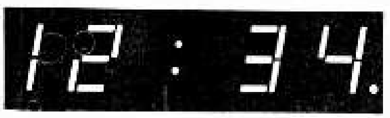
TIME PEACE £9·45*



Not a spelling mistake, but another descriptive term for the National MA1012 *complete* clock & display module

Featuring sleep and snooze timers, 24 hour alarm format, fast and slow setting, alarm output switch

Display area 76 x 20 mm. Total size 3½x8x2 cm.
The MA1012 is non-strobed, with direct drive to the display LEDs, thus causing none of wideband RFI noise associated with earlier clock IC designs. It is suitable for any tuner or radio timing applications, plus all the usual clock applications. Help reduce noise pollution with our MA1012 clock module! The module requires only switches and mains transformer. A suitable 240v AC input transformer is available for £1.50 + 8%vat
Two modules, with two transformers, for £20.00 + 8% VAT.

REFERENCE SERIES TUNER MODULES

EF5803 2 MOSFET AGC RF stages, with low noise selected MOSFETs, MOS mixer, Buffered local oscillator output for counter and synthesizer purposes, 6 tracked tuned circuits, IF and image < 100dB down. £19.75

Ref. FMIF Selectable 2 or 3,6 pole linear phase IF filters, two MOS IF preamps, twin detector coil for 0.07% THD Δf 22.5kHz. Noise mute, deviation mute, adjustable range AFC, meter output £16 25

Ref. MPX With the incomparable HA1196 PLL low noise, wide range decoder IC, preamp and LC low pass filter on input, twin LC pilot and base-bandpass filters on the output. With 2 x LM380N ICs for monitor amp purposes available on the board £16.45

Our other ranges of FM and AM tuner modules available as before

EF5801	17 45	EF5600	12 95	7252	26 50	7122	13 22
7030	10 95	EC3302U	7 50	7253	26 50	*Most also available in kits*	
91196	12 99	8319	11 45	91197	11 35	*details in catalogue & price list*	

COILS FOR LW, MW, SW 1,2, and 3 now listed in catalogue 30 & 33p ea
TOKO 10k series coils now for 1.5 to 30MHz, giving a total coverage in osc and rf coils

Low cost meters: Internally illuminated edgewise meters 200uA, and back lit flat face meters 200uA. A wide choice of scales - or material to DIY.

Equipment boxes: These must be the best value in ABS (black) equipment boxes with close fitting (flanged) lids. 8x6x4 (cms) 54p ea*, 10x7.5x4 (cms) 66p ea*, and 12x10x4.5 (cms) 76p ea*. Also new stackable component storage boxes and trays.

DETECKNOWLEDGEY: theory and practise of metal locator principles including BFO IB, phase angle, pulse induction. A unique reference for users and constructors. £1.00

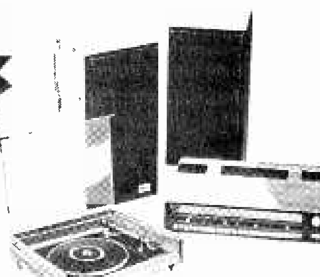
Our usual unique range of coils, filters etc for radio: from TOKO; 350,000 in stock. The best in linear ICs for RF, HA1137:£2.20; HA1196:£4.20; HA1197:£1.40, plus all common radio and multiplex devices, audio ICs (TBA810AS £1.09), MOSFETs, a unique line in varicap diodes for AM tuning :: see the latest catalogue for details. 45p

Postage 25p per order, VAT 12.5% except where otherwise indicated (*8%). Send to: 2 Gresham Road, Brentwood, Essex. tel (0277) 216029. Only 200m from station!

ambit international

WW—051 FOR FURTHER DETAILS

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



from the

Lion House

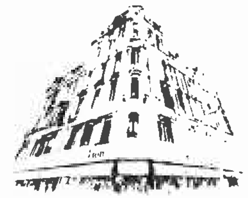
BUDGET HI-FI DEPARTMENT

You can now purchase this fantastic Hi-Fi system complete for only £152.00 at what must be a fraction of its 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 LH6 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.

LION PRICE: Complete MATSI System £152.00
or purchased individually:
TF60 Receiver: £69.90. LH6 Twin Speakers £55.
Goldring Turntable (cartridge Plinth & Cover) £29.95

Leading suppliers of TELEVISIONS, RADIOS, TAPE RECORDERS, BUDGET HI FI, CASSETTE RECORDERS, SPEAKERS, AMPLIFIERS, TUNER AMPS, VIDEO and MUSIC CENTRES and ACCESSORIES. EXPORT TELEVISIONS and MUSICAL INSTRUMENTS. ALL AT KEEN PRICES



Lion House

WW—047 FOR FURTHER DETAILS

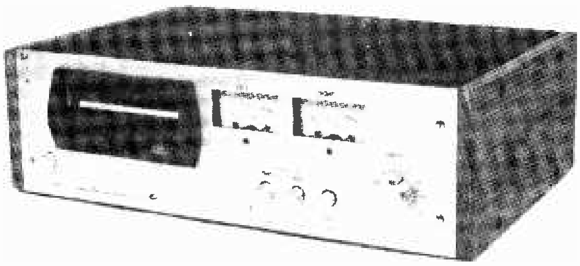
The *Only* Firm for *Quality* Audio Kits

HART ELECTRONICS

Are proud to offer the only DESIGNER APPROVED kit for the

J. L. Linsley-Hood High Quality Cassette Recorder

Now offered with Super Quality Sendust Alloy Head at no extra cost, and incorporating noise reduction modifications given in the postscript article.



As these circuits are capable of such an excellent performance we feel that it is not sensible to sacrifice this potential by designing a kit down to a price We have therefore spent a little more on professional hardware allowing us to design a very advanced modular system This enables a more satisfactory electrical layout to be achieved, particularly around the very critical input areas of the replay preamps These are totally stable with this layout and require no extra stabilising components Many other advantages also come from this system which has separate record and replay amps for each channel plugging in to a master board with gold-plated sockets The most obvious is the reduction of crosstalk and interaction which could cause trouble on a single plane board with our modular system the layout is compact but there is no component crowding Testing is very easy with separate identical modules and building with the aid of our component-by-component instructions is childlishly simple but the finished result is a unit designed not to normal domestic standards but to the best professional practice

All printed circuits are of glassfibre material, fully drilled with a tinned finish for easy and reliable soldering Component locations are printed on the reverse side of the board and are arranged so that all identification numbers are still visible after assembly

71x Complete set of parts for Master Board includes bias oscillator relay controls, etc £9 83 + £1 23 VAT

72x Parts for Motor Speed and Solenoid Control for Lenco CRV deck This is the proper board layout as given in the articles £3 52 + 44p VAT

73x Complete set of parts for stereo Replay Amps and VU Meter drive £8 12 + £1 02 VAT

74x Complete set for stereo Record Amps £6 74 + 84p VAT

75x Complete set of parts for Stabilised Power Supply to circuit given in Article This uses a special low hum field transformer with better characteristics than the commonly used toroid £8 79 + £1 10 VAT

700M2 Individual High Quality VU Meters with excellent ballistics £8 48 + £1 06 VAT Per Pair

700C/2 High Quality Custom built steel Case Complete with Brushed aluminium front plate, mains switch record microswitch turned record level knob plastic cabinet feet, all bolts nuts and mounting hardware All necessary holes are punched and all surfaces are electroplated Complete step-by-step assembly instructions are included The cover is finished in an attractive black crackle surface £16 50 + £2 06 VAT

LENCO CRV CASSETTE MECHANISM — Now fitted with Super Quality Sendust Alloy Head.

High Quality robust cassette transport for Linsley-Hood recorder Features fast forward fast rewind record, pause and full auto stop and cassette ejection facilities Fitted with Record / play and erase heads and supplied complete with Data and extra cassette ejection spring for above horizontal use Price £21 60 + £2 70 VAT

Total cost of all parts £83 58

Special offer for Complete Kits £81 50 + £10 19 VAT

Complete with data and set up notes to achieve best results with the Super Head

Optional extra solid teak end cheeks, £3 pair + 38p VAT

Reprint of 3 Linsley-Hood Cassette Recorder articles 45p post and VAT free

OTHER CASSETTE SPECIALITIES

LENCO MECHANISMS For industrial or domestic use We have in stock SPFF, FFR and CRV with DC and AC motors Mini T8500 502, 504 and Mini TB 'U' for endless loop cassettes Send for details

Super Quality Sendust Alloy R/P Stereo Head for replacement use £6.50 + 81p VAT

Set of components and data for optimising L-H Cassette circuits for use with this head 50p + 6p VAT

Standard Quality Stereo R/P Head, £4 50 + 56p VAT

Economy Cassette Stereo R/P Head, £2 80 + 35p VAT

4-track Cassette R/P Head £7 40 + 93p VAT

TEST CASSETTE to enable the user without instruments to easily set up the Head Azimuth tape speed and VU level, £1 50 inc VAT

Blank Cassettes reliable mechanics and Super Ferric Low Noise tape, C90, 80p inc VAT C10 35p inc VAT

Penylan Mill, Oswestry, Salop

Personal callers are always welcome but please note we are closed all day Saturday

MILITARY VEHICLE NAVIGATION EQUIPMENT

INVERTORS SOLID STATE for use on 24v DC, provides stab sine wave o/p of 26v 3 phase 400c/s max total load 120 watts with short circuit protection, fitted in heavy finned die cast case size 12 x 6¼ x 5½". I/P 7.4 amps for 100 watts o/p connections via two AN type plugs, supplied tested, Price £43.20.

NAVIGATIONAL COMPUTER. Accepts mechanical o/p from vehicle via multi ratio gearbox 9 to 11.1 in 40 steps, also contains two Autosyn Tx units 26v 400c/s, Servo Motor & transis amplifier Mech Ball resolver with elec shaft coders, precision gears, etc. in case size 8 x 5 x 8". Price £16.20.

INDICATOR UNIT display unit shows heading, eastings and northings, contains 26v 400c/s Autosyn Rx unit, two 4 digit veeder counters with shaft digitizers and reset these are driven by two precision 27v DC motors in case size 8 x 4 x 6". Price £10.80.

INDICATOR remote heading indicator with 26v 400c/s Autosyn Rx scale 0 to 64 mils x 100, 3½" dia. Price £3.50.

The above items were made in Canada and contain components of American make or style, all units in good condition.

GENERATOR UNIT. Hand or foot operated portable unit provides nom o/p of 110v AC 40 watts with o/p voltage indicator, comes with various accessories (table and tree clamps), breaks down into 6 major components, supplied in fitted transit container along with carrying haversacks, new unused made for M.O.D. Price £32.40.

SIGNAL GENERATOR. Portable VHF, UHF spot freq generator crystal controlled (crystal fitted in oven) provides o/ps at 105, 125, 150, 230, 300 and 390Mc/s CW or Int lKc Mod, intended for checking operation of VHF/UHF DF equip. Operates from internal 6v lead acid battery with int battery charger 115v 60c/s, supplied with two batteries mounting tripod and copy of handbook, new American equipment. Price £65.

CLOSED CIRCUIT T.V. EQUIPMENT limited number of Marconi Industrial TV systems valve type complete except for camera lense, consists of Camera, Camera C.U. Monitor 14" and camera cable, serviceable condition, with circs, for callers only. Price £108.

SPECIAL PURPOSE EQUIP. AN/TMQ-14 Infra Red Cloud base measuring equipment and AN/TPQ-11 Radar Cloud height measuring equipment. Q Band. GPA-70 Video Map unit, enquire.

Above prices include carriage and VAT goods ex-equipment unless stated new. SAE for list or enquiry. Shop open Tuesday to Saturday.

A. H. SUPPLIES
122 Handsworth Road, SHEFFIELD S9 4AE
Phone 444278 (0742)

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REGULATED POWER SUPPLIES

Protection:

All models internal foldback, overload, thermal and short circuit protected Fully fused.

2-YEAR GUARANTEE

Type AD12 - AD24 (Illustrated)

TYPES AVAILABLE

MODEL NO.	AD12	AD24	AD2412	ADV030
OUTPUT CURRENT	8 amp	8 amp	16 amp	5 amp
NOMINAL OUTPUT VOLTS	12	24	12	0 to 30 Fully varifiable and metered
INPUT VOLTS	115-230-250 50 cycles a/c	115-230-250 50 cycles a/c	24 DC	115-230-250 50 cycles a/c
TOLERATED MAINS VARIATION	15%	15%		15%

PRICES

1 off — AD 12-AD24 . . . £52 50
1 off — AD 2412 . . . £48.00
All subject to VAT @ 8%

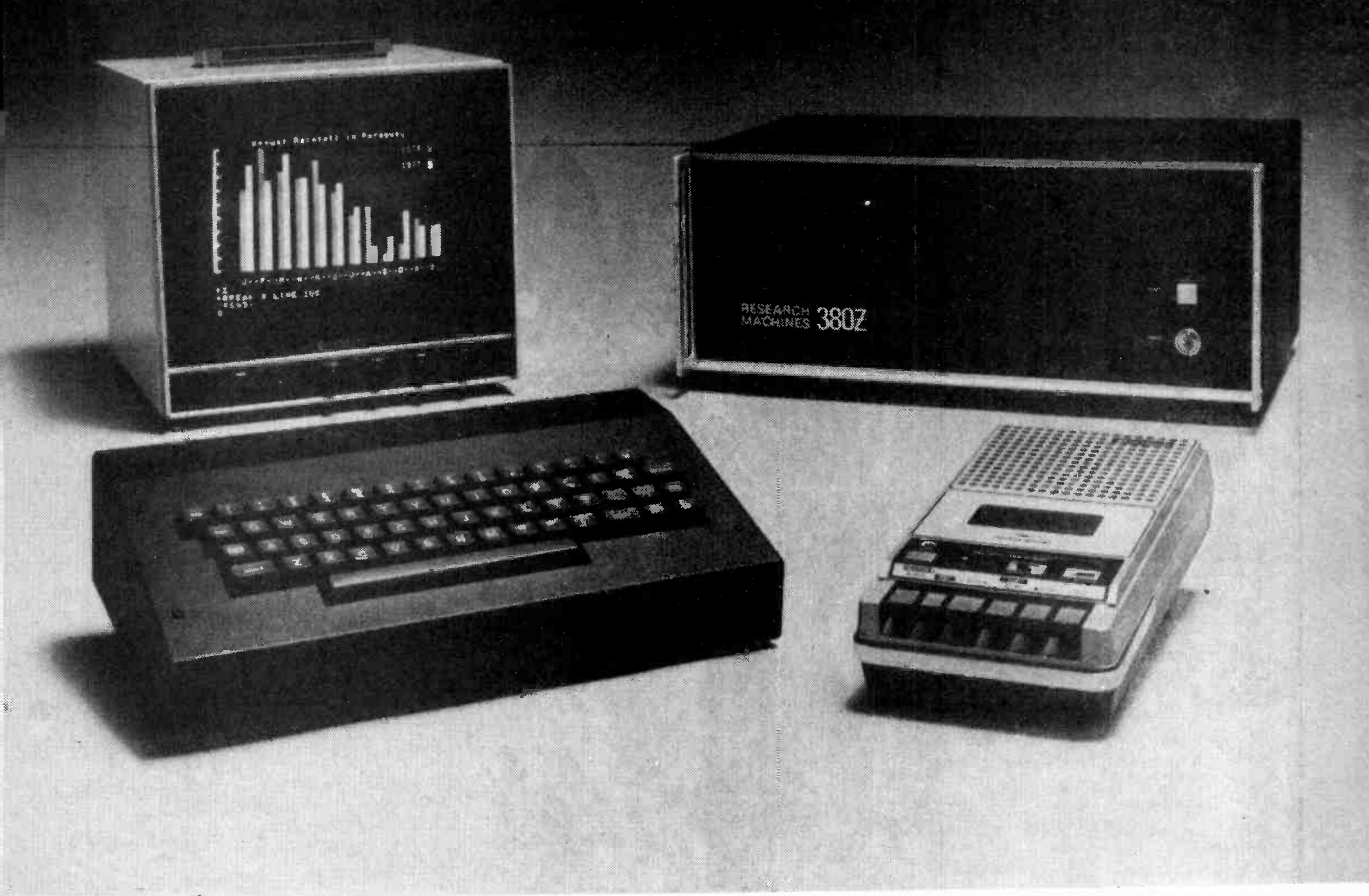
1 off — ADV030 . . . £102 00

SOUTHERN ELECTRONICS

6 WESTCLIFF ARCADE, RAMSGATE, KENT
TEL. THANET (0843) 57888

WW — 118 FOR FURTHER DETAILS

THE EXPANDABLE GENERAL-PURPOSE MICROCOMPUTER



RESEARCH MACHINES 380Z

COMPUTER SYSTEMS

A professional microcomputer system with excellent support for scientific and educational users.

380Z systems come complete with:

- Z80A Processor
- RAM Memory
- 3K ROM Operating System
- VDU Interface
- Cassette Interface
- Parallel Input/Output
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- Room for Expansion
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Only an inexpensive cassette recorder and a television are needed to make the system fully operational. No teletype or VDU terminal are required.

The standard 380Z system is expandable to include:

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The RESEARCH MACHINES 380Z is a professional general-purpose microcomputer. It has found broad application in Scientific Research and Education with a large number of systems in use in the field. The system is supported by an excellent range of software including Text Editor, Basics and Assemblers.

RESEARCH MACHINES 380Z System with 16K Bytes of RAM

£965.00

RESEARCH MACHINES 380Z System with 32K Bytes of RAM

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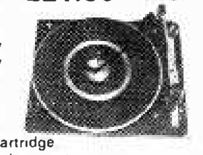
RESEARCH MACHINES Computer Systems are distributed through SINTEL, P.O. Box 75, 209 Cowley Road, Oxford. Telephone: OXFORD (0865) 49791. Please contact SINTEL for the 380Z Information Leaflet. Prices do not include VAT @ 8% or Carriage.

U.K. RETURN OF POST MAIL ORDER SERVICE, ALSO WORLDWIDE EXPORT SERVICE

BSR HI-FI AUTOCHANGER STEREO AND MONO £21.50 Post £1



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. Below motor board 2½in with Sonotone V100 magnetic cartridge

BSR P128/MP60 with magnetic cartridge. Balanced arm Cueing device Bias Compensator **£24.50.** Post £1

NEW BSR SINGLE PLAYER £19.95

Model P182 3-speeds flared aluminium turntable Post £1 "S" shaped arm, cueing device, stereo ceramic cartridge

B.S.R. Budget Autochanger with stereo cartridge, plays all size records **£12.95**

HEAVY METAL PLINTHS

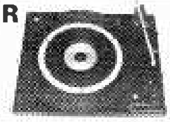
With P.V.C. Cover. Cut out for most BSR or Garrard decks. Silver grey finish **£6.50** Post £1.50

Model "A" Size 12½ x 14¾ x 7½in

Model "B" Size 16 x 13¾ x 7in **£7.50**

Extra large plinth & cover, teak wood base Size 20 x 17½ x 9 **£18.50.** Shop callers only

BSR SINGLE PLAYER



Ideal replacement or disco deck with cueing device and stereo ceramic cartridge. 3 speeds Large turntable, modern design

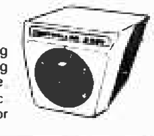
£17.50 Post £1

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 10 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

TEAKWOOD LOUDSPEAKER GRILLES will easily fit to baffle board. Size 10½ x 7⅞in—**45p.**

GARRARD AP75 SINGLE RECORD PLAYER

3-speed balanced arm semi-transcription unit less cartridge **£27.50** Post £1

VOLUME CONTROLS

5kΩ to 2MΩ. LOG or LIN L/S **35p.** D.P **60p.** STEREO L/S **85p.** D.P **£1.** Edge 5K S.P Transistor **45p.**

80 Ohm Coax 8p yd.

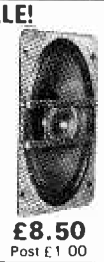
FRINGE LOW LOSS **15p** yd.

Ideal 625 and colour PLUGS **10p.** SOCKETS **10p.** LINE SOCKETS **18p.** OUTLET BOXES **50p.** 300 ohm FEEDER **5p** yd

ELAC 9 × 5in HI-FI SPEAKER TYPE 59RM £3.45 Post 35p

This famous unit now available 10 watts 8 ohm

E.M.I. 13½ x 8in. SPEAKER SALE!



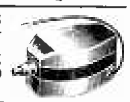
With tweeter and crossover. 10 watt 3 or 8 ohm. **£7.95** Post 45p

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. **£11.50** Post 75p

Bookshelf Cabinet Teak finish. For EMI 13 x 8 speakers. **£8.50** Post £1 00

THE "INSTANT" BULK TAPE ERASER AND HEAD DEMAGNETISER. Suitable for cassettes, and all sizes of tape reels. A.C. mains 200/250V. Leaflet S.A.E. Will also demagnetise small tools. **£4.95** Post 50p



RELAYS. 12V 0 C **95p.** 6V 0 C **85p.** 240V A C **95p.**
BLANK ALUMINIUM CHASSIS. 6 x 4—**95p;** 8 x 6—**£1.40;** 10 x 7—**£1.55;** 12 x 8—**£1.70;** 14 x 9—**£1.90;** 16 x 6—**£1.85;** 16 x 10—**£2.20. ANGLE ALI.** 6 x ¾ x ¾in—**15p.**
ALUMINIUM PANELS. 6 x 4—**24p;** 8 x 6—**38p;** 14 x 3—**40p;** 10 x 7—**54p;** 12 x 8—**70p;** 12 x 5—**44p;** 16 x 6—**70p;** 14 x 9—**94p;** 12 x 12—**£1;** 16 x 10—**£1.16.**
ALI BOXES IN STOCK. MANY SIZES
VARICAP FM TUNER HEAD with circuit & connections **£4.95.**
TAG STRIP 28-way **12p.**
TAPE OSCILLATOR COIL. Valve type. **35p.**
BRIDGE RECTIFIER 200V PIV ½ amp **50p.** 8 amp **£2.50.**
TOGGLE SWITCHES S.P. **30p.** D.P.S.T **40p.** D.P.D.T **50p.**
MANY OTHER TOGGLES IN STOCK
PICK-UP CARTRIDGES ACOS. GP91 **£1.50.** GP95 **£2.50.**
SONOTONE stereo **£2.00. SHURE** M75 ECS **£8.**
WIRE-WOUND RESISTORS 5 watt. 10 watt. 15 watt **15p ea.**

R.C.S. SOUND TO LIGHT KIT Mk. 2

Kit of parts to build a 3 channel sound to light unit 1,000 watts per channel Suitable for home use Easy to build. Full instructions supplied. Cabinet **£4.** Will operate from 20MV to 100 watt signal. **£17** Post 35p

R.C.S. LOW VOLTAGE STABILISED POWER PACK KITS

All parts and instructions with Zener diode, printed circuit rectifiers and double wound mains transformer Input 200/240V a c. Output voltages available, 6 or 7 5 or 9 or 12V d.c up to 100mA or less. Size 3 x 2½ x 1½in Please state voltage required. **£2.95** Post 45p

R.C.S. POWER PACK KIT

12 VOLT, 750mA. Complete with printed circuit board and assembly instructions. 12 VOLT 300mA KIT, **£3.15.** **£3.35** Post 30p

R.C.S. "MINOR" 10 watt AMPLIFIER KIT

This kit is suitable for record players, guitars, tape playback, electronic instruments or small P.A systems. Two versions available Mono **£12.50;** Stereo **£20.** Post 45p. Specification 10W per channel, input 100mV; size 9½ x 3 x 2in. approx. S A E details Full instructions supplied. AC mains powered.

R.C.S. DRILL SPEED CONTROLLER/LIGHT DIMMER KIT. Easy to build kit. Will control up to 500 watts AC mains **£3.25** Post 35p

R.C.S. STEREO PRE-AMP KIT. All parts to build this pre-amp Inputs for high, medium or low imp per channel, with volume control and P.C. Board Can be ganged to make multi-way stereo mixers **£2.95** Post 35p

MAINS TRANSFORMERS ALL POST 75p

250-0-250V 70mA 6 5V 2A	£3.45
250-0 250V 80mA 6 3V 3 5A 6 3V 1A	£4.60
350-0-350V 80mA 6 3V 3 5A 6 3V 1A	£5.80
300-0 300V 120mA 2×6 3V 2A C T 5V 2A	£8.50
220V 45mA 6 3V 2A	£1.75
HEATED TRANS 6 3V ½ amp	£1.00
Ditto 3 amp	£1.75

GENERAL PURPOSE LOW VOLTAGE Tapped outputs

2 amp 3 4 5 6 8 9 10 12, 15 18 25 and 30V	£5.30
1 amp 6 8 10 12 16 18 20, 24 30 36 40 48 60	£5.30
2 amp 6 8 10 12 16 18 20, 24, 30, 36 40 48 60	£8.50
3 amp 6 8, 10 12 16 18 20, 24, 30 36 40, 48 60	£11.00
5 amp 6 8 10 12 16 18 20 24 30 36 40, 48 60	£14.50

12V 100mA	£1.00	20V 40V 60V 1 amp	£3.50
12V 750mA	£1.30	12V 300mA	£1.00
20V 3 amp	£2.45	10V 30V 40V 2 amp	£2.75
30V 5 amp and 17V-0-17V, 2 amp	£3.45	40V 2 amp	£2.95
		20V 1 amp	£2.20
0 5 8 10 16V ½ amp	£1.95	20V-0-20V 1 amp	£2.95
9V 3 amp	£2.75	30V-0-30V, 2 amp	£7.00
24V. 3 amp + 48V ½ amp	£3.50	2 of 18V, 6 amp	£9.00
		12-0-12V 2 amp	£2.95
30V 1½ amp	£2.75	9V ¼ amp	£1.30

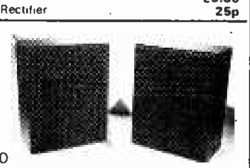
AUTO TRANSFORMERS 115V to 230V or 230V to 115V 150W **£5.00** 250W **£6.00.** 400W **£7.00** 500W **£8.00**

FULL WAVE BRIDGE CHARGER RECTIFIERS 6 or 12V outputs. 2 amp **75p.** 4 amp **£1.00**

CHARGER TRANSFORMERS 1½ amp **£3.50** 4 amp **£6.80**

12V. 1½ amp Half Wave Selenium Rectifier **25p**

BOOKSHELF SPEAKERS



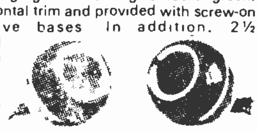
Teak or White 13 × 10 × 6in approx 50 to 14,000 cps 10 watts rms 4 ohms

£16 pair Post £1.30

EXTENSION SPEAKERS £3.95 ea.

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 or 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 Full Range Frequency Response Impedance 8 ohms Power Peak 5 watts



LOW VOLTAGE ELECTROLYTICS
1, 2, 4, 5, 8, 16, 25, 30, 50, 100, 200mF 15V **10p.**
500mF 12V **15p;** 25V **20p;** 50V **30p;**
1000mF 12V **17p;** 25V **35p;** 50V **47p;** 100V **70p.**
2000mF 6V **25p;** 25V **42p;** 420mF/500V **£1.30.**
2500mF 50V **62p;** 3000mF 25V **47p;** 50V **65p.**
3900mF 100V **£1.60.** 4700mF 63V **£1.20.** 2700mF/76V **£1.**
5000mF 6V **25p;** 12V **42p;** 35V **85p.** 5600mF/76V **£1.75**
MANY OTHER ELECTROLYTICS IN STOCK

SHORT WAVE 100pF air spaced gangable tuner. **95p.**
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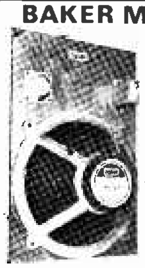
MICRO SWITCH SINGLE POLE CHANGEOVER 20p.
SUB-MIN MICRO SWITCH, 25p. Single pole change over
TWIN GANG, 385 + 385pF **50p;** 500pF standard **75p.**
365 + 365 + 25 + 25pF, Slow motion drive **65p.**
120pF **TWIN GANG, 50p;** 365pF **TWIN GANG, 50p.**
NEON PANEL INDICATORS 250V. Amber or red **30p.**
RESISTORS. 10Ω to 10M. ¼W, ½W, 1W, 20% **2p;** 2W. **10p.**
HIGH STABILITY. ½W 2% 10 ohms to 1 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" £16.88

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 **£20.52** 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 **£12.96**	12in 40W **£15.12**	15in 75W **£28.08**
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 **£22.68** Post £1 60

TEAK VENEERED HI-FI SPEAKERS AND CABINETS
For 12in or 10in speaker 20x13x12in **£14.50** Post £2
For 13x8in or 8in speaker **£8.50** Post £1
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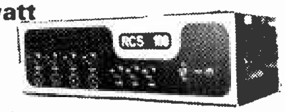
Many other cabinets in stock. Phone your requirements.
SPEAKER COVERING MATERIALS. Samples Large S A E
LOUDSPEAKER CABINET WADDING 18in wide **20p** ft

R.C.S. 100 watt VALVE AMPLIFIER CHASSIS



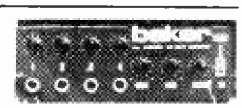
Four inputs Four way mixing, master volume, treble and bass controls. Suits all speakers. This professional quality amplifier chassis is suitable for all groups, disco, P A, where high quality power is required. 5 speaker outputs A/C mains operated Slave output socket. Produced by demand for a quality valve amplifier 100V line output to order Send for leaflet

Suitable carrying cab **£16.50** Price **£94** carr £2 50

Horn tweeters 2-16kc/s 10W 8 ohm or 16 ohm **£3.60.**
Audax Tweeters 3-18kc/s. 50W 8 ohm **£7.50.**
CROSSOVERS. TWO-WAY 3000 c/s 3 or 8 or 15 ohm **£1.90.** 3-way 950 cps/3000 cps. **£2.20.**
LOUDSPEAKERS P.M. 3 OHM 7x4in **£1.50;** 6½in **£1.80;** 8x5in, **£1.90;** 8in, **£1.95.**
SPECIAL OFFER: 80 ohm 2¼in, 2¾in, 35 ohm, 3in 25 ohm, 2½in, 3in, 5x3in, 7x4in., 8 ohm, 2½in, 3in, 3½in, 5in., 15 ohm, 3½in dia, 6x4in., 7x4in, 5x3in, 3 ohm, 2½in, 2⅝in., 3½in., 5in dia **£1.50 each.**
PHILIPS LOUDSPEAKER, 8in, 4 ohms, 4 watts, **£1.95**
RICHARD ALLAN TWIN CONE LOUDSPEAKERS 8in diameter 4W **£2.50.** 10in. diameter 5W **£2.95;** 12in. diameter 6W **£3.50.** 3/8/15 ohms, please state
MOTOROLA PIEZO ELECTRIC HORN TWEETER. £7.95 Handles up to 100 watts No crossover required.

Black Plastic Construction Box with brushed aluminium facia Sturdy job Size 6¼ x 4¾ x 2in **£1.50**

BAKER 150 WATT PROFESSIONAL MIXER AMPLIFIER



All purpose transistorised Ideal for Groups, Disco and P A 4 inputs speech and music. 4 way mixing Output 4 8/16 ohms a c Mains Separate treble and bass controls Master volume control. Guaranteed Details S.A.E. **£85** £1 50 carr

100 WATT DISCO AMPLIFIER

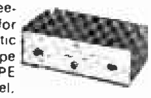
volume, treble, bass controls. 500 M.V. or 1 volt input Four loudspeaker outputs 4 to 16 ohm. All transistor **£59**

GOODMANS COMPACT 12-INCH BASS WOOFER

Standard 12in diameter fixing with cut sides 10⅜ square 14 000 Gauss magnet 30 watts R.M.S 4 ohm imp. Bass resonance = 30 c p s. Frequency response 30-8000 c.p s. **£10.95 each** Post £1

ALUMINIUM HEAT SINKS. FINNED TYPE. Sizes 6½" × 4½" × 2¼" **95p.** 6½" × 2" × 2¼" **65p.**
BALANCED TWIN RIBBON FEEDER 300 ohms. 5p yd.
JACK SOCKET Std. open-circuit 20p, closed circuit 25p;
Chrome Lead-Socket 45p. Mono or Stereo.
Phono Plugs 8p. Phono Socket 8p.
JACK PLUGS Std. Chrome 30p; Plastic 25p; 3.5mm 15p.
STEREO JACK PLUG 30p. SOCKET 25p.
DIN SOCKETS Chassis 3-pin 10p. 5-pin 10p.
DIN SOCKETS FREE 3-pin 25p; 5-pin 25p. DIN PLUGS 3-pin 25p; 5-pin 25p. VALVE HOLDERS, 10p; CANS 10p.
TV CONVERGENCE POTS 15p each
Values = 5, 7, 10, 20, 50, 100, 200, 250, 470, 2000 ohms

MONO PRE-AMPLIFIER. Mains operated solid state pre-amplifier unit designed to complement amplifiers without low level phono and tape input stages This free-standing cabinet incorporates circuitry for automatic R.I.A.A equalisation on magnetic phono input and N.A.B equalisation for tape heads Power ON/OFF, PHONO/TAPE switches and pilot lamp are on the front panel, phono socket input and output are rear located **£4.50 each or £8 pair.** Post 50p



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Catronics

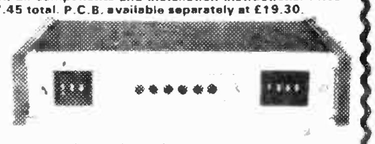
REMOTE CONTROL FOR WW TELETEXT DECODER

A modification kit is now available to give Remote Control selection of all functions except setting the time select thumbwheel switches. The Remote Copford Unit is housed in a cabinet approx. 6" x 3" x 2" and connected to the main decoder by approx. 5 yds. screened cable.

PRICE ONLY £14.60 + 50p P&P

'Board 3' is also 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 December and January issues 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. P.C.B. available separately at £19.30.



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	£23.40	£23.35	30p
Component Kit (incl. PCBs)	£122.65	£135.40	£1 50
Add-on Unit for lower case: PCB	£2.70	—	—
Component Kit (incl. PCB)	£13.75	—	—
Cabinet	£18.00	£18.00	£1.00

PLATED THROUGH hole PCBs for TEXAS version only at additional cost of £26.00

FULL FAULT-FINDING AND REPAIR SERVICE AVAILABLE

'COMPONENTS ALSO AVAILABLE SEPARATELY — SAS for price list

READY BUILT & TESTED DECODERS — £241.87 + £5 Carr.

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CHARACTER GENERATOR, MEMORY, 7400 I.C.S.

TEXAS 74S262N (X887) NOW ONLY £14.50

SIGNETICS 2513 £8.50: NATIONAL 2102/2602 £2.25

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£149.85 ACCESS OR BARCLAYCARD
Details 15p stamps or 4 I R C Foreign

AS WELL AS DRAKE EQUIPMENT, WE ARE THE DIRECT IMPORTERS OF HAL RTTY AND MICROPROCESSORS, ATLAS, NYE MORSE KEYS, PRESTEL VHF/UHF PROFESSIONAL FIELD STRENGTH METERS, HAM RADIO, CIR ASTRO 200, HY-GAIN, CDR ROTORS, HUSTLER, OMEGA-T SYSTEMS, MFJ FILTERS AND SPEECH PROCESSORS, SUPEREX. WE ALSO STOCK SHURE MICROPHONES, YAESU, MICROWAVE MODULES, SOLID STATE MODULES, ICOM, COPAL CLOCKS, G-WHIPS, BANTEX, MOSLEY, DAIWA, ASAHI, JAYBEAM, DECCA AND THE USUAL ACCESSORIES—COAX, CONNECTORS, INSULATORS, VALVES, Etc

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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 14
152	250	12.79	1.50
153	350	16.28	1 84
154	500	19.15	2 15
155	750	29.06	OA
156	1000	37.20	OA
157	1500	45.60	OA
158	2000	54.80	OA
159	3000	79.05	OA

★115 or 240 sec only. State volts required.

12 and/or 24-VOLT

Separate 12V windings Pri 220-240V

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	3.51	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

Pri 220-240V. Sec. 0-20-25-33-40-50V. Voltages available 5, 7, 8, 10, 13, 15, 17, 20, 33, 40 or 20V-0-20V and 25V-0-25V

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

Pri 220-240V
Sec. 0-12-15-20-24-30V
Voltages available 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 20, 24, 30V or 12V-0-12V and 15V-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

Pri 220-240V
Sec. 0-24-30-40-48-60V. Voltages available 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60V or 24V-0-24V and 30V-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	.. ..	23.28	OA
95	2000	.. ..	34.82	OA
73	3000	.. ..	48.00	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

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	41.76	OA
2000	252	54.25	OA

BRIDGE RECTIFIERS

200v	2A	45p
400v	2A	55p
200v	4A	65p
400v	4A	80p
400v	6A	£1.05
500v	10A★	£2.35

★P&P 15p. VAT 12½% ★VAT 8%

CASED AUTO. TRANSFORMERS

240V Cable Input USA 115V
Flat pin outlets.

		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
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

TEST METERS

AVO8 Mk. 5	£77.10
AVO71	£31.30
AVO73	£42.50
AVOMM5 MINOR	£26.10
WEE MEGGER	£64.00
AVO TT169 (tests transistors to circuit, no soldering)	£32.50
U4315 budget meter (42 ranges) 20Km/VDC 1000V AC/DC (9 ranges) 2.5A AC/DC 500Km resistance, in robust steel case with leads, full instructions.	£15.85
EM272	£50.70
DA116 Digital	£100.00
Megger BM7 (Battery)	£42.50

Avo Cases and Accessories
Ex-stock. P&P £1.15. VAT 8%

PANEL METERS

2	0-50µa	£5.50	4	0-50µ A	£6.70
2	0-100µ A	£5.50	4	0-100 µ A	£6.70
2	0-500 µ A	£5.50	4	0-500 µ A	£6.70
2	0-1mA	£5.50	4	0-1 mA	£8.40
2	50V	£5.50		0-50V	£8.40

VU Indicator Panel 48-45 250µ a FSD £2.60
VU Indicator Edge 54x14 £2.60
Carriage 65p VAT 8%

MINI-MULTIMETER

DC1000V, AC-1000V
AC/DC-1000Ω/V
DC-100mA Res — 150K
Bargain at **£5.86**
VAT 8% P&P 62p

NEW RANGE HIGH QUALITY TRANSFORMERS. Sec 45 36-0-36, 45 sec to give 36-0-36, 45-0-45 72V or 90V.

2A **£9.89** PP £1 38 5A **£16.74** PP £2 15
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4A **£13.90** PP £1 84

ABS PLASTIC BOXES

Inset brass nuts, slots to take PC cards (boards) flush fitting lid

PB1 80mm x 62 x 40	.56p
PB2 100mm x 75 x 40	.63p
PB3 120mm x 100 x 45	.70p

P&P 29p VAT 8%

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3300. 6, 7.5, 9v at 300mA plugs direct into 13A socket (fused). £3.30
STABILISED 3, 6, 7.5, 9v at 400mA £6.61

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Avo Meter (107) Ranges DC to 1000V current to 1 amp AC to 1000V 3 ohmic ranges to 10M. ohms 10.000 DC 1,000 AC safety cut out £40.00

ANTEX SOLDERING IRONS

15W **£3.75.** 18W **£3.75.** 25W **£3.95**
Stand for above **£1.40.** P&P 46p. VAT 8%

PLEASE ADD VAT AFTER P&P

SEMICONDUCTOR, RESISTOR, CAPACITOR, SEMICONDUCTOR AUDIO ACCESSORIES & BARGAIN PAKS. SAVE POSTAGE. CALLERS WELCOME (MON-FRI) OR SEND 15p STAMP FOR LISTS

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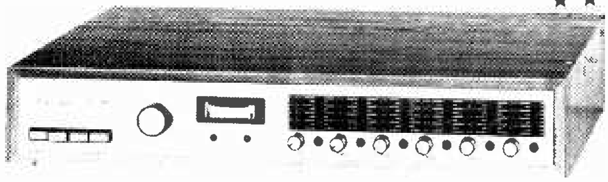
WIRELESS WORLD FM TUNER ★★

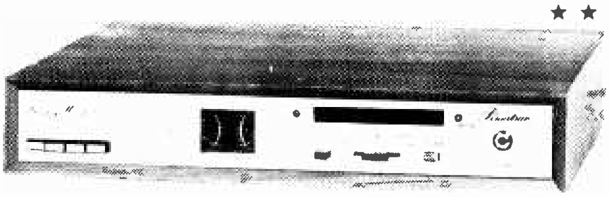


Designed in response to demand for a tuner to complement the world-wide acclaimed Linsley-Hood 75W Amplifier, this kit provides the perfect match. The Wireless World (Skingley and Thompson) published original circuit has been developed further for inclusion into this outstanding slimline unit and features 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.

AVAILABLE AS SEPARATE PACKS — PRICES IN OUR FREE CATALOGUE

SPECIAL PRICE FOR COMPLETE KIT £70.20

LINSLEY-HOOD CASSETTE DECK ★★



SPECIAL PRICE FOR COMPLETE KIT £79.60

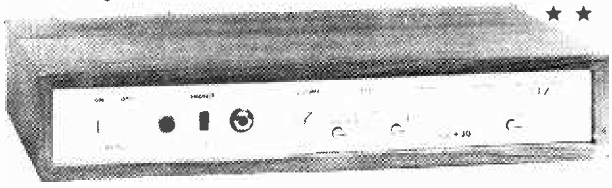
Pack	Price
1. Stereo PCB (accommodates 2 rep. amps. 2 meter amps. bias/erase osc. relay)	£3.35
2. Stereo set of capacitors. M.O. resistors. potentiometers for above	£7.95
3. Stereo set of semiconductors for above	£8.50
4. Miniature relay with socket	£2.90
5. PCB. all components for solenoid. speed control 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 P.C.B. 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. High Quality Teak Veneer 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

Matsushita WY 436 AZ head (optional extra) . £4.50 (free with compete kit)

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. Pushbutton 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. Circuit changes as published in February, 1978, follow-up article are included in the kit AT NO EXTRA COST! A higher performance head (Matsushita WY 436 AZ head as recommended in the follow-up article) is offered as an optional extra but this will be automatically supplied FREE OF CHARGE with all orders for complete kits!

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 rumble 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.

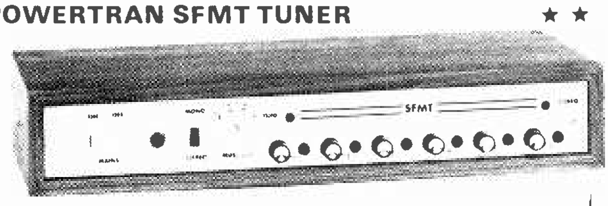
SPECIAL PRICES FOR COMPLETE KITS

T20+20 KIT PRICE £33.10

T30+30 KIT PRICE £38.40

AVAILABLE AS SEPARATE PACKS — PRICES IN OUR FREE CATALOGUE

POWERTRAN SFMT TUNER ★★

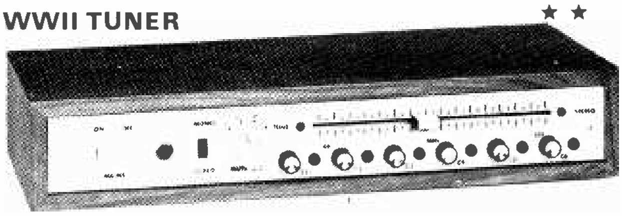


PRICE FOR COMPLETE KIT £35.90

· AVAILABLE AS COMPLETE KIT ONLY

This is a simple low cost design which can 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. 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.

WWII TUNER ★★



SPECIAL PRICE FOR COMPLETE KIT £47.70

AVAILABLE AS SEPARATE PACKS — PRICES IN OUR FREE CATALOGUE

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.

Wireless World Designs: Full kits are not available for the projects below but PCBs and component sets are stocked. Further details of these and other packs are in our Free Catalogue.

30W Bailey Amplifier

BAIL Pk 1 F Glass PCB	£1.00
BAIL Pk 2 Resistors Capacitors	£2.35
BAIL Pk 3 Semiconductors	£4.70

Regulated Power Supply for Bailey Amplifier

60VS Pk 1 F Glass PCB	£0.85
60VS Pk 2 Resistors Capacitors	£2.20
60VS Pk 3 Semiconductors	£3.10
60VS Pk 6A Toroidal transformer	£8.80

Bailey Burrows Stereo Pre-Amp.

BBPA Pk 1 F Glass PCB (stereo)	£2.80
BBPA Pk 2 Resistor capacitors (stereo)	£6.70
BBPA Pk 3R Rotary potentiometers (stereo)	£2.85
BBPA Pk 4R Rotary switches (stereo)	£3.60

Stuart Tape Recorder

TRRC Pk 1 Replay Amp F G PCB (stereo)	£1.30
TRRC Pk 1 Record Amp F G PCB (stereo)	£1.70
TROS Pk 1 Bias Erase F G PCB (stereo)	£1.20

Linsley-Hood Low Distortion Oscillator.

LDO Pk 1 Fibreglass PCB	£1.65
LDO Pk 2 M O Resistors capacitors	£2.60
LDO Pk 3 Semiconductors	£3.90

E. F. Taylor Pre-Amplifier

EFTP Pk 1 Fibreglass PCB (stereo)	£1.45
EFTP Pk 2 M O Res caps (stereo)	£3.20
EFTP Pk 3 Semiconductors (stereo)	£4.20

NEW! Improved stereo decoder (as described in April 1978 W W) F Glass PCB M O Res Caps Cermet pre-sets, IC IC socket. **£6.30**

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	£22.80
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

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. There is no minimum order charge. Prices same as for U K customers but no Value Added Tax charged. Postage charged at actual cost plus 50p documentaton 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.

Value Added Tax not included in prices
UK Carriage FREE

SERVICING FACILITIES: Available for all ★★ complete kits

PRICE STABILITY: Order with confidence! Irrespective of any price changes we will honour all prices in this advertisement until August 31st, 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 current rate if charged

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

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

FOR FURTHER INFORMATION PLEASE WRITE OR TELEPHONE FOR OUR FREE CATALOGUE

DEPT. WW7

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PLEASE ADD 8% TO ALL ORDERS INC. CARR.

CURRENT RANGE OF NEW L.T. TRANSFORMERS OPEN TYPE TAG CONNECTIONS ALL PRIMARIES 220-240v

Type	Sec Taps	Amps	Price	Carr
1	24-30-40-48-60v	12	**£24.60**	£2 00
2	24-30-40-48-60v	10	**£22.31**	£2 00
3	24-30-40-48-60v	8	**£18.11**	£1 75
4	24-30-40-48-60v	5	**£12.47**	£1 75
5	24-30-40-48-60v	3	**£9.30**	£1.00
6	24-30-40-48-60v	2	**£6.60**	£1 00

6-8-10-12-16-18-20-24-36-40-48-60v CAN BE OBTAINED FROM THE ABOVE RANGE

Type	Sec Taps	Amps	Price	Carr
7	19-25-33-40-50v	10	**£20.41**	£2 00
8	19-25-33-40-50v	6	**£14.62**	£1 50
9	19-25-33-40-50v	3	**£7.81**	£1 25
10	19-25-33-40-50v	2	**£6.10**	£1 00

5-7-8-10-13-15-17-20-25-30-40-50v OR 25-0-25v OR 20-0-20v CAN BE OBTAINED FROM THE ABOVE RANGE

Type	Sec Taps	Amps	Price	Carr
11	12-15-20-25-30v	10	**£11.91**	£1 75
12	12-15-20-25-30v	5	**£7.93**	£1 25
13	12-15-20-25-30v	2	**£4.79**	£1.00

3-4-5-6-8-9-10-12-15-18-20-24-30v OR 12-0-12v OR 15-0-15v CAN BE OBTAINED FROM THE ABOVE RANGE

Type	Sec Taps	Amps	Price	Carr
14	12-24v	12v 60A, 24v 30A	**£22.90**	£3 00
15	12-24v	12v 30A, 24v 15A	**£16.33**	£2.00
16	12-24v	12v 20A, 24v 10A	**£12.55**	£2 00
17	12-24v	12v 10A, 24v 5A	**£6.80**	£1 00
18	12-24v	12v 4A, 24v 2A	**£3.74**	£1.00

FULLY SHROUDED TYPE TERMINAL CONNECTIONS

Type	Sec Taps	Amps	Price	Carr
19	28-32v	4	**£7.50**	£1 00
20	14-16v	2	**£4.35**	£1 00
21	12-20-24v	10	**£12.50**	£1 25
22	12-20-24v	5	**£7.50**	£1 25
23	24-30-36v	10	**£12.00**	£1 50
24	24-30-36v	5	**£9.95**	£1.50
25	6-12v	10	**£7.20**	£1 25
26	8-0v	2	**£4.35**	£1 00

CENTRE TAPPED TRANSFORMERS

Fully shrouded terminal block connections. Screen. Pr 220-240v sec. tapped 36-25-0-25-36v 5A **£13.50**, pp £1. 30-25-0-25-30v 2A **£6.75**, pp £1. 18-0-18v 2A **£5.25**, pp £1. Open frame types. Pri 220-240v, sec. 50-0-50v 1A **£5.95**, pp 75p. 50-0-50v 2A **£8.95**, pp £1

ISOLATION TRANSFORMERS

Pri tapped 200-220-240v. Sec 240v 700 watts open type cable lead connections. **£10**, carr. £2

LOW POWER L.T. TRANSFORMERS

Type	Sec taps	Price	Post
1	12-15-20-24-30v 0-8A	**£2.50**	50p
2	6v 4A 6v 4A	**£3.00**	65p
3	6v 1½A 6v 1½A	**£2.50**	50p
4	12v 0 5A 12v 0 5A	**£2.00**	50p
5	15-0-15v 0.4A	**£2.00**	50p
6	12-0-12v 0.5A	**£2.00**	50p
7	6-0-6v 0 5A	**£1.50**	50p

All types open split bobbin construction.

LOW POWER L.T. TRANSFORMERS BY FAMOUS MAKERS. ALL PRIMARIES 240v TAG OR LEAD CONNECTIONS

No 1 20v 3A **£3** pp 75p. No 2 27v 1A **£1.50** pp 50p. No 3 12v 1½A and 24v ½A 2 separate windings **£1.50** pp 50p. No 4 12v 1A **£1** pp 50p. No 5 20v 1A **£1.50** pp 50p. No 6 55v ½A and 6 3v ½A **£1.50** pp 50p. No 7 24v 1A shrouded type **£1.50** pp 50p. No 8 13v 3A and 15v 1A 2 separate windings. C core type **£3.50** pp £1. No 9 15v 1 2A 6.3v 4 5A 250v 80M/A 3 separate windings **£3.50** pp £1. No 10 27v 1 8A 9v 1 8A 3v 1 8A 3 separate windings **£3.50** pp £1

No 11 13-0-13v 1A **£2.50** pp 50p. No 12 24v 1 75A **£1.95** pp 50p. No 13 50-0-50v 1A **£3.75** pp 75p. No 14 50-0-50V 2A **£6** pp £1. No 15 15v 1 2A 6 3v 4 5A and 250v 80 m/A **£3.50** pp £1

SPECIAL PURCHASE BY FAMOUS MAKERS

L.T. TRANSFORMERS IDEAL FOR UP-TO-DATE POWER SUPPLY CIRCUITS

No 1 GRESHAM Pri 240v Sec 43v 3amps. Fully tropicalised. Open type wire connections **£3.95** pp 75p. No 2 HINCHLEY Pri 240v Sec 33-0-33v 5amps and 18-0-18v 1A Tropicalised open frame. Wire connections. Two in series will give 33-0-33v 5A and 18-0-18v 2A **£3.95** each pp 75p. No 3 PARMEKO Pri 240v Sec 30v 5A and 12v 2.2amps. Table top connections **£4.95** pp £1

WODEN HT TRANSFORMERS

Type B600381 fully tropicalised

Pri 110 220-240V Sec 260-0-260V 150 m/A and 205-0-205v 60 m/A 6 3v 6A 6 3v 1A 5v 2A **£3.50 pp** £1

A.E.R.E. HIGH VOLTAGE INSULATION "C" CORE TRANSFORMERS. EX EQUIP

Pri 200-220-240v Sec 2 5v 45amps 30kv DC wkg **£7.50** carr £1 50. Sec 5v 5A 30kv DC wkg **£3.00** carr £1. Potted types. Woden "C" Core Pri 230v Sec 2.5v 10A 2.5v 5A 2.5v 5A, three separate windings **£4.50** pp £1

HOWELLS LT TRANSFORMERS "C CORE" TYPE PRIMARIES 240v TABLE TOP CONNECTIONS

No 1 18-0-18v 12 5A **£12.50** carr £2. No 2 18-0-18v 5A **£6.50** carr £1 50. No 3 18-0-18V 5A and 18-0-18v 2½A 2 separate windings **£8.50** carr £2. No 4 70-0-70v 10A **£17.50** carr £3

AUTO STEPDOWN TRANSFORMERS FOR AMERICAN EQUIPMENT

240/110v 80-3000 watts. Fitted with American two or three pin socket outlet and three core 240v mains lead. Send sae for latest price list. American plugs, sockets, extension leads also available.

Price list and further details sent on application.

PARMEKO ISOLATION TRANSFORMERS

Ex-equipment, perfect condition. Metal shrouded table top connections. Pri 200-250v in 5v steps. Sec 240v 10 amps **£35**, carr £4. Pri 200-250v in 10v steps. Sec tapped 90-100-110-120v 7 5 amps **£19.50**, carr £3. Pri 200-240v in 10v steps. Sec tapped 90-100-110-240v 4 5 amps **£12.50**, carr £2.

WODEN 3000 WATT AUTO TRANSFORMERS

Ex-equipment, perfect condition. Tapped 105-115-125-135-200-215-230-245-260v 3kvA. Open type terminal connections **£25**, carr £3. Can be supplied in metal case with two American 2/3 pin flush sockets or 13 amp British sockets. 3 core 240v mains lead. Carrying handle **£42.50**, carr £3. **WODEN** Auto Transformers tapped 200-220-230-240-250 120-115-100v 750 watts open type **£8.50**, carr £2

HEAVY DUTY HT TRANSFORMERS

GARDNERS Pri 200-220-240v Sec tapped 300-250-0-250-300v 4 amps (DC rated) open type **£30** ex-stores

COSSOR Pri 230v sec 7800-0-7800v 83M/A potted type **£25** ex stores

3 PHASE ISOLATION TRANSFORMERS BY FAMOUS MAKER

Input tapped 380-400-415-430 volts RMS NOM. Line to line 3 phase 4 wire 50Hz output 415 volts NOM 3 phase 4 wire at 2 15kvA. Regulation 2%, secondary fully screened open type construction. Terminal board connections size 16½x7x6½ins. Weight 90lbs. Brand new. Fraction of maker's price **£47.50**, carr £3

HEAVY DUTY L.T. TRANSFORMERS

Famous maker. Pri 415v SP Sec 27 volt 1500 watts connected to 240v 15 volts 55 amp can be obtained **£25**, carr £3

WODEN POTTED TRANSFORMERS

Pri 230v sec tapped 40-41-42-48-49-50v very conservatively rated at 10 amps and 60v 100MA. A Size 9x7x6ins **£15**, carr £3

PARMEKO H.T. TRANSFORMERS POTTED TYPE

Pri 240v sec 1875v 60M/A and 500v 31M/A Fraction of maker's price **£5.75**, carr £1

H.T. TRANSFORMERS BY FAMOUS MAKERS. ALL PRIMARIES 240v

Type MT133 Sec 300-0-300v 150M/A 6 3v ct 4A 5-6 3v 2A **£4.50** pp £1. MT12 Sec 300-0-300v 120M/A 6 3v ct 4A 5-8 3v 2A **£4** pp £1. MT11 Sec 300-0-300v 100M/A 6 3v 3 5A 5v 2A or 6 3v 1A **£3.75** pp £1. MT10 Sec 250-0-250v 120M/A 6 3v 3 5A 5v 2A or 6 3v 1A **£3.50** pp £1. MT7 Sec 350-0-350v 100M/A 6 3v 3 5A 5v 2A or 6 3v 1A **£4.00** pp £1

STANDARD PLUG-IN RELAYS 7 AMP CONTACTS BY FAMOUS MAKERS WELL BELOW LIST PRICE

COIL VOLTAGE	CON-TACTS	PINS	PRICE
240v AC	2 CO	8	85p
110v AC	2 CO	8	65p
110v AC	3 CO	11	75p
50v AC	3 CO	11	75p
24v AC	2 CO	8	85p
12v AC	2 CO	8	85p
12v AC	3 CO	11	95p
48v DC	3 CO	11	65p
48v DC	2 CO	8	65p
12v DC	2 CO	8	85p
10v DC	3 CO	11	95p

STANDARD OPEN TYPE 7 AMP CONTACTS

COIL VOLTAGE	CONTACT	PRICE
240v AC	3 CO	85p
240v AC	2 CO	75p
240v AC	1 CO	65p
110v AC	3 CO	65p
110v AC	2 CO	65p
50v AC	3 CO	65p
48v DC	3 CO	50p
24v DC	2 CO	75p
12v DC	2 CO	75p
10v DC	3 CO	85p

PP 10p per relay. Please add VAT 8% on total

STANDARD MINIATURE PLUG-IN RELAYS

Perspex covers 700Ω 4 CO, three for **£1.75**, pp 25p. 700Ω 3 CO, three for **£1.50**, pp 25p. Metal covers 700Ω 2 CO three for **£1.50**, pp 25p. Bases available **10p** ea

OIL FILLED BLOCK CAPACITORS TCC-DUBILIER. FRACTION OF MAKER'S PRICE

MFD	DCV WKG	Price	Postage
10	450v	50p	25p
8	600v	75p	35p
8	350v	50p	25p
8	250v	40p	25p
8	200v	35p	20p
4	1250v	£1	35p
4	350v	30p	15p
2	600v	35p	15p
2	500v	30p	15p
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7402	0.12	7497	2.38	74192	0.99	74LS123	0.82	4009	0.45	4089	1.55
7403	0.12	74100	0.94	74193	1.05	74LS124	2.45	4010	0.48	4093	0.65
7404	0.13	74104	0.40	74194	0.90	74LS125	0.44	4011	0.15	4094	1.80
7405	0.13	74105	0.40	74195	0.84	74LS126	0.44	4012	0.16	4095	1.10
7406	0.28	74107	0.28	74196	0.90	74LS132	0.69	4013	0.42	4096	1.10
7407	0.28	74109	0.45	74197	0.90	74LS136	0.40	4014	0.80	4097	3.50
7408	0.14	74110	0.46	74198	1.48	74LS138	0.53	4015	0.77	4098	1.12
7409	0.14	74111	0.70	74199	1.48	74LS139	0.53	4016	0.42	4099	1.90
7410	0.13	74116	1.60	74221	1.50	74LS151	1.05	4017	0.77	4404	1.00
7411	0.18	74118	0.82	74273	2.15	74LS153	0.50	4018	0.87	4412	0.30
7412	0.21	74119	1.30	74279	1.25	74LS154	1.20	4019	0.42	4428	0.80
7413	0.25	74120	0.82	74283	1.70	74LS155	0.86	4020	0.92	4445	1.50
7414	0.54	74121	0.25	74284	6.85	74LS156	0.86	4021	0.82	4449	0.30
7416	0.27	74122	0.40	74293	1.35	74LS157	0.47	4022	0.82	4501	0.17
7417	0.27	74123	0.53	74298	1.92	74LS158	0.53	4023	0.15	4502	0.88
7420	0.13	74125	0.44	74390	1.92	74LS160	1.22	4024	0.66	4507	0.50
7421	0.28	74126	0.45	74393	2.12	74LS161	0.69	4025	0.15	4508	2.25
7422	0.17	74128	0.62	74LS00	0.19	74LS162	1.22	4026	1.28	4510	1.05
7423	0.25	74132	0.68	74LS01	0.19	74LS163	0.69	4027	0.50	4511	0.98
7425	0.20	74135	0.68	74LS02	0.19	74LS164	1.20	4028	0.67	4512	0.92
7426	0.25	74136	0.75	74LS03	0.19	74LS168	2.00	4029	0.86	4514	2.85
7427	0.25	74137	0.94	74LS04	0.20	74LS169	2.00	4030	0.48	4515	2.80
7428	0.34	74141	0.58	74LS05	0.20	74LS170	1.76	4031	2.34	4516	1.02
7430	0.13	74142	2.00	74LS08	0.19	74LS173	1.05	4033	1.25	4518	0.99
7432	0.24	74143	2.00	74LS09	0.19	74LS174	1.12	4034	2.00	4519	0.50
7433	0.32	74144	2.00	74LS10	0.19	74LS175	1.05	4035	1.00	4520	1.05
7437	0.24	74145	0.64	74LS11	0.19	74LS189	2.85	4036	2.40	4521	2.00
7438	0.24	74147	1.30	74LS12	0.19	74LS190	0.81	4037	0.99	4522	1.35
7440	0.13	74148	1.18	74LS13	0.46	74LS191	0.81	4038	1.00	4527	1.60
7441	0.52	74150	0.99	74LS14	1.10	74LS192	1.80	4039	2.80	4528	0.92
7442	0.55	74151	0.60	74LS15	0.19	74LS193	1.80	4040	0.88	4529	1.10
7443	0.90	74153	0.60	74LS20	0.19	74LS195	1.12	4041	0.77	4536	3.56
7444	0.90	74154	1.05	74LS21	0.19	74LS196	1.20	4042	0.72	4553	4.20
7445	0.70	74155	0.63	74LS22	0.19	74LS197	1.20	4043	0.82	4555	0.85
7446	0.70	74156	0.63	74LS26	0.24	74LS221	1.12	4044	0.82	4556	0.85
7447A	0.64	74157	0.63	74LS27	0.40	74LS247	0.97	4045	1.40	4558	1.25
7448	0.60	74159	1.70	74LS30	0.19	74LS248	0.97	4046	1.32	4566	1.40
7450	0.13	74160	0.80	74LS32	0.25	74LS249	0.97	4047	0.96	4583	0.75
7451	0.13	74161	0.80	74LS37	0.27	74LS251	1.00	4048	0.60	4585	1.03
7453	0.13	74162	0.80	74LS38	0.27	74LS253	1.05	4049	0.42		
7454	0.13	74163	0.80	74LS40	0.19	74LS257	1.05	4050	0.42		
7460	0.13	74164	0.89	74LS42	0.53	74LS258	1.05	4051	0.84		
7470	0.28	74165	0.89	74LS47	0.97	74LS266	0.39	4052	0.84		
7472	0.22	75166	0.99	74LS48	0.97	74LS273	2.50	4053	0.84		
7473	0.26	74167	2.70	74LS49	0.97	74LS279	0.50	4054	1.10		
7474	0.26	74170	1.68	74LS51	0.19	74LS283	1.00	4055	1.00		
7475	0.30	74172	4.00	74LS54	0.19	74LS289	2.85	4060	0.98		
7476	0.26	74173	1.18	74LS55	0.20	74LS293	0.90	4066	0.48		
7480	0.45	74174	0.89	74LS73	0.30	74LS298	1.60	4067	3.50		
7481	0.90	74175	0.68	74LS74	0.34	74LS352	0.92	4068	0.24		
7482	0.80	74176	0.88	74LS75	0.45	74LS353	1.05	4069	0.17		
7483	0.72	74177	0.88	74LS76	0.32	74LS365	0.50	4070	0.17		
7484	0.90	74178	1.20	74LS78	0.32	74LS366	0.50	4071	0.17		
7485	0.88	74179	1.10	74LS83	0.78	74LS367	0.50	4072	0.17		
7486	0.26	74180	0.90	74LS85	0.90	74LS368	0.50	4073	0.17		
7489	2.00	74181	1.92	74LS86	0.35	74LS386	0.37	4075	0.17		
7490	0.35	74182	0.75	74LS93	0.95	74LS670	2.00	4076	1.05		
7491	0.65	74184	1.20	74LS95	1.10	4000	0.14	4077	0.46		
7492	0.44	74185A	1.20	74LS107	0.36	4001	0.15	4078	0.22		
7493	0.40	74186	7.20	74LS109	0.36	4002	0.16	4081	0.17		
7494	0.80	74188	2.70	74LS112	0.38	4006	0.92	4082	0.20		

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4017	90p	4066	55p
4018	90p	4069	20p
4020	100p	4071	16p
4022	90p	4072	16p
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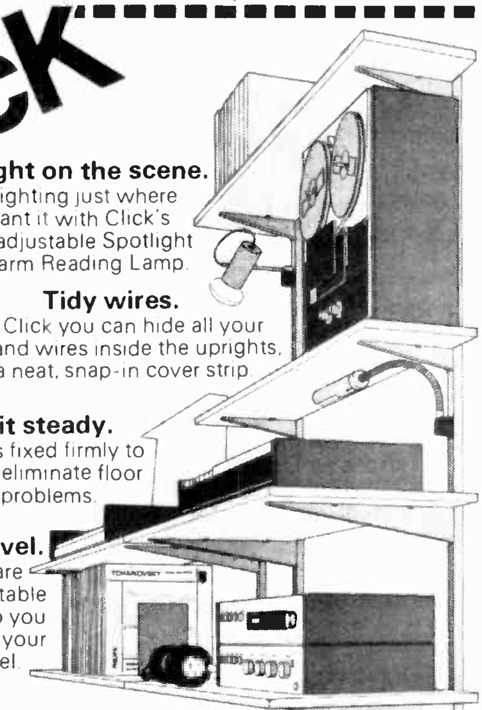

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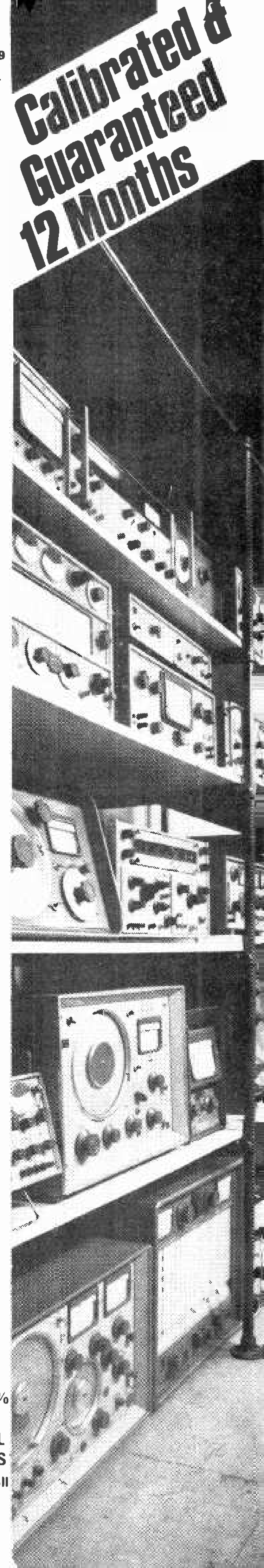

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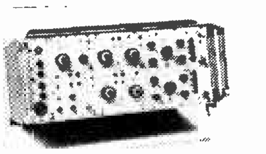

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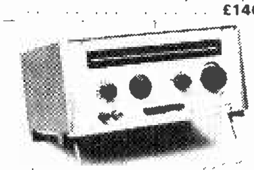

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Timer Counter TC22. Measures Frequency DC-100MHz 6 digit, time, period, period average, count, totalise, pulse width, ratio £275.00

Digital Multimeter DMM3. 3½ digit Maximum reading 1999 25 ranges of measurement. AC and DC volts AC and DC current. Resistance Dual Polarity Remote hold £115.00

STRIP CHART RECORDER OMNI-SCRIBE A.5000 Series. One & Two Pen. "As New Condition" Full specification on request

A.5110-1	£200.00
A 5112-2	£225.00
A 5123-1	£300.00
A.5120-5	£300.00
A 5132-4	£320.00
A 5221-4	£400.00
A.5212-4	£380.00
A.5230-4	£450.00
A.5222-2	£410.00

Off Air Frequency Standard OFS-1 .... £120.00

VHF Square Wave Generator SG21. 10KHz-100MHz £60.00

A.F. Signal Generator J2E. 15Hz-50kHz o/p (600Ω) 0 1mW-1W .... £.120.00

A.C. Millivoltmeter VM77C. 0.001V-300V f.s.d (12 ranges) 15Hz-4.5MHz £55.00

Timer Counter TC14. 9 digit. Display storage. DC-250MHz. Time gate selectable 0 1µs-100s. Multiple period average 10-10⁸. Sensitivity 10mV, 100mV, 500mV. Overload protected £400.00

Timer Counter TC15. 9 digit with storage and plug-in capability. DC-250MHz. Spec similar to TC14 .... £500.00

Plug In Unit TC15 P1. 1MHz-500MHz. 10mV-1V. Full 500MHz display with 1Hz resolution in only 2 secs £150.00

Portable Oscilloscope OS245A. Dual trace, DC-10MHz 5mV/div 4" rectangular CRT BRAND NEW £232.00

Dual Trace Portable Oscilloscope Type OS 3000. DC-40 MHz 5mV-20V/DIV Delayed Sweep £495.00

TEKTRONIX

Bench Oscilloscope Type 531A c/w dual trace vertical plug-in unit CA. DC-13.5MHz Sensitivity 50mV-20V/Div Time base ranges 100ns to 5S/Div Timebase modes. A, X5 Internal voltage calibrator 0 2mV-100V IKHz square wave £290.00

Bench Oscilloscope Type 647A c/w dual trace vertical plug in unit 10A2A & delayed time base plug in unit 1182A DC-100MHz Sensitivity 10mV-20V/Div. Time base ranges 100ns-5s/Div on A & B. Time base modes A only. Intensified. delayed sweep. X10 Internal voltage calibrator 0 2mV-100V. 1kHz square wave £1200.00

Bench Oscilloscope Type 585A c/w dual trace vertical plug in unit Type 82 DC-80MHz Sensitivity 10mV-50V/Div Time base ranges A 50ns-2s/Div, 2 2µs-1s/Div Time base modes A, B, intensified, delayed. X5 Internal voltage calibrator 0 2mV-100V. 1kHz square wave £775.00

Bench Oscilloscope Type 547 c/w dual trace vertical plug in unit 1A1. DC-50MHz Sensitivity 5mV-20V/Div Time base ranges 100ns-5s/Div A and B Time base modes A, B, intensified, delayed sweep, alternate sweep, X 2-5-10 Internal voltage calibrator 0 2mV-100V 1kHz square wave £775.00

Bench Oscilloscope Type 546, c/w dual trace vertical plug in unit 1A1 As 547, but without alternate sweep £740.00

Bench Oscilloscope 545B c/w dual trace vertical plug in unit CA DC-24MHz, sensitivity 50mV to 20V/Div Time base ranges A 100ns — 5S/Div B2 µs/1s/Div Time base modes A, B, intensified delayed sweep. X5 Internal voltage calibrator 0 2mV-100V 1kHz square waves £555.00

Bench Oscilloscope Type 543B c/w dual trace vertical plug in unit CA As 545B & CA, without B time base. With X2-X100 Horizontal gain £450.00

Time Marker Generator 184. 16 marker intervals, 5 sinewave frequencies 500MHz sinewave output Crystal controlled oscillator 10MHz ± 0 001% £275.00

2101 5ns Pulse Generator with Delay. 2 5Hz-25MHz repetition rate. Variable baseline offset 5ns risetime and fall time Paired, undelayed, delayed and output latched on modes External gate input Simultaneous positive and negative going pulses 10volts into 50Ω £575.00

2901 Time Mark Generator. 16 marker intervals, 4 sinewave frequencies 500MHz sinewave output Crystal controlled oscillator, 8 trigger pulse intervals £450.00

TV Waveform Monitor 525 .... £165.00

Plug In Unit Power Supply 132 £120.00

Spectrum Analyser Plug In 3L10 (for 560, and 564 series scopes), 1-36MHz £415.00

4-Trace Plug In Unit "M" (for use with 530, 540 & 580 series) £250.00

Differential Plug In Unit "W" £325.00

Oscilloscope Camera Unit C12 £190.00

Digital Readout Oscilloscope 567. Choice of plug-ins available Mainframe price £510.00

Constant Amplitude Signal Generator 191. 350kHz-100MHz Sine wave 5mV-5 5V constant amplitude 50kHz Amplitude reference £350.00

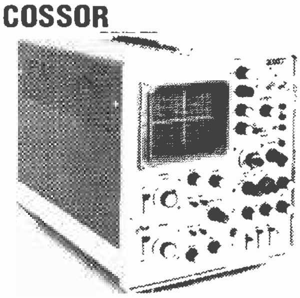
Colour TV Vector Scope Type 526 £425.00

Colour TV Waveform Monitor Type 529 £350.00

E.N.I.

RF Power Amplifier Type 500L. 2-500 MHz 27dB gain. O/P 300mW Superb condition £315.00

COSSOR



Dual Trace Scope 4000. 50MHz 7nsec Rise Time 5mV cm sensitivity Calibrated sweep delay Gated trigger X-Y display 8 x 10cm display Unused £495.00

TELEQUIPMENT

Portable Oscilloscope D75. DC-50MHz at 5mV/Div Dual Trace Delay/Mixed Sweep £575.00

Dual Trace Moduler Oscilloscope D83/V4/S2A. DC 50 MHz 5m V-20V DIV Delayed Sweep Excellent condition £610.00

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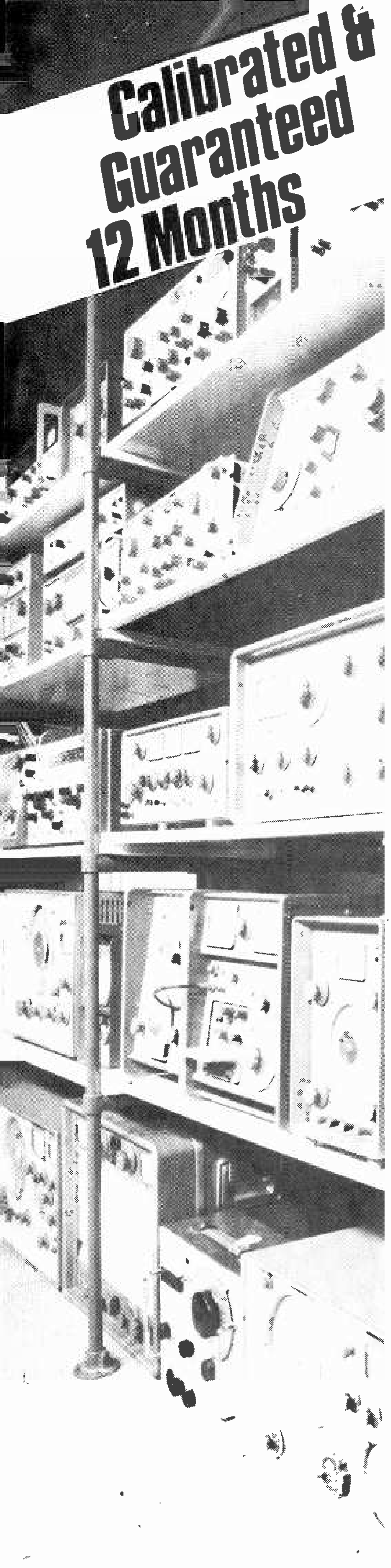

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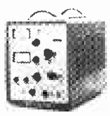
The Test Equipment People

ROHDE & SCHWARZ
Stereocoder Type MSC. BN4192/2. Superb condition £1,200.00
Stereodecoder MSDC. BN4193. Superb condition £850.00
Z-g Diagraph ZDU £860.00
Selective Level Voltmeter . USWV. 30-400 MHZ 10μV-3V £800.00
U.H.F. Millivoltmeter. URV. 1 KHZ-1 6 GHz £235.00

HEWLETT PACKARD
True R.M.S. Voltmeter 3400A. 1mV-300V. (12 ranges) dB range −72-+52 dBm. Frequency range 10Hz to 10MHz £415.00
D.C. D.V.M. 3430A. 3 digit 5 ranges 100mV-100V Input Resistance 10MΩ. Overload protected £145.00
Digital Multimeter 34702A. C/w 34740 display 4½ digit. 4 ranges of A.C. & D C & 6 ranges of ohms. A C = 45Hz-100kHz £350.00



U.H.F. Signal Generator 612A. 450-1200MHz in 1 band Output Voltage 0 1μV to 0 5V. Output impedance 50Ω A M 0-90% Ext. A.M. Facility Pulse mod. facility Various modern versions from .... £900.00-£1250.00
Frequency Doubler 10515A £75.00
A.M. Signal Generator 606A. 50kHz-65MHz £550.00
Bench Oscilloscope 175A. C/w Plug Ins 1754A & 1781B. 4 trace 40MHz band-width Sweep Delay £550.00
Programmable Step Attenuator 355E. DC-1000MHz 0-12 dB in 1dB steps Unused £60.00
Distortion Analyser 332A. 5Hz-600kHz Distortion levels 0 1%-100% are measured full scale in 7 ranges A M Detector operating from 550kHz-65MHz £495.00
DC Standard/Differential Voltmeter 740B. Designed for calibrating digital voltmeters differential voltmeters, potentiometers, voltage dividers and for general standards lab application. 6 digit resolution with discrete steps of 1 p p m of full scale Full specification on request £1,850.00
A.C. Voltmeter 400F. 100V to 300V f s (14 ranges) Freq. range 20Hz-4MHz £195.00
Microwave Power Meter 430C. C/w Thermister mount 477B 10MHz-10GHz Full scale ranges 0 1, 0 3, 1, 3 & 10mW
Portable Oscilloscope 1700B. DC-35MHz 10mV/div sensitivity. Dual Channel Solid State £575.00

> **A.C. Voltmeter 400EL.** 1 mV-300V 12 Ranges 10HZ-10MHZ. BRAND NEW £325.00

S.H.F. Signal Generator 628A. 15-21GHZ 50Ω £495.00

> 5½ Digit DMM Type 3490A. DC-AC Volts Resistance Auto Ranging, excellent condition £725.00

AM-FM Signal Generator Type 8654A, 10-512 MHz 0 3 μ V-IV into 50 ohm £850.00
AC-DC Differential Voltmeter/DC Standard Type 741B £1,095.00
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Multifunction Counter 1900A-01. Same spec as 1900A but with battery pack £215.00
Multifunction Counter 1900A-02. Same spec as 1900A but with BCD o/p £230.00
Frequency Synthesiser 6011A. Performs function of an oscillator, counter and level meter 10Hz-11MHz. Output 0 4mV-5V r m s 7 digit LED display. Accuracy ±3 parts in 10⁹ for one year. Freq. storage. Full spec on request £2650.00

> **Frequency Synthesiser 6160A/DX.** 4MHz-30MHz in 1Hz steps Output 1V into 50Ω. Full spec on request UNUSED, BARGAIN PRICE £675.00

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VHF, UHF Telecomms. Frequency Counter 1980A. C/w Battery Pack. 5Hz-515MHz. 6 digit LED Display. 50mV sensitivity over whole range £400.00

> **MULTIFUNCTION 6 DIGIT AUTORANGING COUNTER 1900A**
> Modes Frequency, period, totalize Frequency range 5Hz-80MHz. In put sensitivity 25mV BRAND NEW £175.00
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Type 1112A £520.00
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Multimeter model 7 .... £40.00
Leads, prods & croc clips for models 7, 8 & 9 .... £4.50 set

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Frequency Counter Type PM 6645B, 30Hz-512MHz 5mV rms, as new condition £710.00
Dual Trace Portable Oscilloscope Type PM 3276, DC-15MHz, 2mV-10V/DIV TV Triggering as new condition £415.00
Dual Trace Portable Oscilloscope Type PM 3260, DC 120MHz 5mV-2V/DIV Delayed Sweep as new condition £1,385.00
Dual Trace Portable Oscilloscope Type PM 3260E. As PM 3260 but no horizontal mag and prob power as new condition £1,300.00
Dual Trace Portable Oscilloscope Type PM 3240, DC-50 MHz 5mV-10V/DIV. Delayed Sweep, as new condition £950.00
Universal RCL Bridge Type PM 6302 .... £390.00
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3½ Digit DMM Type PM 2513A, AC-DC Volts and Current Resistance, as new condition £90.00
4½ Digit DVM Type PM 2443, 10μV-1000V DC only High accuracy, Auto Ranging. As new condition £430.00
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100MHz Double Output Pulse Generator PM5776. Specification on request £900.00

50MHz Pulse Generator PM5712
£495.00

Specification on request.

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Universal Counter Timer 9838. Frequency, single and multiple period, time interval. Freq range 10Hz-100MHz £285.00
H.F. Communications Receiver RA117E. 1-30MHz Full specification on request £350.00
Modulation Meter 210A. 2.5-300MHz A M range 0-100%. F.M. range 0 to ±100kHz .... £245.00-£285.00
A.M./F.M. Modulation Meter 409. Freq. 3-1500MHz A M 0-100% F.M. 0-±600kHz £345.00

T.E.S. (Milan)
L.F. Signal Generator G1165B. Solid State. 10Hz-100kHz 1mV-10V 600Ω impedance Square Wave facility £195.00
Wow & Flutter Meter WF971. DIN & CCIR i./p signal 20mV-20V. Flutter ±0 1% ±0 3% ±1% i./p impedance 10KΩ £210.00
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All ex-demonstrators as new condition

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MARCONI INSTRUMENTS
F.M./A.M. Signal Generator TF995B/2. Frequency Range 20kHz to 220MHz in five bands Output 0 1μV-200mv. Output

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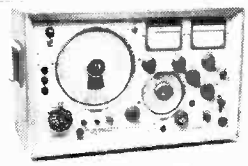
Impedance 75Ω. Modulation (F.M.) Normal deviation continuously variable in two ranges ±25kHz and ±75KHz on all bands. Greater deviation is available on most bands. Modulating Frequency Internal FM: 1kHz, External FM: 50Hz to 15kHz. Modulation (A.M.) Internal AM: 1kHz, 0-50%. External AM: 50Hz to 10kHz, 0-50% **£675.00**

U.H.F. Signal Generator TF1060. Frequency range 450-1250MHz (1 band). Output 0.15μV to 445mV. Output Impedance 50Ω. Int. sine A.M.-1kHz. Ext. pulse mod. **£400.00**

A.M. Signal Generator TF144H & H/S. Frequency range: 10kHz to 72MHz in twelve overlapping bands. Output Attenuator: 2μV to 2V. Output Impedance 50Ω. Modulation: Internal AM: 400Hz & 1kHz to 0 to 80%. External AM: 20Hz to 20kHz, 0 to 80% **£275.00-£400.00**

A.M. Signal Generator TF144H/4. A later version of TF144H with similar spec **£375.00-£600.00**

A.M. Signal Generator TF144H/4S. Electrical specification, as TF144H/4 **£375.00-£700.00**



A.M. Signal Generator TF801D/1. Frequency Range: 10MHz to 470MHz in five bands. Output Attenuator 0.1μV to 1V. Output Impedance: 50Ω (Type N connector). Modulation: Internal AM: 1kHz, 0 to 90%. External AM: 30Hz to 20kHz, 0 to 90% **£400.00-£750.00**

Carrier Deviation Meter TF791D. Carrier Freq. range 4 to 1024MHz. Deviation range up to ±125kHz. Modulating Frequency range: Up to 35kHz. Late models **£295.00**

20MHz Sweep Generator TF1099. Video sweep output. Lower limit 100kHz fixed. Upper limit continuously variable up to 20MHz. 0.3 to 3V p-p Z=75Ω. Input & Output detector probes. Markers at 1MHz intervals **£295.00**

A.M. Signal Generator TF801D/8S. Same spec. as TF801D/1S + freq. counter o/p facility **£695.00**

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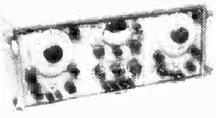
Sensitive Valve Voltmeter TF2600. 12 ranges 1mV-300V f.s.d. 1% accuracy up to 500kHz. Usable up to 10MHz **£175.00**

R.F. Electronic Voltmeter TF2604. 7 ranges 300mV-300V f.s.d. from 20Hz-1500MHz. 8 ranges 300mV-1kV DC. 7 ranges. Resistance 500Ω to 500MΩ **£225.00**

U.H.F. Signal Generator TF1060/3A. Frequency range 500 to 1200MHz. Remainder of spec. on TF1060 **£575.00**

R-C Oscillator TF1101. Frequency Range 20Hz to 200kHz in four bands. Output Attenuator: 1mV to 20V. Maximum Output 20V across external 600Ω load. Output impedance 600Ω **£120.00**

Phase A.M. Signal Generator TF2003. 0.4-12MHz **£150.00**



Two-Tone Signal Source TF2005R. Frequency Range 20Hz-20kHz in six bands (each oscillation can be adjusted and used independently). Harmonic Distortion: Less than 0.05% between 63Hz and 6kHz when using unbalanced output. Intermodulation: Below 80 dB with respect to the wanted signal. Amplitude Reference Level: Up to +10dBm from each oscillator. Output Attenuator: 111dB in 0.1dB steps **£415.00**

Blanking and Sync Mixer TF2908. For 405, 525 and 625 line television systems. Reshapes and mixes blanking and sync pulse waveform with video test waveform **£90.00**

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Wide Range R.C. Oscillator TF1370A. 10Hz to 10MHz sine wave, 10Hz to 100kHz square wave. Output up to 31.6V **£275.00**

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5 watt Dummy Load TM5582 for use with TF2604 **£25.00**

A.F. Oscillator TF2100. 20kc/s to 20Kc/s. Extremely low distortion. Output Impedance 600Ω unbalanced **£150.00**

M.F. Oscillator TF2101. 30c/s to 550kc/s. Stable frequency. Low distortion. Output Impedance: 600Ω unbalanced **£115.00**

F.M./A.M. Modulation meter TF2300S. Incorporating Oscillator TM8045/1. 3.5 to 1000MHz. Full specification on request **£825.00**

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F.M. Signal Generator TF1066B/6. 10-470MHz. R.F. output 0.2μV-200mV e.m.f. Output Impedance: 50Ω. Modulation: Internal AM: 1kHz & 5kHz 0-40%. External AM: 30Hz to 15kHz 0-40%. Internal FM: 1kHz & 5kHz deviation 0 to 100kHz or up to 400KHz according to carrier freq. range. External FM: 30Hz to 100kHz deviation same as int. Crystal Calibrator facility **£685.00**

Variable Attenuator TF338C. 0-105dB Freqs. up to 100KHz 600Ω impedance **£90.00**

M.F. Attenuator TF2162. DC-1MHz 0-111dB in steps of 0.1dB **£120.00**
Also TF1073A Spec as A/2S **£55.00**

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10-Watt A.F. Power Meter TF893A. Frequency range 20Hz to 35kHz. Five power ranges, 1mW to 10W full scale. Impedance 2.5Ω to 20KΩ in 48 steps. Balanced or unbalanced inputs. Direct calibration in watts and dBm **£165.00**

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In Situ Universal Bridge Type TF 2701 **£395.00**

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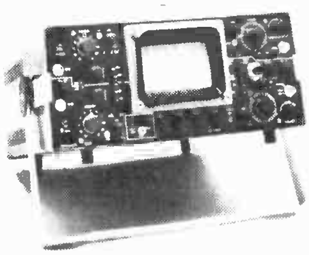

Portable Solid State 'Scope 7500. DC-40MHz. 10mV/div sensitivity ×10 gain extends sensitivity to 1mV/div (3Hz-5MHz). Mixed & calibrated sweep delay. Dual trace. AC & DC coupled Z mod. BRAND NEW **£495.00**

Dual Trace Portable Oscilloscope Type D7210. DC-15MHz. 10mV-5V/DIV. Delayed Sweep. Immaculate **£350.00**

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Precision DC Voltage Standard 304. 0-1 kV in 3 decades 0-50mA at any voltage setting. Accuracy: 10V range 0.003% +10uV. 100V range 0.003% +20uV. 1kV range 0.003% +40uV **£450.00**

WAYNE KERR

Universal Bridge B221A = CT530. 10S/948-8768. 0.1% accuracy. Measures R +ve or -ve. G +ve or -ve. C (x1). L (1592Hz). Source frequency (1592Hz (int) 50Hz-20Hz (Ext). Mains operated. Weight 11 kg **£275.00**

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Component Bridge B521 (Ministry Type CT375). A general purpose component bridge for measuring L.C. & R & combinations of R & Reactance. It can be used to measure components in situ. Capacitance 1pF to 5F. Resistance 1 milliohm to 100Mohm. Inductance 1uH to 500kH **£115.00**

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Please note: All instruments offered are secondhand and tested and guaranteed 12 months unless otherwise stated

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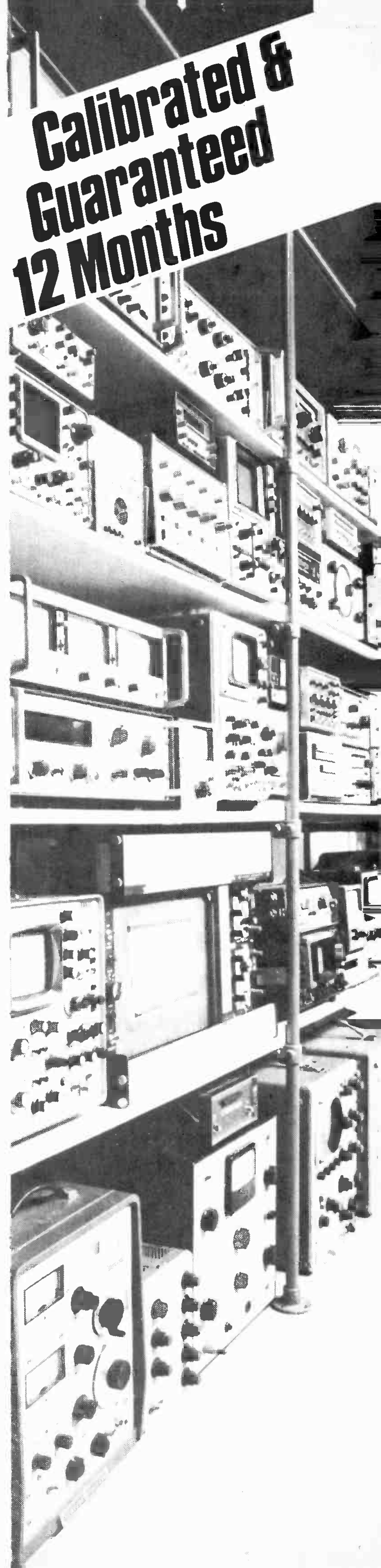

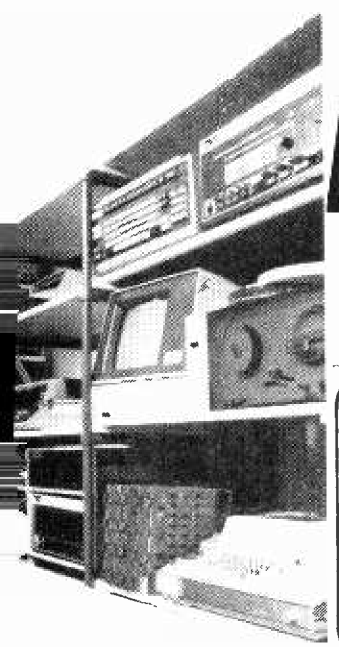

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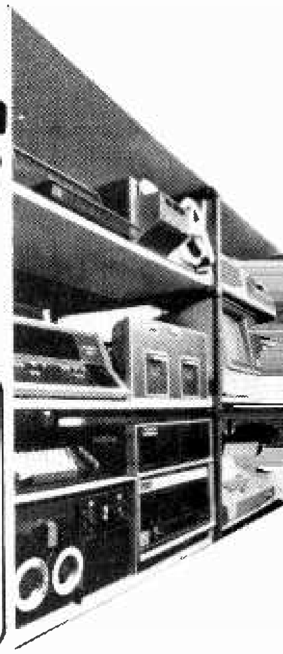

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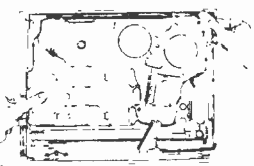

Special purchase of MITE 123P Alphanumeric printer mechanisms solenoid-operated page printer using standard reversible typewriter ribbon. Prints standard 64 — ASCII character set on 8½" paper (80 characters per line, 6 lines to the inch). Maximum speed 11 cps. Power requirements 115VDC. Compact, lightweight unit 12" x 9" x 2¾", 9¾lbs. Supplied complete with full technical manual. **BRAND NEW SURPLUS. Only £75.00** + £3.50 P. & P. + 8% VAT. (Mail order total £84.78).

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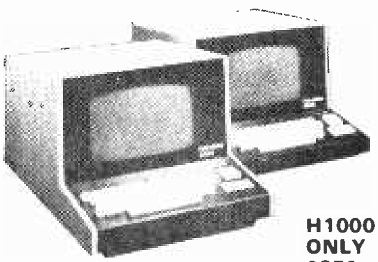


H1000 ONLY £350

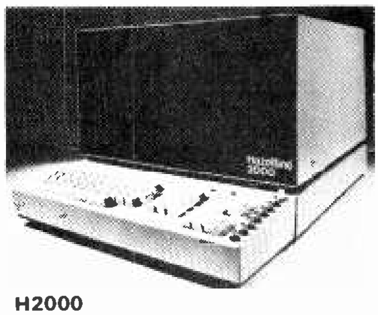
H1200 ONLY £425

HAZELTINE H1000 and H1200 SPECIFICATION

SCREEN SIZE — 12 diagonal.
SCREEN CAPACITY —
H1000 — 960 characters 80 per line x 12 lines.
H1200 — 1920 characters 80 per line x 24 lines.
CHARACTER GENERATION — 5 x 7 dot matrix 625 line raster
CHARACTER SET — 64 ASCII alphanumerics and symbols
CHARACTER SIZE —
H1000-1/8 inch (32cm) nominal height. 3/32 inch (.24cm) nominal width
H1200 — 1/10 inch (25cm) nominal height 3/32 inch (24cm) nominal width.
CURSOR —
H1000 underline. **H1200** reverse image block.
TUBE PHOSPHOR — P4 (white on black)
REFRESH RATE — 50 fields per second.
KEYBOARDS — TTY format attached
INDICATORS — Power On. Parity Error Dataset ready.
PARITY — Parity error indicated by Parity light and question mark (?) displayed in character position
TRANSMISSION — Asynchronous Switch-selectable for any two standard rates up to 9600 baud
OPERATING MODES — Full/half Duplex
MEMORY — High speed MOS refresh
STANDARD INTERFACE — CC ITT V-24. (EIA RS-232 B/C). 202C Optional

HAZELTINE H2000 SPECIFICATION

SCREEN SIZE — 12 diagonal. 1998 characters; 74 per line x 27 lines.
CHARACTER GENERATION — 5 x 7 dot matrix 625 line raster.
CHARACTER SET — 64 alphanumerics and symbols. 32 ASCII control codes.
KEYBOARD — Detachable, solid state, teletypewriter design 10-key numeric cluster plus editing and cursor control keys.
TRANSMISSION — Asynchronous Switch-selectable for combinations of 5 standard rates, 75 to 9600 baud.
OPERATING MODES — Switch-selectable, full duplex, half duplex or batch (buffered)
MEMORY TYPE — 2048 x 8 RAM
EDITING FEATURES — Full Cursor controls plus Insert/Delete Character, Insert/Delete Line, Clear Screen, Clear Foreground Data Only, Tab
STANDARD INTERFACE — CC ITT V-24 (EIA RS-232 B/C) or 202C Compatible
REMOTE COMMANDS — Insert/Delete Line, Clear Screen, Clear Foreground Data Only, Home Cursor, Address Cursor, Set Background Intensity, Set Foreground Intensity, Carriage Return, Backspace, Ring Bell, Transmit, Print.



H2000 FROM £495

AUXILIARY OUTPUT — Standard printer interfaces, standard cassette interface; remote monitor interface.
TUBE PHOSPHOR — P39 (green on black).

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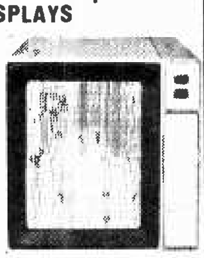

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STEREO FM TUNER Fitted with phase lock-loop

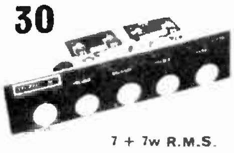
£22·30 + 40p p&p + 12½% VAT

FREQUENCY RANGE	88–108 Mhz
SENSITIVITY	3 0 μV
BANDWIDTH	250 kHz
SPURIOUS REJECTION	50 dB
SELECTIVITY ± 400 kHz	55 dB
AUDIO OUTPUT (22 5 kHz deviation)	100 mV
STEREO SEPARATION	30 dB
SUPPLY REQUIREMENTS	20 to 30V (90mA max)
AERIAL IMPEDANCE	75 ohms
DIMENSIONS	240mm × 110mm × 32mm

The 450 Tuner provides instant programme 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, simply by changing the settings of the pre-set controls. Features include FET input stage. Vari-Cap diode tuning. Switched AFC LED Stereo Indicator.

Stereo 30

COMPLETE AUDIO CHASSIS



£18·95 + 40 p&p + 12½% VAT

7 + 7w R.M.S.

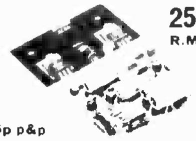
OUTPUT POWER	7 Watts RMS
LOAD IMPEDANCE	8 ohms
TOTAL HARMONIC DISTORTION	Less than 5% (Typically 3%)
FREQUENCY RESPONSE	50 Hz to 20 kHz ± 3dBs
TONE CONTROL RANGE	± 12 dBs at 100Hz and 10kHz
SENSITIVITY	190 mV for full output
INPUT IMPEDANCE	1 M ohms
TRANSFORMER REQUIREMENTS	22 V.A.C. rated at 1A
DIMENSIONS (Less controls and panel)	200mm × 130mm × 33mm

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.

AL60

AUDIO AMPLIFIER MODULE 25 Watts RMS

25w R.M.S.



£4·55 + 25p p&p + 12½% VAT

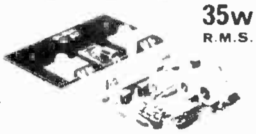
OUTPUT POWER	25 Watts RMS
SUPPLY	30–50 V
LOAD IMPEDANCE	8–16 ohms
TOTAL HARMONIC DISTORTION	Less than 1% (Typically 06%)
FREQUENCY RESPONSE	20 Hz to 30 kHz × 2 dBs
SENSITIVITY	280 mV for full output
MAX HEAT SINK TEMPERATURE	90°C
DIMENSIONS	103mm × 64mm × 15mm

This high quality audio amplifier module is for use in audio equipment and stereo amplifiers and provides output powers up to 25 RMS with distortion levels below 0 1%.

AL80

AUDIO AMPLIFIER MODULE

35w R.M.S.



£7·15* + 25p p&p + 8% VAT

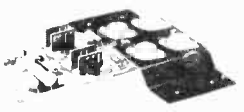
OUTPUT POWER	35 Watts RMS
SUPPLY	40–60 V
LOAD IMPEDANCE	8–16 ohms
TOTAL HARMONIC DISTORTION	Less than 1% (Typically 06%)
FREQUENCY RESPONSE	20 Hz to 30 kHz · 2 dBs
SENSITIVITY	280 mV for full output
MAX. HEAT SINK TEMPERATURE	90°C
DIMENSIONS	103mm × 64mm × 15mm

The AL80 is similar in design to the AL60 above and is of the same high quality but provides output powers up to 35W with distortion levels below 0 1%.

AL250

POWER AMPLIFIER

125w R.M.S.



£17·25* + 40p p&p + 8% VAT

OUTPUT POWER	125 Watts RMS continuous
OPERATING VOLTAGE	50–80 V
LOADS	4–16 ohms
FREQUENCY RESPONSE	25 Hz 20 kHz measured at 100 Watts
SENSITIVITY FOR 100 WATTS O/P AT 1 kHz	450 mV
INPUT IMPEDANCE	33 K ohms
TOTAL HARMONIC DISTORTION	
50 WATTS into 4 ohms	0 1%
50 WATTS into 8 ohms	0 06%

This unit, designated AL250, is a power amplifier providing an output of up to 125W RMS, into a 4 ohm load.

AL30A

AUDIO AMPLIFIER MODULES

10w R.M.S.

£3·75 + 25p p&p + 12½% VAT

MAXIMUM SUPPLY VOLTAGE	30 V
POWER OUTPUT for 2% THD	10 Watts RMS
TOTAL HARMONIC DISTORTION	Less than 25%
LOAD IMPEDANCE	8–16 ohms
INPUT IMPEDANCE	100 K ohms
FREQUENCY RESPONSE	50 Hz–25 kHz ± 3 dBs
SENSITIVITY	75 mV for full output
DIMENSIONS	74mm · 63mm × 28mm

These low cost 5 and 10 watt modules offer the utmost in reliability and performance, whilst being compact in size.

SPM80

STABILISED POWER SUPPLY

£4·25 + 25p p&p + 12½% VAT

INPUT A.C. VOLTAGE	33–40V
OUTPUT D.C. VOLTAGE	33 V nominal
OUTPUT CURRENT	10 mA–1 5 amps
OVERLOAD CURRENT	1 7 amps approx.
DIMENSIONS	105mm · 63mm × 30mm

Designed to power two AL60s at 15 Watts per channel simultaneously. Circuit Techniques include full short circuit protection.

PA100

STEREO PRE-AMPLIFIER

£15·80 + 40p p&p + 12½% VAT

FREQUENCY RESPONSE	20 Hz to 20 kHz · 1 dB
TOTAL HARMONIC DISTORTION	Less than 1% (Typically 07%)
SENSITIVITY INPUTS 1. TAPE	100 mV/100 K ohms — For an output 250 mV
2. RADIO TUNER	100 mV/100 K ohms
3. MAGNETIC P.U.	3 5 mV/50 K ohms
EQUALISATION	Within ± 1 dB from 20 Hz to 20 kHz
BASS CONTROL RANGE	± 15 dBs at 75 Hz
TREBLE CONTROL RANGE	+ 10–20 dBs at 15 kHz
SIGNAL/NOISE RATIO	Better than 65 dBs (All inputs)
INPUT OVERLOAD	Better than 26 dBs (All inputs)
SUPPLY	20 to 40 V
DIMENSIONS	300 · 90 · 33mm (less controls)

A top quality stereo pre-amplifier and tone control unit, the PA100 provides a comprehensive solution to the front end requirements of stereo amplifiers or audio units. The six push button selector switch gives a choice of inputs together with two filters for high and low frequencies.

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SENSITIVITY	3 5 mV for 100 mV output
EQUALISATION	Within ± 1 dB from 20 Hz to 20 kHz
INPUT IMPEDANCE	50 K ohms
SUPPLY	18 to 30 V—re earth
DIMENSIONS	110 × 50 × 25mm (inc DIN socket)

PA12

STEREO PRE-AMPLIFIER

£7·10 + 30p p&p + 12½% VAT

The PA12 Stereo Pre-Amplifier chassis is designed and recommended for use with the AL 20/30 Audio Amplifier Modules, the PS12 power supply and the T538 Transformer. Features include on/off volume, Balance, Bass and Treble controls. Complete with tape output.

FREQUENCY RESPONSE	20 Hz–20 kHz (—3dB)
BASS CONTROL	± 12 dB at 60 Hz
TREBLE CONTROL	± 14 dB at 10 kHz
INPUT IMPEDANCE	1 Meg. ohm
INPUT SENSITIVITY	300 mV
CROSSTALK	—60 dB
SIGNAL/NOISE RATIO	—65 dB
OVERLOAD FACTOR	± 20 dB
TAPE OUTPUT IMPEDANCE	25 K ohms
DIMENSIONS	152mm × 84mm × 25mm

PS12 POWER SUPPLY

Designed for use with the AL30A S.450 and MPA30 in conjunction with transformer T538.

INPUT VOLTAGE	17–20v AC
OUTPUT VOLTAGE	27–30v DC
OUTPUT CURRENT	800mA
SIZE	60mm × 43mm × 26mm

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GE 100 NINE CHANNEL MONO-GRAPHIC EQUALIZER

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A beautifully designed genuine TEAK WOOD veneered cabinet to put the professional touches to your home built amplifier. Full set of parts incl. Front & Back Panels, Knobs, Chassis, Fuses, Sockets, Noen, etc. Ideal for the MA60. Size: 425mm × 290mm × 95mm.
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(8312)

Service and Test Engineers

As aircraft and electronics equipments become more sophisticated and our servicing programme expands, the need for experienced Service and Test Engineers increases.

At Stanmore, we are involved in the provision of spares and the repair, maintenance and overhaul of a variety of British and American airborne electronic equipment.

We need Engineers who can successfully maintain the high standards and efficiency required both in the aircraft and the workshop.

It's skilled work, calling for sound practical experience of radio and electronics theory, ranging from audio to microwave and including the use of advanced test equipment for fault diagnosis. Training in this field will be given to suitable, less experienced engineers.

The Company offers excellent salaries and benefits together with first-class working conditions in well-equipped workshops. This Unit is conveniently situated in pleasant surroundings within easy reach of the A1 and M1.

MARCONI AVIONICS
A GEC-Marconi Electronics Company

If the job sounds interesting and you'd like to put us to the test, write with details of experience to:
Mrs. E. Wagg
Marconi Avionics Ltd.
22-26 Dalston Gardens, Stanmore, Middlesex
HA7 1BZ.
Tel: 01-204 3322

Test Gear

The following vacancies have occurred at the Springfield Road Works of EMI Electronics Ltd., a medium sized, self contained unit concerned mainly with large quantity production of precision electro-mechanical devices

Laboratory Technician

To assist Engineers with testing and development of electronic circuits and test equipment and to produce breadboards and prototype test equipment. Qualification C & G or O.N.C. (Electronics) and/or relevant experience in electronic prototype work.

Test Gear Maintenance Engineer

With sound experience of radio and TV servicing and some further knowledge of maintenance of electronic instrumentation. Qualification of C & G R & TV servicing or equivalent is desirable

For further details contact Miss Pedley, Personnel Officer, EMI Ltd Springfield Road Works, Hayes, Middlesex. Tel. 01-573 2701

EMI — EMI Limited

The international music, electronics and leisure Group.

(4308)

UNIVERSITY OF LIVERPOOL
Institute of Child Health
Alder Hey
Children's Hospital

TECHNICIAN

To assist with reseach. Work includes assistance with design and development of medical electronic instruments and operation of the Institute's digital computer. Applicants must possess ONC or equivalent as a minimum qualification and be experienced in fault diagnosis and use of digital and analogue integrated circuits.

Knowledge of programming an advantage. Salary within range up to £3,720 per annum, according to qualifications and experience. Post tenable to September, 1979, in the first instance.

Application forms may be obtained from the Registrar, The University, P.O. Box 147, Liverpool L69 3BX. Quote ref. RV/794/WW.

(8268)

BAYERO UNIVERSITY —NIGERIA

Applications are invited for the post of

CHIEF ENGINEER

in the DEPARTMENT OF MASS COMMUNICATION. Candidates for the post should be corporate members of a relevant professional institution, with a degree in engineering or an equivalent qualification in television, plus 8-10 years' experience of broadcast television, including substantial colour experience. Experience of digital television equipment would also be an advantage. The appointee will be responsible for the technical facilities to be provided in the Department of Mass Communications. He/she will be required to supervise the installation of the equipment for the complex and to arrange the training of junior staff in the maintenance of the facility. He/she will also be required to make a contribution to the teaching work of the department in the fields of television operations, lighting and sound. Salary N8,868-N9,828 p.a. (£ sterling =N1.18). 25% of salary contract addition (partly taxable) is also payable. Family passages; various allowances; superannuation or gratuity; biennial overseas leave. Detailed applications (2 copies), including curriculum vitae and naming three referees to be sent airmail marked "Application for Senior Post", to Registrar, Bayero University, PMB 3011, Kano, Nigeria, as soon as possible. Applicants resident in UK should send one copy to Mrs. K. Macrowan, Inter-University Council, 90/91 Tottenham Court Road, London W1P 0DT. Further details may be obtained from either address.

(8222)

ST. BARTHOLOMEW'S HOSPITAL
London EC1A 7BE
DEPARTMENT OF MEDICAL ELECTRONICS

Applications are invited for the post of

Medical Electronics Technician

Grade III
(Salary £3787 to £4708 with review pending)

to service radio-telephone equipment in use by District Medical and Ancillary staff. The equipment includes both VHF and UHF base stations, controllers, mobiles and pages.
The successful applicant will be responsible to the Head of the Communications Engineering Section and be required to construct and maintain special purpose data links between patient and computer areas which requires a wide knowledge of digital and analog techniques in addition to R F experience. A current driving licence is also necessary.
For application form and job description please ring 01-600 9000 Ext 3186 or write to the Personnel Department at the above address quoting ref PTB/158

(8269)

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Go to some agencies and you may have 2 or 3 interviews before you even get to meet an employer ... let alone one who's actually interested in meeting you.

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Lansdowne Appointments Register, Design House, The Mall, London W5 5LS. Tel: 01-579 2282 (24 hour answering service).

Our clients are keen to meet men and women aged 20 to 40 years, with potential earnings of between

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Name ....

Address ....

.... WW 21/6

Lansdowne Appointments Register, Design House, The Mall, London W5 5LS. Tel: 01-579 2282 (24 hour answering service).

(8257)

Lansdowne

For those too busy doing a good job to find a better one.

Road Transport Industry Training Board

TV Studio Engineer

The Road Transport Industry Training Board has in operation at its Wembley Headquarters a 3-camera broadcast-quality colour television studio with full telecine and video recording facilities, which includes RCA TR50-2", also 1" Helical Scan systems. We now wish to appoint an experienced studio engineer to join a small team working on the production of training and educational television programmes. Applicants, aged not less than 24 years, should have a good working knowledge of the above equipment.

An attractive starting salary will be offered dependent on qualifications and experience; other benefits include four weeks' holiday, contributory pension and life assurance scheme.

Please send relevant personal history stating how the above requirements are met, quoting reference ZH.563, to Personnel Department, Road Transport Industry Training Board, Capitol House, Empire Way, Wembley, Middlesex HA9 0NG.

(8221)

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facetiousness, flamboyant statements, and downright vulgarity to attract attention to our company's advertisements.

WHAT HAS IT BROUGHT US??

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- Considerably more applicants and vacancies than before.
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- Charlie's Angels don't play, they mean business. Try us.

Like those illustrious ladies, we don't reveal all (our vacancies) — just sufficient to whet the appetite.

1. PROJECT DESIGN ENGINEER

RF equipment particularly frequency synthesisers and spectrum analysers. To £7,000.

South Coast.

2. COMPUTER ENGINEERS

Vacancies throughout UK for field service, permanent site, systems test or technical support. Salaries vary enormously, but up to £11,000 for IBM 360/370 experience.

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Modems and multiplexers for dynamic group marketing US projects. To £6,500.

Middlesex.

4. DESIGN DEVELOPMENT ENGINEERS

For advanced projects group working on application of advanced technology to the widest range of communications imaginable. DC-Blue Light. To £7,000.

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Always in demand

TEST ENGINEERS, COMMISSIONING ENGINEERS, TRIALS ENGINEERS, TECHNICIANS.

Also:

NEW GRADUATES, COLLEGE LEAVERS and H.M. FORCES PERSONNEL.

For further details of qualifications and experience required, salary levels and precise geographical locations, telephone 01-581 0286, or write to

(8173)

Charles Airey Associates

RECRUITMENT CONSULTANTS TO THE INDUSTRY. 155 Knightsbridge, LONDON SW1. Tel: 01-581 0286

ELECTRONICS TECHNICIANS

When you see a good job advertised what do you look for next?

Obviously, before you contemplate a change of job and possibly area you must weigh-up your present job prospects, pay and surroundings and measure them against those that have attracted you.
Really that's all we want you to do NOW—we are confident that the combination of Marconi Instruments and its locations in St. Albans and Luton will persuade you to give very serious consideration to the appointments we have vacant.

Job Satisfaction
If you would like working for a successful Company you'll like us—66% of our products ranging from microwave test equipment to automated test systems are exported. Unlike any other in the business we achieved the 'double' in 1977 with the Queen's Award for both Exports and Technological Achievement—just two reasons why our people have every reason to be proud of their Company and its expertise.

Housing
The Hertfordshire/Bedfordshire area is probably one of the most picturesque of the counties surrounding London and contains some very reasonably priced housing both of the modern and rural varieties. The average family house is priced in the region of £16,000 to £22,000.

Schooling
The family man will be particularly impressed with the local schools both Junior and Senior—modern, spacious buildings are the order of the day and individual successes are very encouraging.

Sports and Social Activities
For the energetic our own sports and social club is very active, particularly with the recent addition of a squash court. Golf courses, cricket and football clubs abound and for the less energetic many social activities are available.

Local Amenities
If you still have time on your hands you will enjoy a visit to the theatre in either St. Albans, Luton or Watford. The local Rep. is very well supported.

All in all we can offer you a really worthwhile job, attractive pay, relocation and equally important, excellent local surroundings. Why not ring John Prodger, Personnel Officer, he lives locally and can give you first hand information about the jobs and surrounding districts.

MARCONI INSTRUMENTS LIMITED
Longacres, Hatfield Road, St. Albans, Herts.
Tel: St. Albans 59292 or after 6pm and weekends St. Albans 30602

8254

mi A GEC MARCONI ELECTRONICS COMPANY

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 appropriate 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 and analytic machinery.

QUALIFICATIONS: Candidates must hold either the City and Guilds Telecommunications Part 1 (Intermediate) Certificate or equivalent HM Forces qualification.

SALARY (inc. supps.) from £2,673 at 19 to £3,379 at 25 (highest pay on entry) rising to £3,883 with opportunity for advancement to higher grades up to £4,297 with a few posts carrying still higher salaries.

Opportunities for service overseas.

Further particulars and application forms available from:

GCHQ

Recruitment Officer (Ref. WW/7)
GCHQ, Oakley
Priors Road, Cheltenham, GL52 5AJ
Cheltenham (0242) 21491 ext 2270

(8035)

HEALTH EDUCATION DEPARTMENT

Production Assistant/ Technician

£3,405-£4,353 p.a. incl. supplements (increase pending)

required in a small developing C.C.T.V. Studio. The successful applicant, who should be a well-qualified technician with several years' experience, will be trained to professional standards in the lighting and production of C.C.T.V. programmes.

As a member of the Health Education Department the applicant should have a pioneering spirit and will be required

— to assist producer in video and audio recordings and editing.
— to train and supervise technical staff.
— to maintain and repair colour and black and white educational television equipment throughout the Area.
— to build and develop ancillary equipment.

Job description and application forms are available from

Area Personnel Department
Northamptonshire Area Health Authority
Beaumont Villa
Cliftonville
Northampton
Telephone Northampton 21155, Ext. 331

Closing date for applications July 21, 1978.

(8309)

NORTHAMPTONSHIRE
AREA HEALTH AUTHORITY

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in a high-technology industry

North Hertfordshire

£4000–£6000

ICL operates at the forefront of computer technology, and in 1977 increased turnover by 45% to nearly £420m.

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The people we need must:

- be capable of running formal training courses on complex equipment to high professional standards
- be able to adapt to new training methods and techniques
- be prepared to run training courses anywhere in the U.K. or Overseas
- have high written and verbal communications skills.

You will have a degree or HNC preferably in a scientific or technical subject and several years' experience in a technical industrial environment. Experience in lecturing in a high technology industry will be an advantage, but is not essential.

However, due to the technical nature of the task and the professional standards required, comprehensive training will be given. This will include technical lecturing techniques and Multi-Media methods. These appointments will be based at our Training Centre in Letchworth and assistance with removal expenses will be given where appropriate.

For further details and/or an application form call David Reeves on 01-788 7272 Ext. 4150 or write to him at ICL, 85/91 Upper Richmond Road, Putney, London SW15 2TE, quoting reference WW1830.

International Computers

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(8240)

APPLICATIONS ENGINEER

ELECTRONICS **C£6K + BONUS**

BURR-BROWN ARE OFFERING a rare opportunity for an ambitious enthusiastic young Engineer to accelerate career and earnings

We urgently need someone to solve applications problems for a variety of Analogue Instrumentation and Data Conversion products. Responsibilities include technical support for the U.K. and Scandinavia, and liaison with the U.S. parent Co

Candidates should have HNC (Electronics) or equivalent, and plenty of practical analogue experience

The Rewards
- Excellent salary and growth potential
- Annual bonus
- Contributory Pension Scheme
- Occasional overseas travel
- Interesting, technical work
- Relocation expenses
- (A Company car may be offered in the future)

If you think you can meet this engineering challenge, call Roger Isaacson at

BB

BURR-BROWN INTERNATIONAL LTD.
WATFORD (0923) 33837

(8261)

FIELD SERVICE ENGINEERS

(SCHOOLS ELECTRONIC EQUIPMENT)

£3584 - £3962 **Ewell / Pirbright**

For the Media Resources Centre. To carry out on-site service to schools A/V equipment, i.e. TV/VCR installations, language laboratories — fault-finding and repairing equipment — and some repair work in workshop base

The department is responsible for the repair of all A/V items in schools, i.e. projectors, record players, radio, tape recorders, TV/Video, etc., and practical experience in some aspects is essential. City and Guilds or ONC in radio/TV/electronic service work desirable

Casual car user allowance payable for use of own vehicle

Application form from Media Resources Centre, Glyn House, Church Street, Ewell. Tel. 01-393 0208.

(8256)

SURREY COUNTY COUNCIL

Graduate Electrical/ Electronic Engineers —

Research and Development in Telecommunications

The Directorate of Telecommunications, London, is responsible for the extensive and sophisticated facilities used by the police, fire, prison and associated services. The role of the Research and Development Section is to ensure that maximum benefit is derived from the use of modern techniques.

The training and experience given to Graduate Engineers covers the training requirements of the IEE — ranging from the initial interpretation of a non-technical statement of requirement through to the management of design, development and contract — and is carefully planned by a senior engineer.

You must have (or obtain in 1978) a good honours degree in electronics or electrical engineering or an allied subject.

Your starting salary will be at least £4150. Completion of training (usually one or two years) leads to a salary rising to £6200. Further promotion prospects to £11000 and above. Non-contributory pension scheme.

For further details and an application form (to be returned by 20 July, 1978) write to Civil Service Commission, Alencon Link, Basingstoke, Hants RG21 1JB, or telephone Basingstoke (0256) 68551 (answering service operates outside office hours). Please quote reference T/9848/1.

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Knowledge or experience of mobile V.H.F. equipment is what we're looking for. Call Mike Rawlings or Bill Clarke on 01-328 5344 Now! (7994)

London Communications (Equipment) Ltd
30 Boundary Road London NW8 01 328 5344

Electronic Test Engineers

We manufacture and market professional audio noise reduction equipment which is widely used by major recording companies, recording studios and broadcasting authorities throughout the world and have enjoyed successful growth since incorporation in 1968.

The success of such films as "Star Wars" and "Close Encounters of the Third Kind" has led to an increased demand for our cinema equipment and a need for experienced test engineers.

If you have practical knowledge and experience of electronic testing, think you can test, calibrate and trouble-shoot our sophisticated equipment, enjoy the challenge of quality and delivery pressures and want to hear about the excellent pay and conditions, telephone Tony Hill, 01-720 1111.

Dolby
Dolby Laboratories Inc

Dolby Laboratories Inc.
346 Clapham Road
London SW9 9AP
Telephone 01-720 1111

(8255)

AMBITIONS IN COMPUTING?

Use your experience to improve your life style

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SALES — SOFTWARE

For expert confidential advice contact GEOFF ALDRIDGE
01-229 9239

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SERVICE ENGINEER

Service Engineer with preferably 2 years' audio and hi-fi servicing experience required to repair high quality audio products. As a broad range of products are covered, versatility in all technically related matters is required.

The successful applicant will have a thorough knowledge of electronics with direct application to hi-fi equipment.

Written applications only to **Tom Barclay**
MARANTZ AUDIO UK LIMITED
Debmarc House, 203 London Road
Staines, Middlesex (8229)

194 RADIO FORTH

Invites applications for the important position of

MAINTENANCE ENGINEER

Applicants must have a thorough working knowledge of Broadcast Audio Systems together with some experience of Telecommunications. Salary will be commensurate with age and experience. For an application form write to **The Chief Engineer, Radio Forth, P.O. Box 194, Edinburgh.** (8238)

ELECTRONICS TECHNICIAN

required for production testing and repair of a wide range of Digital and Audio circuit boards. Also alignment of high quality film recording equipment.

GEG Tech plus one year's experience; or several years relevant experience required.

Ring — Nigel Gardiner at PAG Films, Raynes Park, SW20. 01-542 1171.

Royal Holloway College
University of London
Egham Hill, Egham, Surrey

GRADE 4 ELECTRONICS TECHNICIAN

Required to work on the construction and maintenance of electronic equipment in the Physics Department. Salary on the scale £3349-£3931, plus £275 London Weighting. 4 weeks' holiday a year plus bank holidays and discretionary days. Please apply to the Personnel Officer (WW) giving details of age, qualifications, experience, and the names and addresses of 2 referees. (8223)

Development Engineers

(Hampshire)

Our Engineering Headquarters at Crawley Court was built just over five years ago on a 32 acre site in a pleasant woodland setting.

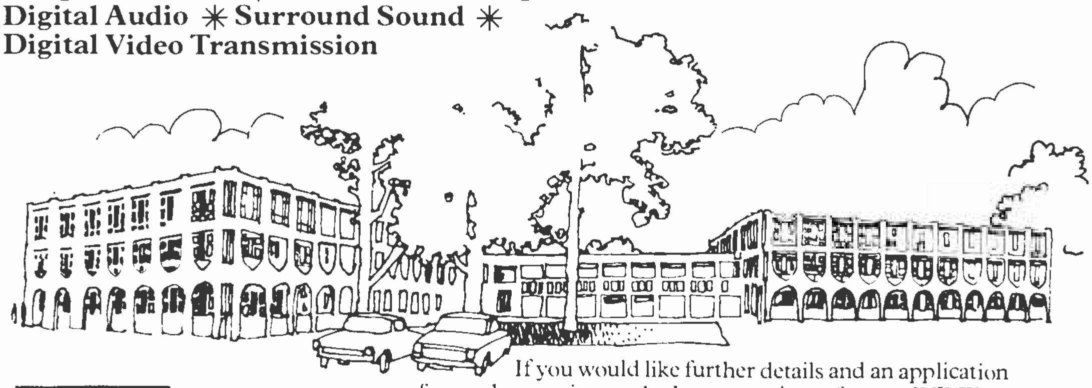
We offer first class facilities in our laboratories for engineers who are employed on stimulating new projects relating to development in broadcasting technology.

Current major projects include:

Digital Video Tape Recording ✳ Application of microprocessors to network measurement and control ✳ Adaptive Aerials ✳ Data Broadcasting Digital Audio ✳ Surround Sound ✳ Digital Video Transmission

If you are a graduate, male or female, with development experience we should like to hear from you. Equally, if you have a good honours degree, but have little or no experience, we should be interested in considering you for an appointment, initially at a lower level.

Providing you have the right level of qualifications and experience, you could start on a salary range which goes up to £5314 per annum (inclusive of pay supplements) our Phase 3 settlement is pending. Generous re-location expenses are paid, where appropriate and subsidised transport is available from local centres.



If you would like further details and an application form, please write or telephone, quoting reference DT/ED to: Glynis Powell, Personnel Officer, Independent Broadcasting Authority, Crawley Court, Winchester, Hampshire, SO21 2QA. Telephone: Winchester 822270.

IBA INDEPENDENT BROADCASTING AUTHORITY

SOUND DEVELOPMENTS PROJECTS DEPARTMENT requires an

ASSISTANT ENGINEER

to help design and construct (with suitable training), professional equipment for its broadcast and sound recording studios (shortly to be updated to 24 track).
Preference will be given to keen motivated applicants, 18-23 years old, with some successful constructional experience, who do not quake at the prospect of hard but rewarding work. We offer good friendly working conditions and excellent promotion prospects. Salary negotiable.
Write with relevant details to Robert Haggas at Sound Developments Ltd. Spencer Court, 7 Chalcot Rd., London N W 1 8L7 (8285)

DESIGN ENGINEER

Design Engineer with DIGITAL and ANALOGUE experience especially in the field of MICROPROCESSORS required by leading manufacturer.

Applicants should have a good working knowledge of Audio and Radio in order to be able to apply the most up-to-date techniques to these fields. Salary c£6000 per annum plus large Company Benefits. London area.

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(8239)

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A vacancy occurs with an old establishment Retailer.

The Post requires someone with a wide range of experience in Television and Audio equipment, a clean driving licence is essential. Large flat available for suitable applicant

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Telephone: Chertsey 63243

(8225)

UNIVERSITY OF KENT AT CANTERBURY

PHYSICS LABORATORY— ELECTRONICS TECHNICIAN

A Grade 3 Technician is required for the Electronics section of the Physics Laboratory. Applicants should have an O N C or equivalent qualification and 3-5 years' appropriate experience. Salary scale £2688-£3060 p a. Application forms and particulars may be obtained from the Assistant Registrar, Faculty of Natural Sciences, Chemical Laboratory, The University, Canterbury, Kent. Closing date 30th June, 1978. Please quote ref. T78/6 (8231)

Engineers

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- TEST
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Our expansion programme means we're looking for additional staff including A **SENIOR AUDIO-VISUAL TECHNICIAN** with management potential and real ability. This is a genuine opportunity for rapid, excellent career progress with a well-established company working for blue-chip clients. Good basic salary, commission, bonuses, car and BUPA cover.

Detailed CV please to Alan Lovejoy, Communications Centre Group 39 Long Acre, London, W.C.2

(8248)

ELECTRONICS ENGINEERS

Are you technically ambitious? Are you looking for a challenging job? If you are then opportunities exist at Rank Research Laboratories, a Company within the Rank Organisation.

We are looking for engineers, male or female, who are keen to tackle interesting work in the following fields — automatic production aids, automatic test equipment, specialised machining processes and controls, new electronic device applications and thermal imaging systems for industrial, military and medical applications.

If this is the type of work that excites you and are seeking to broaden your knowledge, then you could be the person we are looking for.

Ideally you will possess a degree, HND or HNC in Electronic Engineering and have two to three years practical experience in electronic circuit design. Your salary will be competitive and negotiable, supplemented by the excellent Rank Organisation benefits package.

If interested, please drop a line to the Director of Rank Research Laboratories for an application form at: PO Box 33, Phoenix Works, Great West Road, Brentford, Middlesex TW8 9AG.

RANK FILM LABORATORIES

(8307)

CAMBRIDGESHIRE COUNTY COUNCIL
HUNTINGDON TECHNICAL COLLEGE
California Road, Huntingdon, Cambs.
Telephone Huntingdon 52346/7

DEPARTMENT OF ENGINEERING AND CONSTRUCTION

FULL-TIME LECTURER GRADE I

required for 1st September, 1978, to teach ELECTRICAL/ELECTRONICS Principles, Practice plus Associated Studies to TEC National Level.

Salary Burnham F.E. Report, 1978, £3192 to £5334 by 14 increments, commencing salary dependent upon experience and qualifications.

Application forms and further information obtainable from the Principal at the College. (8298)

PRESTON POLYTECHNIC
SUBJECT AREA OF ELECTRICAL AND ELECTRONIC ENGINEERING

Applications are invited for the post of

SENIOR LABORATORY/ WORKSHOP TECHNICIAN

(Research) with experience in Electronics to assist Academic Staff and Research students engaged in research.

Salary Grade T3/4 £2922-£3702 plus salary supplements up to a maximum of £520.

36¼-hour, 5-day week. Post superannuable.

Application forms and further details from Deputy Chief Administrative Officer (Staffing), Preston Polytechnic, Corporation Street, Preston.

Closing date 31st July, 1978. (8306)

Telecine Operator

A major advertising agency requires a Rank Cintel MKIII telecine operator with first line maintenance ability.

The operation is mainly concerned with transfer of commercials to non-broadcast V.T. systems.

Salary is open to negotiation and will depend upon experience.

Please write giving details of experience and salary required to Bill King, Ogilvy, Benson & Mather Ltd., Brettenham House, Lancaster Place, London WC2E 7EZ.

(8274)

ADVANCED TECHNOLOGY

Against a background of long-term government contracts we are expanding our teams working on advanced underwater projects and currently have the following posts available.

Electronics Design Engineers
Electronics Technicians

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.

The company is situated on the Avon/Somerset border, a few minutes drive from Junction 21 of M5. Working conditions are excellent and salaries are negotiable. Please contact Ron Moir, quoting reference EA and the position in which you are interested.

BRISTOL AEROJET

BRISTOL AEROJET LTD., BANWELL, WESTON-SUPER-MARE, AVON

(8288)

CAPITAL APPTS.

FREE LISTS
101 Design/Development and Test Jobs
Permanent and Contract
To £6,000
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29, Windmill St. London, W.1.
637 5551 day; 636 9659 eve.

V.H.F. SERVICE TECHNICIAN required by London Car Telephones to work on base station and mobile radio equipment. Very well equipped busy workshop in Croydon, but also field service engineers required in the home counties. Ample opportunities for unlimited overtime. Experienced persons only. Salary and bonuses commensurate with ability. Contact J. S. CLARK, 01-680 1010. (7987

LUXMAN DISTRIBUTORS

Require an additional

HI-FI ENGINEER

Must be experienced and capable of servicing high quality equipment. Good prospects.

Apply: **Sales Manager, HOWLAND-WEST LTD. 3/5 Eden Grove London N7 8EQ Tel: 01-609 0293**

(8277)

RADIO ENGINEER HAITI

Required to work as technical adviser to the Haitian Radio School team working on a new adult literacy scheme. Responsibility for the maintenance and repair of the Radio station equipment and the training of Haitian counterparts.

A British Volunteer Programme Post, language training provided.

For further information write with details of curriculum vitae to CIIR Overseas Volunteers, 1 Cambridge Terrace, London NW1 4JL.

(8282)

Communicate with Racal

Chief of Sales-U.K.
Systems Engineers

Windsor

RACAL

The Racal Electronics Group have an outstanding growth record based upon sound management and a controlled development programme.
Racal (Slough) Limited located at Windsor is an expanding member of the Group and is engaged in the design and manufacture of sophisticated communications equipment.
The Marketing Department are seeking to appoint:

Chief of Sales—U.K. (MALE/FEMALE)

We offer a very challenging opportunity with excellent career prospects.
Reporting directly to the Marketing Director, responsibilities will include maintaining existing areas of business, seeking and negotiating new contracts and active liaison with U.K. customers such as M.O.D., Post Office and Government establishments.
Applicants preferably to have had at least five years sales/marketing experience and to have worked in the radio communications field. Ex-service personnel without marketing experience will be seriously considered.

Systems Engineers (MALE/FEMALE)

Reporting to the Chief Engineer (Systems), duties will include the detailed planning and engineering of radio communication systems to customer requirements, and the provision of assistance to Marketing personnel to promote the Company's products.
Applicants should preferably be educated to degree level or equivalent and possess experience of systems work.

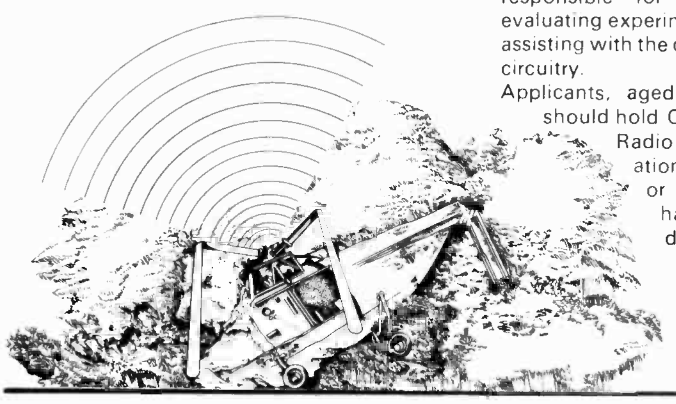
Located in the pleasant Berkshire town of Windsor, we offer attractive conditions, benefits, and salaries. Assistance with relocation expenses is available in appropriate cases.

If you are interested in either of the above posts please write giving details of age, experience and present salary to:
Personnel Officer, Racal (Slough) Limited, Duke Street, Windsor, BERKS.

8279

Hide and seek is something we take very seriously

Especially when the object to be found is a crashed aircraft or a survivor at sea, or a nuclear submarine hiding on the sea bed. These are just some of the activities we're engaged on at UEL Electronic Communications Limited.
A member of the international Dowty Group, we are one of the leading companies in Europe in the development and manufacture of sonar and communications systems. Products include homing and rescue beacons, sonobuoys for anti-submarine and seismic exploration, airborne emergency radios, and communications control systems and intercom installations for civil and military aircraft.



Our latest project is in the area of VHF radio where we are providing British Rail with a communication system between signal boxes and trains.
We are now looking for experienced men and women to work on a variety of interesting projects:

Senior Development Technicians

We require men or women to join project teams working on the design and development of analogue systems and circuits for prototype equipment. Will be responsible for building, testing and evaluating experimental equipment and for assisting with the development of analogue circuitry.
Applicants, aged between 25 and 45, should hold City & Guilds Electronics, Radio & TV, or Telecommunications Certificates up to Part 1 or Intermediate level and have at least 5 years' development experience, preferably involving government contracts.

Electrical Development Engineers

We are looking for men or women to join a small team of Engineers and Technicians working on the design of analogue systems and circuits. Visits to trials may be necessary and opportunities might arise for visits to clients and suppliers.
Applicants should be qualified to HND or preferably degree level with several years design experience.
We are offering attractive salaries, negotiable according to qualifications and experience, plus a wide range of attractive large company benefits. There are good promotion prospects and generous relocation package is available where necessary covering all legal and estate agency fees, Building Society survey fees, viewing expenses, and a disturbance allowance.
For further information and an application form phone or write to: Mr Gavin Rendall, Personnel Manager, Ultra Electronic Communications Limited, 419 Bridport Road, Greenford, Middlesex. UB6 8AU. Tel: 01-578 0081.

UEL
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(8293)

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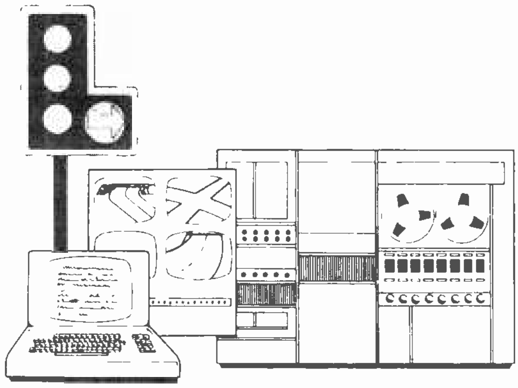

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Vacancies exist for Installation Technicians who have experience of the manufacture, commissioning or operation and maintenance of electronic equipment and who are qualified to ONC or equivalent standard in electrical engineering.

The work includes supervision of craftsmen, liaison with contractors and other specialists at site and assisting professional engineers in the scheduling, assembly, installation, testing and commissioning of broadcasting installations.

The successful candidates, male or female, will be based in the London area but must be prepared to work anywhere in Great Britain for periods which do not normally exceed 4 weeks at a time.

Salary, depending on experience and qualifications, will initially be in the range of £3535 to £3835 rising by annual increments of £150/165 to a maximum of £4800 per annum. Additional allowances are paid for on-site working.

4 weeks and 2 days annual leave.

Requests for application forms to **Engineering Recruitment Officer, BBC, Broadcasting House, London W1A 1AA,** quoting reference 78.E.2138/WW. Please enclose an addressed envelope with your application; no stamp is required. Closing date for completed application forms is 14 days after publication.

8276

BBC

TELEVISION OR RADIO ENGINEER

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Please contact **Mr. B. Meaden at 6 Ponsford Road, Minehead, Somerset. Tel: Minehead (0643) 4186.**

8273

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have a vacancy for an

ELECTRONICS MAINTENANCE ENGINEER

to work on studio broadcast equipment including cameras and video and audio equipment. Shift working may be involved. Salary £5,000 plus. Excellent conditions of service and relocation assistance may be available. Written applications, giving full details, should be forwarded to the **Personnel Manager, Westward TV, Derry's Cross, Plymouth, PL1 2SP.**

WESTWARD TV

8272

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Regional Medical Physics Dept.
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Newcastle Upon Tyne NE4 6BE

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Technician (Electronics)

Grade III (2 posts)

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The successful applicant will have served a recognised course of training followed by a minimum of three years relevent experience, which may be outside the Health Service.

A HNC in electronics, electrical engineering or applied physics or equivalent is required.

Salary £3,744 p.a rising to £4,788. These posts may be offered at a lower grade if no suitable Grade III applications are received.

Applications should be received within 14 days of the appearance of this advertisement.

Application forms and job description may be obtained from the Regional Personnel Officer, Northern Regional Health Authority, Benfield Road, Walker Gate, Newcastle Upon Tyne NE6 4BY (8304)

UNIVERSITY OF CAPE TOWN

MARINE ELECTRONICS TECHNICAL OFFICER

An electronics Technical Officer is required to assume duty as soon as possible in the Marine Geoscience Group of the Department of Geology. Duties will include the maintenance and development of marine geophysical equipment both in the laboratory and at sea. Some experience in this field would be a recommendation. The successful applicant will spend several 2-3 week cruises per year aboard the University's research vessel "Thomas B. Davie".

The salary will be on the scale R4 020 x 180 – 5 100 x 240 – 5 580// x 240 – 6 300 // x 360 – 6 660 per annum plus a pensionable allowance of 15.5% of salary (i.e. maximum monthly salary of R641). In addition, the University offers a housing subsidy, plus medical and pension schemes.

Further details may be obtained from the Professor of Marine Geoscience, Department of Geology, University of Cape Town, Rondebosch, 7700 South Africa.

Applications giving names of two referees must reach the Registrar, University of Cape Town, Private Bag 18, Rondebosch 7700, by 30th June, 1978.

The University's policy is not to discriminate in the appointment of staff or the selection of students on the grounds of sex, race, religion or colour. Further information on the implementation of this policy is set out in a memorandum which is obtainable from the Registrar. (8178)

BBC

TECHNICAL OPERATIONS TRAINING

Staff required at the ENGINEERING TRAINING DEPARTMENT, EVESHAM, WORCESTER.

Duties Contributing towards the operational training of Technical Staff in Television and/or Radio Broadcasting. This includes instructing Technical Operators who are responsible for sound coverage, audio mixing, camera work and lighting in Television Studios and Outside Broadcasts. In Radio, Technical Operators operate the Radio Network Continuity Suites and carry out duties in connection with programme routing and switching.

Qualifications Recent experience in some aspect of Technical Operations or Engineering in the Broadcast or Closed Circuit field. A good technical knowledge of audio or video equipment. A willingness and ability to undertake internal training if necessary to obtain a qualification equivalent to City & Guilds Full Technological Certificate in Telecommunications.

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Further Details If you would like to hear more and receive an application form please send a stamped addressed envelope of at least 9" x 4" to **Head of Technical Operations Training Section, Engineering Training Department, Wood Norton, Evesham WR11 4TF**, quoting reference number 78.E.2177/WW. Closing date for return of application forms 14 days after publication.

8220

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TO: David Reeves, CED Recruitment, ICL, 85/91 Upper Richmond Road, London SW15 2TE.

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Closing date for applications August 31, 1978.

The Recruitment Officer (Ref. ROWW/7)
Government Communications Headquarters
Priors Road
Oakley, Cheltenham
Glos, GL52 5AJ
Telephone: Cheltenham 21491, Ext. 2269

8217

GCHQ

Recruitment Officer,
GCHQ, Oakley,
Priors Road, Cheltenham, GL52 5AJ.
Cheltenham (0242) 21491 Ext 2270

Southern Television Limited have a vacancy for an ENGINEER at their DOVER STUDIO.

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Applications should be made in writing to
The Personnel Administrator, Southern Television Ltd.
Northam, Southampton SO9 4YQ

(8242)

ELECTRONICS TECHNICIAN for educational services unit. Candidate should have interest in television as a teaching and research tool. sound background in electronics with ability to communicate with patience, students and staff at all levels. Major part of the post involves maintenance of small studio in Dept of Psychiatry and replay of video recordings. Salary scale £3,186 to £3,720 p.a. Reference 496/C/135. Application forms from Assistant Secretary Personnel Office, University of Birmingham, P.O. Box 363, Birmingham B15 2TT. (8305

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(8289)

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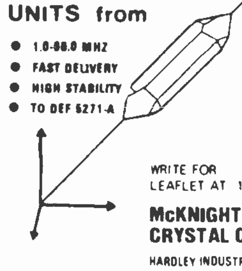

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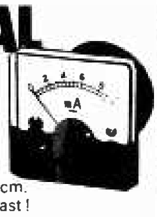

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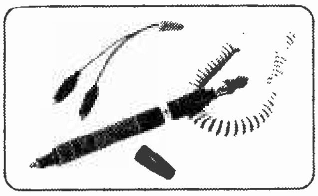

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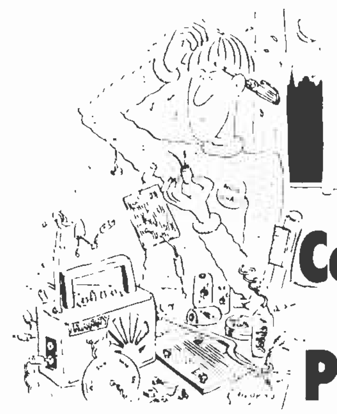

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