wireless world

APRIL 1978 40p

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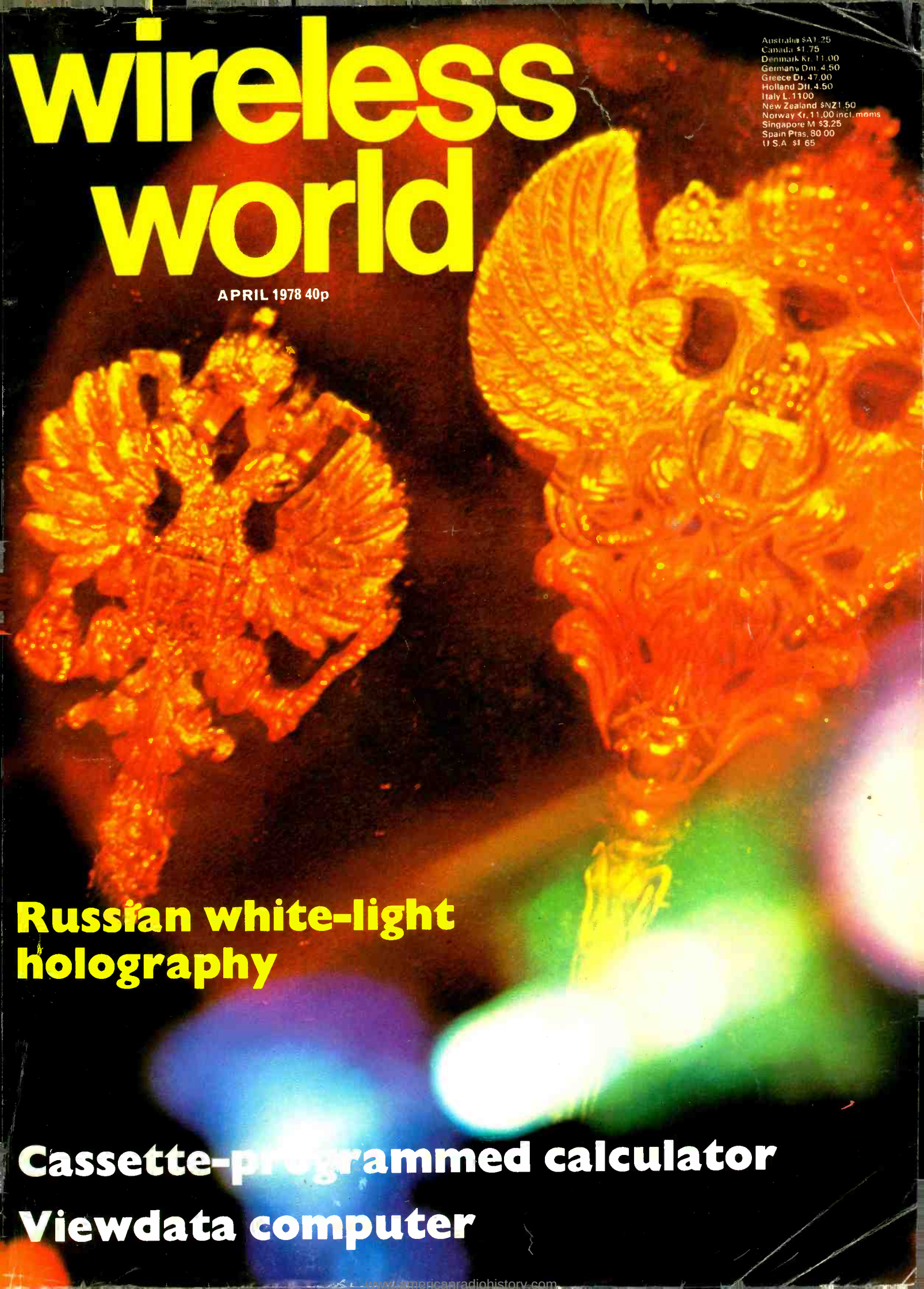

Russian white-light holography

Cassette-programmed calculator

Viewdata computer

The Versatile Fet Multimeter

Eight optional accessories including an r.f. probe, a peak-to-peak probe, a temperature probe, and a co-axial T-connector, make the TF 2650 Solid State FET Multimeter one of the most comprehensive general purpose multimeters available. Such versatility makes the TF 2650 ideal for use in servicing, production, technical education, research, design and many other applications, while the battery/mains option makes it equally suitable for field, laboratory or workshop.

Accuracy is ±1·5% on most ranges and the f.e.t. input amplifier gives an output resistance of typically 100 MΩ with good overload protection. Scales cover from 1·5 mV and 0·15 mA f.s. to 1500 V and 1·5 A a.c. and d.c. The accessories extend the ranges up to 30 kV and 150 A, r.f. up to 1 GHz and temperatures up to 500°C. Resistances can be measured from 100 Ω to 100 MΩ mid-scale with a facility to make in-circuit measurements on solid-state devices. A centre-zero facility is available on most ranges.

The basic instrument is supplied complete with co-axial leads, crocodile grips, test prods and a leather carrying case.

For further information write or phone:

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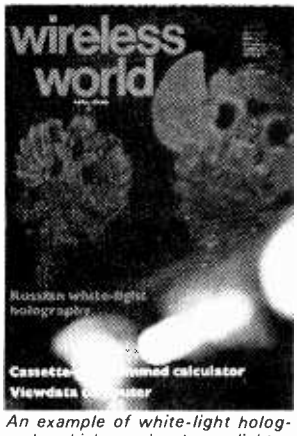

An example of white-light holography which uses incoherent light to create a three dimensional image. For further details see page 68. Photograph by Paul Brierley

IN OUR NEXT ISSUE

***Loudspeaker system* with a common bass enclosure, active crossovers, electronic delay compensation and equalization. Articles discuss choice of drivers, enclosure design and positioning in room.**

***New distortion measurement* using pseudo-random binary test signal gives much better correlation between subjective and objective measurement than does t.h.d.**

***Liquid crystals.* A summary of the techniques used in this, the newest type of display, and the advantages and drawbacks to each technique.**

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wireless world

ELECTRONICS / TELEVISION / RADIO / AUDIO

APRIL 1978 VOL 84 NO 1508

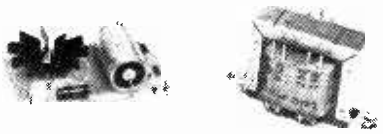
F.M. TUNERS, MODULES & UNITS by *Icon Design*

T3 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. **£149.00**

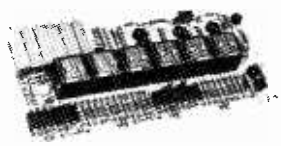
M1 This module is the heart of the above tuner, giving a mono output with a.f.c., mute, and tuning indicator functions. Drift free tuning by 10 turn pot over the range 88 to 108 MHz. This module will not let you hear out-of-tune stations, and the fine tuning lamp is extinguished unless a station is received. The ideal basis for any High quality F.M. system. **£29.95**

M2 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. **£8.36**

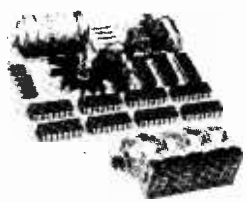
M4 An integrated circuit regulator supplies all the power for the M1, M2 and M5, in addition to being short circuit proof and having automatic thermal shut-down, and ensuring hum free reception. **£6.93**



M5 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. **£17.54**



M6 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. **£44.40**



★★ PLUS TWO NEW ONES ★★

M7 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. **£6.95**

M8 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. **£4.95**

ORDERING INFORMATION

Small orders <£5.00 plus 50p handling charge.

U.K Orders post free, plus 12 5% V.A T.

Overseas, send for Pro-forma invoice first, or send £3.00 air mail for small items

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SL301	£1.67	BC184	£0.15	Cermet pre-sets	£1.20
SL3046	£0.94	BC214	£0.15	Transformers: 120/240v	
TBA750	£1.71	1N4001	£0.06	6VA 4.5v	£2.33
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TBA625C	£1.65	P.C.B. M1	£2.64	Kit K14 (M1)	£27.95
UA78M20	£1.65	P.C.B. M2	£1.65	K57 (M2)	£6.84
UA78M05	£1.65	P.C.B. M3	£1.65	K112 (T3)	£137.80
SFJ10·7MA	£1.71	P.C.B. M4	£1.65	Descriptive booklet	50p
LP1186	£8.53	Coil ass.	£0.55	Overseas	£1.50
2N3904	£0.20	10t 50K pot	£3.89		

TO ICON DESIGN · 33 Restrop View, Purton, Wilts., SN5 9DG

Please supply data on (Circle as required)

M1 M2 M4 M5 Mk 2 M6 M7 M8 ALL

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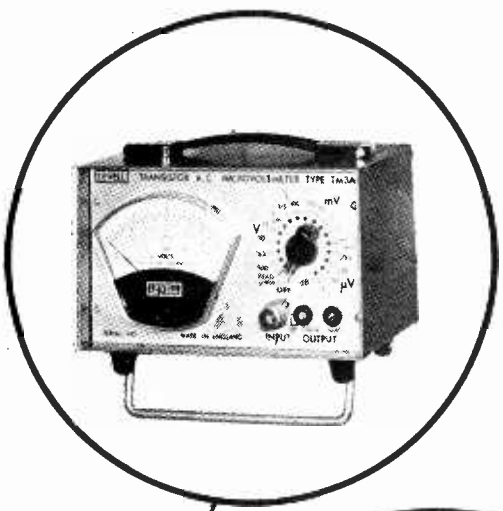
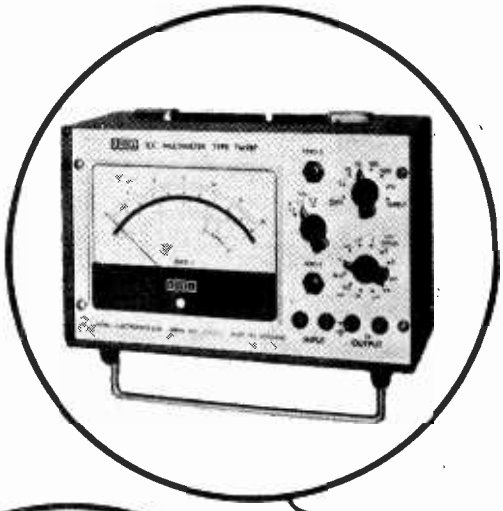
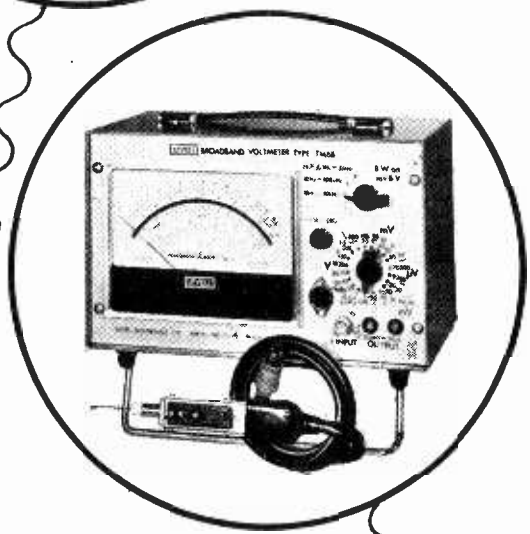
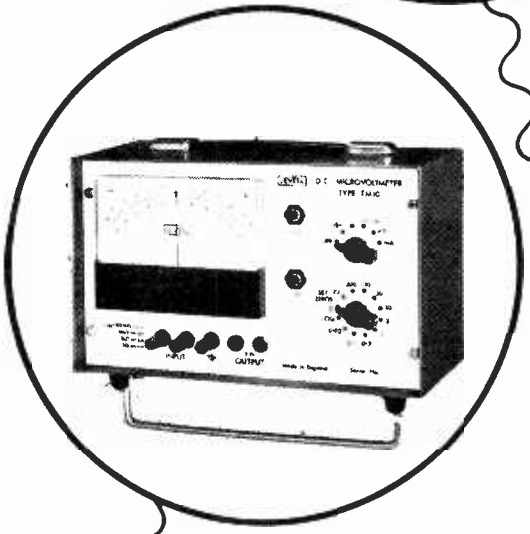
PORTABLE INSTRUMENTS









A.C. MICROVOLTMETERS

VOLTAGE & dB RANGES: 15μV, 50μV, 150μV . . . 500V. Acc. ± 1% ± 1% f.s.d. ± 1μV at 1kHz — 100, — 90 . . . +50dB
Scale — 20dB/ + 6dB rel. to 1mW/600Ω.
RESPONSE: ± 3dB from 1 Hz to 3MHz, ± 0.3dB from 4Hz to 1MHz above 500μV. Type TM3B can be set to a restricted B.W. of 10Hz to 10kHz or 100 kHz.
INPUT IMPEDANCE: Above 50mV >4 3MΩ< 20pf. On 50μV to 50mV : > 5MΩ < 50pf.
AMPLIFIER OUTPUT: 150mV at f.s.d.

type TM3A **£89** type TM3B **£99**

D.C. MULTIMETERS

VOLTAGE RANGES: 3μV, 10μV, 30μV . . . 1kV. Acc. ± 1% ±1% f.s.d. ±0.1μV. LZ & CZ scales.
CURRENT RANGES: 3pA, 10pA, 30pA . . . 1mA (1A for TM9BP). Acc. ±2% ±1% f.s.d. ±0.3pA. LZ & CZ scales.
RESISTANCE RANGES: 3Ω, 10Ω, 30Ω . . . 1 GΩ linear Acc. ±1% ±1% f.s.d. up to 100MΩ.
RECORDER OUTPUT: 1V at f.s.d. into > 1kΩ on LZ ranges.

type TM9A **£130** type TM9BP **£140**

BROADBAND VOLTMETERS

H.F. VOLTAGE & dB RANGES: 1mV, 3mV, 10mV . . . 3V. Acc. ±4%±1% f.s.d. at 30MHz. — 50dB, — 40dB, — 30dB to + 20dB. Scale — 10dB/ + 3dB rel. to 1mW/50 Ω ± 0.7dB from 1MHz to 50MHz, ± 3dB from 300kHz to 400MHz.
L.F. RANGES: As TM3 except for the omission of 15μV and 150μV.
AMPLIFIER OUTPUT: Square wave at 20Hz on H.F. with amplitude proportional to square of input. As TM3 on L.F.

type TM6A **£140** type TM6B **£150**

D.C. MICROVOLTMETERS

VOLTAGE RANGES: 30μV, 100μV, 300μV . . . 300V. Acc. ± 1%, ± 2% f.s.d., ± 1μV. CZ scale.
CURRENT RANGES: 30pA, 100pA, 300pA . . . 300mA. Acc. ± 2%, ± 2% f.s.d., ± 2pA. CZ scale.
LOGARITHMIC RANGE: ± 5μV at ± 10% f.s.d., ± 5mV at ± 50% f.s.d., ± 500mV at f.s.d.
RECORDER OUTPUT: ±1V at f.s.d. into >1kΩ.

type TM10 **£77**

These highly accurate instruments incorporate many useful features, including long battery life. All A type models have 83mm scale meters, and case sizes 185x110x130mm. B types have 127mm mirror scale meters and case sizes 260x125x180mm.

LEVELL ELECTRONICS LTD.
Moxon Street, High Barnet, Herts. EN5 5SD
Tel: 01-449 5028/440 8686

Prices are ex works with batteries. Carriage and packing extra. VAT extra in U.K. Optional extras are leather cases and mains power units. Send for data covering our range of portable instruments.

SEE US ON STAND 111, AT THE SCOTTISH ELECTRONICS EXHIBITION
WW—058 FOR FURTHER DETAILS

The competition's days are numbered

The AVO DA 116 is the latest digital multimeter to come on the market. It may not be the first, but it's certainly the best. Why? Because it's from AVO. We've taken time to get everything right. The size, the shape, the performance, the lot. After all, it's taken us many years to establish our reputation for quality and we're not prepared to throw it away for the sake of being first into the market place. These features prove our point.

Built to last For a start, we've avoided building a pocket-sized multimeter. They can slip out of a pocket or just as simply be 'lost'. We've also worked hard on the casing. It's designed to take all the knocks and still come back for more.

Easy to read We've used a 3½ digit liquid crystal display which gives large easy-to-read numbers (in any light) and decimal placement as well as automatic polarity indication on d.c. ranges.

Wide ranges Measurements may be made up to 1000V and 10A on both a.c. and d.c. ranges. There are six resistance ranges measuring up to 20 MΩ. Added to this, the AVO DA116 also incorporates a special Junction Test range for the testing of diodes or transistors in circuit.

High Speed Ohms We've incorporated a Fast Ohms range for continuity testing, with a normal response time of about one-tenth of normal resistance ranges.

Long battery life There's not a digital multimeter to beat it for long battery life. Four ordinary zinc carbon 1.5V batteries should last you more than 500 hours. And when the batteries need replacing, you get immediate visual indication.

Handy protective cover It doesn't only protect the instrument, but it also houses the test leads and provides a ready made support stand when you're using the instrument on a bench.

Value for money The AVO DA116 is really competitively priced. After all, what's the point of building a great multimeter if nobody can afford it?

We think we've done a great job on the AVO DA116. Once you've tried it we think you'll agree.
Get in touch with us today and we'll let you have the full facts. Or better still, call your usual supplier for a demonstration.

AVO LTD., Archcliffe Road, Dover, Kent. CT17 9EN.
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...a low cost/high performance range of μP-based bridges

GenRad's new range of μP-based bridges make full use of advanced technology to meet tomorrow's testing needs today. Check the list of features, and contact us for further information, price and delivery.

1658 RLC Digibridge
* Automatically measures R,L,C, D and Q
* 0.1% Basic accuracy
* 10 Bins for sorting
* Autoranging
* IEEE 488 bus/handler interface option
* Three test speeds
* Selectable continuous, average or single component measurements
* Three types of display programmed bin limits, measured values or bin number
* **Five**-digit display for R,L and C
* **Four**-digit display for D and Q
* Selectable test frequencies of 1 kHz and 120 Hz (100 Hz)
* Series or parallel measurement mode selection
* Built-in Kelvin test fixture tests radial and axial lead components

1657 Digibridge ™
* Under £1,000

The 1657 Digibridge
* Automatically measures R,L,C,D and Q
* 0.2% Basic accuracy
* **Five**-digit display for R, L and C
* **Four**-digit display for D and Q
* Microprocessor-directed ranging
* Selectable test frequencies of 1kHz and 120Hz (100 Hz)
* Series or parallel measurement mode selection
* Built-in Kelvin test fixture tests radial and axial lead components

1687 Megahertz LC Digibridge
* Automatically measures Ls & Q, Cs & D, Cs & Rs, Cp & Gp
* 0.1% basic accuracy for C
0.2% basic accuracy for L
* Automatic limit-comparison (10 bins)
* Autoranging
* IEEE 488 bus/handler interface option
* Two test speeds
* Selectable continuous, average or single component measurements
* Four types of display - programmed bin limits, measured values, deviation measurement (ΔL or ΔC), or bin number
* **Five**-digit display for L and C
* **Four**-digit display for Q,D,R and G
* Optional Kelvin test fixture tests radial and axial lead components

1658 RLC Digibridge™
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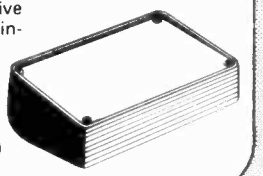
WW—085 FOR FURTHER DETAILS

BIMCONSOLES
BIMBOXES
BIMBOARDS
BIMDRILLS
BIMDICATORS

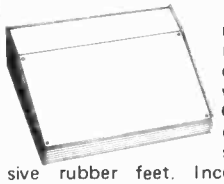
MINI DESK BIMCONSOLES

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) £1.97*
BIM1006 (215x130x75mm) £2.70*

LOW PROFILE BIMCONSOLES

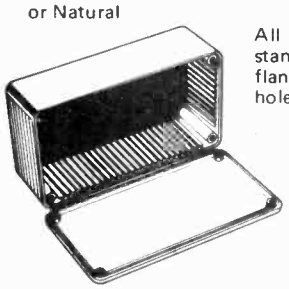


1mm Grey Aluminium panel sits recessed into front of console base, which is moulded in Orange, Blue, Black or Grey ABS and sits on 4 self adhesive rubber feet. Incorporating guides for holding 1.5mm thick pcb, the base also has stand-off bosses for supporting small sub-assemblies etc. and ventilation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

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

ABS & DIECAST BIMBOXES

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



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

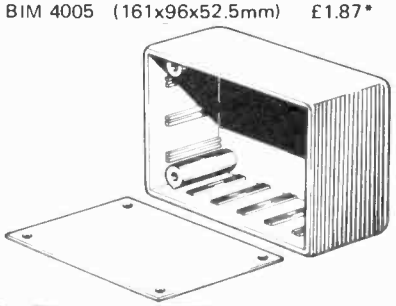
	ABS		Diecast	Hammertone	Natural
(100x50x25mm)	BIM2002/12	£0.87*	BIM5002/12	£1.20*	£0.97*
(112x62x31mm)	BIM2003/13	£0.97*	BIM5003/13	£1.50*	£1.20*
(120x65x40mm)	BIM2004/14	£1.05*	BIM5004/14	£1.86*	£1.49*
(150x80x50mm)	BIM2005/15	£1.18*	BIM5005/15	£2.38*	£1.91*
(190x110x60mm)	BIM2006/16	£1.84*	BIM5006/16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

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

MULTI-PURPOSE BIMBOXES

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

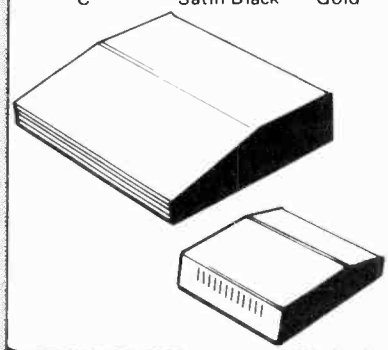
BIM 4003 (85x56x28.5mm) £1.13*
BIM 4004 (111x71x41.5mm) £1.42*
BIM 4005 (161x96x52.5mm) £1.87*



ALL METAL BIMCONSOLES

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

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



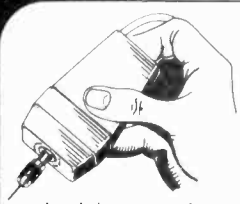
15° Sloping Panel

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

30° Sloping Panel

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

MAINS BIMDRILL



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

DIL COMPATIBLE BIMBOARDS

Bimboards accept all sizes of DIL packages as well as resistors, diodes, capacitors and LED's etc. They have integral Bus Strips running up each side for carrying Vcc and ground as well as Component Support Brackets for holding lamps, fuses and switches etc. Available as either single or multiple units, the latter mounted on 1.5mm thick, matt black aluminium back plates which stand on non slip rubber feet and have 4 screw terminals for incoming power.

Bimboard 1 contains 500 individual sockets whereas the multiple units containing 2, 3 or 4 Bimboards incorporate 1,100, 1,650 or 2,200 individual sockets, all arranged on a 2.5mm(0.1") matrix.

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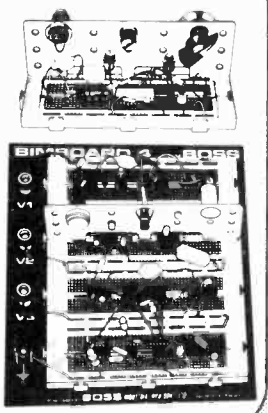

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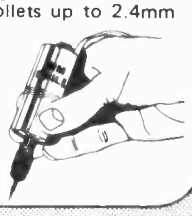

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The new, comprehensive JVC ¾" video cassette range

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. 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.

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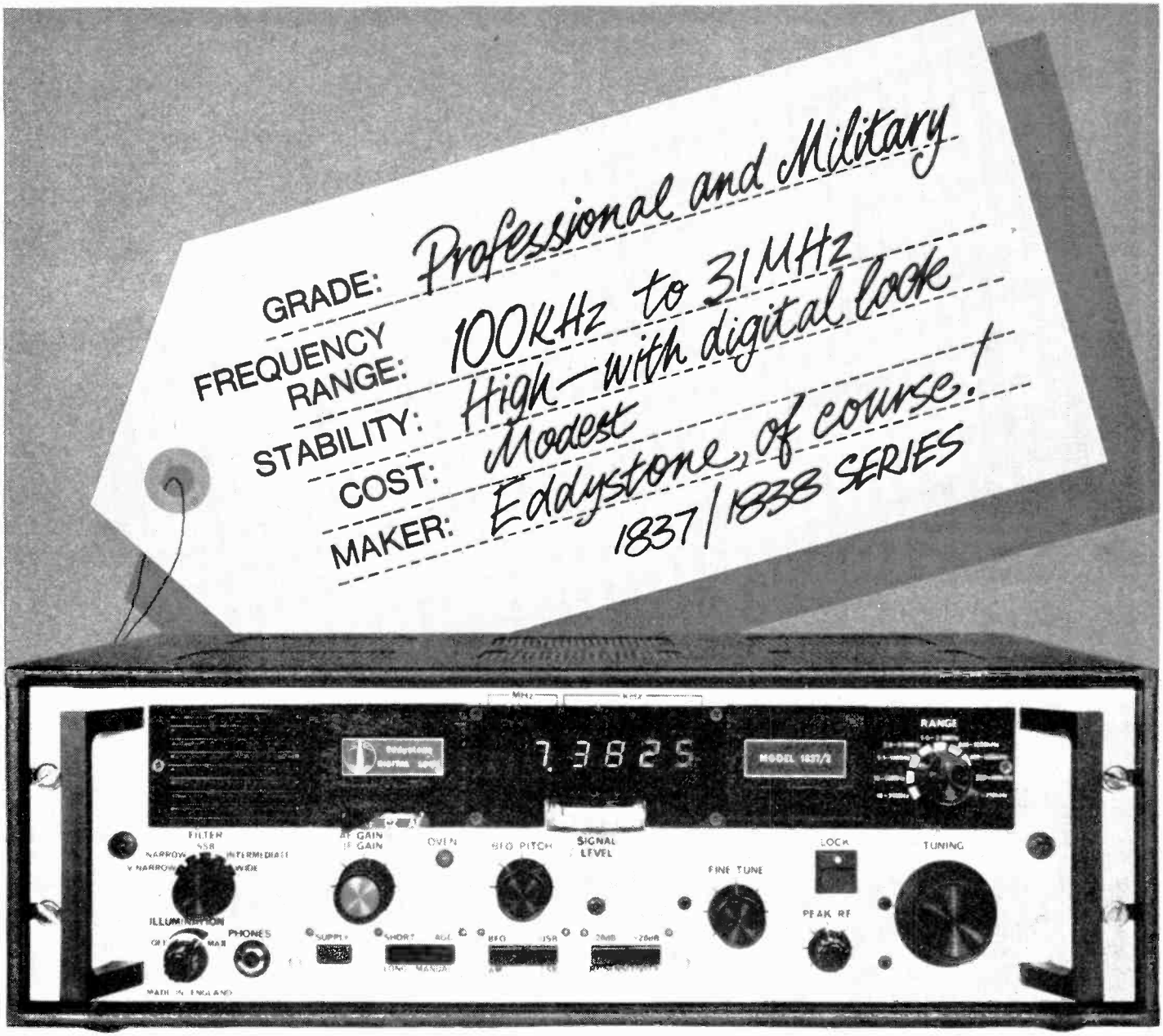
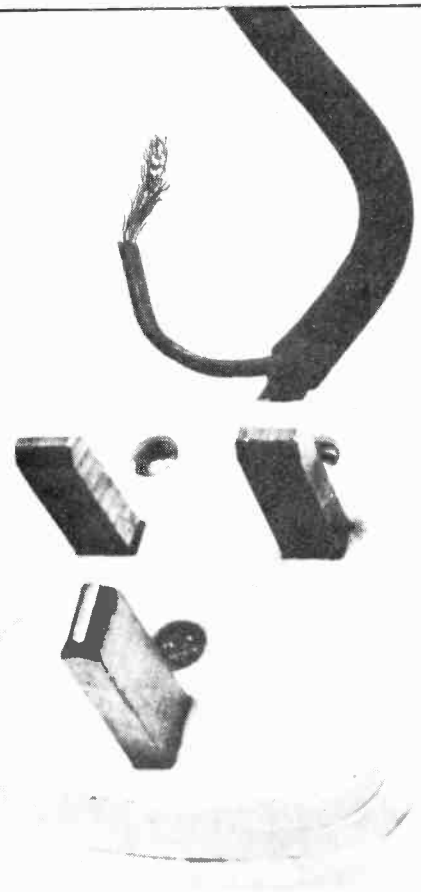


Eddystone's new 1837/1838 series of high-grade h.f. communications receivers covers most general-purpose applications in professional and military communication, including marine use where speech, telegraphy or f.s.k. teleprinter signals are employed.
A particular feature of the new receivers is the unique method used for frequency stabilization, which provides the convenience of manual tuning with the facility for locking the frequency to a high degree of accuracy.

The 1837/1838 series has been approved by the British Ministry of Posts and Telegraphs as complying fully with specifications MPT 1201, 1216, 1217, 1204. Reliability is an outstanding feature, and the performance is maintained under severe environmental conditions of climate and location.
Please ask for full details: 1837/1 Ship's Main and Reserve Receiver: 1837/2 General-Purpose High Stability Receiver: 1838 Series General-Purpose Telephony Receiver.



It's easy enough checking this end, but what about the other?

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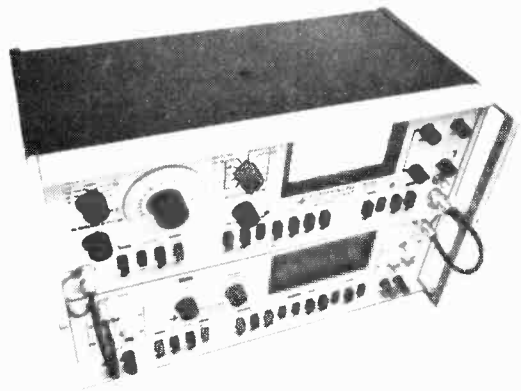

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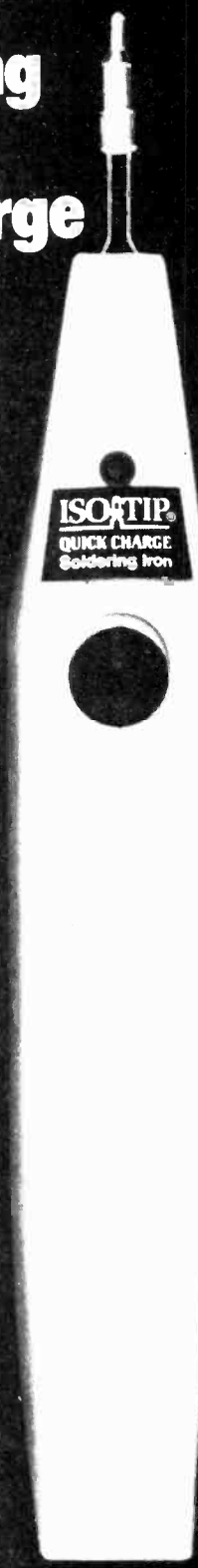
Introducing the new Quick Charge Cordless Soldering Iron



- **Solder heat in five seconds**
- **No wires to restrict use**
- **Completely recharges in only 4 hours!**
- **No need for earthing**
- **Capacity to solder up to 125 joints**

This new rechargeable soldering iron from Greenwood brings added freedom to professional soldering. The Quick Charge recharges so fast that completely dead battery cells can be brought to full charge in about 4 hours – three times faster than before. In its stand the Quick Charge is, of course, being continually charged. A wide range of tips and now also a P.C. Drill attachment make this the most 'versatile' professional soldering iron available.

Illustration actual size.

Greenwood Electronics

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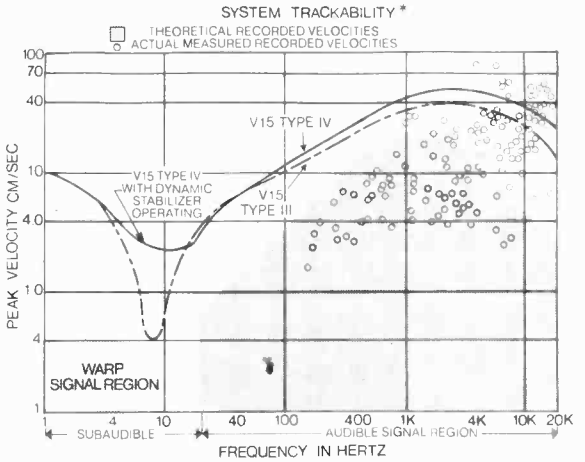
WW—054 FOR FURTHER DETAILS

fact: the IV does more... *much more!*

Era IV begins! The new Shure V15 Type IV cartridge is an altogether new pickup system that exceeds previous cartridge performance levels by a significant degree. It systematically solves not one, but several problems prevalent in modern disc sound reproduction.

Demonstrably improved trackability across the audible and subaudible range at ultra-light tracking forces

The V15 Type IV has a new stylus assembly design for dramatically increased trackability. The effective stylus mass has been lowered significantly by utilizing a telescoped shank structure and a new lightweight high-energy magnet. The reduced effective mass of the new structure helps improve trackability in the critical mid and high frequencies. A newly designed two-function bearing system has been independently optimized for low frequencies and for high frequencies so that trackability is enhanced across the audio spectrum.



*Cartridge-tone arm system trackability as mounted in SME 3009 tone arm at 1 gram tracking force.

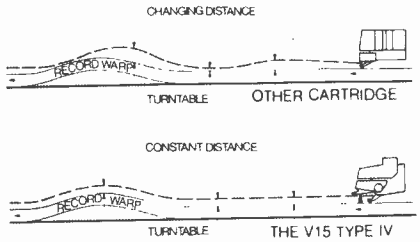
See top of next page

WW—064 FOR FURTHER DETAILS

The shaded area at right in the Trackability chart on preceding page represents recommended theoretical limits of record cutting velocities However, the scattered points are the "hottest" recorded velocities actually measured on today's difficult-to-track records. *The new V15 Type IV tracks far more of the "hottest" points at a low stylus force* than any other existing cartridge! (The curve shown is for 1 gram tracking force By increasing this to 1¼ grams, even more of these points—which encompass virtually all records produced thus far—will be tracked)

Dynamically stabilized tracking that overcomes record warp problems

Our war on warp...



The warp problem

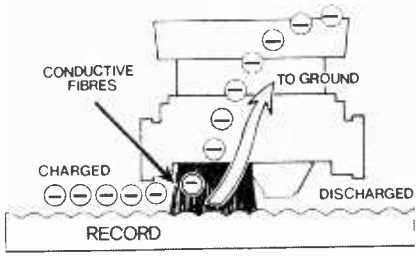
Note the shaded area (at bottom left of the Trackability chart at left) which represents actual warp signals found on records, and the revolutionary subaudible warp trackability characteristics of the SUPER TRACK IV. Reactions of the playback system to these very low frequency warps (between 0.5 and 8 Hz) existing on virtually all recordings can result in gross changes in the distance between the cartridge and the record. This distance change alters the stylus tracking force and the vertical tracking angle and can result in groove skipping, cartridge bottoming, signal wow, and even amplifier and/or speaker overload. Trackability at all frequencies is diminished by these warp-caused changes in tracking force!

Also, at some very low frequency (from 5 to 15 Hz), the tone arm-cartridge combination has a resonance frequency. When this resonance frequency is excited by the warp, all the above symptoms are intensified.

The Super Track IV® total design solution:

A viscous-damped Dynamic Stabilizer on the V15 Type IV combines with a new stylus assembly to minimize or completely eliminate warp-related problems. It raises the arm-cartridge resonance frequency and attenuates the arm-cartridge system resonance effect

An electrostatically-neutralized record surface



The static problem:

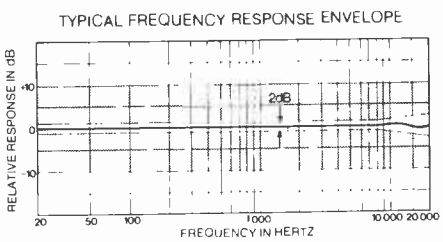
Static charges are omnipresent and unevenly distributed on all records. These charges can attract the cartridge unevenly and change the arm-to-record distance, the vertical tracking angle, and stylus tracking force. The result is wow and flutter. Also, static discharge through the stylus and amplifying system can be a cause of annoying pops and clicks.

The Super Track IV total design solution:

Electrically conductive fibres in the Dynamic Stabilizer of the V15 Type IV ride on the surface of the record and continuously sweep the grooves just ahead of the stylus This picks up the static electricity and discharges it to ground, much like a miniature lightning rod The record surface is thus electrically neutralized. The static charge is prevented from affecting the arm-to-record distance, or from causing static noise in the system Discharging the static stabilizes tracking force during the entire record playing process and does away with the electrostatic attraction of dust to the record surface

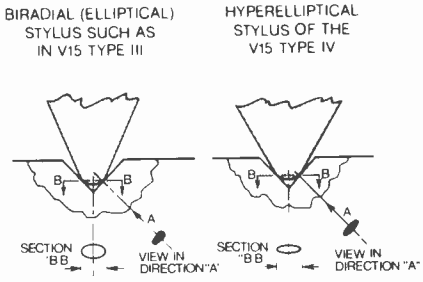
In addition, the conductive fibres effectively sweeo the record surface to remove loose dust and lint

Ultra-flat response

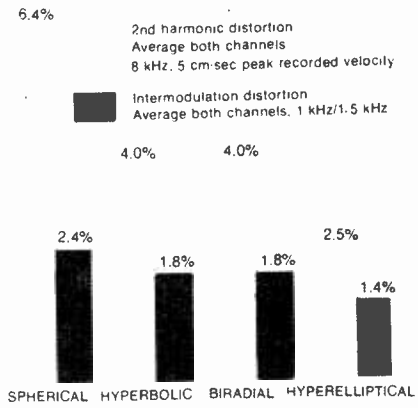


Each V15 Type IV cartridge is individually tested for frequency response that is well within the 2 dB envelope shown here.

Dramatically reduced distortion



The Hyperelliptical nude diamond tip configuration of the V15 Type IV represents a significant advance in tip design for stereo sound reproduction. As the above figures show, its "footprint" (represented by the black oval) is longer and narrower than the traditional Biradial (Elliptical) and narrower than long-contact shapes (such as the Hyperbolic). This results in an optimized tip-groove contact area and dramatically reduces both harmonic distortion (white bars in graph) and intermodulation distortion (black bars).



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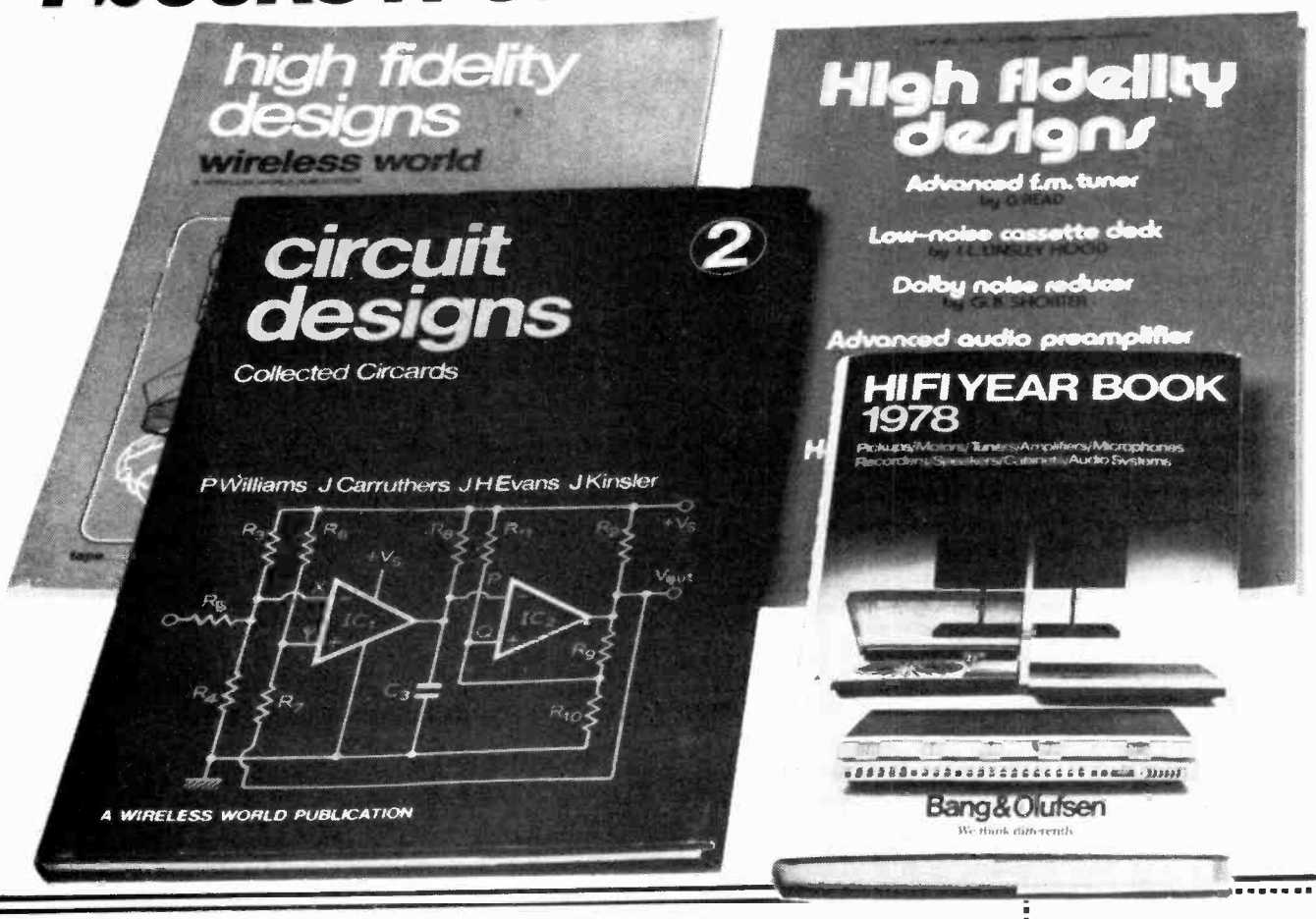

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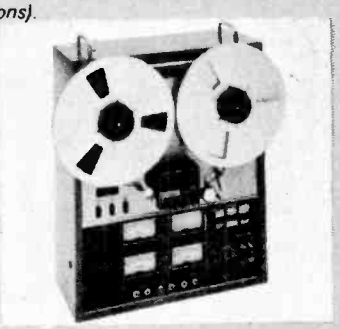

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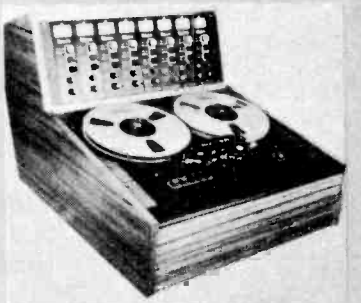

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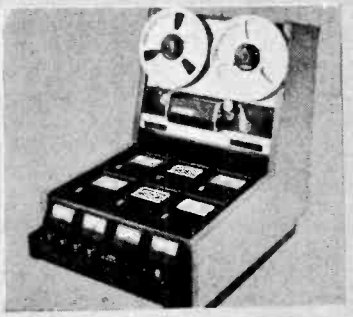

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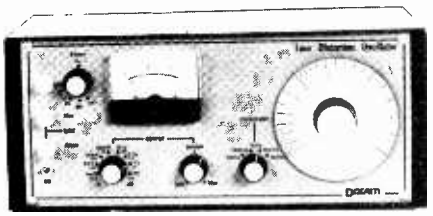

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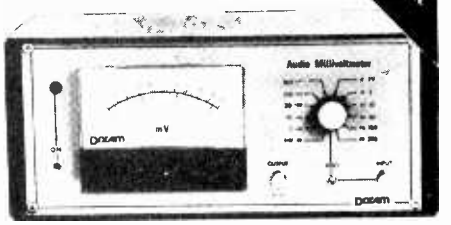

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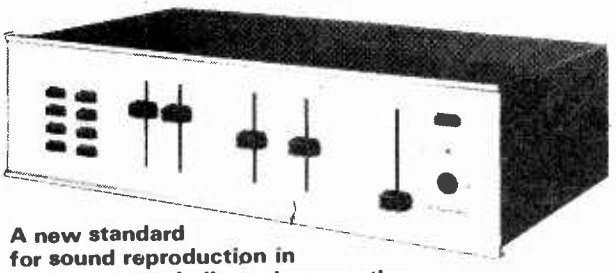

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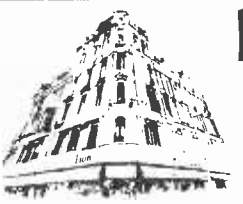

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wireless world

Speakers cornered

It seems that some of the loudspeaker manufacturers are unwilling to help audio magazine equipment reviewers test their products, their disapproval extending to a refusal to lend the reviewers samples of their speakers. This is a curiously ineffective method of protest — perhaps magazines should, as a matter of principle, buy the products anonymously to fend off criticisms of having tested "tweaked" equipment, but that apart, one finds oneself to some extent in sympathy with the makers. It must be galling in the extreme to put in the work, time and money to develop and launch a new loudspeaker, investing heavily in highly-advanced test instrumentation only to find that some "popular" reviewer (no disrespect: popular — of the people) who may, or may not, have sufficient knowledge or facilities for proper testing, decides that he doesn't like it much and proceeds to say so in print. It could be very damaging to the new speaker's chances in the market and, perhaps, for no good reason.

On the other hand, there appears to be no very good reason why speaker manufacturers should be protected from this kind of publicity, any more than washing-machine makers or supermarket operators. So long as a writer stays within the law of Injurious Falsehood, it must be wrong to attempt to prevent him from putting forward his opinion, however ill-founded it may be.

Bearing in mind that the room in which the loudspeaker is to be used is as much a part of the system as is the enclosure itself, and also remembering that the majority of readers of "high-fidelity" magazines are not trained to understand acoustic measurements made in highly artificial anechoic conditions, it could reasonably be said that the popular reviewing of loudspeakers is simply not possible. But until every retailer can be persuaded to allow customers to hear speakers in their homes, it is difficult to see how any guidance can be given except in the form which is currently seen.

The use of anechoic chambers to test speakers is often criticised because the conditions bear little relation to those experienced in a room. Well, of course they do, but which room? The use of such a chamber removes the unknown variables from a test and gives each unit the same conditions. To be of value to the average untrained reader of reviews, the results of such tests would have to be viewed in conjunction with results of acoustic measurements on his listening room, with a view to reducing the acoustic deficiencies of one by a judicious selection of the other. A set of loudspeaker types heard by a panel and listed in order of preference in a particular room can be listed in a completely different order in another room — a test carried out fairly light-heartedly by *Wireless World* staff some time ago. Perhaps a British Standard Room should be specified.

While the above state of affairs remains impractical, the methods of testing and reporting currently adopted by reviewers will probably remain. Adjectives, selected by reviewers to mean something to themselves, will still be used because a subjective experience is difficult to describe in other than subjective terms. Manufacturers have no chance whatever of putting a stop to reviews of any standard of competence; they must be prepared, like any other maker of equipment which is expensive and complicated enough to be difficult to assess by the customer, to take the rough with the smooth.

Radio landing systems

Background to radio blind landing aids and the choice of i.l.s. replacement.

by P. R. Darrington

EVERYTHING that goes up, barring the more exotic space machinery, eventually comes down again and, so far as aeroplanes are concerned, they start trying to get back the instant the wheels clear the runway. Flying, as someone must have said, is a controlled fall — a concept which can be successfully concealed from airline passengers while they cruise at 20,000ft. During the landing phase, particularly in fog or at night, pilots earn their salaries and nervous passengers recall the relevant statistic — 75% of all flying accidents occur during approach and landing or during take-off.

Radio assistance to pilots engaged in locating runways and landing on them began in earnest during the '30s and experienced a tremendous spurt in development during the war, when thousands of hurriedly-trained pilots had to be rounded up. The assistance offered took two forms, with responsibility in the air or on the ground. MIT developed a system known as Ground Controlled Approach (GCA), in which the aircraft is tracked on radar. A wide-ranging p.p.i. surveillance radar locates the aircraft many miles away from the runway and, using a v.h.f. link, the operator guides the aircraft into the purview of a short-range, more precise radar, with which the pilot can be 'talked down' in azimuth and elevation on to the runway. All the aircraft needs is a v.h.f. receiver. This type of system is still used, although the short-range radar is now given the name precision approach radar (p.a.r.). Synthetic displays, generated by computer, are used to give bright displays and to handle multiple targets with little or no clutter from precipitation or static returns. The aircraft must now carry a transponder, triggered from the ground, which supplies pulses for range and angle of approach determination.

The second approach, in which information is derived in the air from ground transmitters, is the basis of many modern systems and is at the centre of both leading systems of microwave landing assistance, of which more later.

Probably the first attempt at this was the Lorenz design[1], later known as Standard Beam Approach. This was based on an idea by P. von Händel and worked out by the German Lorenz company — later to become part of ITT. The Lorenz system used a single transmitter, working at 36MHz, to provide azimuth and glide path indication. Some idea of contemporary practice can be obtained from the preamble to the article referred to: "In the best modern altimeters . . . error does not exceed about 75 feet. Now, with no more detailed height information than is provided by such means as this, it is actually possible on a large aerodrome to land an aeroplane in safety, by throttling the engine down and awaiting contact with the ground".

Guidance was obtained in azimuth by switching a mildly directional beam from side to side of the runway as shown in Fig.1, the range being claimed as 40 miles at 3000 ft. The beam was switched by keying reflectors spaced half a wavelength away from the vertical dipole, the time spent on each side of the landing path being different — 'dots' and 'dashes' were formed in this way. The dots were equal in length to the spacing between dashes, so that on the centre line they merged to form a continuous tone. The pilot listened to the

A technical battle, with political and commercial undertones, has been grinding on between US and UK aviation organizations for some four years, with the microwave landing system of the future as the prize. Allegations and counter-allegations are launched with reckless abandon and, less than two months before ICAO (the International Civil Aviation Organization) is due to make its choice of system, a US Congressional committee is investigating British charges of deception brought against the Federal Aviation Agency. The FAA, not to be outdone, is retaliating with assertions that the British are trying to palm the world off with an under-developed system.

signals and was able to keep within a "few degrees' of the ideal landing path.

Range was determined roughly by signal strength, but also by outer and middle markers radiated on 7.9m. These markers took the form of low-power transmitters, feeding horizontal dipoles, located 0.5 and 3km from the downwind end of the runway. Visual contact with the ground was necessary, although Denman said that a "completely blind landing (could) perhaps be made, if necessary".

Glide path information was dependent on an assessment of signal strength: the pilot would read the beacon signal strength from a meter on the display when passing the outer marker and try to maintain the same reading until touch down, as in Fig. 2. Indication of directions to the pilot was by means of headphones (dots, dashes for azimuth and superimposed tones for the markers) and by meter for field strength. Later the system was modified to use a similar system for elevation as for azimuth.

Lorenz was used, in SBA form, until the '50s, with improved display and beam-forming aerials. It was the basis of the Knickebein and X-Gerät bombing aids used by the Germans during World War II, in which applications nothing needed modification save the receiver, which required enough sensitivity to work at a range of several hundred miles.

This method of identifying on which side of the ideal flight path the aircraft was flying was to remain and to be used for many different systems. In 1935, three separate Lorenz-type systems were under test at Croydon airport, made by S.T.C., Plessey and Marconi.

A radar system developed during the war to assist a lot of very confused bomber crews to limp home was BABS —Beam Approach Beacon System. This was a secondary system in that a beacon would radiate two beams, overlapping on the runway in the approved manner, but only when triggered by an airborne Rebecca equipment from up to 20m away. One advantage was that distance-to-go information determined from go-and-return timing of the pulses, was continuously available and no distance markers were needed. Presentation was by c.r.t., which required the assistance of a second crew member to interpret the display and to direct the pilot.

Several other schemes of landing guidance were proposed. For example, in 1963 F. G. Miles proposed and developed a television system[2] whereby the pilot was presented with a picture of the airfield. A scale model was scanned by a television camera, the picture being transmitted to the aircraft by normal television methods. The position of the camera was directed in azimuth, elevation and range by a locked-on radar, while roll, pitch and height information were derived from the aircraft's flight instruments and telemetered to the ground control. Both air and ground-derived sets of information were used by a computer to adjust the attitude, position and movement of the camera. In the report referred to in reference 2, the system was said to have reached a breadboard stage, but to have been used successfully by the Army in tank training.

C.S.F. in France[3] developed a system in 1953 which again used the principle of overlapping beams, but on a single transmission frequency. The scheme was to use a time-multiplexed switch to launch the signal from four aerials, arranged as upper and lower for elevation and laterally for azimuth. As the beam was switched round the aerials by a 600Hz mechanical rotary switch, the modulation frequency was changed at each one to give the effect of four beams. A gap between sets of transmissions was used to interrogate an airborne transponder which gave a range measurement. Presentation of localizer and glide-path information was by means of the usual crossed-pointer instrument, and accuracy of the localizer was within ±0.5° at 1.5m from the transmitter: distance was measured to within 150 yd at 5 miles.

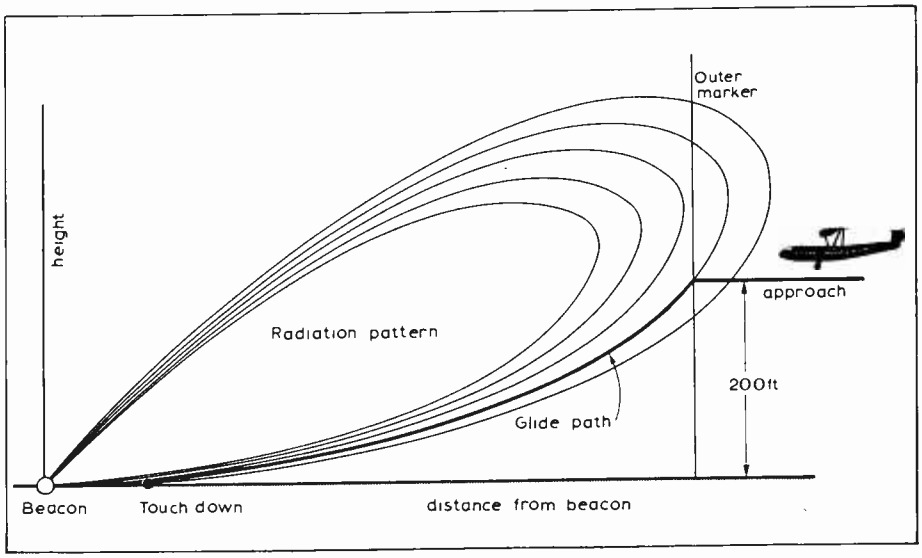
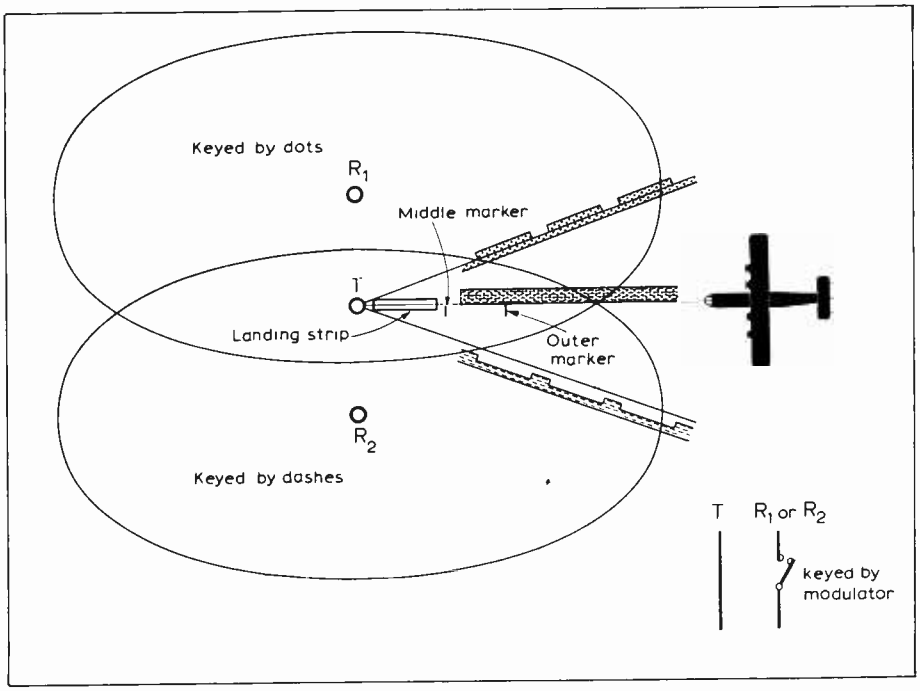


Fig.2. *Lorenz glide-path guidance. On passing the outer marker, the pilot tries to keep the signal level constant until near touchdown.*

Fig.1. *Elements of the Lorenz landing aid. The diagram is based on one which appeared in Wireless World for April 5, 1935, and the field diagrams may appear a little strange; though the principle remains.*



I.l.s.

All the systems so far described suffered from one or more defects. Perhaps accuracy was poor, or they did not fail safe or they presented the pilot with too great a work load at precisely the time when he needed all his faculties to be free to fly the aircraft.

Instrument landing systems (i.l.s.) surmounted most of these drawbacks. It

was developed in America before the war and was first demonstrated by the Federal Aviation Agency (then the CAA) at Indianapolis in 1939. The International Civil Aviation Organization adopted it in 1946 in an attempt to obtain a world standard system.

The system adopted was chosen from five possible approaches, one of which was a microwave localizer and glide path. It was decided to go for a v.h.f. equi-signal localizer and u.h.f. glide-path indicator, the CAA system being the final choice. It was itself a development by the CAA of a military aid, the SCS51, which had seen much service and was well proven. I.l.s. works on higher frequencies than the earlier systems (110MHz localizer, 330MHz glide path) and it was thought the anomalous propagation would be reduced.

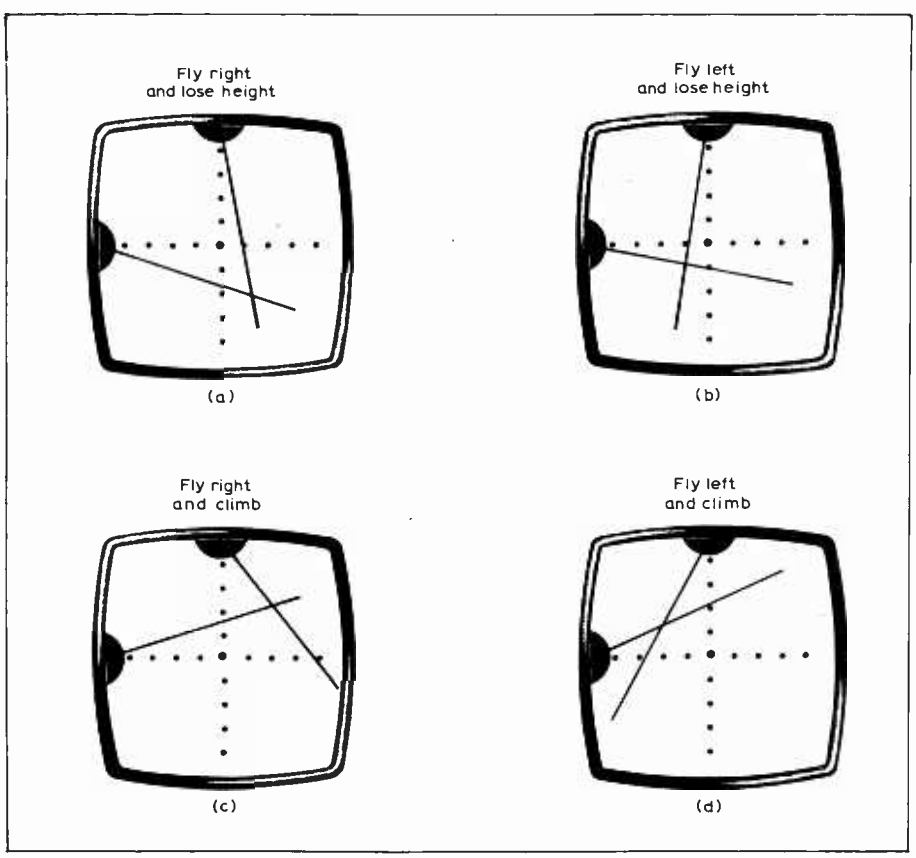
Figure 4 shows the system in broad outline. Horizontal guidance is obtained from a large aerial sited at the upwind end of the runway, working at around 110MHz, and radiating two beams modulated at 90Hz and 150Hz. The two beams overlap and give an equal modulation on the runway centre-line. Efficient a.g.c. is provided in the airborne receiver to avoid the effects of variations in transmitter power. The receiver produces an output proportional to the difference between 90Hz and 150Hz modulations, with which is driven a centre-zero meter, zero being vertical. A voice channel can be provided and the localizer is identified by morse signals every 10s.

A similar system to that used in the localizer is used to give glide-path information, the array being sited at the approach end of the runway. Frequencies lie in the band 328.6 to 335.4MHz and the required beam shape to give an overlap at the glide-path angle is achieved by a combination of direct and ground-reflected waves. Two aerials are used, the effect being to produce a set of lobes, a large central 90Hz one and several smaller 150Hz ones.. The effect is that the overlap between the large lobe and the smaller gives an assymmetrical fly up/fly down signal.

Outer and middle markers are provided, as shown in Fig. 4. These are transmitted on 75MHz with modulations of 400Hz for the outer and 1300Hz at the inner marker, which sometimes tends to be ignored by pilots, since at a distance of 3500 ft from touch-down they rely more on altimeter readings. Marker signals are made to switch on warning lamps and provide a tone warning.

I.l.s. has been the standard system since the late '40s and is to continue in service at least until 1985. It has been extremely successful in service and is almost mandatory all over the world. The system has been used for automatic landing[4] with either a highly accurate version of the localizer or a Murphy leader-cable layout. Radio altimeter data plus that from i.l.s. was used in an autopilot computer to provide "hands-off" landings, although an element of blind faith was invoked in the interval between 150ft and 60ft, in which interval the aircraft would probably be flying over rough ground. The radio altimeter would not give a good height indication relative to the level of the runway and was therefore switched out, the autopilot maintaining the aircraft in an attitude based on a stored history of its behaviour from 2000ft until the 60ft level was reached. Radio altimeter assistance was again called upon in the expectation that the runway was now below, whereupon rate of descent was made proportional to height, a process which was intended to produce an exponential flare-out.

Fig.3. *Crossed-pointer type of indicator, used in many landing systems. The centre dot represents the aircraft, the pointer crossing the centre of the approach path.*



In 1967, however, it was becoming apparent that i.l.s. was not the complete answer. A paper read by Benjamin[6] at an a.t.c. conference indicated that i.l.s. was just not good enough for regular automatic landing because of reflections of radiated energy, noise, and overflying aircraft causing anomalous signals at the receiver. In addition, the signal level dropped by up to 20dB just before touchdown due to the beam directing much of its energy above the aircraft. The author proposed a method of overcoming these drawbacks, giving it the name. Correlation Protected I.L.S. (CPILS). The principle was that transmitters would be placed halfway along the runway at each side, their transmissions being cross-correlated. The noise would then be 'cancelled out', leaving the pristine i.l.s. signal. A similar system was proposed for the glide-path plane.

The initiative for further work came from the U.S. In 1967, the Radio Technical Commission for Aeronatics formed its Special Committee SC-117 to develop a new system. Two systems were proposed—Doppler and a frequency reference scanning beam method. Meanwhile, the British Department of Industry, the Civil Aviation Authority (CAA), Ministry of Defence and Plessey came up with the British proposal, which was a Doppler system (DMLS). Australia put forward a time referenced scanning beam and Germany a distance-measuring equipment (d.m.e.) based landing system (DLS), all of the proposals using microwaves. France proposed AGDLS (Air-to-Ground Data Link System). The All Weather Operations Panel of ICAO proposed, in 1971, a development and testing period for the submissions and the final agreement on the choice of a future system was to be taken in 1976. For one reason or another, minds have been changed, systems have been dropped or discounted, one country has effectively "taken over" another's proposal and the three systems now being considered are:

- Doppler Microwave Landing System (UK) —DMLS
- Time-Referenced Scanning Beam (USA and Australia) — TRSB

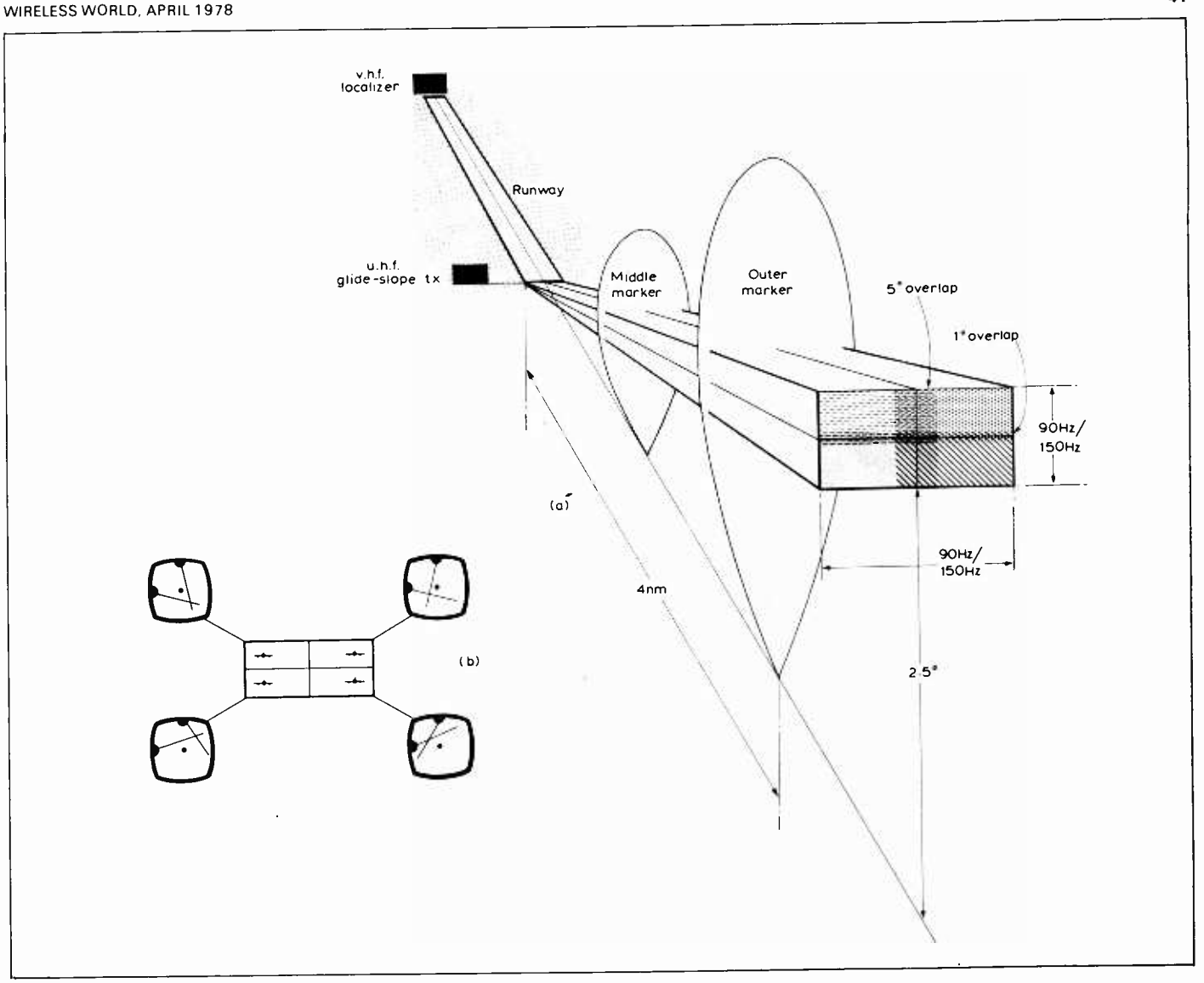


Fig.4. *V.h.f. instrument landing system (i.l.s.) The aircraft recognizes the 90 or 150Hz tone and determines its position in the beam in vertical (u.h.f. transmitter) and lateral (v.h.f. transmitter) directions, as shown at (a). The resulting indication is as seen in (b).*

- D.m.e.-based Landing System (West Germany) — DLS

A decision is due to be taken in April 1978 on the system to be adopted.

Requirements

The facilities required by ICAO in the system to be adopted internationally are

- Azimuth guidance up to ±40° relative to the centre line and up to at least 15°.
- Azimuth guidance in overshoot to ±40°.
- Elevation guidance to 20°.
- Flare guidance from −2° to 8°.
- Range by d.m.e.

Doppler

Early work on effects eventually to be used to advantage in DMLS was done by Dr H. G. Busignies[7] and C. E. Strong and C. W. Earp[8]. Busignies had worked on propagation from a commutated linear array of aerials and found that such an array produced "a transmitted wave characterized by having a spectrum of frequencies, the frequencies varying with different directions of propagation". Earp's work was concerned with the relationship of the aperture of an array and its site error suppression characteristics.

The basic Doppler principle is seen in Fig. 5. A linear array of radiators is successively energized by a commutating switch, all having been energized in turn after around 1ms. The microwave frequency is about 5GHz. When the radiated energy is observed from a position normal to the line of the array, the frequency received is f_o, but if the observer is to one side, as in Fig. 5a the commutation gives the effect of a moving source and a Doppler shift is experienced, positive or negative, depending on the observer's direction of offset. The amount of shift is $f_D = \frac{V}{\lambda} \sin \theta$, where V is the speed of commutation, and λ is the wavelength of the source. The angle of the observer relative to the array can be calculated. In fact, the airborne receiver sees a phase progression which can be said to be a frequency.

To make use of the principle, the azimuth array is placed at the upwind end of the runway and a similar array placed vertically at the approach end to provide glide-path guidance. The error which would be produced by the aircraft's own movement is eliminated by radiating a fixed reference frequency from one element in the array, offset by a small amount from the swept frequency. The aircraft detects the beat between the two signals and all processing is therefore carried out at the low beat frequency.

The short array of elements, together with the commutation, produces a spectrum whose envelope shows a peak, which defines the angle of the receiver with respect to the array normal. The width of the peak is inversely proportional to the aperture of the array. In the aircraft, a tracking filter, feeding a counter, measures the frequency of the peak in the spectrum. Range is determined by an ordinary d.m.e. beacon and interrogator.

A time-division multiplex format is adopted for the DMLS system which contains time-slots for azimuth and

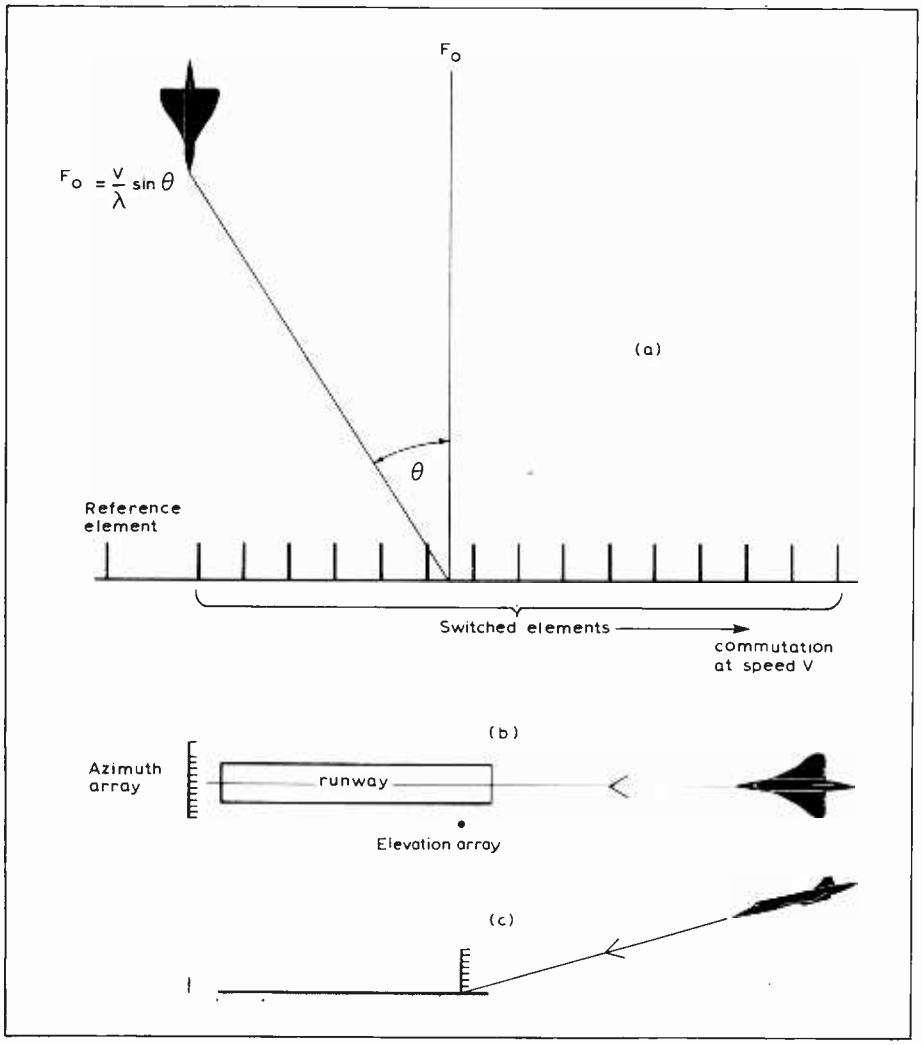


Fig.5. *Principle of Doppler m.l.s. in its basic form. A full-capability system would have two azimuth and elevation aerials for missed-approach guidance. The elevation transmitter and aerial are shown in the heading photograph*

elevation and also for flare. Before each azimuth or elevation slot, a preamble is transmitted which contains

- unmodulated carrier for a.g.c. reference.
- a 5-bit framing code.
- function (azimuth or elevation) identification.
- Morse signal for runway identification.
- 32-bit word to give the airborne processor data on runway length, etc.
- a signal to determine whether the aircraft is outside the system coverage.

The resulting field pattern gives coverage to 20 nm, azimuth angle of 80° up to 20,000ft and back guidance for missed approach or take-off of 40° azimuth up to 5,000ft.

During trials of Doppler m.l.s. in automatic landing it has been found that no 'gap' between the 150ft and 60ft levels, as was needed by i.l.s. is required, since the glide-path indication is sufficiently improved to offer accurate guidance down to the altitude where a radio altimeter takes over.

TRSB

The Australian Interscan proposal and American time referenced scanning beam system[8] are essentially identical in principle. Differences lie in the aerial designs—an area in which most of the problems experienced with TRSB seem to have been experienced.

The principle is simple and is seen in Fig. 6. In azimuth a 5GHz beam, narrow laterally and wide vertically, is scanned to and fro over the entire coverage of the system. The aircraft has a receiver and processor which determines the time taken for the beam to pass the aircraft in one direction, go to the limit of its sweep and pass the aircraft again on its return sweep. From this time interval, the processor determines the position of the aircraft in azimuth relative to the centre of the sweep. A similar beam performs the same process for the elevation plane. The position of the aircraft in azimuth and elevation, relative to the runway centre line, is uniquely determined by the two time intervals.

The signal format is in the synchronized time-division multiplex mode, in which auxiliary data can be transmitted using differential phase-shift keying at 15kb/s. The azimuth sector of the time-multiplexed signal consists of an identification block followed by up to three pulses used for the suppression of beam side lobes outside the required coverage volume, if required — a scanning-beam system is more vulnerable to side lobes, since the beam is used as a timing signal. After the pulses comes the time allotted for the scan and the pulses used for test purposes. The rate of angle data refreshment is 13.5 readings per second for azimuth and 40 per second in elevation.

The auxiliary data, transmitted in blocks immediately before the angle measurement period, is concerned with airport identification, deviation sensitivity scaling factors, the operational status of the ground equipment, data on the glide-slope for the airfield and which function is about to be measured.

DLS

Both Germans (Standard Elektrik Lorenz) and French (Service Technique de la Navigation Aérienne) have considered microwave landing as only part of a wider scheme of integrated air traffic control and en-route navigation. Both use existing L-band d.m.e. beacons at around 1GHz and, in azimuth and elevation, are ground-derived systems, which means that the information is obtained in ground equipment and transmitted to the aircraft. The data is, therefore, available on the ground for use in other systems or in emergency.

Distance measuring equipment (d.m.e.) is, essentially, a ground transponder. The aircraft transmits a pair of pulses to trigger the beacon, which replies by transmitting a pair of pulses back to the aircraft (pulse pairs are used to avoid spurious beacon triggering). The delay between transmission and reception is a measure of the distance. Much additional circuitry is needed to obtain reliability, security and lack of ambiguity, but this does not affect the landing system.

The sequence of events is that the airborne d.m.e. interrogator emits a train of pulses to the two aerials—DLS-E for elevation and DLS-A for azimuth, shown in Fig. 7. The direction of the incident radiation is determined by each aerial, the elevation data being added to that from the azimuth aerial. The DLS-A station is also the d.m.e. transponder and, after a fixed delay, the station transmits a pulse pair for distance in the ordinary d.m.e. manner, followed by two other pulse pairs for azimuth and elevation information. The time between reception of the original pulse and each pulse pair is an indication of the relevant quantity.

The aerials consist of vertical staggered dipole interferometers (up to 40) each with its own receiver. The outputs from the receivers give amplitude and phase data which is fed to a processor, which calculates the angle of incidence of the radiation.

The coverage of the system is almost hemispherical, but accuracy is greatest

in the ICAO-required azimuth of ±40° out to 30n.m. Only a small addition to airborne equipment is required and indication is by numerical reading of range and cross-pointer meter. Flare guidance is provided by triangulation of DLS-A and E stations.

AGDLS

The name of the French system (Air/Ground Data Link System) is almost the whole story. As in the German DLS, AGDL is part of a wide-ranging rationalization of aircraft navigation and guidance, which is currently being undertaken by the Service Technique de la Navigation Aérienne.

Again, this is an L-band ground-derived system, using interferometer aerials to determine azimuth and elevation, but the most important point is that the system is basically a two-way, full-duplex data link, operating in the 1500-1600MHz band.

Ground-to-air communication is a continuous data stream, which allows the aircraft clock generator to lock. The down-link is solely for responses to interrogation. As the aircraft is addressed by ground control, it transmits data for other purposes, the incident angle of which can be determined by the aerials. The time for the round trip again provides distance. Data on elevation, azimuth and distance are processed by a ground computer and sent to the aircraft as part of the data stream in numerical form.

The reasons for the development of m.l.s. have been aired at length, but a reiteration may help to put the present situation into perspective.

One of the main advantages of any of the proposed systems is the possibility of incoming aircraft adopting curved approaches, rather than being constrained to follow the straight and narrow i.l.s. beam. Where the i.l.s. takes noisy aircraft over densely-populated areas, for example Hounslow, the change to m.l.s. should be of great help. Many aircraft can be handled simultaneously, all of them coming in from different directions, if necessary. An aircraft could also retain its altitude until very near the runway.

I.l.s. suffers from anomalous v.h.f. propagation, the beam being deformed by terrain, buildings and aircraft flying over the localizer. M.l.s. offers reduced vulnerability to these effects—the beams can be tailored to suit particular situations and the frequencies used and beamwidths employed avoid trouble of this kind, although those interested in denigrating any particular system seem to sieze on this aspect as being the least easily proven.

It is said that m.l.s. will need less maintenance than i.l.s. equipment, leading to lower life-cycle costs. Doppler has certainly been shown to require very little installation and setting up—3 days is about the current par, against 3 months for i.l.s.

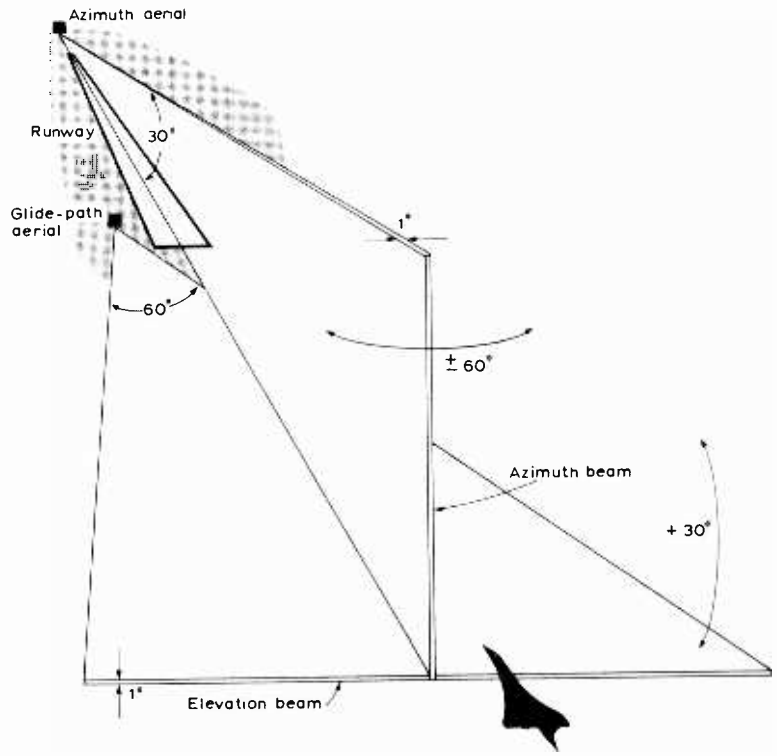


Fig.6. *Basic TRSB system of microwave landing aid. The two beams scan to produce time / position data. Vertical beams widths down to 1° are used for 15000ft runway, up to 3° for 5000ft runways.*

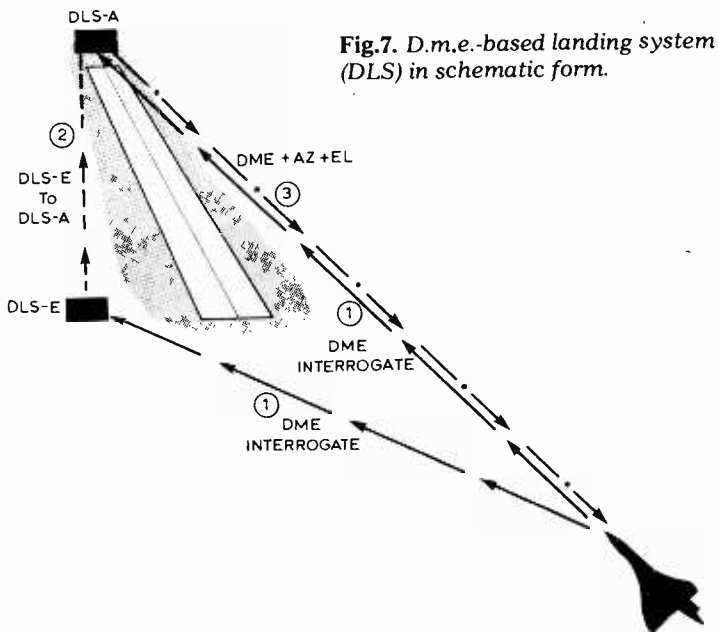


Fig.7. *D.m.e.-based landing system (DLS) in schematic form.*

Finally, the reduction of m.l.s. beam deformation by terrain (particularly in the elevation beam of i.l.s.) means that landing guidance can be provided at airports such as Berne (Belp) where i.l.s. is simply not possible at all.

Pros and cons

There has been an unedifying scramble between the US, UK and Australian candidates to have their systems adopted. If the writings emanating from each camp are examined in isolation it is as though no other system had ever been mooted, so completely has competitor's work been ignored. The Australian work was the basis for the American TRSB, but one looks in vain for any acknowledgement of the fact. Americans do their best to

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The Viewdata computer

How information is retrieved at the command of the subscriber

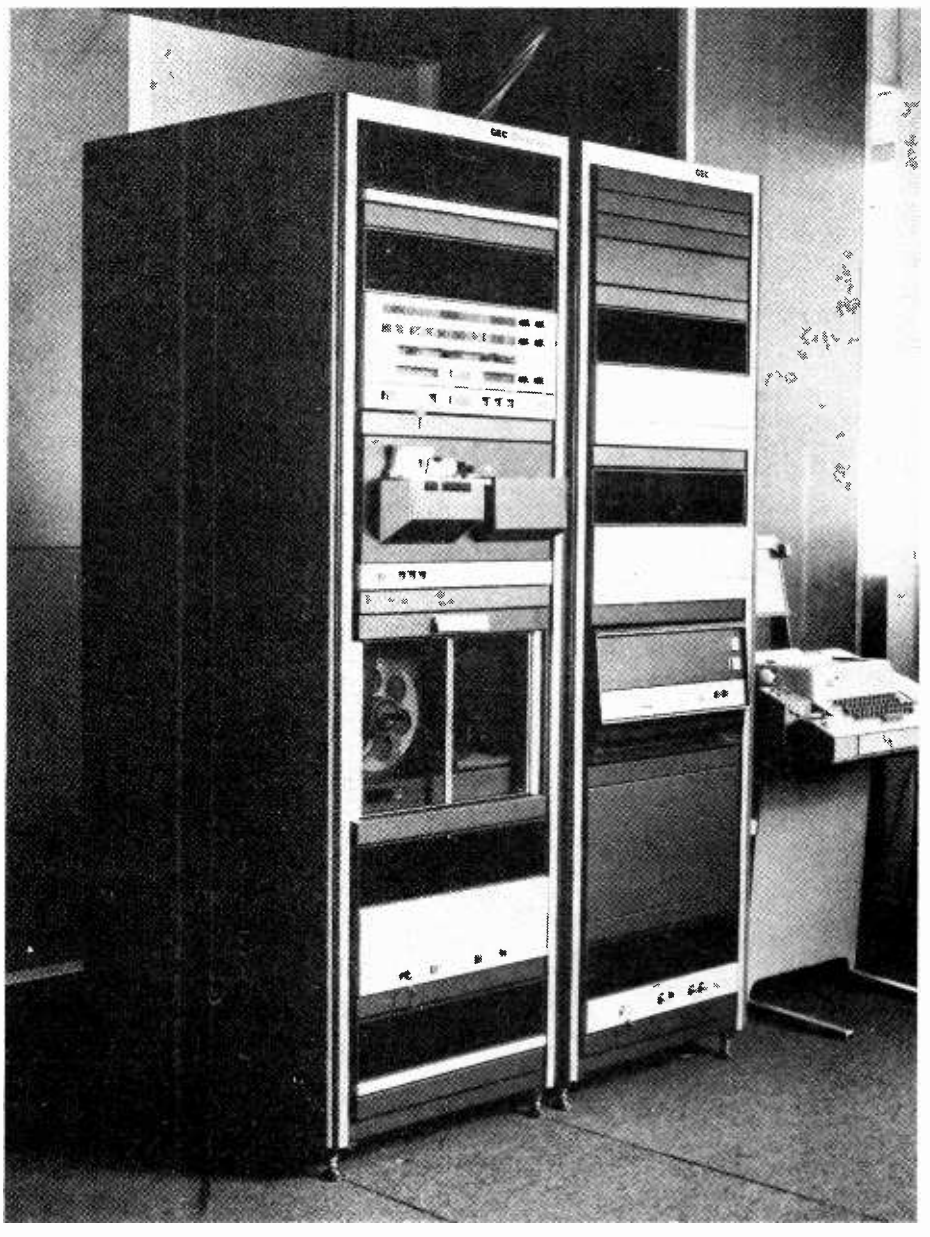
by S. Fedida B.Sc.(Eng.) M.Sc., F.I.E.E., A.C.G.I. Post Office Research Centre

Concluding our series on Viewdata, the Post Office's information retrieval system (February, March, April, May issues, 1977), this article explains how information is held in the data base and controlled by a digital computer so that it can be made available on demand to distant subscribers equipped with Viewdata terminals.

IN THE initial studies on Viewdata four important assumptions were made about the system. First, the data base had to be very large in order to satisfy the information needs of modern society and to ensure that the range was broad enough to attract a sufficiently large body of users and thus establish a low-cost mass market. Also we did not want to duplicate the fairly costly services already available to meet the needs of the specialists. Secondly, the communications medium between users and data bank was to be the existing telephone network, which is essentially narrow band but so well developed and established as to provide an ideal medium for this service. Thirdly, the time taken for information retrieval had to be very short, a maximum of two seconds to ensure satisfactory quality. And fourthly, the Viewdata system potentially had to be capable of supporting a host of communications and other facilities, such as person to person messages (including communication with and between the deaf), educational services and simple computational work for the student and small business.

Given these four assumptions it followed inevitably that the information provided had to be based on a distributed network of computers, each of which would be capable of storing the data in a random access device. A wideband communications medium such as cable tv could have been used to provide a similar service, including the interactive ability, with the scope and speed of response of Viewdata, but the cost of establishing such a network on a nation-wide basis is very high indeed (estimates vary between £1000 million and £5000 million). This choice was eliminated from the start because of cost, but had it been pursued it might have operated on a frame grabbing basis, like broadcast teletext, with a minimal computer used for convenience.

The choice of a computer for Viewdata was based primarily on the need to support on each machine as many simultaneous users as possible, in order to reduce the cost per user per unit time. A rugged, reliable machine capable of running continuously for long periods of time without supervision, and not requiring a special environment such as air conditioning and a false floor, was wanted for the same reason. Since in the information retrieval mode it was obvious that the processing time required to service enquiries could be made very small indeed, the need was for a data concentration and communications switching system rather than a data processing or computation machine. Thus the choice was for a real-time control and automation type of computer, rather than a number cruncher. Of the machines existing on



The GEC4080 digital computer used for Viewdata.

the UK market at the time the GEC4080 was selected as the most suitable for this purpose. One advantage of this machine is a hardware micro-programme, the nucleus which gives it added speed in the scheduling operation in addition to ensuring a high degree of software security and protection when handling a large number of users.

The GEC4080 is a medium scale processor designed for use in real-time applications. The main parts of the machine are shown in Fig 1. First there is the central processor unit (c.p.u.) with its associated main store modules. An integral part of the c.p.u. is a multiplexer unit, which controls communication between the c.p.u. store and the peripherals. A range of input/output processors is used optionally to increase data throughput to the peripherals. These may vary in design and some special ones may be connected to the c.p.u. as required. The range of peripherals includes paper tape readers, a paper tape punch, a line printer, a card reader, magnetic tape units and exchangeable disc stores. Data flows to the outside world are controlled by single channel and multichannel "communications controllers." Further details of the machine are given in the appendix.

Disc store

A most important part of the whole computer is of course the store which holds the data available to the Viewdata users. This is in fact the disc store shown in Fig 1, and a great deal of the overall performance and economics of the system depends on it. Two models of disc store have been used in the experimental system, a 9.6Mbyte disc and a 70Mbyte disc, the latter having arrived rather later on the scene. Indeed the emphasis is now shifting towards disc stores of even larger storage capacities as economies of scale are becoming very significant in this particular component.

The 9.6Mbyte store comprises one fixed disc and one exchangeable disc, both of 14in diameter on one spindle rotating at 2400 r.p.m. There are four data recording surfaces, with 408 tracks on each surface, at a density of 200 tracks to the inch. Maximum bit densities along the track are 1500 to 2200 per inch according to the track position, thus giving a maximum bit rate of 2.5Mb/s. The machine has a set of four read/write heads on a single moving arm, each head "flying" at a distance of about 80 microinches from the surfaces. The significant parameters of the drive are the "latency" (average time to find the required record on the track = ½ revolution time) of 12.5ms, and the "seek time" (or time to position the moving head onto the required track) which is 8ms for a one-track movement or 70ms for traversing the complete range of track. In this store the magnetic recording method is double frequency. A flux reversal is recorded at regular clock rate intervals, the space between reversals defining a bit cell. A "1" is recorded by an additional flux reversal between two consecutive clock time reversals.

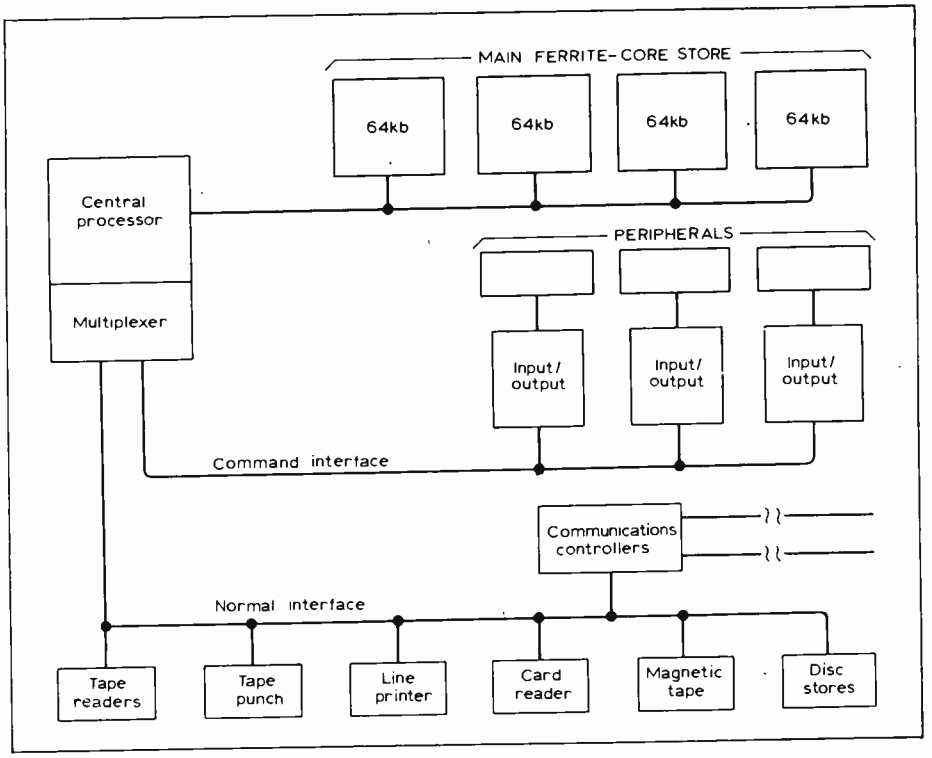
The 70Mbyte store is essentially a similar to the 9.6Mbyte one, but with five recording surfaces, a nearly doubled track density and a more than doubled bit density, thus providing almost seven times the storage capacity. The increased bit density along a track results from the improved recording method used called "modified frequency modulation" which, while still using the same bit cell definition between two consecutive clock pulses, only requires flux transitions at data "1", and between consecutive "0"s, but not between the bits of a "10" or "01" combination or at clock pulse instants, i.e., at cell boundaries. Because of the higher speed of revolution and faster moving head actuators, both latency and seek times are substantially reduced.

A comparison between the parameters of the two drives is given in Table 1. We shall see later that the

Table 1 — characteristics of disc drives

	9.6Mbyte	70Mbyte
No. of data surfaces	4	5
Disc diameter	14in	14in
R p.m.	2400	3600
Track density	200 per in	384 per in
Total no. of tracks per surface (cylinders)	408 (8 spare)	823
Bit densities (bits/in)	1500/2200	4038/6038
Data transfer rate	2.5MHz	9.677MHz
Average latency	12.5ms	8.33ms
Seek timing		
track to track	8ms	7ms
average	41ms	30ms
maximum stroke	70ms	55ms
Capacity (sectored)		
No. of sectors per track	24	64
Bytes per sector	256	256
Bytes per track	6,144	16,384
Bytes per cylinder	24,500 (4 tracks)	81,970 (5 tracks)
Bytes per drive	9.83×10^6 (400 tracks)	66.19×10^6 (808 tracks)
Capacities (unsectored)		
Bytes per track	7,812	20,160
Bytes per cylinder	31,250 (4 tracks)	100,800 (5 tracks)
Bytes per drive	12.75×10^6	82.9×10^6
Modulation method	double frequency	Modified frequency modulation
Drives per controller	4	16

Fig. 1. Main units of the GEC4080 digital computer used for Viewdata. See appendix for detailed description.



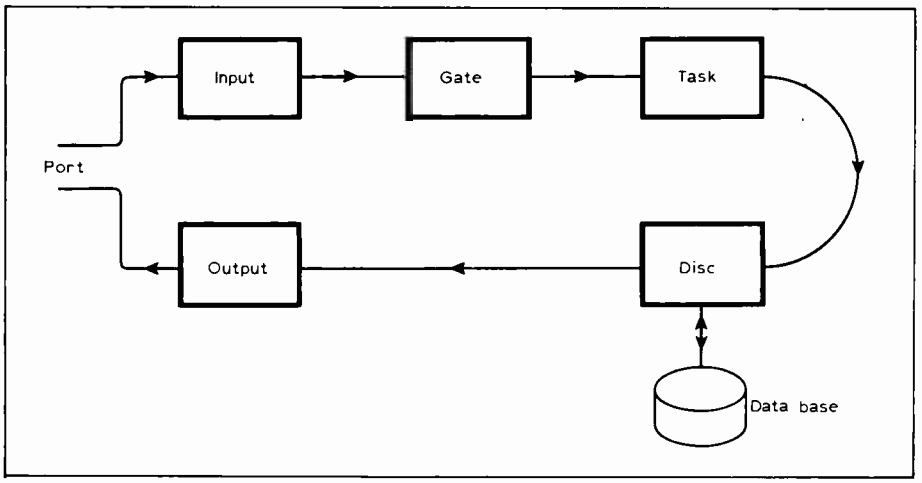


Fig. 2. The five main processes in Viewdata.

improved performance of the 70Mbyte disc has a significant impact on the performance and hence the economics of the overall system.

Viewdata software

The programmes run on the Viewdata computer contain a number of independent processes (or logical computer routines), each executing a well defined task, as we shall see later, and invoked by all the users in turn. Communication between processes — the links which ensure that a whole sequence of operations each implemented by a separate process may be carried out *in toto* – is accomplished by messages and by shared segments of store defined by these messages, which contain all the relevant data enabling a process to take over where a previously operating process has left off. The situation is illustrated graphically in Fig 2.

There are five main processes involved in the operation of the computer system as follows:

Input. This accepts a character from one of the computer ports and assembles a message in which it deposits the character received. The message is identified by the port number.

Gate. This process accepts the message from **input,** identifies the task to be performed on the character just received and places the message in a queue awaiting processing by **task.**

Task. This process uses the input character and other data in the message, identifies the next frame to be output in response to the user's request and sends the message on to **disc.**

Disc. This process retrieves the required frame from disc storage, as indicated by **Task,** adds it to the message and passes it on to **output.**

Output. This process extracts the information from the message and transmits it to the originating port. When this is completed **output** returns the message to **gate** to await the next instruction from the same port.

We have seen that the Viewdata software is based on the principle of dividing programmes into a number of modules or processes, which are substantially independent of each other, not only in their function but also in the timing — they can run in an asynchronous way. The main requirements which have to be met in this situation are as follows:

Store protection. To prevent different programmes or processes from interfering with one another in accessing each others' store areas for data or code.

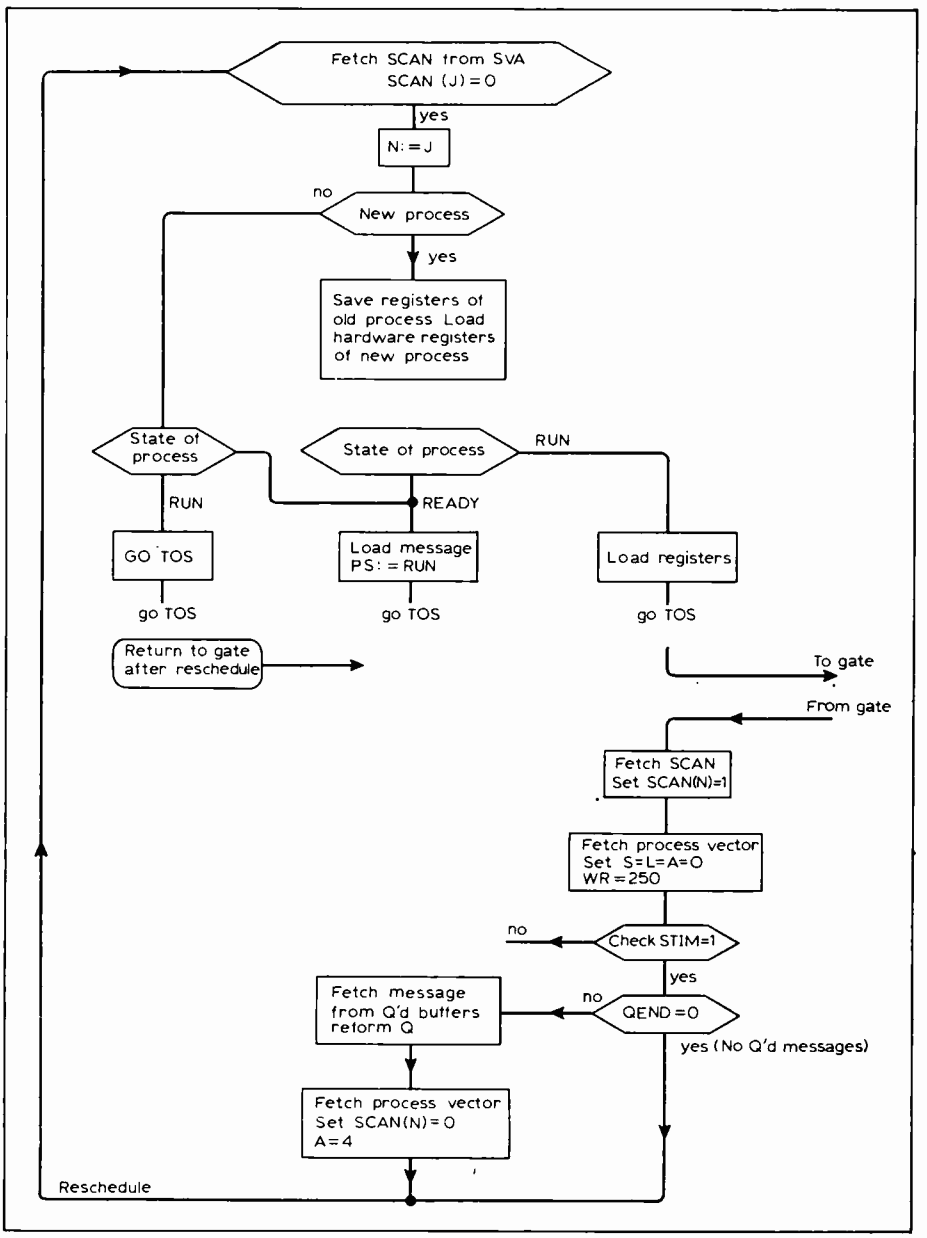
Communication between processes. This has to be organised in a controlled manner to ensure that only previously defined and allowable communications modes between processes take place.

Fast and simple scheduling. To ensure that should a process need to pass control to one or more other processes, the scheduling needed to implement this operation can take place safely and fast.

Fast response to peripheral interrupts. In a multi-user environment events which take place outside the computer, e.g. a user response or command, must be able to evoke a fast response by raising interrupts on the current processes whenever necessary.

Protection of shared data areas and codes. This is to ensure that several

Fig. 3. Viewdata software: control of operation of processes by the "Nucleus" programme.



processes can share data areas and codes without mutual interference. The semaphore system ensures this.

Error detection. This is to ensure that errors in processes are quickly detected before they are propagated throughout the system and cause "crashes".

These functions are normally performed by the executive software of a multi-user system, and tend to create time-consuming overheads in terms of c.p.u. processing time. In the machine selected for Viewdata these functions are performed by a programme called "Nucleus," which provides a substantial increase in speed and substantial freedom from corruption by virtue of its being implemented by a hardware microprogramme (hardware logic).

Control by "Nucleus"

The way in which Nucleus supervises and controls the interrelation between processes and ensures adequate protection of data and code areas in store is explained briefly below in the context of the Viewdata software, as illustrated in Fig. 3.

Process selection. Beginning from the initial programme loading procedure which starts the software system, Nucleus examines a 32-byte area of main store which extends from location 0 called the SCAN area, Fig. 4, in order to find out which process is due to be run next. The SCAN area is one component of the "system variable area" (SVA) in which are stored a number of parameters essential for running Nucleus. To each declared process in the system there corresponds one bit (a SCAN bit) in the SCAN area; SCAN bit (J) which corresponds to process number J, is set to 0 if the process is in the READY state or the RUN state and set to 1 if the process is in the FREE, WAIT or STOPPED state (more about these later).

A process is placed in the READY state, when a message for that process is received; it implies that the process should now be run. A process is in the RUN state either when it is actually running or when it is transferred from the READY state in order to start running. The other states will be explained later. When Nucleus finds a SCAN bit J

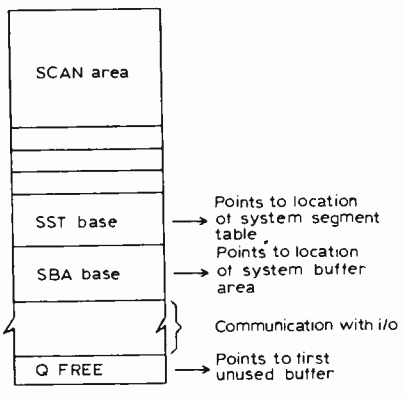


Fig. 4. The system variable area of the main store.

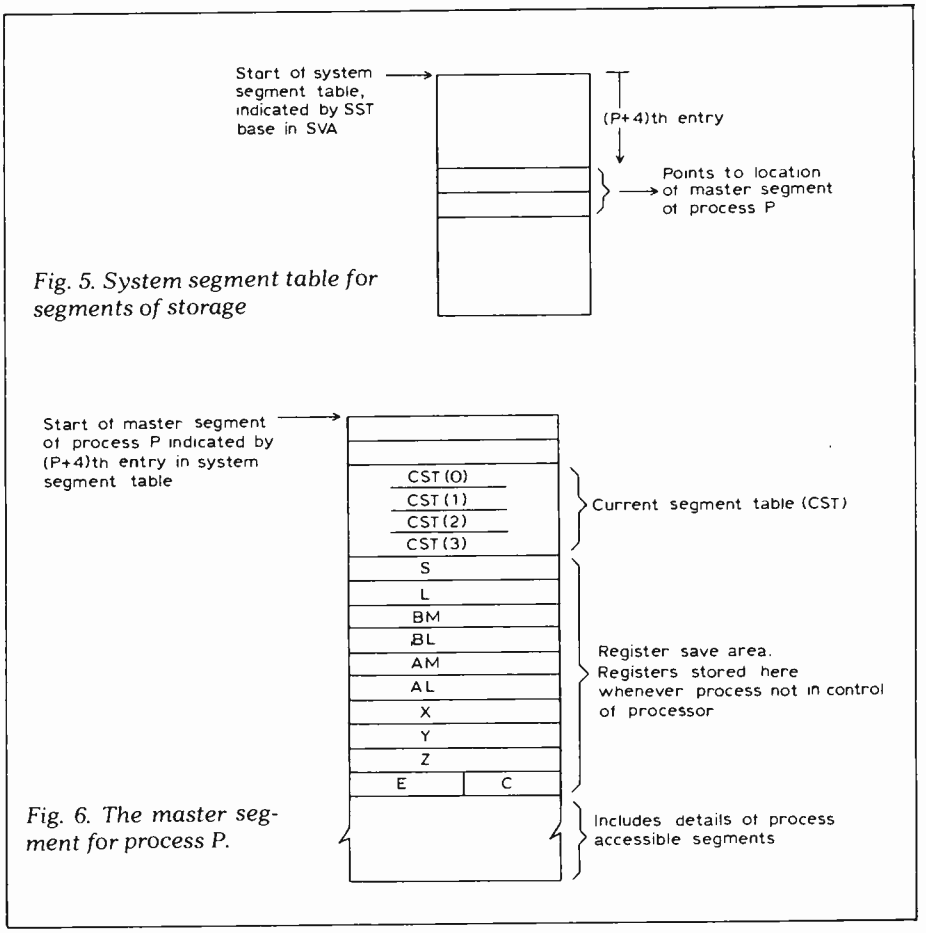


Fig. 5. System segment table for segments of storage

Fig. 6. The master segment for process P.

in the READY or RUN state, it has to decide whether the corresponding process is the current process which has just completed a run or another one. This it does by comparing the SCAN bit J with the number N of the process currently in control of the processor.

The process change. If a new process is to be run, i.e. $N \neq J$ (we shall see later how Nucleus knows which process is currently in control of the processor) the following procedure is followed:

(a) *Save working registers of old process:* The working registers of the old process are saved in the "register save" area of its master segment as explained below:

The segmentation system. The storage used by the Viewdata computer is divided into a number of segments, each of which is identified by a number and consists of a multiple of 64 bytes of storage each, up to a maximum of 64 kbytes. Segments may be in non-contiguous locations in the main store or in a backing store.

Each process may have at any time access to four segments known as its current segments. It also owns a fifth segment known as its master segment, which is accessed normally only by Nucleus, but certain other privileged systems processes may also have access to it.

A process is not normally given access to its master segment. A process may also "own" other segments, but these are not accessible at the same time as the current and master segments. A table kept in main store called the system segment table (SST) Fig. 5 contains for each segment an entry which specifies the location and size of the segment in main store. The entry for segment number N is found in location $4N$ of the system segment table. The entry for the master segment of a process is the $(P+4)$th entry in the system segment table.

The master segment of a process P contains amongst other details the following:

(i) A register save area in which the contents of working registers are stored whenever the process is not in control of the processor.

(ii) Entries giving details of the current segments.

(iii) Entries giving details of all programme accessible segments.

(iv) Entries specifying communication channels between processes, i.e. defining the possible destination for inter-process and i/o messages generated by the process.

(v) Entries regarding error traps and recoveries. The layout of a master segment table is given in Fig 6.

Thus, given the process number P, it is possible for Nucleus to locate the address of its master segment through the $(P+4)$th entry in the system segment table and of all the process's other segments by reference to the master segment. □

(To be continued)

Appendix: the GEC4080 computer

Details of the GEC4080 digital computer outlined at the beginning of the article and in Fig. 1 are as follows:

The central processor unit comprises three sub-units: the central processor, which provides the arithmetic, logic and programming capability of the system; the basic multiplexer channel (b.m.c.) which provides the basic input and output capability to the peripherals; and the control and monitoring unit (c.m.u.) which provides for the overall control of the system and a range of maintenance facilities.

The central processor has a repertoire of about 180 16-bit long instructions, 8 programme accessible registers and a main-store capacity of 32kb to 256kb. Store protection is provided by means of 4 hardware segment registers. A hardware microprogramming element, Nucleus, provides facilities for protection, communications, scheduling and input/output. Although the c.p.u. is essentially a 16-bit machine, arithmetic and logical operations may be performed on 8-bit, 16-bit and 32-bit operands, while logical operations may be performed on 1-bit operands, and floating point arithmetic may be carried out on 32- and 64-bit numbers.

Typical operating times, with a 550 nanoseconds store, are as follows:

Add (single precision)		1.1μs
Multiply	16 × 16	3.6μs
	16 × 32	5.85μs
Divide	32 ÷ 16	20.35 μs
Register to register		2.35 μs

The main store. The maximum internal addressable store of the 4080 is 256 kilobytes, which is partitioned in 64 kbyte modules, each with its own power supplies. It is a ferrite core store in a 2½D organisation, with a cycle time of 550ns nominal and width of 16 bits + 2 parity bits. Data may be read out or written in as 8-bit bytes or 16-bit half-words. During a write operation, parity bits are formed for each byte and during a read operation the parity of each byte is checked, parity failure being indicated to the c.p.u. The c.p.u. may access any one of the store modules, by way of a store access director, connected to the c.p.u. via the primary store interface. Each store module may also be directly accessed, independently of the c.p.u., by any of the i/o's and by the b.m.c.

The basic multiplexer channel. The b.m.c. is one of the input/output processors, associated with the c.p.u. and integral with it. The b.m.c. and the c.p.u. share a common interface with the main store, Fig. 7. The b.m.c. executes or controls all data transfers to and from the main store, and while sharing with the c.p.u. a common interface (or channel of communication) with the main store, it has priority over the c.p.u. in the event of simultaneous requests for data transfers.

Data transfers between the b.m.c. and a peripheral dependent on it are carried out via the normal interface (n.i.), while the overall control of input/output facilities is exercised by the c.p.u., using the command interface (c.i.).

The b.m.c. performs two types of data transfer: programme transfers and autonomous transfers. In a programme transfer a single byte or halfword of data is transferred between the c.p.u. registers and a peripheral, while in an autonomous transfer a block of data, which may consist of one or more bytes or halfwords, is transferred between the main store and a peripheral independently of the c.p.u.

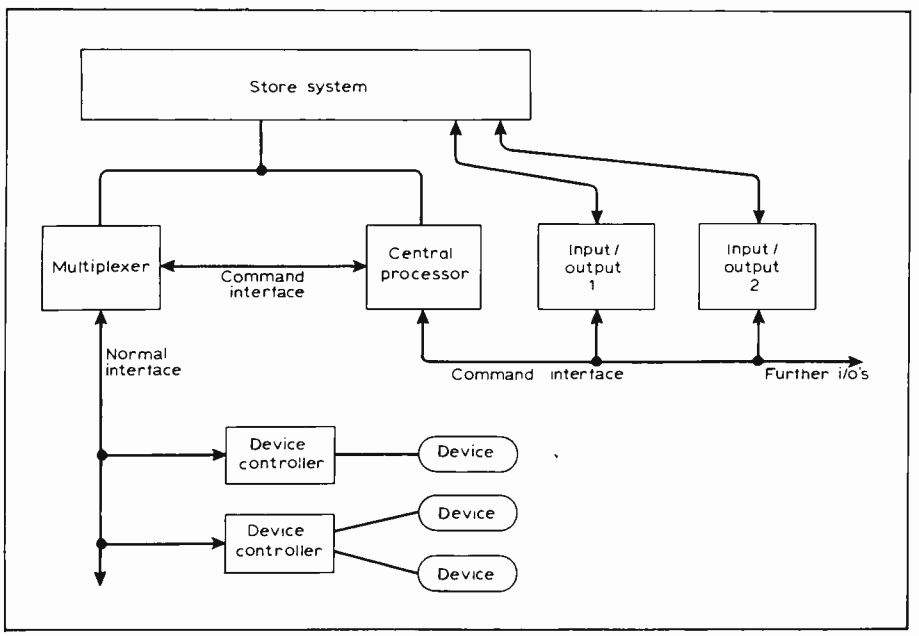
Thus the b.m.c. executes all programme transfers, over the normal interface at the instigation of the c.p.u. via the command interface. However, it only controls the transfer of data, over the normal interface, between peripherals and main store. Finally, the b.m.c. executes the transfer of data between main storage and control and monitor unit. Autonomous transfers are originated by the peripheral controller, associated with one or more peripherals, which alerts the b.m.c., whereupon the latter allocates the necessary autonomous transfer cycles. The b.m.c. can handle up to 256 concurrent autonomous transfers on up to 256 ways.

The control and monitoring unit. This unit, as the name indicates, provides sets of switches and indicators for the control and monitoring of the c.p.u. and associated peripherals. There are basic controls for the operation of the equipment, controls for commissioning and maintenance purposes, displays of data available on a number of highways selected by rotary switches and means for keying in data into selected registers in the central processor.

The c.m.u. provides facilities for the control of the c.p. and b.m.c., and facilities for the monitoring of registers and data highways within the c.p. and b.m.c. for maintenance purposes. The c.m.u. controls comprise: (a) the display of register contents and data highways, selected by a rotary switches; (b) the setting-up on switches of data patterns which may be written into hardware registers and may also be read, for engineering purposes, by programmed instructions; and (c) control switches and indication lamps to reset, run or initial programme load the c.p., and display the c.p.u. run state.

In particular it is possible to read or write to store, to initiate autonomous transfer of the b.m.c., to insert instructions or operands from data switches and to initiate microstep and instruction steps.

Fig. 7. Basic systems configuration. The GEC4080 digital computer used for Viewdata.



Input output processors. Up to three input/output processors may be attached to the c.p.u. — although more may be also connected by way of extension units. The standard i.o.p. is called the external multiplexer unit. This is used when the b.m.c. throughput is not sufficient to serve the number of peripheral controllers supported by the system. The e.m.c. is capable of performing autonomous data transfers up to a maximum rate of 1.5×10^6 bytes/half-words per second, the actual maximum depending on peripheral and interface design. The e.m.c. is connected to the c.p.u. via the command interface, to one or more store modules via the store interface and to the appropriate peripheral via the normal interface.

Communications controllers. These units provide the interface for transferring data between the c.p.u./b.m.c. and telephone lines.

A single channel asynchronous controller is capable of directly controlling P.O. Datel services using standard modems at speeds between 50 and 9600 bauds, in a half duplex mode. It accepts parallel data from the normal interface, converts it to serial data and adds start and stop bits. In the receive mode it looks for a start bit and strobes-in the following data bits which it offers in parallel to the normal interface. In addition the controller is capable of operating the automatic answering facility provided by the P.O. Data Control Equipment No 2A (DCE2A). Data transfer between modem and normal interface take place in 8-bit bytes in autonomous input/output cycles.

A multichannel asynchronous communications controller is capable of handling 16 half duplex channels, in a way similar to that indicated above for the single channel unit. Data transfer rates are, however, limited to 4800 bauds or 2400 bauds when the unit is extended to handle 32 channels.

A single channel synchronous communications controller controls the flow of data in a half duplex mode between the normal interface and modem lines in autonomous input/output cycles, and converts data from 6- or 8-bit binary to serial and vice-versa. Character synchronisation is achieved by generating on transmission two 6- or 8-bit synchronising characters, and on reception by looking for two 6- or 8-bit synchronising characters. The controller is capable of handling data transfers at rates up to 50kbauds. □

Viewdata to go public

THE POST Office intends to start Viewdata as a full public service early in 1979, without waiting for the results of the market trial due to start this June. The launching date of the new service will be at least a year earlier than was originally intended because of the "tremendous support for Viewdata from the organizations providing the information and from the television and electronics industry" the Post Office says. More than £20 million will be spent in the next twelve months to start the public service. Of this £5 million will be spent immediately to set up ten Viewdata centres in London and at least two other cities. Centres are planned for Birmingham, Cardiff, Edinburgh, Leeds, Manchester and Norwich. By 1985 it is expected that about £100 million will have been invested in Viewdata. (See article in this issue on the Viewdata computer; also February, March, April, May 1977 issues).

Wireless World's call for Viewdata services to be run by independent operators in competition with the Post Office (February, p25) has been publicly supported by the leader of the British radio and television dealers. Gerry Plowright, national president of the Radio, Electrical and Television Retailers' Association told York Centre members at their annual dinner in Leeds: "I feel it will be helpful — to gain wider experience — if some parts of the Post Office trials could be placed with independent operators who will no doubt be a major part of the market promotion when the system eventually comes into overall public service". Mr Plowright was referring to the market trials of Viewdata starting this June.

After the clear statement by Dr Alex Reid, the Post Office's project manager for Viewdata, that the system is not a PO monopoly and that completition would be welcome (Letters, March issue), there is now a pretty strong invitation for commercial organizations to take part. We wait, in particular, for member firms of the National Association of Radio Communication Services to come forward with schemes, for it was this organization in its recent manifesto (February, p25) which claimed that the necessary computers, data bases, software and domestic terminals could be provided by private enterprise. "There could be competing systems, there could be alternative computer services, there could be a number of software organizations all providing similar, stimulating and competitive services to the public. All would use the telephone network".

A leading campaigner for NARCS is Mr John Stanley, chairman of Air Call Ltd, the message handling company. So what about it, Mr Stanley? Air Call has already had experience in using its own computer for information handling.

In another part of his speech, reported in *Electrical and Electronic Trader*, Mr Plowright delivered a message to the television set makers that RETRA will fight to keep independent dealers in the market for Viewdata receivers. He said it was evident that manufacturers are concentrating their efforts towards the multiple rental companies, but "there is no way in which this association can stand by and see a domination of this area by the multiple rental industry. My message to the set makers is therefore that they must recognise this area of the market and provide equipment to the independents – both for the market trial and the subsequent public service".

C.c.d. colour tv camera

NEXT YEAR RCA hope to start selling a hand-held tubeless colour tv camera. Although the camera will not be of broadcast quality, it represents a further promise of even greater reductions in size and weight for cameras used in electronic news gathering.

The 3.6lb camera has three c.c.d. image sensors, one each for red, blue, green. The sensor is made from a silicon wafer with 512 to 320 elements on it, and the image diagonal is 13mm, corresponding to a ⅔in vidicon tube. After processing, say RCA, the image is compatible with 525 line video displays.

EBU condemns Geneva m.f./l.f. plan

THE EBU technical centre hopes that the Geneva medium and long wave frequency plan agreed in 1975 "will never be fully implemented since this would lead, as is generally known, to an intolerable congestion of these bands."

The EBU's analysis of the plan points out that the total carrier power provided for in the Copenhagen plan was 20MW, that this had risen to 82MW by 1974, and that the latest Geneva plan might push the figure up to 214MHz. Apart from low-power channels there are about 500 new stations in the plan.

In the l.f. band the projected increases are from 9MW to 23MW, and from 35MW to 83MW on medium wave. Yet these massive increases, around 150%, will only result in a 30% increase in ground-wave coverage. "With the low absolute coverage at night in the m.f. band, this seems to indicate that the possible investments for the transmitters (modification of the aerial systems or power increases) hardly seem to be justified in general."

Coverage might be increased during the day by increasing power "but this would lead to even more pronounced differences between day and night time service ranges than at present. From the programme angle this seems to be really undesirable."

As to the provision of a sky-wave service, the analysis says the prospects are "not encouraging". There would, strictly speaking, be no sky wave reception unless listeners accepted lower-quality standards of service. "However, due to the excessive power increases in the Geneva plan ionospheric cross-modulation would naturally cause higher interference."

The EBU's rejection of the plan is based on the belief that it does not amount to a plan at all. The 1975 conference ended by more or less agreeing that there could be no agreement, and that everyone could have what they asked for. The results are bound to be chaotic, though it is some comfort that the plan only lasts for 11 years.

It became clear at the end of the conference that the British delegation's strategy, mapped out largely by the Home Office, had been mistaken. Their approach had been that the British Isles, having done pretty well at the previous conference in Copenhagen in 1948, would do well if they merely held on to what they had got, so they adopted very limited objectives. On their return from Geneva, BBC delegates were furious at what had happened, and blamed the Home Office and the Government for trying to restrict the British demands.

This partly explains the wavelength changes due to be made in November. Had the BBC not made these changes the interference would be intolerable, particularly for Radio 3 since Albania may build a 450 kW station on 464m, now used by Radio 3. But it remains that these are internal changes made to make the best of a bad job, rather than changes which are clearly stated in the plan itself.

There were other changes that have been made because the BBC wanted to rearrange the national frequencies, and because it was felt in some quarters that we ought to have a national station covering the whole of the UK. One reason for that is that everyone could be reached in the event of some unspecified national emergency. The BBC and the Home Office appear to have worked closely on the plan, and the initial differences appear to have been patched up.

Channels increase

From an engineering point of view it might have been easier and cheaper to make all the changes gradually, but the difficulty of educating the public to a series of continual changes outweighed that, and all of the changes were hung on the 1975 conference peg.

The EBU document, prepared by the Technical Centre in Brussels, shows that UK transmitter power will go up overall by only 15%, but the number of channels goes up from 25 to 42, and the number of transmitters from 83 to 126 (night-time) or 127 (day-time). That does not mean that the number of frequency assignments to the UK has increased by 17, since, as always, there is provision for the use of non-assigned frequencies, provided there are certain safeguards against interference in the country to which the frequency has been assigned, and that the extra user puts up with interference on that channel. The only extra frequency that the BBC got was the 227 kHZ needed to obtain fully national coverage on Radio 4, including the Scottish borders. Bearing in mind the low increase in power, the table indicates that the extra 17 medium wave frequencies are being used mainly for low-power local radio stations. □

Revived interest in solar energy

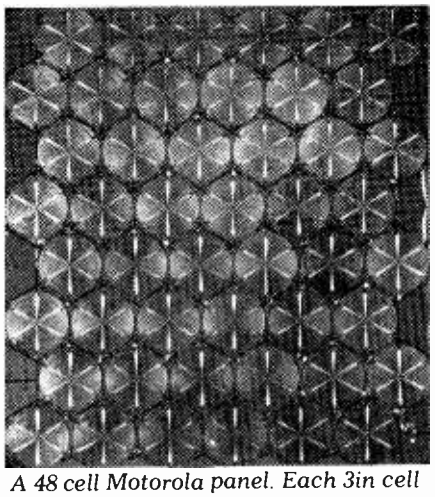
RECENT STUDIES appear to have dismissed solar energy as an alternative to dwindling oil supplies, largely on the grounds that the greatest energy is always falling on those parts of the earth where the energy is not needed. The energy needs of big cities will have to be met by nuclear energy.

Yet a clear pattern is emerging in the uses to which solar energy is being put so far. The Post Office is experimenting with solar powered telephones at the Blakeney Point, Norfolk, bird sanctuary and plan to provide a similar installation on the remote Scottish island of Soay which, off the south coast of Skye, should give valuable information about the energy obtainable in areas not noted for long periods of sunshine.

At a seminar held in London on February 7, Motorola described the work they had been doing on solar cells since 1974. Their conclusion was that, at least in the short term, solar cells would be used for what they described as "remote site power", where there were no power lines, and which were difficult for maintenance engineers to reach.

At a secret laboratory in Phoenix, Arizona, Motorola are developing a great many solar devices, largely photovoltaic. The emphasis on photovoltaics arises largely from investment in solar research by the US government, some $110 million in photovoltaics of a total $150 million budget. That $110 million, comments Hammond, represents only one-tenth of the investment in nuclear energy sources.

Until now solar cells have been inefficient and expensive. At the moment the price is about $15 to $25 per watt, while the economic price has to come down to $O.5/W. Accordin to Motorola's solar operations marketing manager. Mr Bob Hammond, this will not happen until at least 1990. The future of solar energy lies in photovoltaic cells of silicon. Silicon is abundant, and the production of silicon wafers is a fairly well-understood technology. Most of the savings, says Hammond, down to about $2/W, will be gained by cutting down the waste in cutting slices from the silicon ingot. At the moment the diamond saw, which has been used to cut silicon wafers for the last 20 years, wastes a great deal of material between slices, and the swarf, being mixed with cutting oil, has been thrown away. Once the slice gets down to 4 to 5 mils it shatters. Motorola have developed a new technique which uses a wire saw to get thinner slices with only 3 mils of swarf loss.



A 48 cell Motorola panel. Each 3in cell has six contacts and 16 thin metal rings to collect the charge without masking the cell from sunlight. This array is rated at 26W. These arrays are counting traffic in Arizona, powering a police radio repeater in Idaho, and protecting buried pipes in Texas.

The theoretical maximum efficiency of a photovoltaic silicon cell is about 22%, and arises from the difference between the energy distribution pattern of sunlight, and the corresponding output obtainable from a cell throughout the spectrum. Motorola's new cell, shown in the picture, can produce 500W from an array six by eight feet. The operating point for each cell in the array is 0.44V at 1.3A. The cell acts as a constant current source, with output directly proportional to light intensity. Each cell has six contacts on the cell surface, and the two modules on offer from next year, one of 36 and another of 48 cells, can be supplied with a variety of interconnections to meet various voltage and current needs.

The cell surface is made up of tiny pyramids which Motorola say allows the cell to absorb up to 99% of the incident light since reflections from the first contact with the silicon will bounce into an adjacent surface. A coating of silver nitride reduces reflections further.

An energy source for a typical medium-sized radio repeater would be about $3,000, including regulators, batteries and so on. Other applications include oil rigs, cathodic anticorrosion protection systems for pipelines, and navigation beacons. It seems likely, however, that Motorola has its eye less on the supply of solar cells than the supply of complete repeater, navigational and other systems, with a solar energy option.

As to the future they think that the $2/W barrier can be broken with their ribbon technique, replacing the silicon wafer with a 100m long, 7.6mm wide and 125 micron thick ribbon made of polycrystalline silicon deposited on a substrate. A swept laser beam moves down the ribbon, melting it as it goes and forming more efficient monocrystalline silicon.

They believe the market will rise to $1,000 million by the end of the 1980s, when solar cells will be used for other remote sites. By 1983 solar cells will be used on farms, and rural electrification will begin three years later. By 1988 solar energy may power houses, they say.

Perhaps. Meanwhile the European Space Agency has awarded our own British Aerospace with a contract worth £311,000 to develop a lightweight solar array to power a direct broadcast tv satellite in the mid-1980s. BA have already built such arrays for Intelsat IV and IVA, the Ariel series and many more. The biggest contract was a £6 million order to build the solar array for NASA's space telescope. The sites don't come any remoter. □

Games chip confusion

THE VIDEO games market is growing at a rate which outstrips its supply. One distributor has been so caught up in the scramble that he appears to have been misled.

A recent issue of *Practical Wireless* carried an article about video games in which they named as a supplier A. Marshall (London) Ltd.

Marshall's were inundated with requests for a GI tank battle game chip, AY3 8700, and they accordingly started searching high and low for them. At the beginning of February they issued a press release saying they had "finally succeeded in obtaining supplies of the tank-battle games chips AY3 8700 and are offering these at £21.95 each, inclusive of VAT plus 40p postage and packing."

When a member of the *Wireless World* staff called on Marshall's a day or so later, however, he was told that the chip would not be available for four weeks. Worse, GI in London told us that the 8700 was an obsolete device which had not been available for some time and which was not pin-compatible with GI's new range of dedicated games chips. Neither was it available in a 625 line version.

When we phoned Marshall's they said the type number "had been changed to 8710," and that a telex had arrived at their office saying that a plane-load of 8710s were on their way. The 8710 is in fact a new device which is available in a 625 line version, and is pin-compatible with GI's new line, but GI in New York told us that, far from being on a plane to Marshall's, the device was not even available in America yet. When we told GI in New York that Marshall's had obtained a plane-load they told us "that can't be."

Marshall's had ordered the chips through an American factor called JSH, with whom they had done business before. When we phoned Marshall's again to tell them what GI, the only makers of the chips, had said, they expressed concern and said they would ring the US and report back to us.

In the face of our information JSH's plane-load of 8710s vanished, we presume in the Bermuda triangle, and JSH told Marshall's they would deliver in mid-March, but the experience has made Marshall's a little sceptical even about that.

The distributor's life is not a happy one, it seems, even when he does his best to keep supplies running, which is why *Wireless World* has decided to look into the supply scene. Our report will appear in the next few months.

Economic and electronic market prospects

THE UK semiconductor market will grow by 19%, 7% more than its nearest rival, in 1978, according to Piero Martinotti, European marketing director of Motorola. Sweden will have the lowest growth at 5%, 7% below the average for Europe. In addition, the market in 1979, previously predicted as a slump for Western Europe, and indeed the world, will merely be a period of no growth.

Martinotti predicts real growth in the British economy at 3% a year. Investment will go up 12%, he estimates. One sign of the times is that much of this growth will arise through increased government intervention, leading to increased growth in military and telecommunications, but the consumer electronics sector will suffer further in Europe as a whole, and hence in Britain. It will form 35% of the European market in 1978, a drop of 2% this year, and fall to 32% in 1979. □

In brief

Surrey University are to hold an introduction to programmable automation from April 10 to 20.

Bleasdale are running various courses on computer systems design using the Motorola 6800 microprocessor, for advanced students.

Chelsea college's 1978 digital system design course will run from May 15 to 19.

Essex University will hold their teachers' electronics summer school from July 10 to 14, covering both linear and digital design.

AES at the IEE: April 11, Hearing and noise by Peter Wilkins BMech Eng, MSc; May 9, Underwater acoustics and seabed studies by Professor W. D. Chesterman of Bath University; June 13, Multidimensional audio by Henning Möller of B & K, all at 7 pm.

The **ERA** and the **Institute of Physics** are to hold the first international science and security conference and exhibition at Brighton from September 12 to 14, to be opened by Sir Harold Wilson.

BASF have introduced a cassette tape whose bias point has been chosen to coincide with that of the greatest number of high-bias Japanese machines. Ferro-Super LH1 needs a setting such that there is 1.75dB overdrop from maximum output, about mid-way between the typical variations on Japanese machines.

Dr C. Kao and D. G. Hockham of **STC**, who developed the basis of optical fibre communications, have been awarded the £25,000 Rank Prize for important developments in the future of world telecommunications.

The first **fibre optic** and communications exhibition and conference is to be held on September 6 to 8 in Chicago's Hyatt Regency Hotel.

Cambridge Consultants have developed a fibre optic tee coupler for use in single fibre data highways.

General Instrument Microelectronics have moved their London office to Regency House, 1-4 Warwick Street, W1. Telephone 01-439 1891.

Racal have taken over Fairey Electronics, of Barnstaple, Devon, part of the Fairey Group, for £700,000. Racal have also delivered 100 s.s.b. two way mobile radios to the Nigerian highway patrol. Eastern Gas's customer credit records, enquiries, billing and stock control is to go onto two ICL 1904S mainframe computers, connected to 100 remote v.d.us at ten sites, and another 50 v.d.us based at Enfield. The system was designed by Computer Automation.

The Gulf of Suez Petroleum Company have ordered a 24-channel communication system to run between Cairo and the Gulf of Suez oil terminal at Ras Shukair from **Plessey EAE**. The order is worth £1.8m.

The FCC has rejected the idea of an undersea cable to link Europe and North America on the grounds that it is not needed. Extra capacity would be provided by satellites. ITT World com, which wants to build the TAT7 cable, is to ask for a review of the decision. In January the "world's largest capacity undersea cable, between Roma and Palermo, Sicily, carried colour tv signals alongside 8000 phone channels. The 250 mile cable was installed by ITT subsidiary STC.

The Public Broadcasting Association of Australia has called for Australian delegates to the **WARC** to re-think their policy.

Developing countries "deplore" Western retention of frequencies

THE NEEDS and allocation of spectrum space "are at variance between the developing and the more developed countries," says a recent editorial in the journal of the Asian Broadcasting Union. "In countries with poor or meagre communications, the need for extensive broadcasting coverage is essential for social and economic growth." The education and unification of a community can be efficiently achieved by radio and tv, but other telecommunications services are yet to be developed "and progress can be frustratingly slow. Although there are over 358 million telephones in the world, only 65 million of them are in Asia, Africa, Central and South America. Radio and television are vital to these areas and [results] can often be obtained faster through these services than by other means. Consequently their demand for spectrum has become acute."

The editorial, in the January 1978 issue, is written in the context of the prospects for the 1979 World Administrative Radio Conference, and it will add weight to the arguments of those who believe that there will be great pressure from the developing countries for a more favourable distribution of the spectrum in those countries.

The journal notes that broadcasting coverage in the developed countries has reached saturation. Of the world's 25,500 radio broadcast transmitters 75% are in the developed countries, and America has 1,790 receivers per 1,000 inhabitants, while the developing countries have only 76 per 1,000. Radio use in the developed countries has become so extensive that technology is aimed at developing methods to remove certain services from radio altogether and put them on cables and wires, "making room for the expansion of new and existing services which can only exist by means of radio propagation." Yet some users "tenaciously maintain their hold over [their previous allocations] for variously described 'back-up' or 'stand-by' purposes ... In today's overcrowded spectrum where space is at a premium this selfish dog-in-the-manger policy can only be deplored."

The editorial presses for the WARC to dispense with the "artificial ITU geographical zones" and the adoption of new zones based on development, economics and need. It goes on to add that, on these grounds, the developing countries are more deserving of the l.f., m.f. and h.f. bands, since these "provide the only economical and direct means of reaching a large audience ... The h.f. bands provide the only presently available method for world-wide broadcasting, without any apparent alternative, as well as providing the most economical means for internal coverage of the larger developing nations."

Single-sideband modulation would mean the re-equipping of a large audience with new receivers, and satellite broadcasting will take many years to develop and will be limited to national coverage.

Short waves are the only alternative for world-wide broadcasting. To alleviate overcrowding in this band elbow room in the allotted spectrum will have to be found, and this will be had at the expense of the fixed services. This would involve only expenditure on the part of the sender and the recipient of the point-to-point fixed services, as opposed to prohibitive expenditure in equipping the world's population with new receivers.

An article elsewhere in the journal points up the greater emphasis in the developing countries on frequencies below 30MHz. In the lobbying for WARC it has been mentioned that the broadcasters have 60% of the usable space above 30MHz, while Mr Irfanullah of the Pakistan Broadcasting Corporation notes that broadcasting claims 9.5% of the spectrum in his region, while fixed and mobile services together have 85% of the allocations. Totals like that convey the reasons for the editorial's impatience to cut the fixed portion (49%) down to size. But there is little indication of the way the proportions allocated to each use within the h.f. band have been worked out.

The emphasis on short wave for worldwide broadcasting arises from the desire to convey cultural and political ideals to the rest of the world. This sensitivity to the way the West sees the developing world was also reflected in the suggestion last year that there should be alternatives to the news reporting of the international news agencies, such as Reuters, UPI and AP. In addition, a conference of the non-aligned nations' broadcasting organisations was held in Sarajevo last October "to consider the ways and means by which broadcasting organisations could co-ordinate to project the image of member countries to each other and to the world at large." There is no doubt that all eyes were fixed on WARC 79. □

Batching by microprocessor

THE USE of a microprocessor in Pye Ether's electronic weighing equipment, demonstrated in mid-February, shows many of the benefits of automation and the results that will flow from it: the need to save costs by reducing wastage of raw materials, the need to save energy, and the desire to cut down on costly labour. In addition, quality control is made easier, and the processes themselves more safe.

The PR1654 will control the amounts of up to 14 ingredients and the time of their arrival. It will also operate heaters and stirring equipment at the appropriate parts of the cycle. Should weights or timings depart from the pre-set tolerances the whole process is stopped. Pye Ether, part of Philips automation, claim accuracies of 0.1% for a machine which they say combines batching techniques in a single instrument which were previously available only in separate packages at many times the price.

It takes its information from up to eight load cells, and can be programmed from a computer or punched card reader.

Pye also showed an eight channel contactless transmission system which uses low frequency multiplexed f.m. radio to measure the temperature, pressure, acceleration or torque of fast-rotating objects. The transmitter on the object, six to eight inches from its stationary receiver, can stand accelerations up to 3,000G, say Pye. □

"Authorities can be made to concede frequency space"

HOME OFFICE and Ministry of Defence secrecy about the radio spectrum prevents potential users from making a proper assessment of the conflicting demands for frequencies, according to a book just published by the Consumers' Association. "Many observers suspect," says its author, Peter Lewis, "that the amount of the spectrum held on to for 'defence purposes' is as unwarranted as was the post-war retention of land commandeered for the duration of hostilities."

"The cause for concern," he writes, "is not that the defence services should have frequency space — obviously they have need of it, but that behind the mists of secrecy they are holding on to more than they need."

On the 1979 World Administrative Radio Conference, the book says this will decide "how the radio-frequency spectrum is to be allocated as between broadcasting and the many and growing claimants for non-broadcast use. There will," it continues, "be intense struggle on the part of individual countries to at least hold on to the share of frequencies each already possesses, but it is also to be expected that the Third World will press its claim to receive a fairer share than it has had so far. This apparently remote bureaucratic and technical wrangle will affect us all."

Lewis reminds us that the Post Office and the then Ministry of Posts and Telecommunications (whose officials now work at the radio regulatory department of the Home Office) "based their case against the North Sea pirates in part on the interference they said would be caused to existing broadcasters and to maritime communications — a view which later re-arrangements of radio channels showed to be unduly pessimistic."

Similar obstacles were placed in the way of the establishment of local commercial radio, but these were overcome by reallocating two BBC frequencies (194m and 261m) and developing directional m.f. transmitters. In addition, the Post Office, the Ministry and the BBC were forced to concede that frequencies not assigned to the UK could be used in certain circumstances, "arrangements whose existence [they] had not publicly admitted before."

Further, the Annan committee had been misled into believing that the shortage of frequencies was greater than it was. This only emerged, however, when the shortage of frequencies was adduced as a reason for depriving the BBC of its local radio stations and putting them in the charge of the proposed Local Radio Authority. Back-pedalling furiously, the BBC protested that Annan had got it wrong.

"From these examples it does appear that under pressure the authorities can be made to concede frequency space." The battles still to be fought were

- Faster clearance of Band II. At the moment frequencies from 97.6 to 100 MHz are used by the Home Office for police and ambulance services. The BBC is pressing for broadcasting use up to 108MHz at the 1979 WARC. The Annan report said the clearance would take several years, and that the frequencies should eventually be used for a national channel. Lewis asks: "Should we not, however, be pressing for speedier withdrawal by non-broadcast users, for use of 100 to 108MHz as well, and public discussion on the merits of another national channel as opposed to more local stations?"

- Hoarding of u.h.f. frequencies. These are needed if small, isolated communities are to receive tv signals. Four government committees since 1967, including Annan, have urged that these frequencies, above 854MHz, be released, to no effect. "There has been no public response to this by the Home Office explaining the reason for its stand, which some observers think is due to the presence in this area of the spectrum of a large NATO communications system."

- Citizens' band. The Annan committee acquiesced in the conservative attitude to c.b. saying that 27MHz c.b. would cause interference — in fact the proposal had been for a service on some other frequency. At the back of the Home Office's objection to c.b. is the Calvinistic assumption that such a use would be frivolous.

- Duplication of services on v.h.f. and medium wave. At night there are sometimes five different places on the dial where one can receive Radio 2.

Even more serious than the hoarding of frequencies is "the secretiveness with which the Home Office makes decisions without public accountability, even if there is liaison with many of the bigger users of frequency space. There is no way the Home Office approach to frequency spectrum management can be questioned and two unsatisfactory consequences follow: "one is that in a 'lobbying' type of situation users take what they can get and often keep quiet for fear of losing even what they have.

"The second, much more serious consequence is that the Home Office negotiates on our behalf internationally without public knowledge of its intentions. The World Administrative Radio Conference (WARC) in 1979 is the next occasion for a thorough appraisal of frequency allocation, at which decisions must be taken in order to accommodate the likely increase in the number of different services throughout the world during the rest of the century. The American FCC has made known its intended position at WARC, but attempts, for example by the Community Communications Group (Comcom), to find out what the Home Office are proposing on behalf of the UK have been met with refusal on the grounds that the information is classified."

For the rest *Whose Media?* is concerned mainly with the content and organisation of broadcasting. There is hardly a mention of mobile radio, and just a little on citizens' band. The book is intended as a fairly intelligent discussion of the consequences of the Annan report, which it describes in detail. There is at least one minor technical error, where the frequencies above 1MHz are described as microwaves, where it should be 1GHz.

- Talks with the Home Office have elicited their view that to open the discussion wider would by-pass parliament and would therefore be unconstitutional. They believe that they are answerable, through the Minister in Parliament. There has never been, and there is unlikely to be, a full scale debate on radio frequencies in the Commons, however. Neither do they intend, even by pulling the strings of their minister in the Commons, to submit their proposals to Parliament *before* the WARC; the "classified" label serves to relieve them of that obligation.

Peter Lewis is a leading activist in the Community Communications Group (Comcom), formed early last year. It has attracted a considerable support from cable broadcasting companies and some local authorities, as well as a Gulbenkian Foundation grant.

Peter M. Lewis, Whose Media? The Annan report and after: a citizens' guide to radio and television. Consumers' Association. £3.95.

Feedforward limiting and compression

THE LEVEL of sounds which must pass through noisy signal channels has to be controlled so that the signal is always above the level of the system noise but is not so high as to overload the channel. The gain of the channel is increased below a certain threshold, and reduced progressively above another threshold, depending on the instantaneous level of the sound.

The effect on the signal is often noticeable and intrusive. Since the gain cannot immediately be returned to its former value, the effect on signals which have continually varying periods of low and high intensity sound is to cause breathing as the system noise increases during the recovery periods, and drops sharply as the next loud sound arrives. The effect is well demonstrated during long periods of applause on a.m. radio.

An alternative approach, developed by Dr L. Philips and Mr L. Thomas of Swansea University, has won backing from the National Research & Development Corporation.

The new method uses a delay and feedforward technique. Each half-cycle of the waveform is scaled up to a maximum level by adjusting the channel gain of the delayed signal at the zero-crossing point. The amount of adjustment is obtained by sampling the maximum level of the non-delayed half cycle and feeding the scale factor forward. The delay must be greater than a half cycle of the lowest frequency to be transmitted. The scale factor is determined by sampling the maximum level between two consecutive zero-crossings.

A noise threshold prevents any change in gain below that level. With an eight bit companding analogue-to-digital convertor and a noise-free sinusoidal input the output is constant through a 70dB change in input, and the peak to r.m.s. ratio of speech is reduced from 12dB to 6dB.

The inventors say that one change in the quality of speech is to make sibilants more noticeable, and the description of the device stresses its use for speech and not musical sounds, but they add that each sample's scaling factor could be transmitted along with the processed signal to restore it to the original quality. A demonstration model has been made using an Intel 8080 microprocessor, and manufacturers interested in making the device should contact Mr Roy Easson of NRDC in London. □

Integrated-circuit memories — 2

A summary of techniques developed in the last ten years

by John Dwyer

This concluding article outlines the prospects for new types of device designed to supplement the rapidly developing random-access memory. It describes the different types of read-only memory available, and examples of how they are used.

RANDOM ACCESS memory access times and prices are such that the core is being replaced by m.o.s. r.a.m. and the fixed head disc, at 10ms and around 8 bits/cent, is giving way to bubble and charged couple device (c.c.d.) memories. They are not yet cheaper but their access times are lower than disc.

The bubble memory is generally regarded as one of the brightest stars on the memory horizon, which is ironic since it is not a semiconductor but a magnetic device. Magnetic devices do, after all, have an inherent binary characteristic and are non-volatile. They are quickly readable at high speed and low power. They are also capable of packing great amounts of information in a small space.

The first magnetic bubble devices, available last year, are easier to make than semiconductor devices and have ten times the information density. The way they store information, as a stack of circulating loops, makes them very similar to the magnetic drums they are likely to replace.

The principle is that in some magnetic films the plane of magnetisation is either up or down in the crystal. The material normally used is a magnetic garnet film on a non-magnetic garnet substrate. When no external field is applied half the area of the film will be magnetised upward to the surface and the other half downward, the areas having common magnetisation joining up to form long, thin strings of common polarity.

If an external magnetic field is applied in the up direction, the domains of the opposite polarity will shrink until they form round cylinders which, under the microscope, look like bubbles. The stronger the field the smaller they become until a critical field is reached where, at about 1/3 of their original diameter, they disappear, suddenly and irreversibly.

The bubbles can be created in the crystal by placing above it a single 'hairpin' conductor through which a current is passed. The bubble will form at the sharp elbow of the conductor.

The bubbles are highly mobile in two dimensions and can be moved around at will. They also repel one another. The normal method of propagation is to rotate the magnetic field which produced them. This induces local changes in the polarity of permalloy T or chevron shapes on the surface of the crystal. These changes in polarity move the series of bubbles along a predetermined path. In memory applications the bit of information is stored by the presence or absence of a bubble, though bubble memories are being developed in which the 0 or 1 are determined by two different types of bubble.

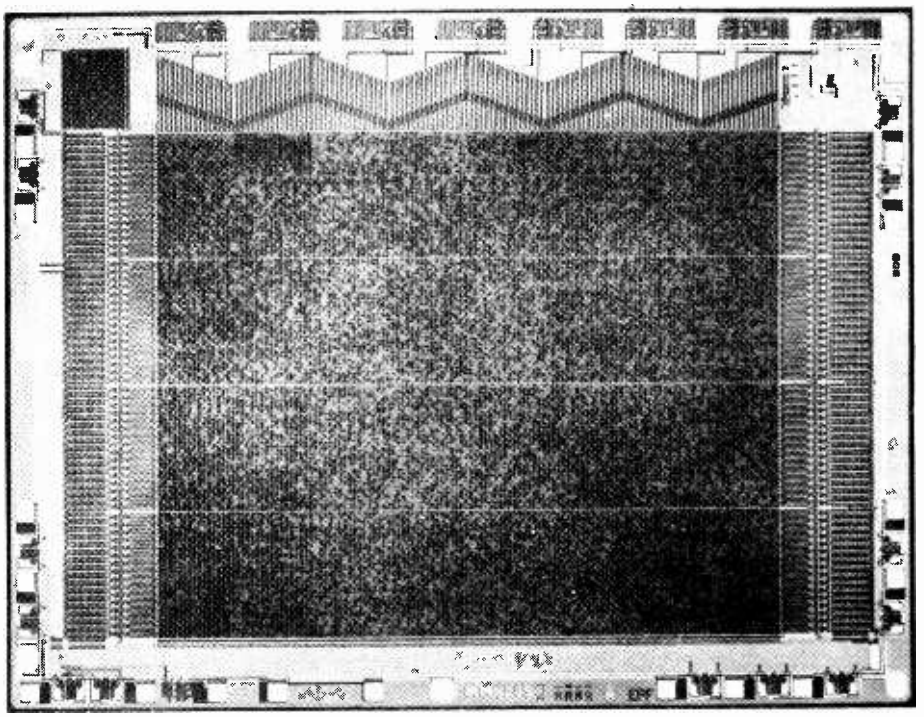
The bubbles are detected in three ways. As a bubble passes under the sense wire it induces a voltage. This was a satisfactory method until bubbles became so small the voltage they induced became too difficult to detect.

A more satisfactory method is to measure the change in resistance of permalloy as the bubble passes underneath it. The third method is to use an indium antimonide detector and measure the Hall voltage the bubble produces. These two methods give signals of a millivolt or so.

Bubbles are coming into general use. In 1975 Hitachi delivered a 2Mbit memory to the Japanese government for a special project. The stores were made up of 32 64K chips each 6 by 6.5mm and with an average access time of 5ms. They have now made 256K chips.

Around the same time NASA announced that they had contracted Rockwell to produce a bubble storage system, and that Rockwell had produced what they called "the largest integrated circuit memory element ever fabricated." It held 102,400 bits, and was designed for a 100 Mbit solid-state recorder. The recorder they had produced was one third the size, half the weight and took half the power of its conventional equivalent.

The final 100Mbit store is due for delivery this year. In February last year the Bell telephone company, whose associate, Bell Labs, first developed



National Semiconductor's 65,536 bit r.o.m. the MM5235. Made with a triple ion-implant metal gate m.o.s. process the 28 pin array has a typical access time of 450ns.

magnetic bubbles ten years ago, installed a recorded-message machine, the 13A, which used bubble memories to store a 12s, 272,000 bit message. Each chip held 68,000 bits.

A couple of months later, in April 1977, Texas Instruments launched two portable computer terminals which used bubble storage to store 20Kbytes, expandable to 80Kbytes. This represents a typical application of bubble memories, since these terminals have used ordinary audio tape cassettes as a cheap storage medium until now. An indexed item might take seconds or even minutes to find on the cassette, but the access time using the bubbles is less than 15ms.

However, two notes of caution were struck last year by independent marketing consultants. Venture Development Corporation announced in June that it would be at least five years before floppy disc makers need worry about bubbles or c.c.d, and in November Creative Strategies Inc said bubbles would not be "a reality" until 1980, when its market would expand with the arrival of a 1Mbit chip.

C.c.d. has even less to look forward to, according to CSI. "The charge coupled device, once regarded as the answer to large memory array problems, will not match earlier sales predictions due to its failure to become price-competitive. Caught between the large dynamic n.m.o.s. arrays and bubble memory technology, c.c.ds will be squeezed into a small market niche, capturing 2% of total memory sales."

Other interpretations of the way the market is going include the view that c.c.d. has a good future for at least the next five years since it is a semiconductor technology and therefore the ability to use it is already present. After that floppy discs will begin to disappear, and their going will coincide with the appearance of bubble memories large enough (1Mbit) to offer a low cost/bit. During that five years, c.c.d. technology will have advanced by an amount we can only guess at.

Essentially the c.c.d. memory is a very long shift register, with diffusions at either end of the register, corresponding to source and drain, and a series of electrodes in between. The application of a clock voltage to successive electrodes causes the silicon layer beneath to become depleted, and minority carrier charges can be injected into this depletion well. If successive clocks are applied to successive electrodes the minority charge is moved along the silicon surface. The clock signals have to be overlapped, which means that successive electrodes are supplied with signals which are lagging by 360°/n, where n is the number of separate, isolated but interleaved, electrodes. Early systems used four-phase clocks, where every fourth electrode was commoned, but devices with three and two phase clocks have been produced. C.c.ds can store analogue as well as digital quantities.

The memories are organised so that a 0 or 1 corresponds to the presence or absence of minority carriers in the depletion well. Operation can be serial-parallel-serial, recirculating loops, or line-addressed.

In the first the bits enter the memory horizontally, one bit at a time. When the row has been filled a column pulse (with a frequency of F/m, where F is the serial clocking frequency into the row and m is the number of bits the row can hold) moves the whole input row down a row, leaving the next set of row clock pulses to fill the input register again. When all the rows are filled the information is clocked out at the bottom at row-input speed. The access time is high and the device requires both fast and slow clocks, but according to Plessey Memories, who are working on c.c.ds "it is almost certain that this will be the most commonly-used configuration for low cost computer memories.

In the recirculating loop method the end of each successive row is connected to the beginning of the one below it and the information simply zig-zags its way to the bottom. In line addressing each row has its own clock and can work independently of the others. Information is read into empty registers and left there until it is needed.

Last spring Texas Instruments introduced a 64K c.c.d. chip, and Plessey have just announced a device compatible with Intel's IN65 c.c.d. memory. National are to second-source Intel's 2464 64K (65,536 bit) c.c.d. serial memory, a device organised as 256 short recirculating loops of 256 bits. The access time for a c.c.d. device is about 1μs but it is volatile.

Read-only memories have a great many uses, apart from conversions, say from one alphabet to another or from one programme language to another. Indeed, most future systems are likely to contain many times as much r.o.m. as they are r.a.m, especially as the r.o.m. is non-volatile. A r.o.m. can store waveforms if its input is applied cyclically, as in electronic music. It can also serve as a code convertor, as when a series of inputs can give a predetermined and perhaps different number of outputs. The example we have shown is the simple conversion of a series of binary numbers into signals suitable for application to a seven segment display.

Read-only memories (r.o.m.) have achieved 64Kbits on an m.o.s. chip, and t.t.l. r.o.ms are available up to 8K. Access times vary between 500ns, and 50ns for a 1K t.t.l. r.o.m. There are a number of types available. Manufacturers may make a standard r.o.m. for which the final connections programming the r.o.m. are added at the last stage and are different for each user. The user supplies a tape which is used to programme the memory at the factory. This method is only suited to very large-scale production.

Field-programmable read-only memories are more popular for smaller runs. The user programmes these by putting them on a commercially available machine, and addressing the places where he wants 1s and 0s. A field-programmable r.o.m. is programmable only once. P.r.o.ms are usually bipolar, and are more expensive than mask-programmable r.o.ms.

A third, more recent type of memory is the erasable programmable read-only memory. Developed by Intel, these became available in 1970. They use a floating-gate m.o.s. process. Each cell is a p-channel silicon-gate m.o.s. transistor in which the gate is an island of silicon

Fig. 8. *Converting a four-bit number to operate a seven-segment display.*

TRUTH TABLE

Input → Decoder				→ r.o.m. →							→ Output
A	B	C	D	a	b	c	d	e	f	g	
0	0	0	0	1	1	1	1	1	1	0	0
0	0	0	1	0	1	1	0	0	0	0	1
0	0	1	0	1	1	0	1	1	0	1	2
0	0	1	1	1	1	1	1	0	0	1	3
0	1	0	0	0	1	1	0	0	1	1	4
0	1	0	1	1	0	1	1	0	1	1	5
0	1	1	0	1	0	1	1	1	1	1	6
0	1	1	1	1	1	1	0	0	0	0	7
1	0	0	0	1	1	1	1	1	1	1	8
1	0	0	1	1	1	1	0	0	1	1	9

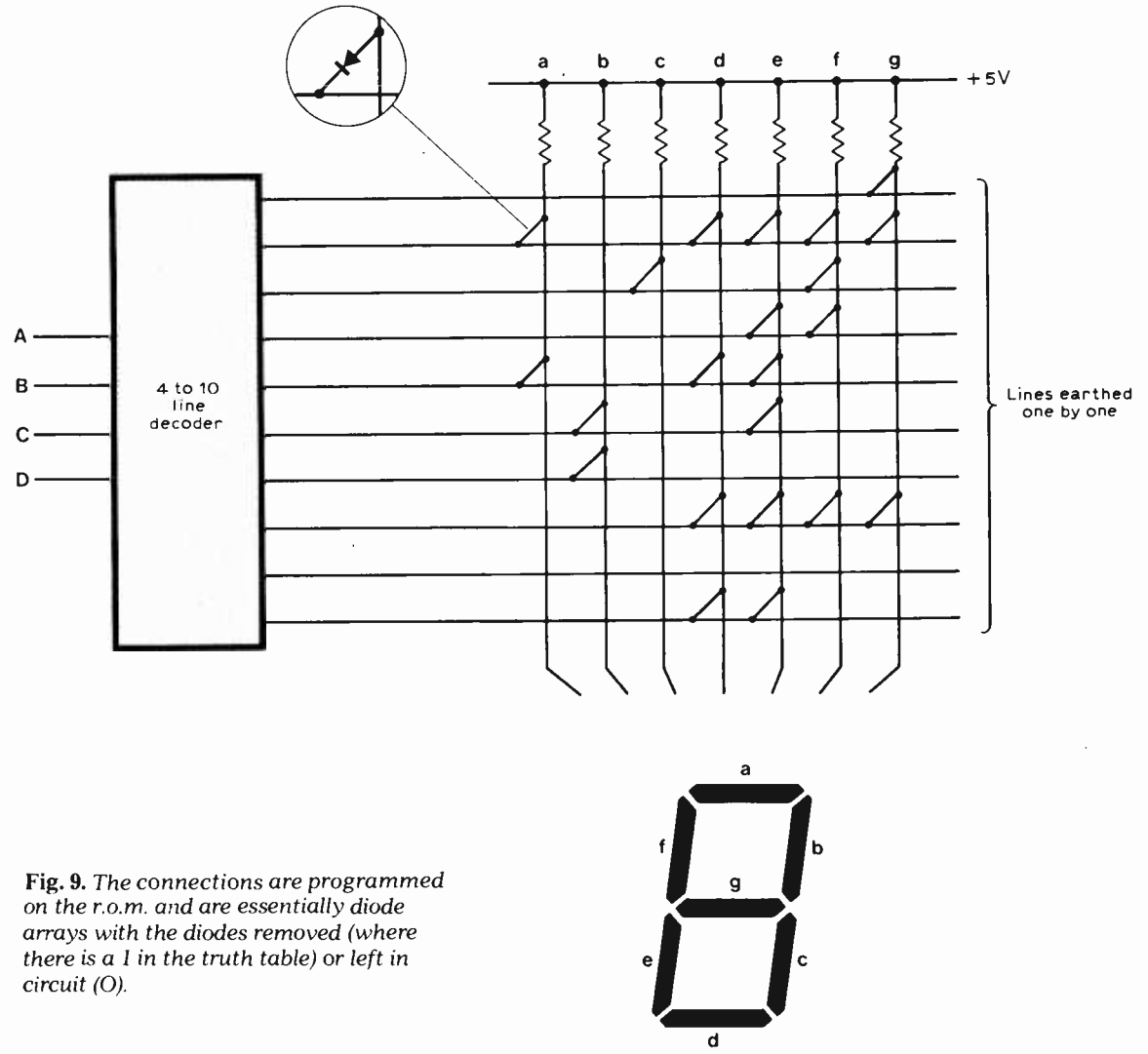


Fig. 9. *The connections are programmed on the r.o.m. and are essentially diode arrays with the diodes removed (where there is a 1 in the truth table) or left in circuit (O).*

surrounded by silicon oxide between the aluminium source and drain terminals. No electrical contact is made to the gate, but electrons can be injected into it by avalanche injection from either the source or the drain p-n junctions. The presence or absence of charge can be sensed by measuring the conductance between the source and drain regions. The array is programmed by applying a reverse bias of 30V or so to the gate or drain p-n junctions in particular cells.

The programme is erasable by shining ultra-violet light on the chip, which allows electrons to return to the silicon substrate via a photocurrent.

Last year Intel produced a 16K n-channel version with a single 5V power supply, an access time of 400 to 1,000ns and a programming time of 30 to 100s. National now have a 64K 450ns r.o.m. and are working in 128K and 256K additions to this triple-layer, ion-implanted family.

Newer devices are electrically alterable memories (e.a.r.o.m.). In programming voltages are applied which are well outside the memory's working range and which define the memory's operation until those large voltages are reapplied in a different way. In some applications the distinction between r.o.ms and r.a.ms is beginning to blur. Some e.a.r.o.ms use a modification of the floating gate principle, others use nitride storage (m.n.o.s.). Eight kilobit e.a.r.o.ms of around 0.5 to 1μs are now available.

One point worth bearing in mind on p.r.o.ms is the length of time they are able to retain their programmes. If nichrome fuse links are used, for example, and selected fuse links on the matrix are blown, some of the fuses may re-form themselves within a few hours of programming. Certain e.p.r.o.ms, it is reported, lose their programmes wihin a year. The normal guarantee is about ten years, and it may be one hundred, but with avalanche-injected charges it is not forever, especially if the device is operating in high temperatures.

Several other storage techniques have surfaced over the last few years, such as holography, domain tip memories and others. Many of them have no advantage over the techniques already described and, though in some cases as good, therefore offer no reason for a transfer to them. Some once seemed promising but have fallen from favour. A couple of years ago the electron-beam addressed memory (e.b.a.m.) was hailed as a future winner. At the end of last year, however, it was believed that only Micro-Bit of Massachusetts was still pursuing the idea, and General Electric were trying to sell their technology, having stopped the project.

Over the last five years around fifty companies have been involved in memory development in Europe, the US and Japan. The following list gives the names of the most important manufacturers and those who have agencies in the UK.

AEG-Telefunken, Postfach 1109, Heilbronn, Germany. Telephone 01 131-8821.

American Microsystems Inc, 108A Commercial Road, Swindon Wilts. (0793) 31345. Agents: Ritro, see Solid State Scientific.

Advanced Micro Devices, c/o Quarndon Electronics Ltd, Slack Lane, Derby DE3 3ED. Derby 32651.

Electronic Arrays Inc, 550 E Middlefield Rd, Mountain View, California.

Fairchild Semiconductor, Kingmaker House, Station Road, New Barnet, Herts. 01-440 7311.

Ferranti Semiconductors, Gem Mill, Fields New Road, Chadderton, Oldham OL9 8NP.

General Instrument Corporation, 57/61 Mortimer Street, London W1N 7TD. 01-636 2022.

Harris Semiconductor, Memec Ltd, The Firs, Whitchurch, near Aylesbury, Bucks. Whitchurch (029 664) 366/7/8.

Honeywell Ltd, Charles Square, Bracknell, Berks. Bracknell 24555.

Hitachi (UK) Ltd, Hitachi House, Station Road, Hayes, Middlesex UB3 4DR. 01-848 8787.

Intersil Inc (including AMS), 8 Tessa Rd, Reading, Berks RG1 8NS. Agents: Macro Marketing.

Intel Corporation (UK) Ltd, Broadfield House, 4 Between Towns Road, Cowley, Oxford OX4 3NB.

Matsushita Electronics Corporation, 1 Kotari-Yakemachie, Nagaokakyo, Kyoto 617, Japan.

ITT Semiconductors, Maidstone Road, Footscray, Sidcup, Kent. Harlow 26777.

Monolithic Memories Inc, 1165 E Arques Ave, Sunnyvale, California. Agents: Ritro, see Solid State Scientific.

Mostek Corporation, 240 Upper St, London N1. 01-359 6271.

Motorola Semiconductor, York House, Empire Way, Wembley HA9 0PR. 01-903 0944.

Mullard/Philips/Signetics, Mullard House, Torrington Place, London WC1E 7HD. 01-580 6633.

Nitron, 10420 Bubb Road, Cupertino, California.

National Semiconductor (UK) Ltd, 19 Goldington Street, Bedford MK40 3LF. 0234 211262.

Nippon Electric Company (NEC), 43 Civic Square, Motherwell ML1 1TH. (0698) 69121. Agents: Celdis, Macro Marketing.

Philips: see Mullard.
Plessey Semiconductors Ltd, Cheney Manor, Swindon, Wilts. (0793) 6251.

RCA Ltd, Lincoln Way, Windmill Road, Sunbury-on-Thames, Middlesex. Sunbury-on-Thames 85511.

SGS-ATES (UK) Ltd, Walton Street, Aylesbury, Bucks. (0296) 5977.

Siemens Ltd, Great West House, Great West Road, Brentford, TW8 9DG. 01-568 9133.

EMM-Semi, Semi, Electronic Memories, 3883 No. 28th Ave, Phoenix, Arizona. Agents: Memec Ltd.

Signetics, see Mullard.

Thompson CSF, Ringway House, Daneshill, Basingstoke RG24 0QG. Basingstoke 29155.

Texas Instruments Ltd, Manton Lane, Bedford MK41 7PA. Bedford 67466.

Solid State Scientific (SSS), agents: Ritro Electronics (UK) Ltd, Grenfell Place, Maidenhead, Berks. (0628) 36227.

Toshiba (UK) Ltd, Toshiba House, Greater South West Road, Feltham, Middlesex. 01-751 1281.

Zilog, Nicholson House, Maidenhead, Berks. Maidenhead 36131.

Fairchild, Mostek, NEC and Motorola are also sold by Celdis Ltd, 37-39 Loverock Road, Reading RG3 1ED.

Most of the products made by the manufacturers listed above are available through a number of distributors, and the British suppliers are not necessarily the sole agents or the only suppliers of those products. In other cases, British subsidiaries may refer inquiries to head office. □

continued from page 43

ignore the British Doppler in the face of highly successful practical tests of the system and rumours of skulduggery are rife. On the other hand, the French and Germans do not see the ICAO choice of a system as final, since their own systems are of a more far-seeing nature and are intended to form part of a total air navigation system in the future. Whether TRSB or DMLS is chosen by ICAO, it seems possible that it will all have to be examined again in ten year's time.

As seen by their proposers, the points for (very few against) their systems are, looking on from the outside, fairly contrived, and are to do mainly with aerials and propagation.

It has been shown that all systems proposed, with the exception of the m.l.s. part of AGDLS, have satisfied most of ICAO's requirements in all major particulars. (AGDLS is still a 'paper' proposal, although it has successfully performed in tests at Brétigny).

However, the arguments will not be stilled until after the April ICAO meeting. Proponents of Doppler strenuously deny that their system suffers from 'scalloping'—a type of signal deformation by reflection from objects—and can point to many successful trials at 'difficult' airports, after each of which they have distributed their tracking results. In contrast TRSB had, until recently, only been tested at Atlantic City, and results from the tests have been very difficult indeed to come by. Now, the UK camp have coerced the Americans into tests at the same airports as Doppler and the first results, from Kristiansand and Brussels, show that there is little difference in performance. The Doppler men say that their system is easier to monitor, needing only a one-point field monitor, whereas TRSB needs monitors in several parts of the coverage volume. They also say that the Americans have had continual trouble with aerial design, although it appears that they have at least one which performs well now—probably an Australian design. Plessey say that over 10% of the elements in a Doppler array can fail before any deterioration in performance is seen—they call this a 'fail-soft' characteristic. In contrast, TRSB needs all elements in the array to be energized, with a well-graded amplitude and phase at each. (Doppler elements are fed with the same signal in turn). It is said that a 'thinned' Doppler array, with elements 'missing' will work well, with acceptable side lobes. With a shifting reference frequency, a vernier-like effect can be employed to restore the Doppler signal. A scanning beam with side-lobes (the result of missing elements) cannot, say the British, be acceptable and cost cannot be reduced by 'thinning' the array, although Cox and Sebring[8] have said that 20% of a phased array can be failed without destroying the characteristics.

Doppler men point to the high cost of development (really rather irrelevant now), high maintenance costs and lack of flexibility of TRSB. They also point out that the high sampling rate of Doppler, whose beams exist continuously, unlike those of TRSB, mean better 'smoothing' of aircraft motion.

Those interested in the adoption of TRSB appear to pin most of their faith on allegations that Doppler will suffer from multipath propagation errors. The fact that UK workers have shown little confidence in Lincoln Laboratories computer simulation, preferring to fly the tests and see what happens in practice, is seen by some Americans as a failing, even though practice has shown that multipath trouble predicted by the computer is conspicuous by its absence. Both Doppler and scanning beam proposers claim one disadvantage for DLS. It is said that, since it is 'open' continuously, interference can be more of a problem when compared with TRSB, which gates the information and Doppler, which has its tracking filter.

In retaliation, the German and French companies point out the fact that the use of L-band techniques affords a considerable saving in spectrum allocations — a factor which may not be of prime importance at this time, but which could assume greater significance in the future. DLS has the advantage that it uses existing L-band d.m.e. airborne equipment with comparatively small attachments which can be fitted at any time, and can use this equipment for navigation as well as landing. Flare is also provided by triangulation of DLS aerial signals.

Tests at John F. Kennedy airport are to take place as this is being written and further tests at Montreal will be undertaken in a few weeks. In April, ICAO makes its choice, which seems a pity. There is absolutely no reason why the decision must be made now — the deadline has been postponed once already and could be put back again.

It could well be that, given a month or two to cool down, the French AGDLS or German DLS integrated systems would appear more attractive. A complete new look at air navigation methods must surely make more sense than another piecemeal alteration. □

References

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2. Full visibility landing system, *Wireless World*, May 1963, p.209.
3. New navigational aids, *Wireless World*, August 1953, p.375.
4. No hands blind landing, *Wireless World*, December 1958, p.579.
5. Benjamin, J. Correlation-protected i.l.s., IEE/IERE Conference on Air Traffic Control Systems Engineering and Design, 1967.
6. U.S. Patent 2411518, November 26, 1946.
7. British Patent 549530, August 4, 1944.
8. Cox, R. M. and Sebring, J. R., M.l.s.—a practical application of microwave technology, *IEEE Trans. Microwave Theory and Techniques*, Vol. MTT-24, No. 12, December 1976.

Cassette tape programmer — 1

A simple interface for calculators

by Evert Olsson

The interface described in this article was the winning entry in a designer's contest arranged by the Swedish electronics journal *Radio & Television*. It is an add-on unit which makes a simple calculator programmable by using an ordinary cassette tape recorder as a programme storage medium. No modifications are required on the recorder, but the calculator must be provided with two connectors to make programming possible. The original article was first published in the above mentioned journal.

Although modifications are described for the Sinclair Cambridge, almost any calculator can be adapted. The programming unit is not intended to compete with commercial units, particularly in terms of speed, but it is an interesting project for people who want to gain experience in programming and interfacing. The complete circuit can be hard-wired on two boards measuring about 10 × 16cm and the only test equipment necessary is a d.c. coupled oscilloscope with triggered time-base, and a voltmeter. A quiz machine is also described which uses the same principle and almost the same hardware as the programming unit. Details are given for the construction of both or either one of the circuits.

Basic principles

The block diagram in Fig. 1 shows the operations for recording a programme. Signals from the 18 calculator keys are converted into a five-bit code by the diode matrix. A pulse from the detector circuit loads the code into a shift register which converts it to serial form. The detector also enables the RS flip-flop which drives the tape recorder via a buffer stage. After a delay of about two seconds, which allows the recorder's motor speed to stabilize, a clock generator is started. Output pulses from this circuit are gated with counter outputs and used to shift the code out of the register. This serial code is shown in Fig. 2 and is basically a five-bit telex format with the time element altered to suit the calculator de-bounce logic. On the last counter pulse the start flip-flop, shift register, and counter are reset. The serial code is amplitude modulated on a carrier of about 5kHz so that when the carrier is off no code is being processed.

Each key depression runs the tape for about three seconds which allows 600 programme steps per side of a C60 cassette. Speech signals from a microphone can be mixed with the modulated carrier but the tape runs for as long as the remote-button on the microphone is pressed. Therefore, fewer programme steps can be recorded. Although the serial code could be packed much more densely onto the tape, a lower density was chosen so that single programme steps can be edited. In addition to the 18 calculator keys there is a pause switch which is used to make programmed stops on the tape.

The execution of a programme is shown in Fig. 3. The tape is started by the same RS flip-flop and buffer stage

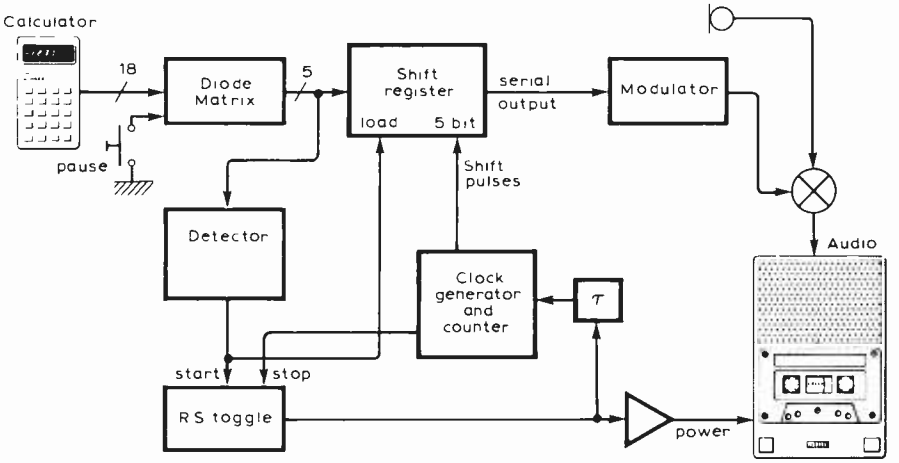


Fig. 1. *Circuit operations for the record mode where the logic acts as a parallel-to-serial converter.*

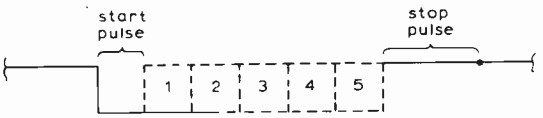
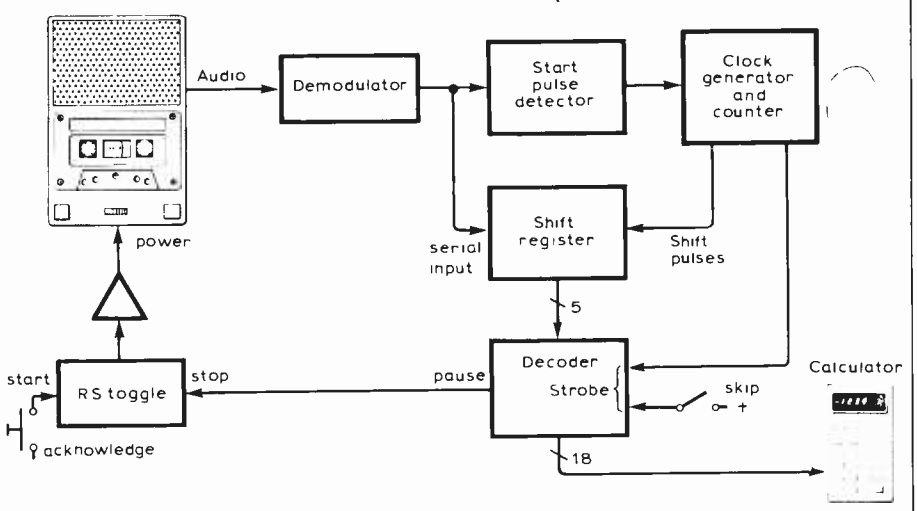
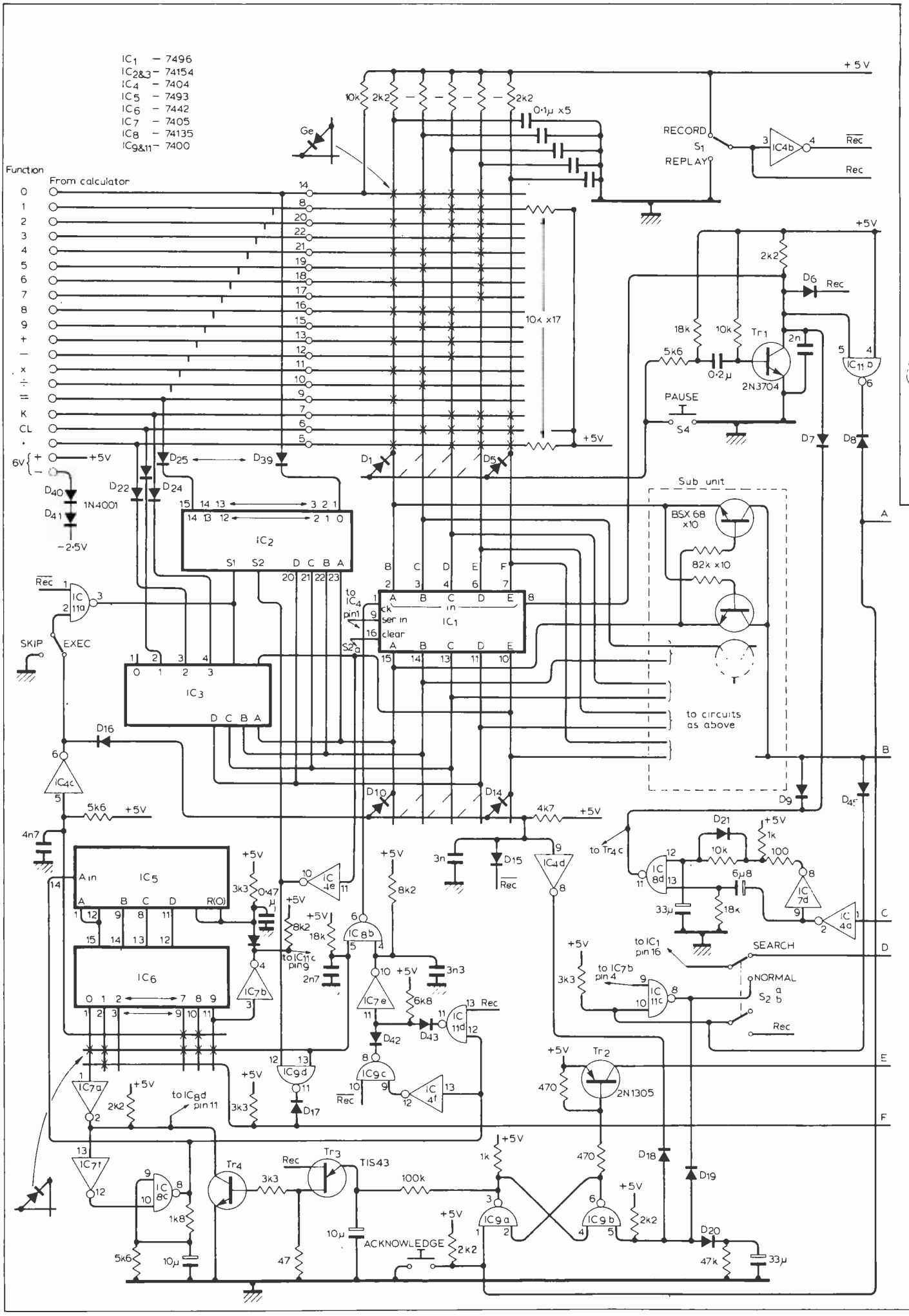


Fig. 2. *Serial five-bit code.*

Fig. 3. *Circuit operations for the replay mode where the logic acts as a serial-to-parallel converter.*





when the acknowledge switch is pressed, and runs continuously until a pause code is encountered. The acknowledge switch is also used to restart the tape after a programmed halt. When a carrier signal is detected on the tape a tuned demodulator recreates the pulse train in Fig. 2.

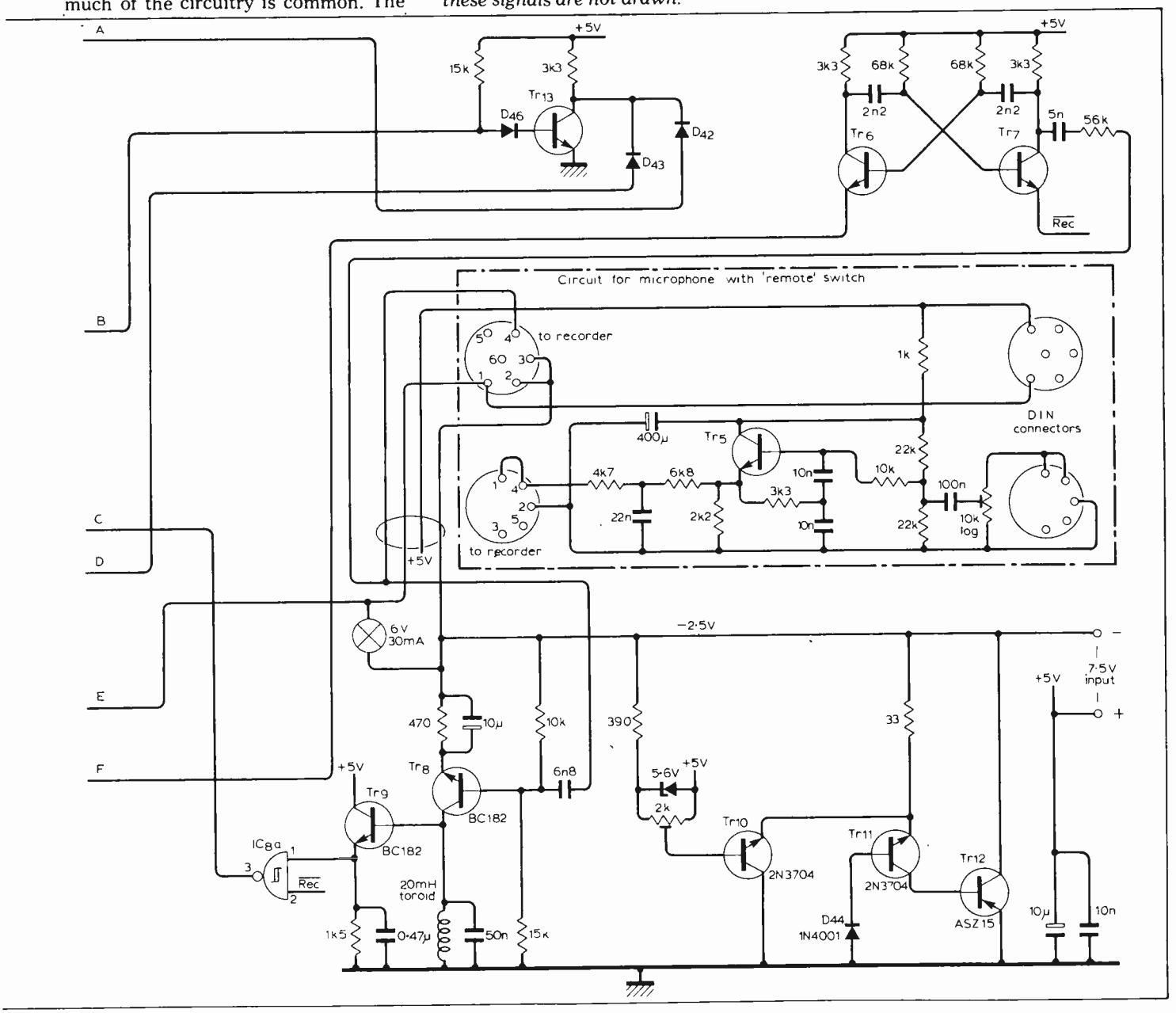
The start pulse of this pulse train activates the clock generator and its associated counter which in turn loads the pulse train into a serial-in-parallel-out shift register. When the complete pulse train is loaded the parallel outputs are decoded back to 18 lines which are wired-OR with the calculator keys. A 19th output from the decoder, which corresponds to the pause switch, activates the RS flip-flop to stop the tape. The pause facility allows the calculator keys to enter numerical values between programme steps without rushing.

All of the decoder outputs except pause can be turned off by a skip switch which is used to make jumps forward in the programme. Because the record and replay modes operate in a similar way, much of the circuitry is common. The complete circuit is shown in Fig. 4. Switching between record and replay takes place at several points in the logic, so normal and inverted signals are used for the two modes.

Circuit operation

As described earlier, the recording cycle is started by pressing any calculator key. Because germanium diodes are used in the matrix, and the calculator adaptation circuits, to be described later, are very sensitive, pull up resistors have to be used in the code and key lines. Diodes D_1 to D_5 detect when a key is pressed and turn off Tr_1 momentarily. The short pulse on the collector of Tr_1 loads the contents of the code lines into shift register IC_1. Because the pause switch turns Tr_1 off without passing through the diode matrix its code is 11111. To eliminate contact bounce the relevant code lines are held low for about 20μs by five 0.1μF capacitors. The load pulse starts flip-flop IC_{9ab} via IC_{11b} and further loading of the shift register is prevented by D_7. The flip-flop turns Tr_2 on which supplies current to the recorder, and also starts a unijunction-transistor timer. After about two seconds this timer enables the Schmitt trigger oscillator IC_{8c} via Tr_4 and IC_{7f}. The oscillator output is connected to the input of counter IC_5 which always starts with a negative-going edge. The counter outputs are decoded by IC_6 and a small diode matrix. When the counter leaves its zero state IC_{7f} is held low by IC_{7a}, and IC_{8c} continues to oscillate until the counter is again reset by decoder output 9. The 0.47μF capacitor is used to extend the reset pulse which makes trouble-shooting easier. In the record mode the oscillator output is gated by IC_{11d}, IC_{7e} and IC_{8b}. This output is used as a clock pulse for the shift register. Shifting occurs on the negative-going edge. The shift-pulse input must be

Fig. 4. *Full circuit diagram of the tape programmer. All diodes in the matrix of IC_1 should be gold bonded germanium types. Two clock phases are used and are shown as REC and $\overline{REC}$. To improve clarity connections between these signals are not drawn.*



high when the register is loaded. Clock pulses reach the register during counter states 2 to 6. The register's serial output is also gated via IC_{9d}. Diode D_{17} allows wired-OR connection with the decoders output. Counter state 1 corresponds to the start pulse, and state 7/8 to the stop pulse. At state 9 the counter, shift register, and flip-flop are reset to complete the recording cycle.

During this cycle the waveform in Fig. 2, which appears at the anode of D_{17}, turns on the astable flip-flop Tr_6 Tr_7 to produce the carrier. The carrier level is set by a 56kΩ resistor together with the input impedance of the replay amplifier Tr_8. Speech signals from the microphone are first filtered by Tr_5 and its associated components, before being fed into the tape recorder. This filter, which prevents normal speech from disturbing the pulse decoding during replay, is provided with a separate volume control for speech signals. The cassette machine's record level control is set to maximum which is around 100mV into 1MΩ.

In the prototype the author used a Philips EL3302 recorder which uses the same pin for record and replay. Change-over occurs in the recorder, and the output level is unaltered by the volume control which can be used to adjust the level of speech without affecting the replay logic.

Replay mode

In the replay mode the recorder is started by its mechanical switch and the acknowledge switch in the logic. When a carrier is encountered on the tape the signal is amplified by Tr_8 and band-pass filtered by an LC network which is tuned as closely as possible to the astable multivibrator. Transistor Tr_9 is a high-impedance emitter-follower detector which produces about 2V on its emitter when the carrier is present. Because the pulse edges are quite slow at this point due to the LC filter, a Schmitt trigger IC_{8a} is used to improve the pulse shape. Pin 3 of IC_8 exhibits the waveform shown in Fig. 2. This pulse train is fed to the shift register's serial input and a start pulse detector consisting of IC_{4a}, IC_{7d} and IC_{8d}. The clock generator IC_{8c} is started synchronously with the start pulse's leading edge and stays on for 9 cycles. The clock phase used for IC_1 shifts in the middle of each data pulse in the train to prevent any small tape speed errors from destroying the reproduced code. When the complete pulse train has been shifted into the register, decoders IC_2 and IC_3 are enabled via IC_6, IC_{4c}, switch S_3 and IC_{11a} unless S_3 is in the skip position. However, the pause code 11111, will still be operating so it is decoded by the diode gate D_{10} to D_{16}. Diodes D_{22} to D_{39} are included to enable wired-OR-connection to the calculator keys but these do not need to be gold-bonded germanium types.

Switch $\bar{S}_2$ is used when single instructions in a programme are to be changed. When the tape is replayed with S_2 in the search position the tape stops after every instruction. Restart is achieved with the acknowledge key. Therefore, when the instruction before the one to be changed is found, S_1 is switched to record, S_2 to normal and the old instruction is replaced with a new one. □

to be continued

Electronics, computers and the industrial strategy

IMPATIENCE WITH the government's industrial strategy, which is based on the Government's 1975 white paper, is growing. The Hitachi debacle (*WW* Jan and Feb) has reinforced the view that the NEDO sector working parties through which the strategy is supposed to work are little more than lobbying groups, and there is less planning than merely pleading for lumps of government cash.

On few of the economic sectors does so much depend as on the electronics, computers, components and telecommunications sectors. A spate of reports has appeared in the national and specialist press in the last few weeks outlining the massive tasks these sectors face if Britain is to survive to the 1990s and beyond. Yet all that is officially available from the NEDO is a long series of anodyne memoranda marking the end of the industrial strategy's second year, and the oft-intoned remark that the job of the sector working parties so far has been "analytical", to produce reports.

"They have had to collect and analyse complicated sectoral data, reach conclusions about constraints and opportunities, propose targets and begin the formulation of sectoral strategies," says a memo from Denis Healey and Eric Varley to the NEDO. "They have made impressive progress over the past two years."

Yet the chairman of the Industrial Strategy Staff Group, second permanent secretary to the Treasury, Mr Lawrence Airey, says in another memo that "Any attempt to add together the figures produced by different SWPs is hazardous since it relies on material which was never intended for that purpose; the SWPs did not use uniform methods, assumptions or presentation; The SWPs cover only part of manufacturing industry . . .; SWP's proposals for action are often novel."

The memo also notes that the firms in each industrial sector have very little to do with the work of the SWPs; "Feedback, evidence of discussion and reaction in the firms are often slight."

Not encouraging when you consider that the whole point of the industrial strategy is to arrive at "an agreed approach by feeding information upwards from the various sectors of industry into macro-economic planning."

Elsewhere a report published by the computer SWP says that little is being done to quantify the impact that microprocessors will have on the office and the shop floor: "The bulk of the expansion of cheap computing into machine tools, telecommunications and office equipment is still to come."

The working party is also concerned at the effects on computing of the weakness of the home-based semiconductor industry, particularly in mainstream products based on advanced technology.

But another report, this time from the Department of Industry to the NEDO, suggests that it is pointless putting money into strengthening the mainstream semiconductor industry since this would require £400 million, and the home market would, unlike that for the Americans, be too small. Neither is there any point trying to engineer a merger between our three biggest companies, GEC, Ferranti and Plessey, since they would still be much smaller than any of the 15 giants.

The report notes that British expertise has been concentrated largely in the special systems market, where there is a large requirement for custom-built equipment, at low volume. £60 million should be found over the next five years to build an industry on which its future customers can rely, and another £20 million should be found to promote that special expertise abroad. Half of this total of £80 million should come from the government and half from the industry itself, though the government would put more in.

As to the non-home-based UK companies such as Mullard (Philips) or ITT, these should be encouraged to invest in standards manufacturing plants in the UK, with the benefit of Government or EEC financial encouragement.

The report notes the massive amounts of investment going into very large scale integration (v.l.s.i.) microelectronics in other countries: $500m a year in the USA, £500m in Japan, and £50m to £60m in France and Germany, with heavy government involvement. So far the British industry has been promised £30m, and another £25m at least is under discussion.

This explains why, when we spoke to Jack Akerman, managing director of Mullard and deeply involved in the industrial strategy, before Christmas, he was evidently satisfied with the prospects for government help: "Before long there will be further support in the solid state area," he had said. But he added that none of these schemes would work "if there are too many strings." Thus the government's hopes for some kind of planning agreements with the various sectors would seem to be optimistic, even though Akerman later said he was in favour of planning. He added that he was also optimistic about the prospect of aid from Brussels.

Akerman believes that, wherever the investment comes from, we have to make it in order to have a stake in an electronic future that he describes as mind-boggling: "With electronics the blind can see and the dumb can talk and the deaf can hear. We can do so much with electronics." And if we missed the boat? "We can't even contemplate that we miss it." □

CIRCUIT IDEAS

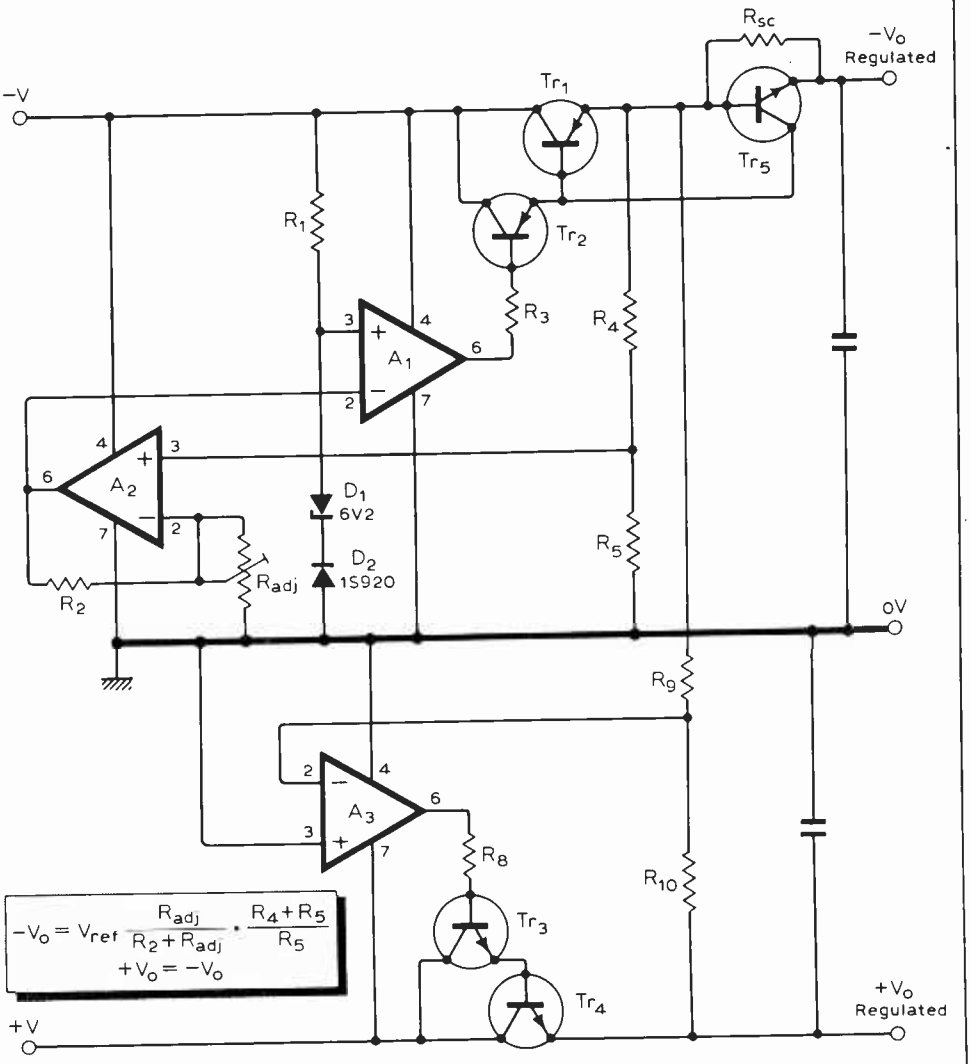
Adjustable tracking voltage regulator

BOTH OUTPUTS of this regulator can be adjusted simultaneously by one potentiometer. Diodes D_1 and D_2 act as a reference, where the positive temperature coefficient of D_1 is cancelled by the negative temperature coefficient of D_2. Amplifier A_1 regulates—V_0 so that the output of A_2 is always at the reference voltage. Amplifier A_3 has its non-inverting input connected to 0V and the point between R_9 and R_{10} is also at 0V. Because $-V_0$ is fixed, $+V_0$ has to be regulated at the same voltage as $-V_0$. Resistor R_9 equals R_{10}, R_4 and R_5 are scaled to give a constant K so that $-V_0$

$$= V_{ref} \cdot \frac{R_{adj}}{R_3 + R_{adj}} \cdot K.$$

R_{11} acts as a current sense resistor, and provides a current limit of approximately $\frac{0.68\ A}{R_{11}}$

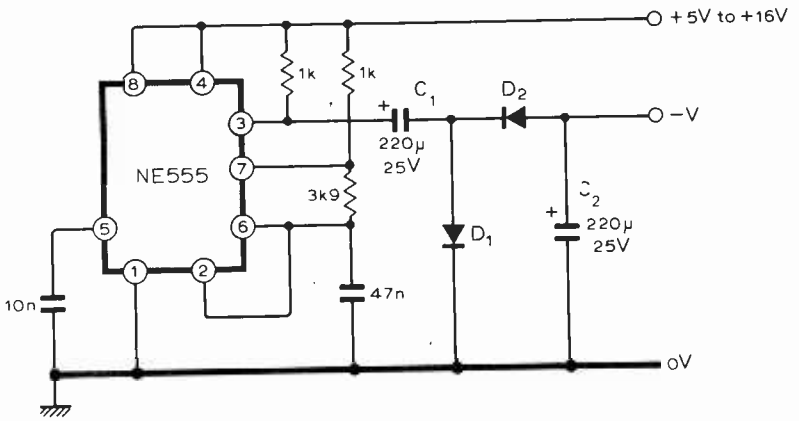
S. Choudhari,
Trondhiem,
Norway.



Negative supply for op-amps

A SINGLE TIMER i.c. used as an astable multivibrator can provide a 200mA negative supply from a positive rail voltage. The square-wave output drives a diode-clamp consisting of C_1 and D_1. Components C_2 and D_2 smooth the squarewave to give a negative d.c. output. With the component values shown the oscillator frequency is about 2kHz, but any value between 1kHz and 4kHz is satisfactory.

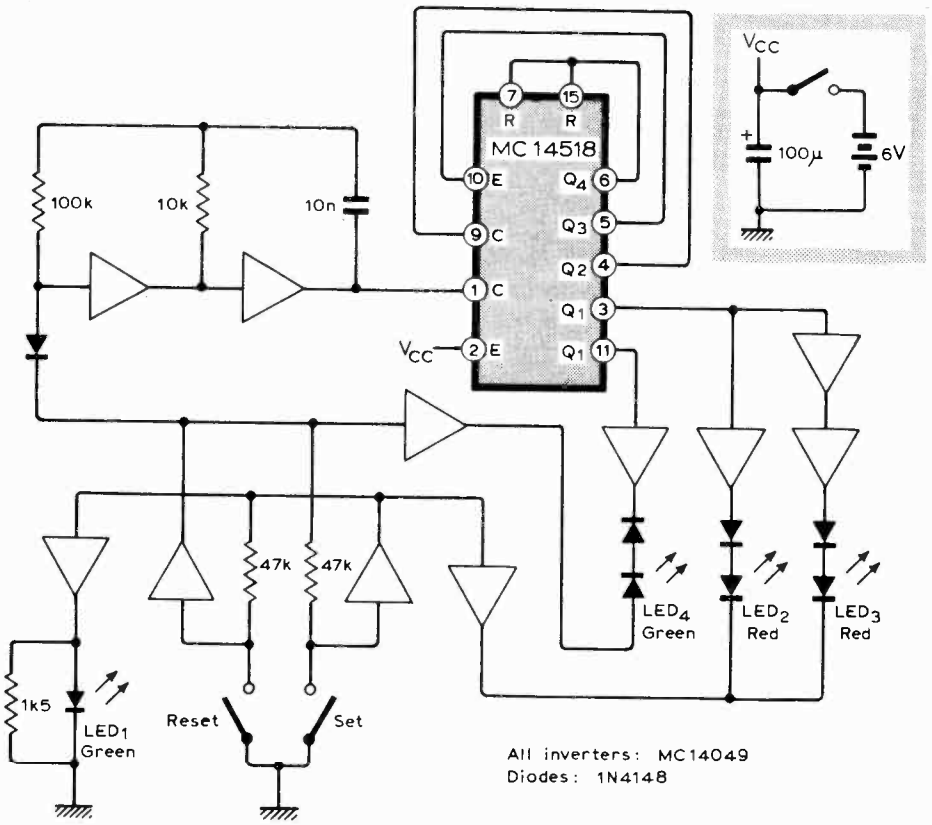
A. Pongsupaht,
Dept. of Electronic Engineering,
University of Birmingham.



I Ching

THIS CIRCUIT is the electronic equivalent of I Ching, a form of divination originally from China. In its classic form a response is obtained by the manipulation of 50 sticks or by the combination three coins. A book on the subject is then required to interpret the result. The whole process must be repeated six times to have a complete response. The electronic version consists of an oscillator running at 4 kHz, a double counter which produces a 2 kHz waveform with a 50% duty cycle, and a 500 Hz waveform with a 25% duty cycle. This is the correct relationship which reflects the combinations obtainable from I Ching in its original form. When reset is pressed the oscillator runs, l.e.d. 1 is on and all other l.e.d. are off. When set is pressed the oscillator stops, l.e.d. 1 goes off, l.e.ds 2, 3 and 4 are enabled and the information in the double counter is displayed. Either l.e.d. 2 or 3 will always light up representing a Yin and Yang line respectively. In those cases when l.e.d 4 also lights, it means that the Yin or Yang line is also a moving line. The circuit is then reset and is ready for a new reading until all 6 have been taken. The circuit is not critical and will operate from a supply between 3 and 12V.

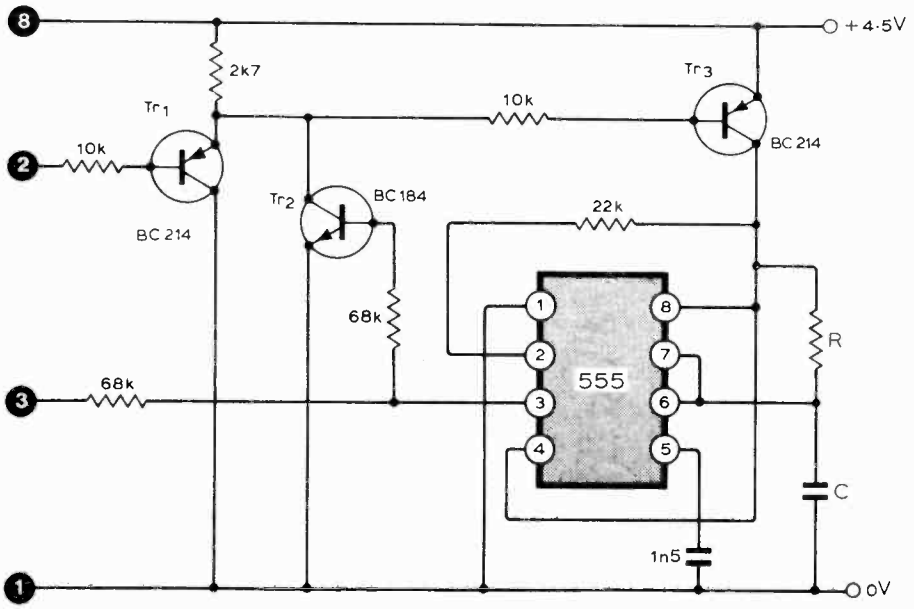
D. Di Mario,
Johannesburg,
S. Africa

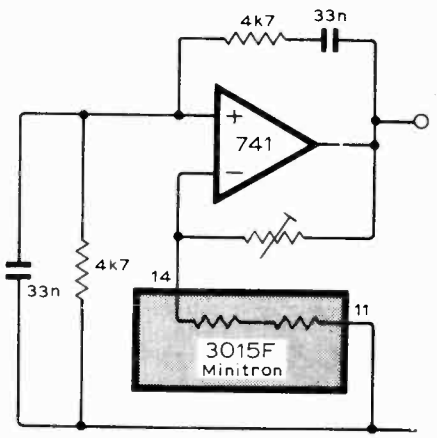


Low current 555 timer

IN THE OFF STATE the supply current to a 555 timer is about 3mA. For battery powered circuits where this is too high the modified circuit shown can be used. This reduces the current to about 2µA although the on state current rises to about 3.5mA. Other properties of the timer remain practically unaltered. When the circuit is off, pin 2 is disconnected from ground so Tr_1 and Tr_3 are turned off. Because the 555 has no supply voltage Tr_2 is also off. When a negative trigger pulse is applied to pin 2, Tr_1 and Tr_3 are turned on and connect the timer to the supply rail. A positive pulse from pin 3 of the timer turns Tr_2 on which keeps Tr_3 on. After the delay period has elapsed the timer returns to the off state. Connections 4, 5, 6 and 7 of the i.c. are still used but pins 1, 2, 3 and 8 are replaced by the new connections.

Dr O. B. Hellman,
Turku,
Finland.





Minitron replaces thermistor

IN CONVENTIONAL Wien bridge oscillators an expensive and delicate thermister is used to stabilize the amplitude. This circuit uses segments of a minitron display whose resistances increase from about 100Ω at one volt, to about 700Ω at six volts. Various combinations of the seven segments can be used and one minitron can be used in several circuits.

The design shown operates at around 1kHz and produces one volt r.m.s. For setting up, a 10kΩ variable resistor to give one volt output.
give one volt output.

R. Gough,
Shenstone,
Staffs.

Pickup arm design techniques — 2

Continuing the story of the pickup arm and the factors influencing its design

by Tejinder Singh Randhawa VU2TSR

In its account of the historical development of the pickup arm, Part 1 described how the problems of tracking error could be countered by clever design. This second part introduces additional factors to be considered in pickup arm design, beginning with tracing error distortion, and describes how they influenced the author in the design of his own pickup arm.

Rear view of mounting post and weighting arrangements for author's pickup arm.

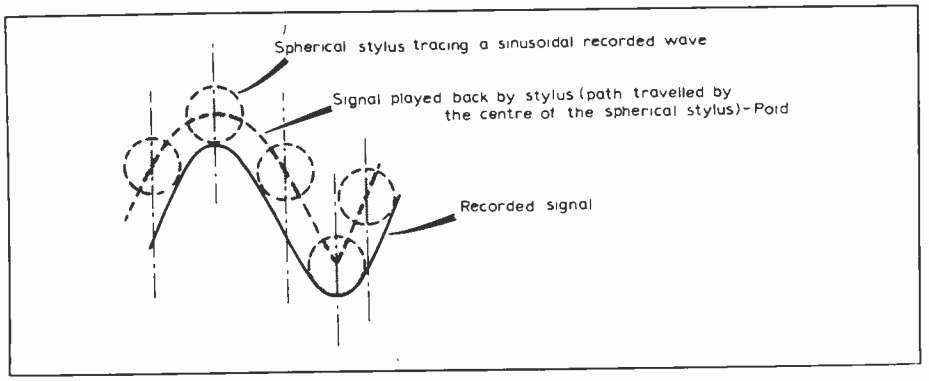
A serious form of distortion introduced by a finite-radius spherical stylus reproducing a cut record is tracing error distortion. This problem, illustrated in Fig. 4, was first recognized in 1932 by H. A. Frederick[12], and the present name was given to the problem by M. J. D. Toro[13] in 1937.

The first rigorous analysis of tracing error distortion was done in 1938 by J. A. Pierce and F. V. Hunt[14]. The topic has since attracted considerable attention and further analyses have been carried out[15,16,17]. Tracing error distortion, which consists mainly of odd harmonics, and tracking error distortion, are the two major causes of distortion in record reproduction. Tracing error distortion, which is a problem relating to the transducer, is considered in this article on pickup arm design because it is instructive to compare the two.

Using the formulae for tracing error distortion with typical figures (a spherical stylii with a tip radii of 0.0006 inch), and using a relatively small arm, one finds that, after correcting for recording characteristics, the break frequency between tracking error distortion and tracing error distortion occurs at about 2,000Hz. In other words, for the recorded signal below 2,000Hz tracking error dominates, while above this figure, tracing error distortion takes over. However, with the coming of elliptical stylii, the break frequency is shifted to between about 4,000 and 6,000Hz because the effective stylus radius (the portion of the stylus that traces the groove modulations) is reduced to about one-half or one-third that of spherical stylii, and the tracing error distortion is proportional to the square of the effective radius and the frequency.

Since tracing error consists mainly of odd harmonics, the harmonic distortion components will lie above 12,000Hz. However, in practice the actual tracing error distortion produced is less than the theoretically-calculated figure because of the deformation of the groove. To further reduce tracing error distortion, papers have been published[11,18,19] describing equipment that has been

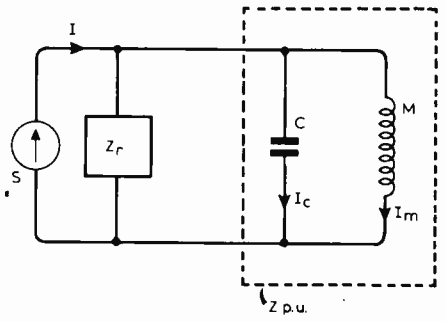
Fig. 4. *Graphical representation of how a recorded pure sinewave becomes a distorted sinewave when played back by the stylus.*



designed to compensate for tracing error in the recording process itself. One method that was suggested (and used briefly for vertical recordings, in the earlier days) was to reproduce the distorted traced signal and re-record it in reversed phase. The main disadvantage with this method is that it would require strict standardization of reproducing stylii on all domestic cartridges.

If one considers that tracing error distortion is comparable to tracking error distortion, and that a properly mounted 9in (effective length) arm will give second-harmonic tracking-error distortion figures of less than 1% (see table), it might seem pointless to reduce tracking error distortion by articulating arms, pivoted heads and associated gadgetry, which only increase the inertia of the pickup arm and its effective mass. This is undesirable, as will be explained later. An earlier device, the Burne Jones arm, which had a pivoted head, was claimed to have a maximum tracking error of 1 degree. The Ortho-Vox arm corrected for tracking error by varying the effective length of the arm and the overhang as the arm moved across the record. The resulting reduction in tracking error was claimed to be equivalent to extending the arm length to 8 feet. Perhaps the ultimate, accurate application of the pivoted head method has been achieved by the Garrard Zero 100 arm. This arm has a maximum tracking error of 0.022 degrees at the record radius of 3.25in. For a detailed computer analysis of the linkage of this arm, see reference 20.

For minimum tracking error distortion, it is important to set the offset angle and overhang accurately. Different cartridges have varying positions for the stylus relative to the mounting screws. To overcome this problem, in some pickup arms, the cartridge can be moved within the shell to place the stylus at the correct position, while in others the entire pickup arm can be moved to or away from the turntable centre to vary the overhang. The former method has its advantages because, when the stylus position changes considerably, both the overhang and the effective stylus-pivot length of the arm change. Consequently, a new effective length would require a recalculation of the offset angle, overhang and the zero tracking error points. Now, as seen from the table, a change in the effective length of the arm does not significantly change the zero tracking error points. However, this assumes that the offset angle is the optimum one for the length. In the above case the offset angle is fixed and will differ from the optimum. Fortunately, it will be corrected automatically to some extent because an increase or decrease in the effective length will correspondingly decrease or increase the offset angle. This can be verified from the geometry of a pickup arm. Also, from the formula it can be seen that, as the arm length increases the offset angle required decreases, and vice-versa. On the other hand, the latter method has the advantage that the shell can be made smaller and lighter.



Since $Z_r \gg Z$p.u., S acts as a constant current source and Z_r can be neglected from the analysis, then for the parallel resonant frequency $(f_0) = \frac{1}{2\pi\sqrt{MC}}$

Fig. 5. *Equivalent circuit of a pickup arm and cartridge. S is the current (velocity) source, C is the stylus compliance, I is the current (modulation velocity), I_c repesents the velocity of the stylus tip relative to the arm (transducer velocity), and I_m represents the arm velocity. Z_r is the mechanical impedance of the turntable as seen by the stylus and is a function of the compliance and resistance of the record material and supporting means. M is the mass of the arm referred to the stylus point ($M = I_h/R^2$) where I_h is the total inertia of the arm about the pivot and R is the pivot-to-stylus length.*

An accurate iterative procedure for setting the arm optimally has been suggested by Stevenson. This procedure requires the use of an alignment protactor. At the first zero tracking error radius R_1, Fig. 1(b), the overhang should be adjusted until the tracking error is zero (with the offset angle set to approximately the optimum value). At R_2, the second zero tracking error point, one should observe whether the tracking error is positive or negative. A positive tracking error will be obtained at radii greater than R_2. If it is postive, it indicates that both the offset angle and the overhang are less than the optimum value and should be increased slightly. If the tracking error at R_2 is negative, it indicates that the offset angle and the overhang are larger than the optimum value and should be decreased slightly. The above steps should be repeated until minimum tracking error at R_1 and R_2 is obtained.

Pickup arm-cartridge resonance

The electrical equivalent circuit of the arm and cartridge combination is illustrated in Fig. 5 and, as can be seen, the stylus compliance and effective mass of the pickup arm form a parallel resonant circuit. This will create problems if the resonance frequency coincides with an audio frequency or any other annoying frequency. For various M and C combinations, the range of f_0 lies in the lower end of the audio spectrum – below about 40Hz. There was a time when f_0 used to lie at about 60Hz because of the extremely low compliance of the stylii of the available cartridges, and attempts were made to lower it. Nowadays, it is the opposite; with high compliance cartridges available, f_0 tends to go down to below 10Hz and manufacturers are desperately attempting to lower the value of M for their arms, making small improvements wherever possible, even to the extent of doing away with headshell collar nuts. This is justified.

To have a low value of M, a light gauge aluminium tube should be used in a way that employs the shortest length of the tube (as in Fig. 6(b)). Why bends are still used despite this disadvantage can be appreciated only when one tries to design a turntable oneself. With the bend, the arm in Fig. 6(a) will have a smaller angular motion from the rest position (parallel to the side edge of the record player unit) to the end of the record than the straight tube arm. Further, a heavier counterweight near the pivot, rather than a lighter one at a correspondingly greater distance, decreases M. All this trouble to decrease M and raise f_0 has to be taken because the region 0 to 10Hz can be full of troublesome frequencies due to eccentric centre holes in records, warps, ripples, turntable platter excitation, and so on. Even though the inherent response of the cartridge at these very low frequencies might be extremely small, resonance effectively magnifies the response, and if these frequency signals reach the speaker, a Doppler effect will result. Given a choice M should be smaller in the vertical direction than in the horizontal direction to raise the vertical f_0 component, since rumble is greater in the vertical direction than in the lateral direction. Also, less vertical inertia helps the arm in coping with record warps.

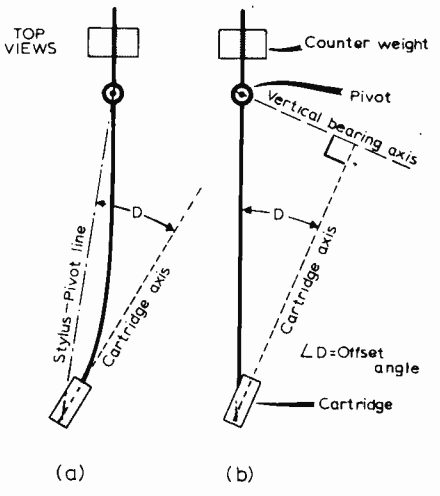
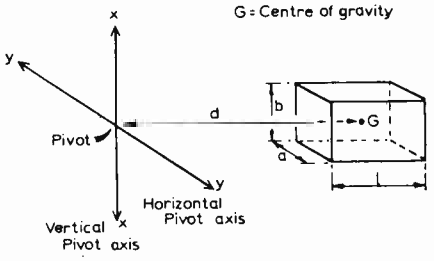


Fig. 6. *Two methods of setting a cartridge at an angle to the pickup arm. Employing a short tube, as in (b), helps to reduce the effective mass of the arm.*



Inertia about vertical pivot = $I_{xx} = \frac{1}{12} M(b^2+l^2) + Md^2$

Inertia about horizontal pivot = $I_{yy} = \frac{1}{12} M(a^2+l^2) + Md^2$

Fig. 7. *Optimum design of a rectangular parallelepiped counterweight (M is the mass of the counterweight).*

Fig. 7 gives the optimum design for a rectangular parallelepiped counterweight and the inertia formulae relating to it. Unfortunately, some designers use counterweights of this kind but with b much greater than a. As can be seen from the equations, this results in a condition where the vertical inertia is greater than the horizontal inertia. This is undesirable because it results in a lower vertical resonance frequency (with respect to horizontal resonance frequency) and this decreases the arm's ability to track warped records. In fact, for a lower vertical inertia (with respect to horizontal inertia) both b and l should be made smaller, however unconventional the counterweight might look.

Damping

The pickup-arm cartridge resonance can be damped by mechanical resistance damping in the stylus and the pivot, or by dynamic damping. Figure 8(a) shows the equivalent circuit for the first method. This method of damping the pickup arm-cartridge resonance was dropped when it was pointed out in 1951[21] by W. S. Bachman that large tracking weights will be required if R is selected for effective damping. For effective damping $R = \sqrt{(4M/C)} = 2000\Omega$ assuming $M = 16$gms (H) and $C = 16\mu F$. Now $F = RV/\sqrt{2} = 20{,}000$ dynes, approximately 20gms (where V is the peak recorded velocity) for a recorded velocity of 10cm/s r.m.s.

Figure 8(b) shows the equivalent circuit of the popular pivot damping method, which Bachman recommended. An efficient way of applying this method of damping was to have a pivot in the form of a hemisphere and a complementary cup or mandrel and sleeve arrangement. The distance between the two was variable, and the volume in between was filled with a viscous fluid. In this way, knowing the dimensions of the arrangement and the fluid viscosity, a value of R could be calculated. (For details of the 'Gray', viscous damped arms 108C and 212, see reference 22.) This method was suitable for the high-tracking-weight, low-compliance cartridges of 20 years ago, but not for the low-tracking-weight, high-compliance cartridges of today. Indeed, the arms were damped so much that manufacturers used to boast that, with their viscous damped arm, a record could not be damaged due to the arm being accidentally dropped over the record, because it would simply fall down very gently.

As can be seen from the equivalent circuit, at low frequencies, the insertion of a resistance in the M branch tends to reduce the current in that branch and divert more to the C branch. Physically, this means that the low frequency response of the cartridge would be increased. This may be a disadvantage if the cartridge already has a good low frequency response characteristic because it would increase its response in the danger zone 0 to 15Hz. It is worth mentioning that in the older designs R was calculated and applied meticulously. These days we sometimes come across the deplorable quack tendency of applying a dash of oil or a spot of grease to effectively damp all resonances.

In the third method, dynamic damping, the arm mass is divided into two separate parts and joined through a visco-elastic coupling, as shown in Fig. 9. Fig. 8(c) shows the equivalent circuit for this method. B. Bauer[23] has experimentally determined that, for this method to be effective, the ratio of the mass associated with the rest of the arm (M_2), should be at the most 3:7 (ideally it should be 0:10 which of course is impossible). To obtain this, the cartridge and shell portion of the arm should be as light as possible and the visco-elastic coupling should be immediately behind the shell. It is unfortunate that manufacturers place the coupling way behind the shell, just in front of the counterweight, as this makes the damping less effective.

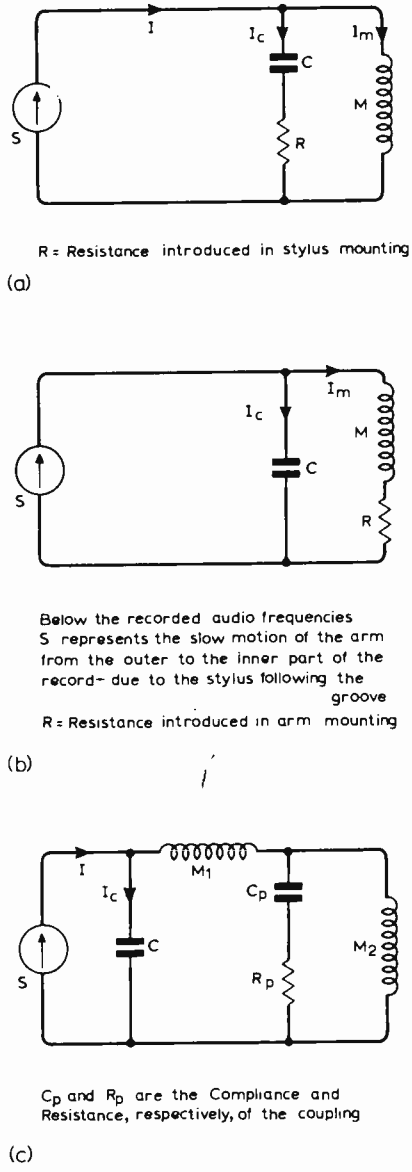


Fig. 8. *Equivalent electrical circuits for (a) stylus resistance damping, (b) mechanical resistance damping in arm pivot, and (c) dynamic damping.*

All the above methods work optimally, only within certain restrictions. Resonance problems were mainly associated with audio frequencies on the older units, but today rumble pickup, which is greater in the vertical direction, and warps and ripples on the record, are the main cause. Keeping these points in mind the author tried to use mechanical resistance damping in the vertical pivot only, keeping the horizontal pivot resistance free so that it did not oppose the slow motion of the arm from the outer to the inner portion of the record. In this design, the resistance applied to the vertical pivot was not of the constant-resistance fluid type. Instead, a static value of resistance was applied when the arm was stationary in the vertical plane, but when a warp moved the arm upward a dynamic value came into effect (which

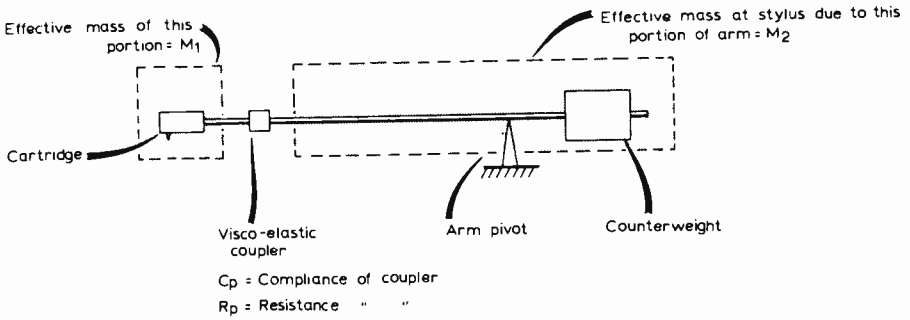


Fig. 9. *Physical arrangement of dynamic damping parameters.*

was less than the static value), which made it easier for the arm to cope with the warp. However, the author dropped this method because even the smaller dynamic value resulted in an audible wow when a high compliance cartridge went over a warp.

Another feature that the author had in his older arm was adjustable inertia. It is perfectly alright to design an arm with a minimum M but sometimes the M and C values combine to place f_0 where it coincides with an annoying frequency (assuming inefficient damping). Since M cannot be decreased further, the only way out would be to change C – the cartridge. However, when M can be increased it can help in decreasing the pickup of the annoying frequency, as explained in Fig. 10(a). To vary the inertia while keeping the tracking weight fixed, the author made a counterweight in three parts such that M could be increased by moving the outer parts of the counterweight outwards, as shown in Fig. 10(b). He did not use this counterweight in his latest arm because it required a heavy counterweight as near to the pivot as possible. Nonetheless, the author still strongly advocates the use of adjustable inertia since, if one is troubled by the pickup of a troublesome frequency, M can be increased by adding external weights to the arm to see if it helps.

Skating force

Skating force, or sidethrust force, is perhaps the most debated topic in pickup arm design. Points raised by audio enthusiasts include, whether skating compensation is necessary, what kind of compensation is the best and the best way to calibrate it, whether it stays constant across the record radius or increases or decreases. It is something like the Yagi versus Quad controversy among radio amateurs. Different arguments, with certain qualifications, can be put forward both for and against the necessity of skating compensation.

At the outset, the author would like to stress that the total sidethrust force is not that component of the tangential frictional force that is directed to the record centre, as is popularly but erroneously thought. The true skating force is that component of the tangential frictional force which acts at right angles to the pivot-stylus line. The former is less than the latter. This restatement is necessary because, often in articles the formula for the former is derived and it is said that it is this force that the antiskating mechanism has to counter. The formula for skating force and the force diagrams are given in Fig. 1(b). A look at this figure also points out another fallacy that exists regarding skating force. It is said that the skating force arises because of the offset angle and the overhang. This is wrong. Even if there were no offset angle and overhang in an arm, skating force would exist because of the large tracking error.

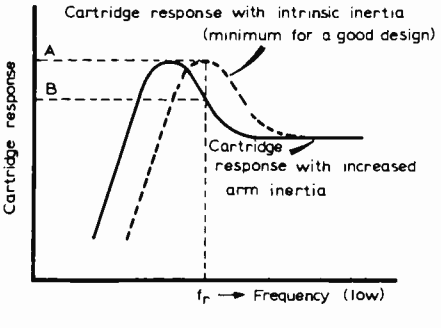
The stylus position for a straight arm passing through the centre of the record is also shown in Fig. 1(b). The tracking error of such an arm at the start of a 12 inch record will be 18.6° for an effective arm length of 9in. (This is obtained by putting C and D equal to zero in the tracking error equation — Equation 4). The skating force for this case would therefore be equal to FSin(18.6) which is slightly less than the skating force for an arm of the same effective length having the optimum offset angle and overhang (FSin(25)). In fact, offset angle and overhang help in reducing drastically the variation of the skating force across the record, since, in the former straight-arm, zero overhang case, the skating force at the minimum recorded radius would equal FSin(7) — an enormous variation compared to the value at the start of the record. The variation in skating force for a 9in optimum design is shown in Fig. 2(c), which follows from Fig. 1(b). It is maximum at the start of play, decreases and then increases.

For a blank disc, providing the disc speed is constant, the skating force should remain constant, because it depends on the dynamic friction coefficient. In practice, when playing a modulated disc, the skating force is increased and made slightly dependent on the groove speed because of the modulations. This dependence on record speed is insignificant and so different calibrations are not necessary for 33⅓ rev/min and 45 rev/min records. Elliptical stylii require negligibly greater skating compensation than spherical stylii. Different arm lengths have different offset values and tracking error angles, and therefore the skating force, will vary, its value being smaller for longer arms. In other words, there is no fixed value for it.

Experiments have proved that skating force does give rise to considerable distortion[24] and so it is desirable to counter it. Various bias adjustors or sidethrust compensators may be used to counter this force. These include magnetic repulsion, levers and the 'weight on a nylon thread' method, which was suggested by John Crabbe in 1960 and till today remains a popular, simple method to oppose the skating tendency. One cartridge manufacturer even claims that a brush attached permanently to the front of the cartridge (primarily to clean the record) is sufficient to counter the skating force.

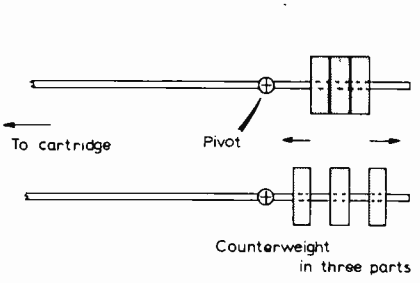
Fig. 10(a). *Diagram shows that an increase in the effective mass of the pickup arm helps to reduce the pickup of an annoying frequency which coincides with the resonance frequency. When the arm inertia is increased the effective mass referred to the stylus tip increases and the resonant peak (assuming insufficient damping) shifts to the left.*

Fig. 10(b). *Physical implementation of Fig. 10(a). By moving the outer parts of the three-part counterweight outwards, the inertia will be increased without affecting the tracking weight.*



f_r = Rumble frequency
A = Rumble pickup for minimum inertia case
B = Rumble pickup when M is increased – resonance frequency decreases

(a)



(b)

Lateral balancing

The most misused and misunderstood feature on modern pickup arms is the lateral (or angular) balance adjustment control. It comforts the user, assuring him that all forces are balanced, leaving the cartridge to turn angles. The basic reason why the lateral force arises when the mounting is tilted is because the entire arm turns angularly around the arm tube axis. This is illustrated in Fig. 11(a). Due to the bend in the arm the centre of gravity (c.g.) of the arm section in front of the mountings will lie somewhere in the triangle ABC in the horizontal plane of motion of the arm. If the mounting is vertical, then at the second position of the arm the plane of the triangle ABC will remain horizontal. Now, suppose that the mounting is tilted forward, as in Fig. 11(b). Observe that the arm is still perfectly horizontal. (The following example is valid only for a gymbal mounted as shown in Fig. 11(c). That is, one with a vertical bearing in the inner ring, a knife edge mounting for vertical motion and a

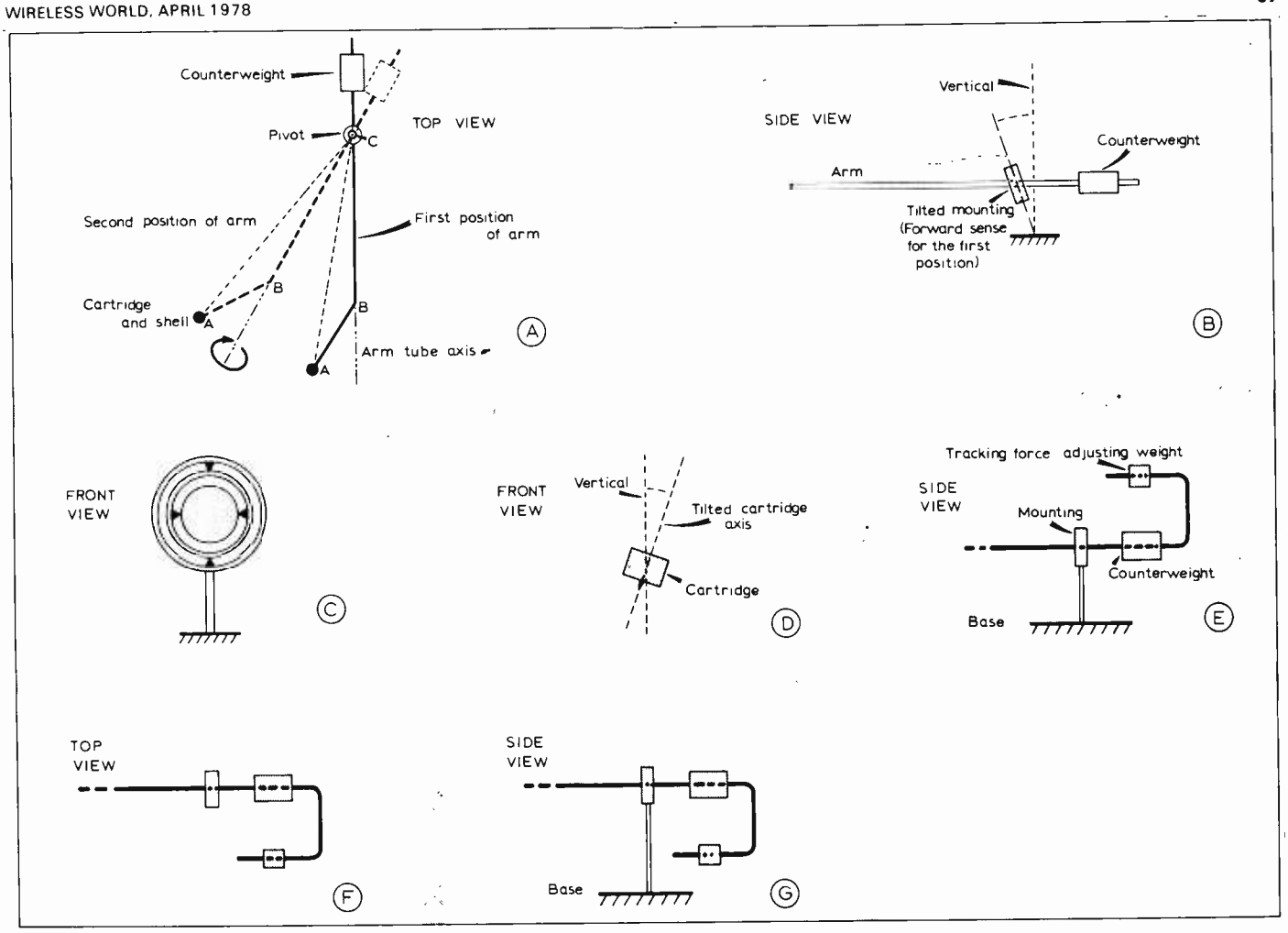


Fig. 11. *Tilted mountings. If a mounting, of the gymbal type as in 'c' or the 'knife-edge and bearing' type, is tilted forward as in 'b', the arm will tend to turn about the tube axis. In a bent-arm construction, this results in a torque in the anticlockwise direction because the c.g. of the triangle ABC will tend to occupy the lowest possible position. (Observe that the arm is horizontal in 'b'.) Tendency of arm to rotate as in 'a' results in axis of cartridge tilting as in 'd'. Anticlockwise force can be countered using tracking-force adjusting weight in horizontal plane of the arm on side of counterweight opposite the offset, as in 'f'. 'e' illustrates an unstable arrangement for the weight, and 'g' illustrates the stable arrangement.*

bearing for horizontal motion). In this case, when the arm moves to the second arm position, the arm and hence the triangle ABC, will tend to turn around the arm axis in the direction indicated. As this would entail the raising of the centre of gravity of ABC, such a movement will be opposed. In simple words, an anti-clockwise torque will result. In the conventional lateral balancing arrangement, a weight (which can be the tracking force adjustment weight itself) is placed in the lateral plane on the side opposite to the bend (Fig. 11(f)). Then, for the above case, an anti-clockwise movement would tend to raise the weight and give rise to a clockwise torque. The distance of this weight from the arm in the lateral plane is adjusted so that the two torques are equally opposed. An eccentric counterweight is sometimes used for this purpose.

This method successfully counters the lateral force but the arm mounting is still not vertical. Consequently, when the arm moves to the second position, the cartridge axis will not be vertical but will be at an angle to the vertical (Fig. 11(d)). Clearly, this is to be avoided. In effect, the lateral balancing control is a solution to one of the outcomes of the problem and not a solution to the basic problem itself. The author believes that a few extra minutes spent while mounting the arm, to ensure that the mounting is vertical, would be a better solution and would be time well spent. In the author's latest arm design, lateral force adjustment is possible because the U-shaped rod carrying the counterweight and the tracking-force adjusting weight can be rotated around the arm tube axis enabling the perpendicular distance (in the horizontal plane) between the tracking weight and the axis to be varied. This can be used to apply a variable lateral force to both sides of the arm. However, it is better to ensure that the gymbal is mounted absolutely vertical in the first place. In any case, the straight tube design obviates the need for lateral balancing since the so called lateral force for tilts will be negligible. It might seem odd, therefore, that the author has chosen to mount the tracking force weight in the horizontal plane of the arm and not the vertical plane, thereby deliberately off-balancing the arm laterally, in the conventional sense. The reason is that the term lateral balance is a misnomer and a more appropriate term would be 'angular balance.' For example, consider Fig. 11(e), where all the mass elements of the pickup arm lie in the vertical plane of motion of the arm. It might be construed that, in this case, the arm would be inherently laterally balanced. This is not so, and a little thinking (and the reader is urged to experiment himself) shows that if the mounting is tilted forward, a slight displacement of the arm in the clockwise sense will result in a clockwise torque. A small displacement of the arm in the anticlockwise direction will result in a torque in the anti-clockwise direction (that is, relative to the centre position).

The tracking force weight can be placed in three positions. It can be placed in the horizontal plane of the arm on the side of the counterweight (Fig. 11(f)), in the vertical plane of the arm above the counterweight (Fig. 11(e)), or below the counterweight (Fig. 11(g)). A little thought (and experimentation) will show that Fig. 11(f) corresponds to neutral equilibrium, Fig. 11(e) corres-

ponds to unstable equilibrium and Fig. 11(g) corresponds to stable equilibrium. Physically, it means that in the last two cases, for a fixed setting of the tracking force weight, the tracking force at the stylus will vary for different levels of the arm (for record changer arms). In general, to measure the vertical friction and stiction of the arm at the stylus position, the arm should be balanced and a small weight placed on the shell. The value of this weight, which is sufficient to move the arm appreciably, gives the required figure. Clearly, there is going to be a difference, for the 'stable' and the 'unstable' position (the value for the former will be more than the latter). So, to appreciate the friction figures of an arm, a knowledge of the equilibrium condition of the arm will be in order.

Pickup arm length

After discussing the essential features of pickup arms, it is now possible to decide the optimum length of a pickup arm. The various points that are affected by pickup arm length are: tracking error distortion, record wear due to tracking error, elliptical-stylii lag effect due to tracking error, effective mass of the arm, the inertia of the arm, skating force, and friction and stiction measured at the stylus point. A 12in arm gives less tracking error distortion than a 9in arm (see table) but a properly mounted 9in arm gives less than 1% harmonic distortion. Since tracing error distortion is comparable to tracking error distortion, it would seem pointless to increase the length beyond 9in to further decrease tracking error distortion. Since a 12in arm has less maximum tracking error than a 9in arm (0.58 degrees less) it might be construed that it will wear records less. However, with the high compliance cartridges available nowadays, this will be insignificant.

It is said that elliptical stylii can reduce tracing distortion at the expense of increasing error by causing a lag effect (reproduction delay) between the two channels of a stereo record[9]. This arises because, due to tracking error, the elliptical stylus does not trace the groove exactly as it was recorded since one point of contact will be slightly delayed or advanced relative to the other. Calculations show that a 12in arm does not improve matters considerably over a 9in arm, in this respect. In any case, it should be noted that tracing error is itself a form of delay (or lag and lead) distortion. This is illustrated in Fig. 4. Calculations show that the effective mass M for a 9in arm is smaller than for a 12in arm. As stated earlier, a smaller value of M is desirable. To be able to play a warped record properly, the term $I_H\omega$ (angular momentum) has to be a minimum for a particular arm. For a given warp amplitude, the angular velocity imparted to the 12in arm will be 9/12th of the angular velocity imparted to the 9in arm, but, because there is also an increase in the inertia, the beneficial effect of using the longer arm is cancelled. Since a smaller offset angle is required for a 12in arm than for a 9in arm, the former will have a smaller skating force. Compensation will still be required for the longer arm and so this advantage does not really help matters, unless the user is averse to using sidethrust compensation. For given friction and stiction figures for a mounting, a smaller force will be required to move the arm at the stylus position 12 inches from the pivot, than at 9 inches from the pivot. A good mounting has a low enough inherent friction and stiction, so this is of negligible advantage in favour of the longer arm.

From the above points it is evident that a smaller 9in arm has a clear advantage over a longer 12in arm. Not surprisingly, the trend these days is towards smaller arms and some manufacturers have even stopped production of their longer models. □

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White-light holoraphy

Our front cover shows the gold keys of the city of Leningrad (formerly St Petersburg) recreated by one of the finest reflective white-light holograms ever produced. The holographic plate was made in a similar way to conventional types using the coherent light from an argon laser. Instead of splitting the laser light into an incident and reference beam, a single beam is passed through the plate onto the object. Part of the light is reflected back onto te rear of the light is reflected back onto the rear of the plate where it creates an interference pattern with the original beam. This pattern is then recorded on the emulsion. The main differences, however, are in the type of emulsion, a fine-grain thick layer type, and the process used to "develop" the plate. This allows the image to be seen in incoherent white light from a point source such as a filament lamp.

During the developing process the emulsion and hence the interference pattern shrinks. Because this inteference pattern acts like a diffraction grating when white light is directed onto it, the image is seen in one particular colour. By expanding the emulsion the plate can be "tuned" for the natural colour, gold in the case of the keys.

The ability to optimise a single colour helps to make the image look very solid and sharp. In Russia the pioneer of white light holography Yu. N. Denisyuk has developed the technique of white-light holography to the point where it is intended to replace certain treasures on display by holographic replicas. Unfortunately information concerning the emulsion and developing process is limited, but as can be seen from our photograph the image of the keys is very convincing.

We would like to thank Laser Light Controls Ltd whose photographic assistance during their recent Science Museum exhibition was appreciated.

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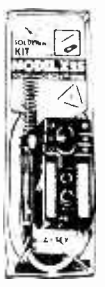

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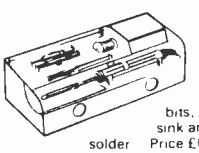
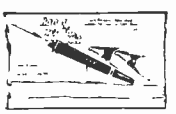


This kit contains a 15-watt minature soldering iron, complete with 2 spare bits, a coil of solder, a heat sink and a booklet, "How to solder Price £6 18 inc VAT & P&P

Model MLX KIT



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Some tests on extended response cartridges

Tests complement those of July 1976 issue

by David Heller, B.Sc.(Eng)

Earlier tests on nine extended-response cartridges with white noise record, demodulator and spectrum analyser are augmented with results for six further pickups.

In addition, damping properties are investigated and stereo compatibility assessed. Within the limitations of the tests the moving-coil pickups appear to be superior to the moving-magnet types.

APPEARANCE OF EARLY extended frequency response (e.f.r.) cartridges on the market highlighted the fact that while cartridge manufacturers placed much importance on extending the amplitude response of cartridges, few paid much attention to high frequency separation or phase response and delay properties of these cartridges. This initial oversight was a major contributing factor in the poor quality of recovered audio from CD-4 discs and only over the past few years have a new generation of extended-response cartridges appeared which display much superior characteristics in this regard.

Criteria which I believe e.f.r. cartridges should fulfil are as follows.

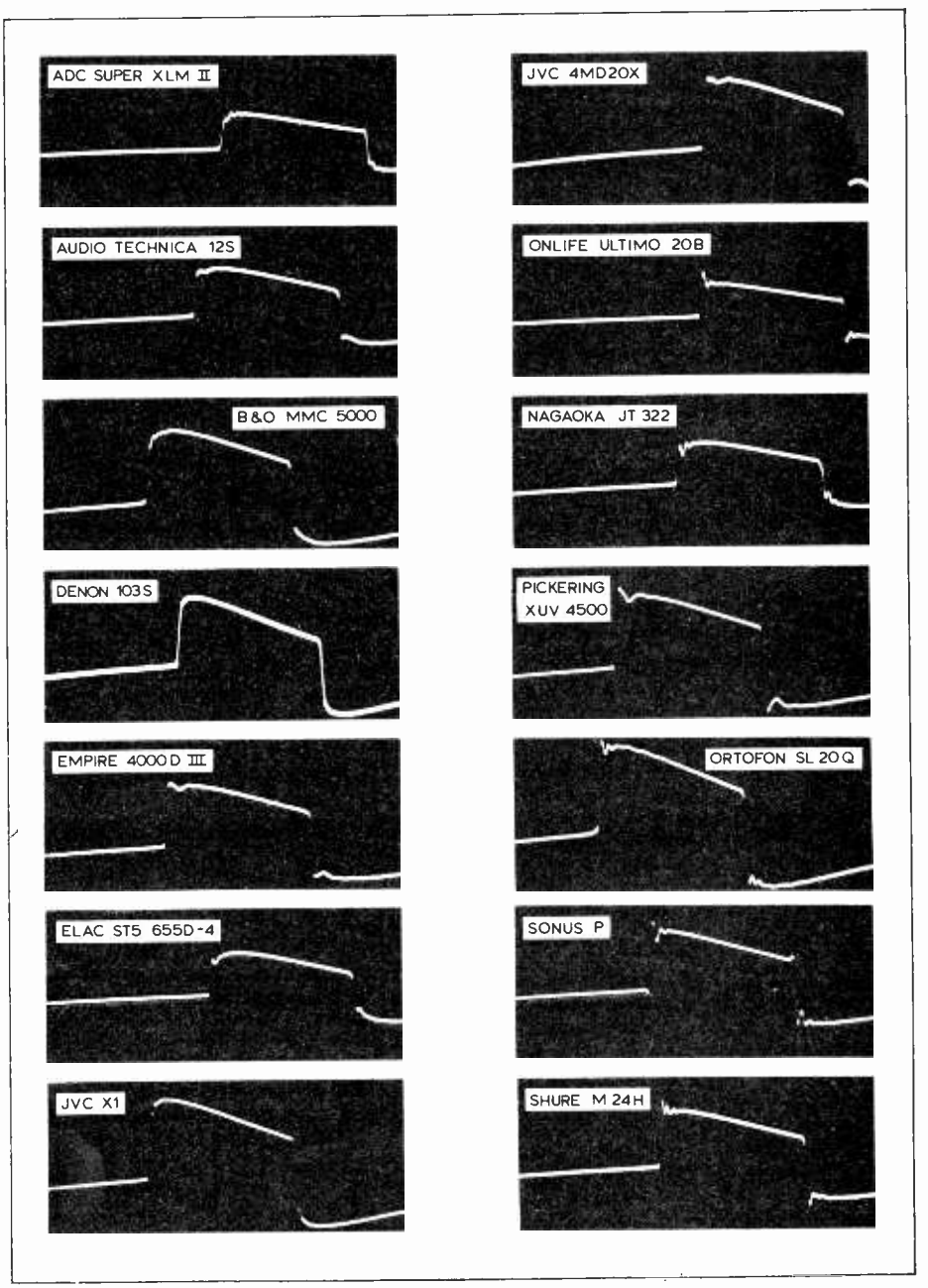
Amplitude response. When equalized through the required circuitry (normally RIAA) the frequency response should be flat to about 18kHz. In the range 18kHz to 45kHz the cartridge should be able to track such frequency bands with high output (0.5mV or greater) but a flat response over this range is not essential, because the signal is frequency modulated.

Crosstalk. High channel separation should exist over the frequency range to 45kHz, otherwise frequency beats occur in the carrier range which leads to distortion and degradation of the recovered audio signal. This phenomenon was apparent with earlier e.f.r. cartridges and data issued seldom gave reference to crosstalk characteristics in the carrier region. Crosstalk figures in excess of 15dB in the carrier region should be the minimum obtainable.

Phase response and delay. Two-channel matrix systems use amplitude and phase relationships for encoding and decoding so that phase differences between the left- and right-hand channels of the cartridge may affect performance. In the carrier region, phase imbalance may result in crosstalk. Delays between baseband and demodulated carrier signals should be determinable and constant over the required frequency band. (Early e.f.r. cartridges displayed delays of about 25μs at 30kHz and which varied over the frequency band. The latest type have cut this delay to about half this figure and are also less frequency dependent.)

In addition to these criteria I believe it is important that the cartridges should reproduce mono and stereo discs with the same quality as high-grade conventional cartridges, so listening tests were also carried out with reference to a good quality stereo pickup.

For the white noise tests a Rotel RP3000 turntable fitted with an SME Series II Improved arm with detachable headshell was used. Each cartridge was separately aligned according to SME instructions.



A CD-4 test record distributed by Sutton-Miller and produced by Louis Dorren and James Yabbert together with the aid of a Hewlett Packard audio spectrum analyser proved an invaluable tool. The record, whose pressing quality is not all that I would have liked, has a band of white noise which when passed through the cartridge and demodulator is used to maximize separation of the demodulator. The spectrum analyser then draws out the amplitude response for the front and back channels. The shape and distance between these two responses gives a good indication of amplitude response and delay characteristics.

The results of these tests are shown in the accompanying photographs. The top trace is the front channel response, the bottom trace is the rear channel and the difference between the two is the separation between front and back. In all cases only right-channel measurements were made. Each horizontal division is 1kHz while each vertical division accounts for 10dB separation.

The demodulator used (*Wireless World* June and July issues, 1976) had extremely linear phase, i.e. constant delay, through both the baseband and carrier signal paths. Therefore any variation in the delay of the cartridge would show up in the separation characteristics. Crosstalk would not do so because the white noise is played on one side of the groove only, the other side having no baseband or carrier modulation.

Examination of the various curves shows that the Denon 103S produced by far the best results with a consistent 18dB front/back separation over the range to 13kHz (only 10kHz shown here).

The JVC X1, ELAC ST5655D-4, Ortofon SL20Q and Onlife Ultimo 20B produced roughly equivalent results with peak separation of 18dB falling to 10dB at 7kHz and little separation at 10kHz.

The Pickering XUV4500 showed maximum separation of 10dB, but this was constant over the 10kHz bandwidth. This cartridge therefore has a constant delay over the desired frequency band, but its value is significantly different from the other cartridges tested in the group.

The B & O MMC5000 had slightly better separation (about 14dB) more or less maintained over the 13kHz band, again illustrating the constant delay characteristics of the cartridge.

The Audio Technica AT12S and the JVC 4MD20X (a selected version of the AT12S) produced peak separation of about 18dB, decreasing to 5dB at 8kHz and remaining at such to 13kHz.

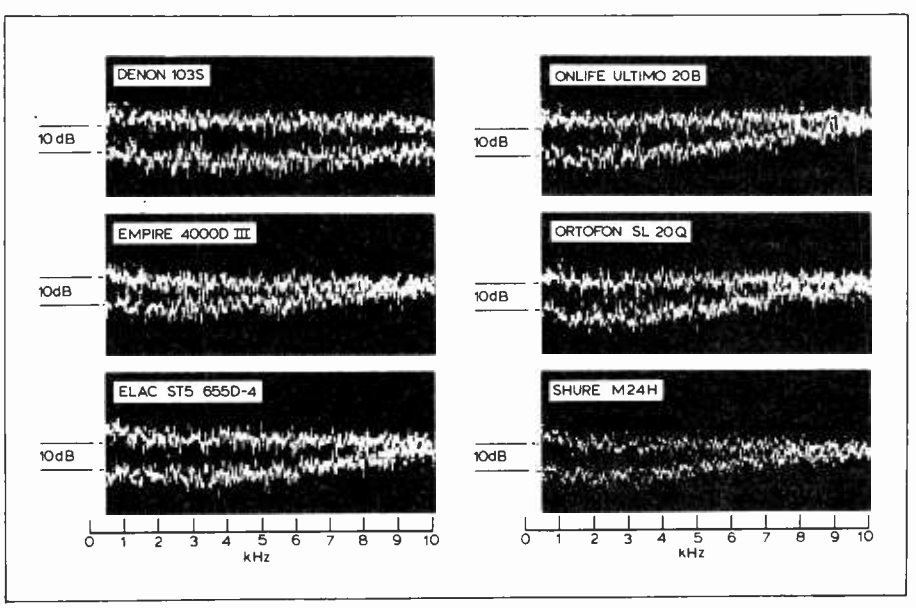
The Nagaoka JT322 showed peak separation of 15dB, but no separation was apparent after 9kHz.

The Shure M24H showed peak separation of 15dB, dropping to 10dB at 6kHz and disappearing at 9.5kHz, with the Empire 4000DIII following much the same pattern, but only displaying peak separation of 12dB.

Finally the ADC Super XLM/II and the Sonus P failed completely to show any separation for the white noise test. On closer examination, this did not prove that either of these cartridges could not track the carrier, only that they were incapable of doing so effectively during high and rapid baseband modulations. This was later borne out in listening tests with CD-4 discs.

With the aid of a JVC test record which had 300Hz square-wave tracks, it was possible to test the various damping properties of the test cartridges. No RIAA equalization was used. Page 71 shows the results.

Again the Denon 103S proved superior with the B & O MMC5000 and JVC X1 showing very similar results to the Denon. Although the remaining cartridges exhibited some overshoot, this was rapidly damped in all cases. The Ortofon SL20Q would probably have exhibited better results in another arm with heavier damping as the SME/Ortofon combination is not believed to be particularly good.



Listening tests

The test disc already mentioned has a track with music coming from the four speakers in sequence. This track is used to set the demodulator for maximum separation and this is achieved by turning the front channel gain down and adjusting a separation control for a null in the back channels. As both left and right channels are done independently, one can listen for crosstalk between left and right. In only one case (the Shure M24H) did this prove noticeable and not annoyingly so, but it was higher than with the other cartridges.

A second disc used was a CD-4 pressing of Mandigo which had a severe warp. All the cartridges, except the Ortofon SL20Q, tracked the worst track with no audible loss of carrier. I believe that the Ortofon problem relates to its combination with the SME arm and headshell and SME have themselves recognised this and intend releasing an attachment which may be added to the SME arm to improve performance of such cartridges in their arms.

A third disc was a fairly early CD-4 pressing which had some noticeable carrier loss, but which was not warped. Here the JVC X1, the Pickering XUV4500, Ortofon SL2Q, Elac ST5 655D-4 and Denon 103S proved best. Next the AT12S, Empire 4000DIII, JVC 4MD20X, and Ultimo 20B gave very acceptable results. The Shure M24H was not as good but proved superior to the Nagaoka JT322. The B & O MMC5000, ADC Super XLM/II and the Sonus P displayed frequent carrier loss especially when high baseband modulation was present.

Finally informal subjective listening test were carred out by a small panel using the Shure V15III as a reference. It is difficult to choose a standard for such comparative tests, but the V15III was chosen because of its relative popularity and well-known tracking ability. The first result was surprise at the very high standard of reproduction when used on conventional discs. Secondly, the major default of most cartridges tested was their susceptibility in picking up noise from dirty or scratched discs. And a final point was the consistently good results achieved by the moving-coil cartridges.

Conclusion

The cartridges which tracked well and exhibited large carrier outputs so that so-called "carrier breakup" was less apparent on bad records were the JVC X1, Pickering XUV4500, Shure M24H, Elac ST5 655D-4, Denon 103S, AT12S, Empire 4000DIII, Ortofon SL20Q, Ultimo 20B and JVC 4MD20X. Of these the only one whose tonal quality I found disturbing was the Empire 4000D which seemed very "brittle". As regards playback of conventional two-channel or mono discs the best were undoubtedly the moving-coil types, with the Denon 103S being superior and the Ortofon

continued on page 75

Logic design — 12

M.s.i. — applications of read-only memories

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

This is the second part of the article on applications of medium-scale integrated logic circuits. The first part was a discussion of the use of multiplexers and decoders, and the article now continues with a look at the use of read-only memories as function generators.

Read only memories

THE CIRCUIT shown in Fig. 11 is that of a 64-bit r.o.m. organised as 8 words of 8 bits each. It consists of a 3-bit address decoder, a 64-bit memory, and 8 output buffers. An enable input, when at logical 0, enables all the gates in the address decoder. The vertical lines in the memory section are called word lines and the horizontal ones bit lines.

Words are programmed into the r.o.m. at each address and the output on the bit line depends on whether it is connected to the addressed word line or not, the connexion being made by the presence of an m.o.s. or bipolar transistor, depending upon which technology is used. If connected, the bit line is raised to a logical 1 and if not it remains at logical 0. In this way the word programmed at the selected address is transferred to the output.

A schematic way of representing a programmed 64-bit r.o.m. is shown in Fig. 12, where at those intersections of bit lines and word lines marked by a dot there is an OR input for the output function. For example, the output at Z_8 is $P_0+P_5+P_7$. Hence the r.o.m. shown in Fig. 12 is being used to generate eight 3-variable functions, each of which is expressed in canonical form.

If a customer wishes to realise the functions shown in Fig. 12 he must supply the manufacturer with either a connexion matrix, such as the one shown in that diagram, or a truth table, as shown in Table 1. Alternatively, the customer may have his own programming facilities and in those circumstances he would purchase a programmable read only memory (p.r.o.m.).

Addressing. The connexion matrix shown in Fig. 13(a) is for a two 8-bit word r.o.m. addressed in one dimension only. The total capacity of the r.o.m. is 16 bits and the Boolean functions generated by it are:

$$Z_1=P_2+P_5+P_7$$
and $$Z_2=P_0+P_4+P_5+P_7$$

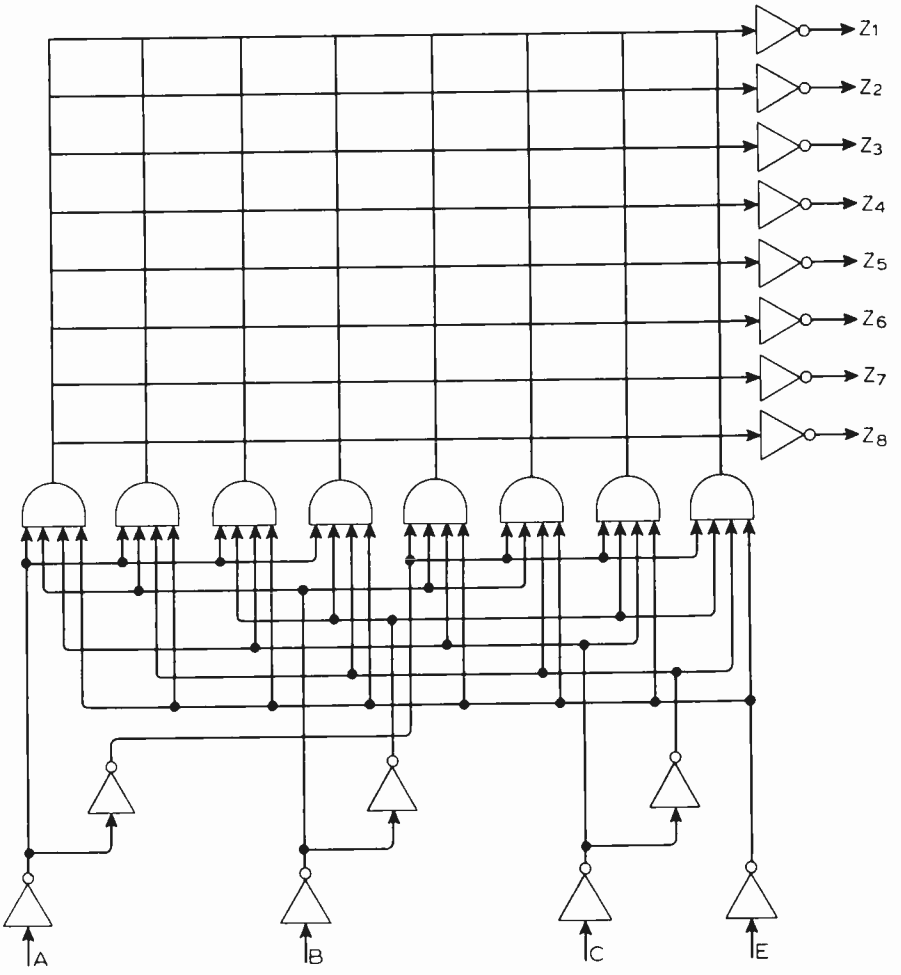


Fig. 11. 64-bit r.o.m. with address decoder and enable input. No intersections are programmed.

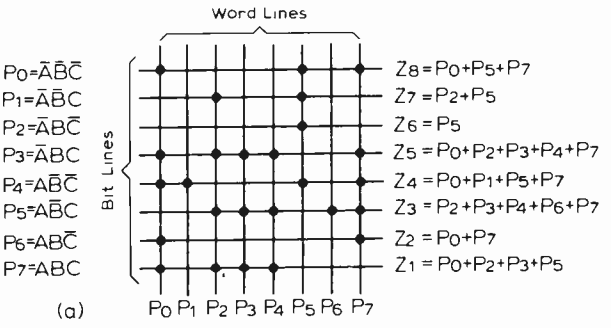
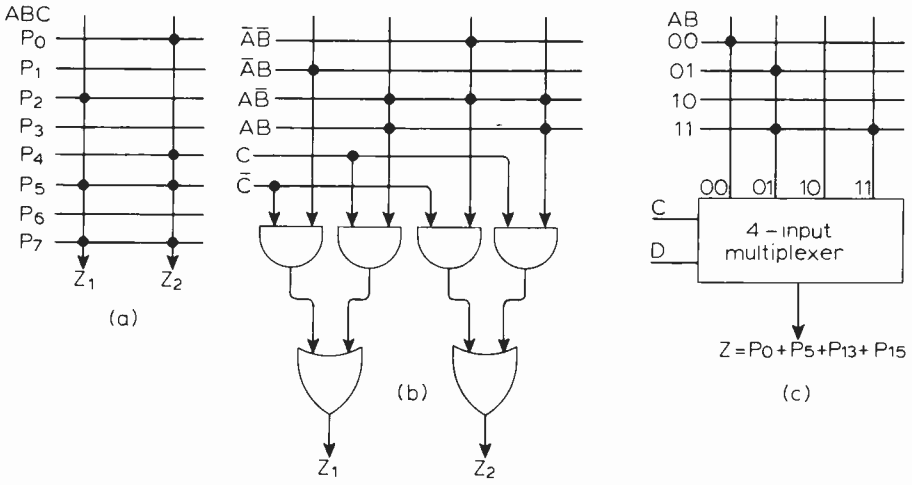


Fig. 12. Connexion matrix for a 64-bit r.o.m. at and the equivalent truth table in Table 1.

Table 1

Address			Output functions							
A	B	C	Z_1	Z_2	Z_3	Z_4	Z_5	Z_6	Z_7	Z_8
0	0	0	1	1	0	1	1	0	0	1
0	0	1	0	0	0	1	0	0	0	0
0	1	0	1	0	1	0	1	0	1	0
0	1	1	1	0	1	0	1	0	0	0
1	0	0	0	0	1	0	1	0	0	0
1	0	1	1	0	0	1	0	1	1	1
1	1	0	0	0	1	0	0	0	0	0
1	1	1	0	1	1	1	1	0	0	1



◀ *Fig. 13. A 2×8-bit word r.o.m. addressed in one dimension is shown at (a), while at (b) is the two-dimensional method. Generation of one 4-variable function using two-dimensional scheme is seen at (c).*

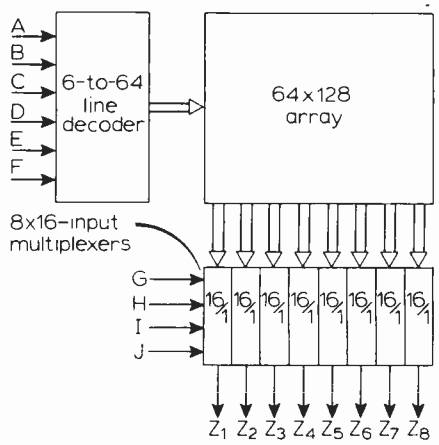


Fig. 14. Reduction of number of lines to and from r.o.m. by two-dimensional addressing.

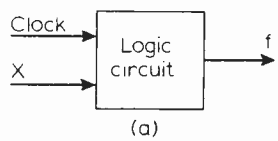
Table 2.

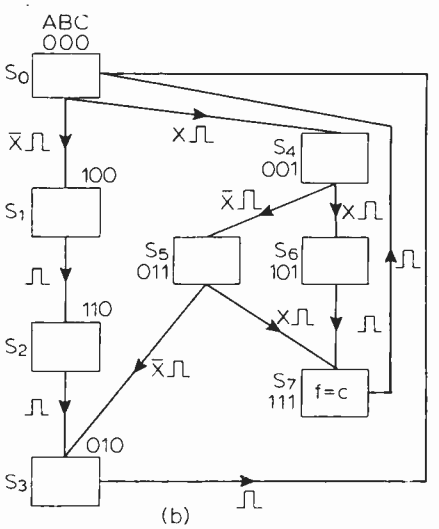
Present State				Output Word				Present State				Output Word			
A	B	C	X	A	B	C	Z	A	B	C	X	A	B	C	Z
0	0	0	0	1	0	0	0	0	0	1	0	0	1	1	0
0	0	0	1	0	0	1	0	0	0	1	1	1	0	1	0
1	0	0	0	1	1	0	0	0	1	1	0	0	1	0	0
1	0	0	1	1	1	0	0	0	1	1	1	1	1	1	0
1	1	0	0	0	1	0	0	1	0	1	0	1	1	1	0
1	1	0	1	0	1	0	0	1	0	1	1	1	1	1	0
0	1	0	0	0	0	0	0	1	1	1	0	0	0	0	1
0	1	0	1	0	0	0	0	1	1	1	1	0	0	0	1

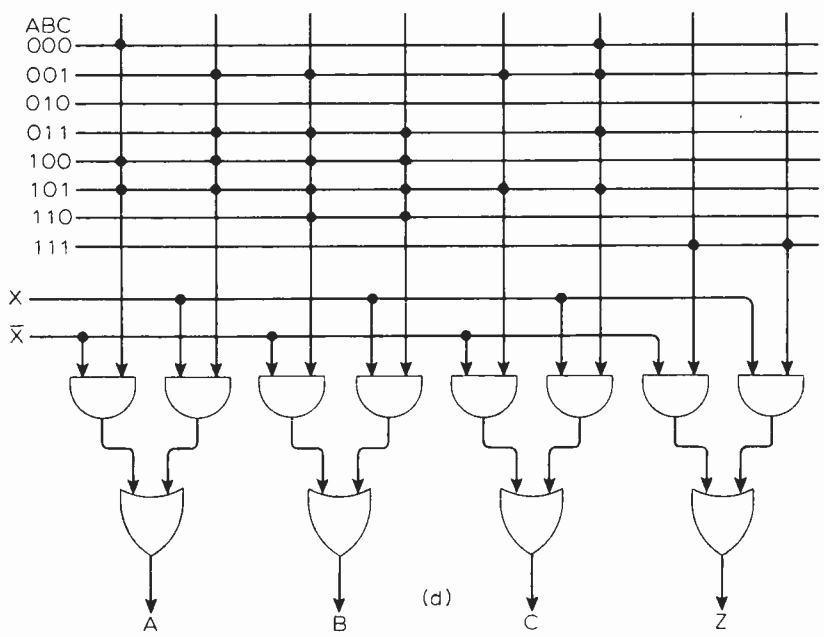
Table 3

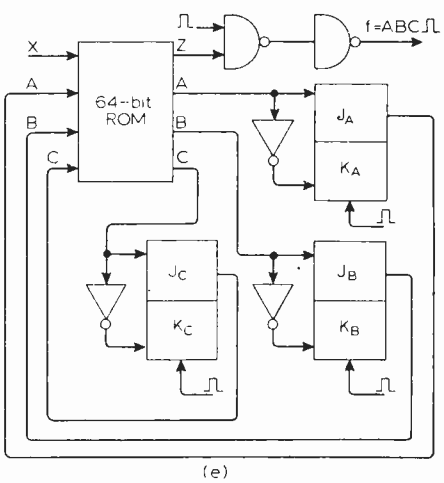
Present State					Output Word								
A	B	C	X	P	A	B	C	g_1	a_1	r_1	g_2	a_2	r_2
0	0	0	0	d	0	1	0	0	1	0	0	0	1
0	0	0	1	d	0	0	0	1	0	0	0	0	1
0	1	0	0	d	0	1	0	0	1	0	0	0	1
0	1	0	1	d	1	1	0	0	0	1	0	0	1
1	1	0	0	0	1	1	0	0	0	1	0	0	1
1	1	0	0	1	1	1	1	0	0	1	1	0	0
1	1	0	1	d	1	1	0	0	0	1	0	0	1
1	1	1	0	d	1	1	1	0	0	1	1	0	0
1	1	1	1	0	0	1	1	0	0	1	0	1	0
1	1	1	1	1	1	1	1	0	0	1	1	0	0
0	1	1	0	d	0	0	1	0	0	1	0	0	1
0	1	1	1	d	0	1	1	0	0	1	0	1	0
0	0	1	0	d	0	0	1	0	0	1	0	0	1
0	0	1	1	d	0	0	0	1	0	0	0	0	1
1	0	0	d	d	1	0	1	0	0	1	0	0	1
1	0	1	0	0	1	0	1	0	0	1	0	0	1
1	0	1	0	1	1	1	1	0	0	1	1	0	0
1	0	1	1	d	1	0	1	0	0	1	0	0	1

Fig. 15. Block diagram from problem of Example 5 at (a) and state diagram at (b). State table is in Table 2 and connexion matrix for 64-bit r.o.m. is at (c). R.o.m. implementation is shown in (d).▼









An alternative two-dimensional method of addressing a 16-bit r.o.m. is illustrated in Fig. 13(b), in which examination of the connexion matrix shows that the same Boolean functions are generated as in the previous case. Using this technique there is a reduction in the number of address lines required, but additional gating is needed.

The same r.o.m. in conjunction with one 4-input multiplexer can be used to generate one 4-variable function as shown in Fig. 13(c), where six address lines only are needed as compared to the sixteen address lines required with one-dimensional addressing.

Clearly, large capacity r.o.ms can be similarly addressed in two dimensions. For example, a 1024-word by 8-bit r.o.m., using single dimensional addressing, would require 1024 address lines for the 10 input variables. On the other hand, a two dimensional addressing scheme such as the one shown in Fig. 14 can be used, in which the numbering of lines entering and leaving the 64 × 128 array has been reduced from 1032 to 192. For this particular r.o.m. a 1 or a 0 can be specified in any of 8192 locations and the number of possible stored combinations is, therefore, 2^{8192}.

Sequential circuits using r.o.m.

R.o.ms are suitable devices for the implementation of clock driven and event driven logic circuits and their use in this application will be illustrated with the aid of two examples.

Example 5. Serial b.c.d. messages arrive on line X, most significant digit first. Each data bit is synchronised with a clock pulse. Design a circuit using a r.o.m. that generates a fault signal on terminal f each time an invalid code is received.

Step 1. I/O characteristics. These are described in the statement of the problem and are summarised in the block diagram Fig. 15(a).

Step 2. Internal characteristics. A suitable state diagram is shown in Fig. 15(b)

Step 3. State table. This is shown in Table 2 and is displayed in a suitable form for r.o.m. implementation.

Step 4. Connexion matrix. This is shown in Fig. 15(c) for a two dimensionally addressed 64-bit r.o.m.

Step 5. Circuit implementation. This is shown in Fig. 15(d). Besides the 64-bit r.o.m. additional logic is required to produce the output signal $f = ABC\sqcap$. Additionally three D-type flip-flops are required in each feedback line to synchronise the operation of the circuit to the clock.

The next example illustrates the implementation of an event-driven logic circuit with a r.o.m.

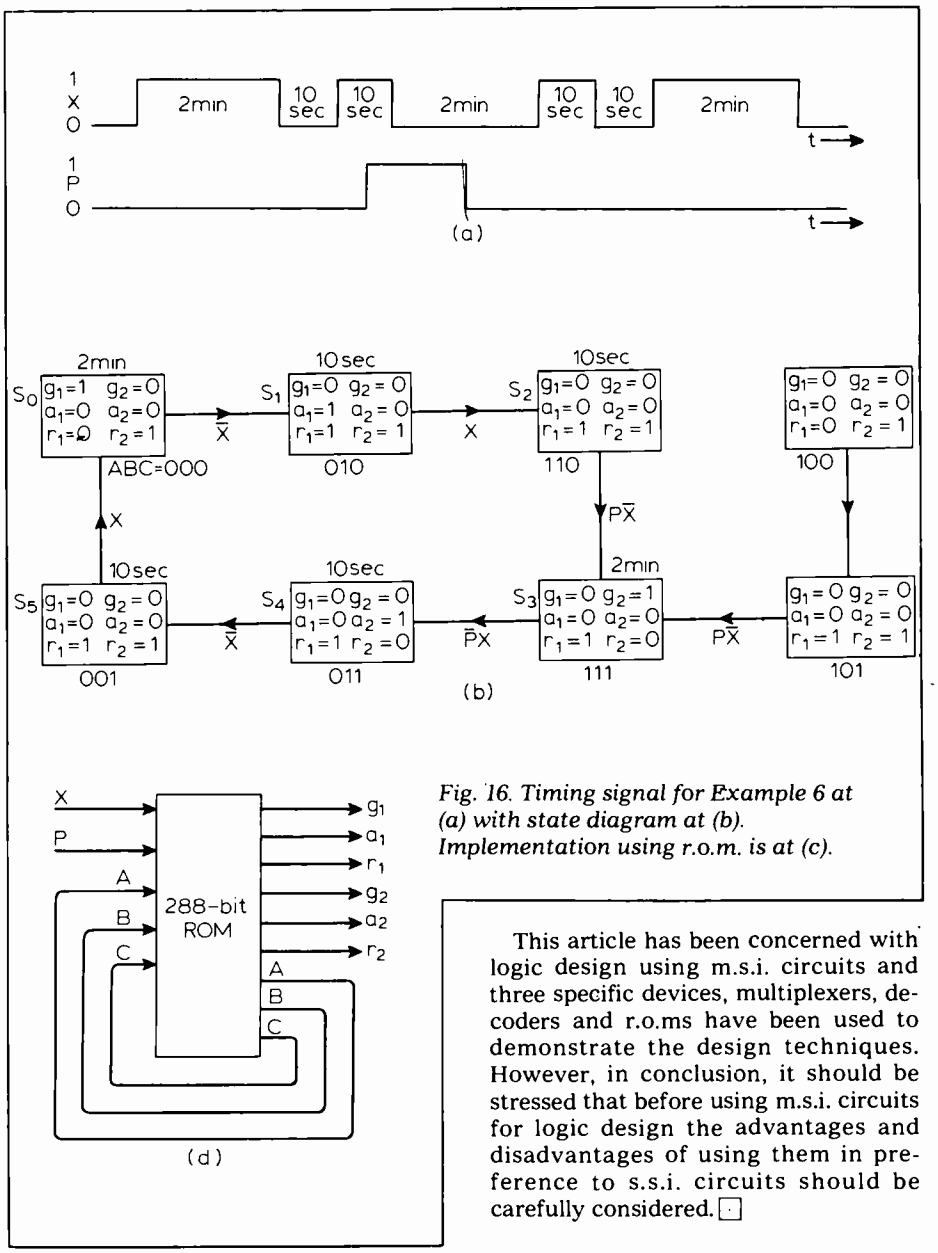


Fig. 16. Timing signal for Example 6 at (a) with state diagram at (b). Implementation using r.o.m. is at (c).

Example 6. A road intersection is controlled by a set of traffic lights. For each road the light sequences are tabulated below:

Road 1—green amber red red red red
Road 2—red red red green amber red
The lights are driven by a timing signal X and a synchronisation signal P as shown in Fig. 16(a).

Step 1. I/O characteristics. These are described in the statement of the problem.

Step 2. Internal characteristics. A suitable state diagram is shown in Fig. 16(b).

Step 3. State table. This is shown in Table 3 and is displayed in a suitable form for r.o.m. implementation.

Step 4. Circuit implementation. This is shown in Fig. 16(c). In practice, r.o.ms are manufactured in standard sizes and a suitable r.o.m. or combination of r.o.ms would have to be chosen from those available.

This article has been concerned with logic design using m.s.i. circuits and three specific devices, multiplexers, decoders and r.o.ms have been used to demonstrate the design techniques. However, in conclusion, it should be stressed that before using m.s.i. circuits for logic design the advantages and disadvantages of using them in preference to s.s.i. circuits should be carefully considered. □

continued from page 72

SL20Q a close runner-up. The JVC X1, B & O MMC500 ADC Super XLM, Nagaoka JT322, Elac and Sonus P gave a very good account of themselves.

My choice overall would be the Denon 103S followed by the Ortofon SL20Q which is about a third of the price of the former and gave a really good account of itself. It would probably do even better in another arm. The best of the non-moving coil types would be the JVC X1. The best of the cheaper type is undoubtedly the AT12S which still gives very good value for money.

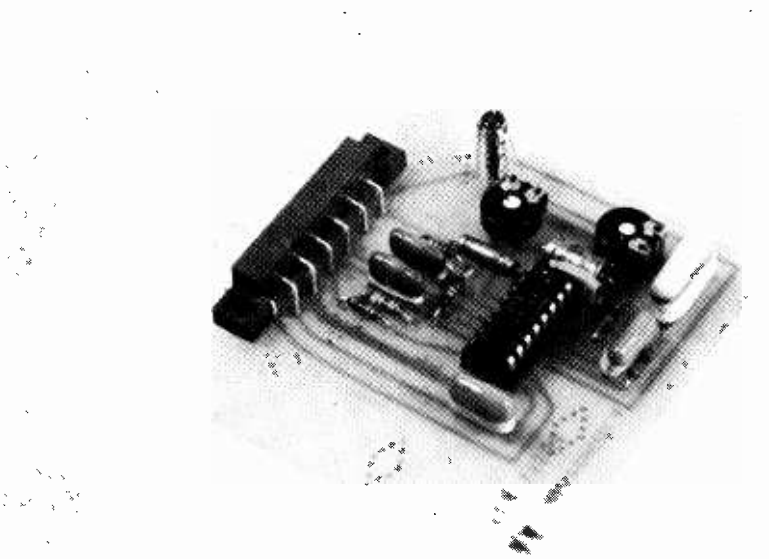
Acknowledgment. Thanks to Hewlett Packard, Telfor Cameras and Sansui Audio Europe for the loan of equipment.

Improved stereo decoder i.c.

Phase-locked loop decoder with variable blend is insensitive to interference at 57 and 114kHz

Michael J. Gay, Motorola Semiconductor Inc

In the TCA4500 stereo decoder digitally generated waveforms eliminate a previously troublesome sensitivity to interference at 114kHz, the third harmonic of the subcarrier. But the introduction of the ARI road traffic information system in Germany means that f.m. transmitters carrying this service have an a.m. subcarrier at 57kHz which interferes with the regeneration circuits of stereo decoders. The TCA4500A overcomes this with a three-state switching function; it also includes a variable blend facility that gives a smooth change from mono to stereo reception.



THE TCA4500A differs from its predecessors[1,2] essentially in the development and use of special modulating functions to avoid certain interference problems, and in the introduction of the variable separation control.

The performance of the modulators in the phase-locked loop and decoder sections is critical to the performance of the whole circuit. The first-mentioned must provide a correction signal derived from the pilot-tone while handling a composite signal ten times larger, without introducing any significant spurious low frequency components.

The last-mentioned must provide a demodulated channel difference signal of precisely controlled level, uncontaminated by sum signal.

To achieve the necessary performance the modulators must be switching types, in which the modulating function contains only the levels +1, −1 or 0. Such modulators have been used in previous decoders driven with accurate, digitally generated square waves to yield square-wave modulating functions of levels +1 and −1, and which provide precise fundamental components, zero mean level, and no even harmonics. Their characteristics suffice for treating the composite stereo signal alone or, in the U.S.A., a stereo signal to which an SCA signal has been added. They become inadequate, however, if the signal is contaminated by interference at the third harmonics of either the pilot-tone (57kHz), or of the subcarrier (114kHz).

Interference at 114kHz can be translated into the audio band, by multiplication with the third harmonic component of the decoder modulating

Basic decoder operation

The composite stereo input signal is applied to a preamplifier which provides two outputs, one passed via a phase lead network to the p.l.l. and stereo switch sections, and one fed directly to the decoder section.

The loop employs an RC oscillator operating at six times the subcarrier frequency (228kHz) from which waveforms at the subcarrier and pilot frequencies are developed by a digital divider. One pair of 19kHz waveforms is returned to the loop phase detector (modulator) where they develop a modulating function, which operates on the pilot component of the incoming signal and develops the loop error signal. The error signal after filtering and amplifying is applied to the v.c.o. which consequently becomes phase-locked to the pilot tone. As the loop error is nominally zero, it follows that the 19kHz waveforms applied to the loop phase detector will be in quadrature with the pilot tone when the loop is locked. To obtain a signal proportional to the pilot-tone amplitude a second pair of 19kHz waveforms is derived, in quadrature with the first pair, and these are multiplied with the composite signal in the stereo switch modulator. The output of this modulator is filtered and applied to a trigger circuit which permits or inhibits the application of the 38kHz waveforms to the decoder section. The trigger circuit also operates the stereo indicator lamp.

When applied to the decoder section modulator, the 38kHz waveforms develop a modulating function which, operating on the composite signal, translates the difference signal into audio while translating the other components into the supersonic range. The modulator provides anti-phase outputs which pass through a blend circuit and are then added, individually, to the unmodified composite signal. Assuming that the relative signal levels are correct, the blend circuit being set for full separation, the addition will in one case cancel the left channel audio components, leaving only the right channel signal, and in the other case cancel the right channel components leaving the left channel. The separated signals are applied to the output amplifiers which provide gain and de-emphasis, the last-mentioned serving also to reduce the spurious high frequency components present.

function, while interference at 57kHz can multiply with the third harmonic component of the phase-locked loop modulating function, producing low frequency outputs which phase modulate the v.c.o., and all the waveforms derived from it, thus causing intermodulation distortion. With European channel spacing the sidebands of adjacent transmitters can fall in the 114kHz region – too close to be eliminated by the i.f. filter – and the ARI system has now added a signal at 57kHz.

To eliminate the adjacent channel interference European receivers have commonly used a 114kHz notch filter preceding the decoder, although this is not entirely satisfactory as rejection is really required over the band 99-129kHz. To eliminate the ARI system interference a second notch filter at 57kHz would be required.

The two forms of interference could be better eliminated by using modulating functions from which the third harmonic has been removed, as well as the second. The necessary functions are three-state forms (1, 0, −1) but they can be obtained by applying two-state waveforms to an appropriate modulator, such as the common chopper type, as shown in Fig. 1. The desired modulating function contains no second nor third harmonic terms nor any multiples thereof.

The driving signals can be produced from a three-stage shift register connected as a Johnson counter, operating at 114kHz. The shift register in Fig. 2 is formed of six bistable circuits, coupled by transmission gates, and driven by 114kHz C and $\overline{C}$ signals from a binary divider which is fed by the 228kHz v.c.o. The shift register provides six pairs of antiphase 50% duty-cycle square waves spaced at 30° intervals. Two NAND gates provide the desired 19kHz 66⅔% duty-cycle square waves, while two exclusive-OR gates provide the same forms at 38kHz. A pair of shift register outputs are used directly to drive the modulator in the quadrature-correlator section of the circuit.

The system has a slight drawback in that the 38kHz modulating function lags the 19kHz p.l.l. modulating function by one half period of the oscillator. The loop and correlator-section modulators are, however, necessarily a.c.-coupled to the preamplifier to eliminate d.c. offset problems. By using an appropriate coupling capacitor, a 15° phase lead at 19kHz can be obtained to cancel the error.

Variable separation and decoder section

A major difference between the TCA4500A and earlier decoders is the addition of the variable blend control. Intended to allow a receiver to change continuously between mono and stereo operation, it avoids abrupt changes in sound energy distribution. It is intended

Characteristics for circuit of Fig. 4 with Vcc 12V and 2.5V pk-pk L or R-channel stereo signal.

	Min.	Typ.	Max.
Stereo channel separation: unadjusted	30dB		
optimized on other channel	40dB		
Mono voltage gain	0.8	1	1.2
Harmonic distortion			
2.5V pk-pk composite input			0.3%
1.5V pk-pk composite input		0.1%	
Signal to noise ratio		90dB	
Capture range		±5%	
Ultrasonic frequency rejection			
19kHz		31dB	
38kHz		50dB	
Stereo switch levels			
19kHz input for lamp "on"	12mV	16mV	20mV
hysteresis		6dB	
Quiescent output voltage change			
with mono/stereo switching		5mV	20mV
Stereo blend control voltage (pin 11)			
3dB separation		0.7V	
30dB separation		1.7V	
Minimum separation (pin 11 at 0V)			1dB
Blend control current		100μA	
Mono channel imbalance (pilot off)			0.3dB
Pilot tone harmonic rejection 57kHz		45dB	
Subcarrier harmonic rejection			
76kHz		45dB	
114kHz		50dB	
152kHz		50dB	
Supply ripple rejection		55dB	
Input impedance		50kΩ	
Output impedance		100Ω	
Operating supply voltage	8V		16V
Current drain (lamp off)		35mA	

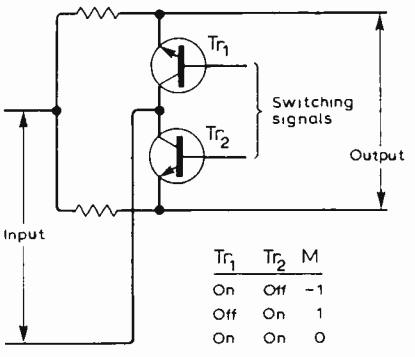
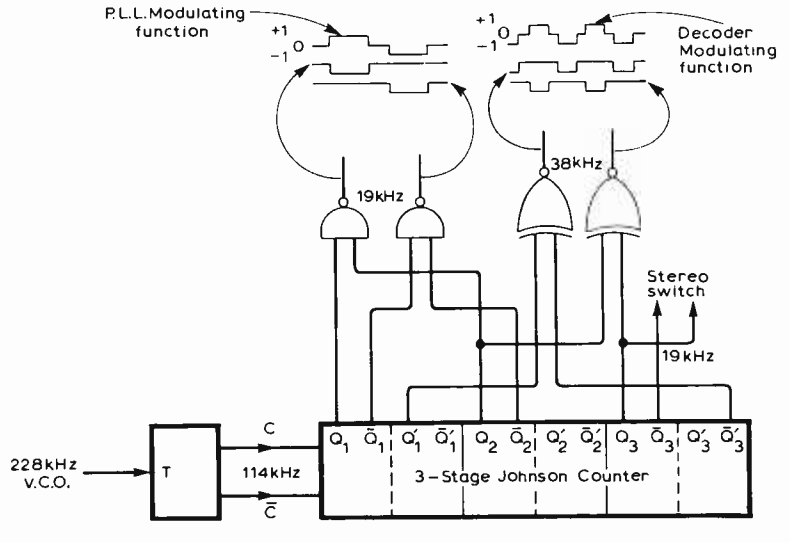


Fig. 1. *Instead of using filter to prevent distortion due to interference at 57 & 114kHz, the decoder switching function is arranged to have no second or third harmonics. The three-state function is obtained from a chopper as shown.*

Fig. 2. *Driving signals for the modulators are formed from six bistable circuits arranged as a Johnson counter, providing six pairs of antiphase square waves at 30° intervals.*



that the separation be controlled by an external signal derived from the receiver's S-meter or a.g.c. system, although a user control is obviously possible as well. The control is additional to the normal mono-stereo switch, activated by the pilot-tone level at the decoder input.

The operation of the variable separation control can best be explained by reference to the complete circuit of the decoder section[3], Fig. 3. Biasing arrangements have been omitted for simplicity. The composite stereo signal is applied to the modulator R_1, R_2, Tr_1, Tr_2 and to the amplifier Tr_3, Tr_4, R_4, R_5, R_6. The amplifier output currents contain the sum signal as the sole audio components, while the modulator output contains the difference signal as the sole audio component. The collector currents of the transistors Tr_5, Tr_6 thus contain antiphase difference signals which after passing through the blend circuit Tr_7, Tr_8, Tr_9, Tr_{10} are added to the currents from Tr_3, Tr_4 for matrixing. The blend circuit acts by partially combining, and thus mutually attenuating, the antiphase difference signals according to the control voltage applied. Full cancellation, and hence mono operation occurs with equal conduction in the blend transistors, while full separation is obtained when Tr_8, Tr_9 are taken out of conduction. A particular advantage of this method of obtaining variable separation is that, provided the blend transistors are matched, neither their base resistances, nor the biasing resistors R_9, R_{10} cause distortion. The distortion components cancel due to the signal currents being in antiphase.

The decoder section is followed by the output amplifiers Tr_{11}, Tr_{12} (only one is shown in Fig. 3) which provide gain and de-emphasis defined by the external components R_{12} C_2. Stability is assured by R_{11}, C_1.

The recommended application circuit is shown in Fig. 4 and the main characteristics are given in the table. Of particular interest are the residual levels of third harmonic in the p.l.l. and decoder section modulating functions, which have been reduced to 40 to 50dB below the fundamental components.

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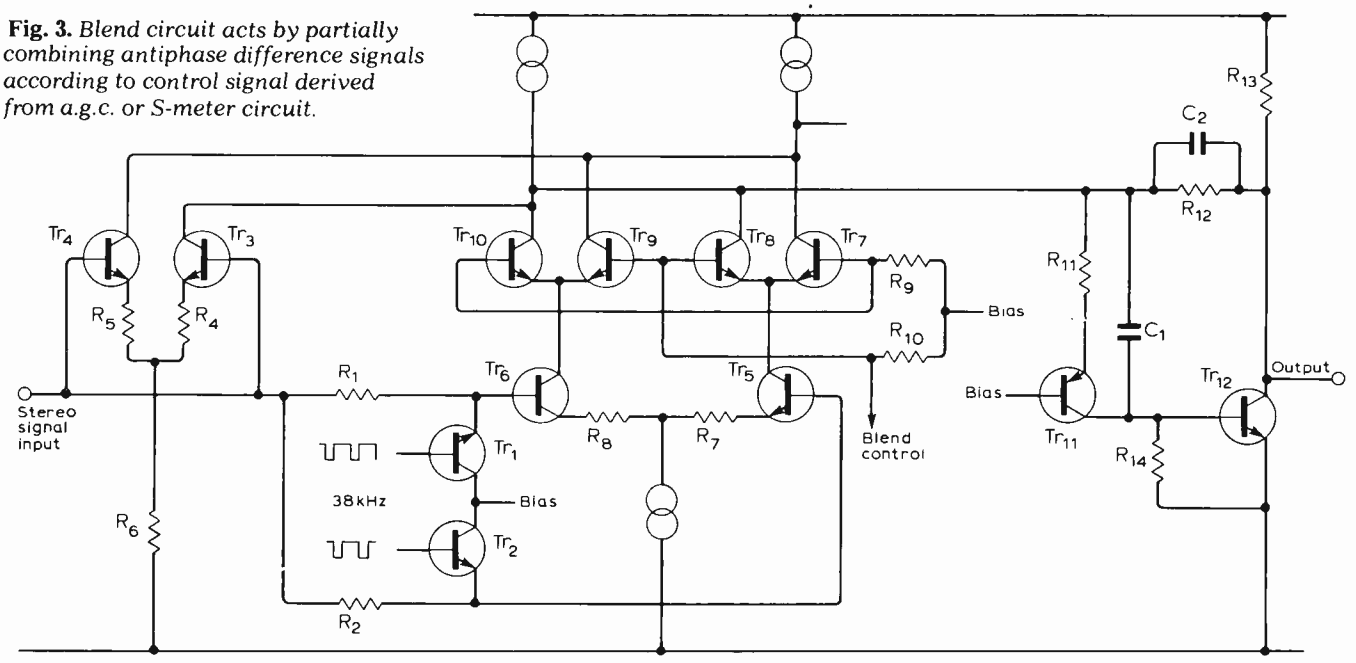

Fig. 3. *Blend circuit acts by partially combining antiphase difference signals according to control signal derived from a.g.c. or S-meter circuit.*

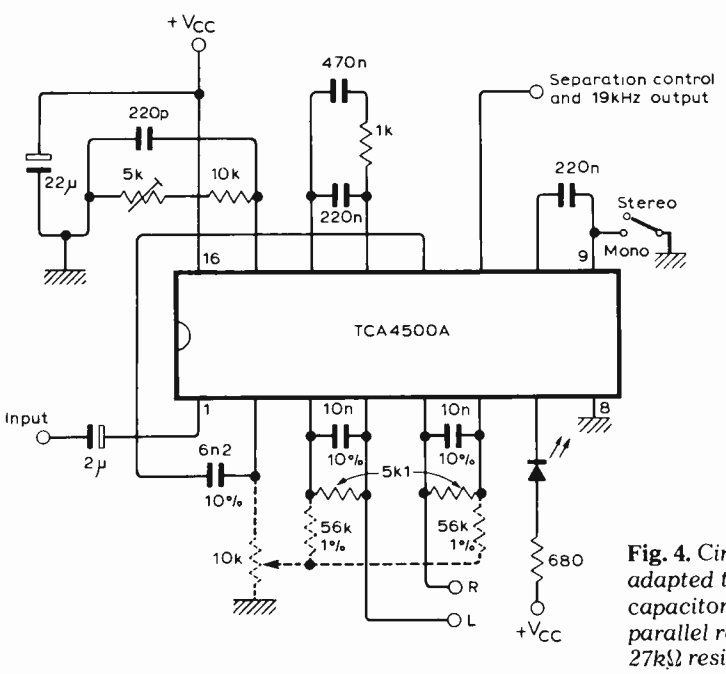

Fig. 4. *Circuit giving unity gain can be adapted to give 6dB gain by changing capacitors at pins 4 & 5 to 4.7nF, their parallel resistors to 10kΩ and adding 27kΩ resistors from pins 3 & 6 to earth. Broken lines indicate optional wiring for pre-set separation control.*

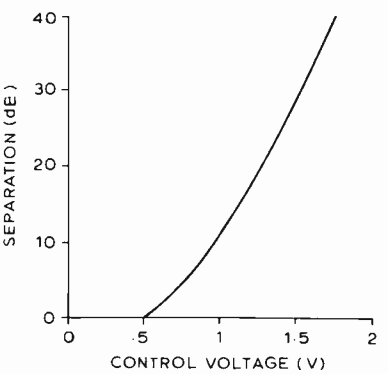

Fig. 5. *Separation is 4.3qV/kT where V is the control voltage applied across the blend transistor bases.*

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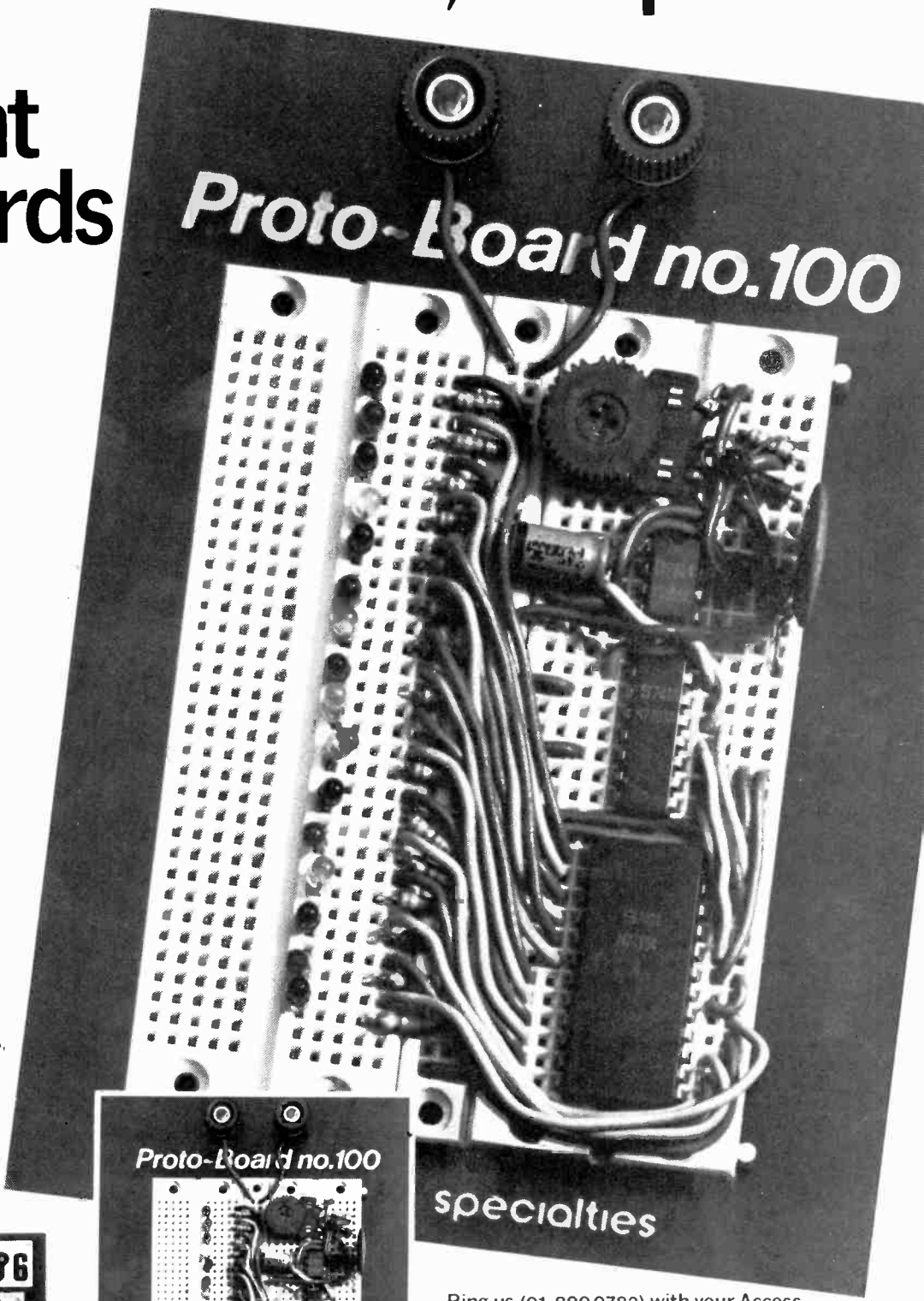

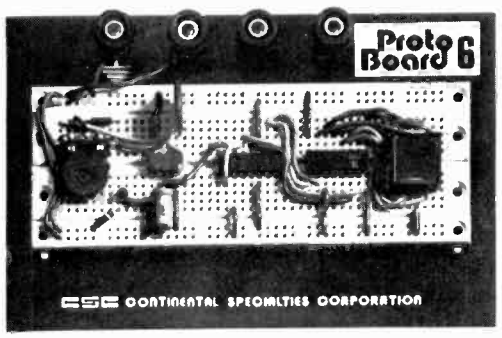

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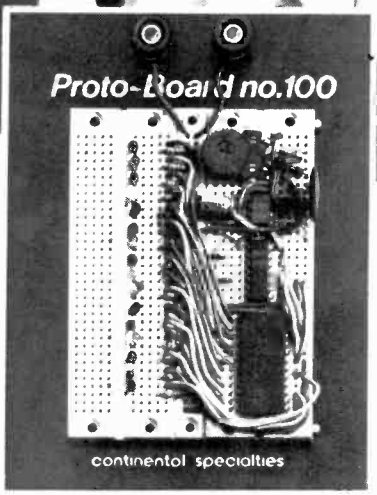

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The control voltage applied to the blend transistors is derived from a resistor-transistor network, designed to provide a convenient control characteristic. To retain a 16-pin package the blend control terminal has been combined with a terminal which provides a 19kHz output, derived from the v.c.o. for alignment. The blend control operates over a 0 to 2V range, giving full separation at 2V, Fig. 5. If the terminal is left open-circuit, the 19kHz signal appears about a mean level of 4V.

Acknowledgment. I am indebted to H. Maeder of Motorola Semiconductor Inc., Geneva for many useful discussions concerning the digital parts of the circuit.

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1. Gay, M. J. Monolithic phase-lock loop stereo decoder, *IEEE Trans on Broadcast and Television Receivers*, vol. BTR-17 no. 4 Nov. 1971.
2. Gay, M. J., U.S. patent 3962551. Methods and Systems for Providing Stereo Decoding Signals.
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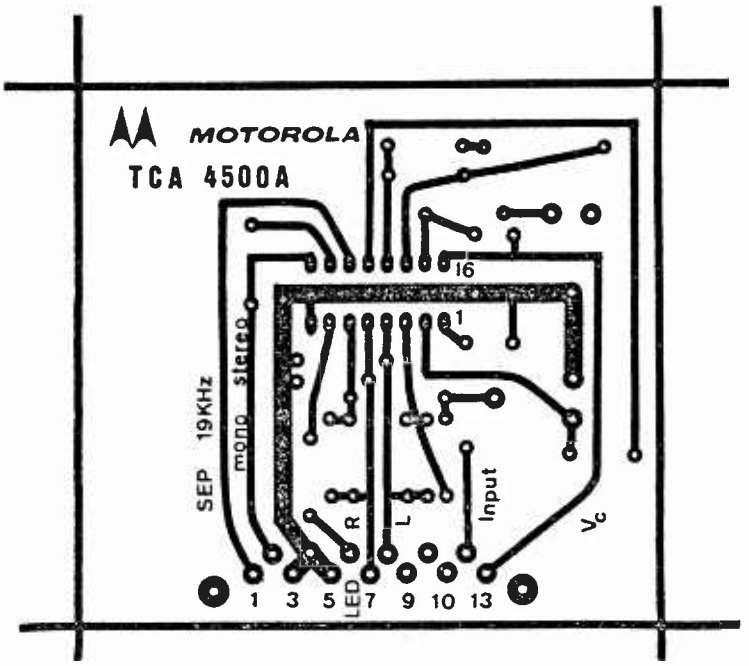


Fig. 6. *Actual size circuit pattern for making printed boards. (M. R. Sagin at 23 Keyes Road, London NW2 plans to supply ready-made and drilled boards for £1.80 inclusive.)*

Circuit design

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

THERE ARE TWO EXTREME WAYS of designing a circuit: most of us use each without depending totally on either. We can look up a standard circuit in a reference book, in an article from a technical journal or in some manufacturer's application note. We *should* look these up – there is no advantage in foregoing the accumulated experience of others. A good designer is one who pinches the best ideas; it is what he does with those ideas that is important.

The other extreme is the creation of a novel circuit. When we achieve this, rarely enough to be memorable, the results are long-term as well as short. It lights up the mind and the idea can be transmitted and transmuted into useful variants for months or even years afterwards. These gems cannot be planned for or relied on but like Humpty Dumpty's words they have to earn their living. At a lower level we can encourage the appearance of good ideas in our own thinking by exposing ourselves to as many good ideas of others as possible. We should question all assumptions – lateral thinking, the leap-in-the-dark, serendipity are different aspects of this viewpoint.

A frustrating but valuable experience in point was that provided by a chief engineer at a R & D establishment. Most of the projects were long-term with few of the variables quantified at the point where the designs had to start. An outline design would be prepared and a prototype finished amazingly close to 5 o'clock on a Friday evening. On bursting through the door on the following Monday the first words the chief would spring on his minions were "what happens if . . . ?". It left a lasting impression on those who worked in that department: that even when the prototype was "out-the-door" it was not the end of the idea, that there was still meat on the bones.

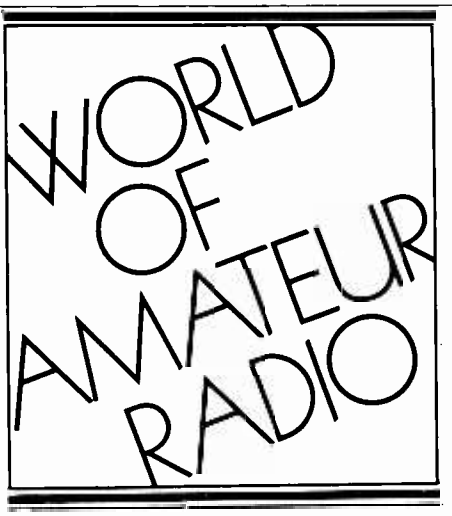
It is the experience of circuit designers that the same idea can be worked over time and again, each time yielding fresh insight. Once the grammar of circuit design has been grasped then even a limited vocabulary of particular circuits can cover a wide range of problems.

The argument can be extended. By exposing ourselves to the greatest variety of influences, we increase the chance of spotting relationships between apparently unrelated topics.

This all suggests three interrelated ways of improving our performance: read voraciously; be ready to accept and start operating on any new idea as it appears; worry at each basic idea until it can be fitted into as many other familiar ideas as possible. It was with these feelings that Circards was started some five years ago. To find information on a particular circuit was not too difficult; to find information on the practical implementation of a class of circuits was much harder. The hope was that by collating as many variants as possible on a given circuit type, that this search could be circumvented or at least shortened for the reader. By including as many suggestions as possible for varying the circuit operation and for adapting it to other purposes, the user could get started faster on his real function that of making the circuit do something for him. Thirdly, as many novel ideas as possible were included; often those appearing in the less familiar journals, sometimes those of the authors or their colleagues. The value of these lie not so much in the particular solutions but in the way they might act as triggers for the user's own insight.

Over these five years the range of circuits touched on has been very wide – arguably too wide in that with necks stuck out that far we were liable to have them chopped-off pretty frequently. There have been innumerable close shaves but we have survived, just. We are immensely grateful for all the encouragement we received. In the process of writing these cards and articles, we have un-muddled much of our thinking on circuits, acquired experience in design that would have come in no other way, and exposed in ourselves further and deeper levels of ignorance than we dreamed possible! It has been mixed pain and pleasure all the way, and to anyone else who feels like tackling a project as big as this (380 cards with 600 graphs and 1200 diagrams and well over 200,000 words) we would say: you'd have to be daft to try. But in this daft world you have to be daft to survive. □

We hope to publish a full list of card titles; meanwhile a copy is available from WW.



Topical techniques

The American Radio Relay League has begun promoting a novel form of speech processing that is claimed to be applicable to all the usual speech modes, including s.s.b., n.b.f.m. and a.m., and capable of reducing spectrum bandwidth by one half. Called "narrow-band-voice-modulation" (n.b.v.m.), the system has been developed by Dr R. W. Harris, University of the Pacific, in conjunction with J. F. Cleveland, WB6CZX and T. Lott, VE2AGF/W6. It was first tested on the 14MHz band in May, 1977. The system exploits the fact that while consonants provide much of the intelligence in speech, the vowel sounds normally dominate by some 20-25dB. In n.b.v.m. transmissions the consonants are emphasized and the signal spectrum folded to occupy only half the normal bandwidth. It is stated that the signal can be resolved on conventional s.s.b. receivers using the lower sideband mode, tuning the receiver 3kHz higher in frequency and adjusting the b.f.o. to give maximum intelligibility. In an introductory article in *QST* only an outline of the system was given with few specific details.

The Yagi aerial is over 50 years old, although the contribution made in 1937 by Dr George Brown of RCA in emphasising the value of close-spaced elements should not be forgotten. But surprisingly, even today, many designs are developed as much by trial and error as by theoretical calculation. A valuable, although not unchallenged, treatise on practical design was published about a year ago by the US National Bureau of Standards in NBS Technical Note 688 "Yagi Antenna Design" as the result of extremely detailed investigations by Peter Viezbicke. This attempts to present in graphical form the effect of many different aerial parameters on realizable gain, based on measurements made on 400MHz at a model aerial range.

However, Leslie Moxon, G6XN, has pointed out a number of oddities that appear to resurrect some old controversies, including the maximum gain (reference dipole) that can be achieved with two elements, and also the question of optimum length of directors. Peter Viezbicke, in assessing the effect of reflector spacing on measured gain, maximises this to 2.6dB with a single-element reflector, plus an extra 0.75dB with three reflecting elements. Yet there is plenty of reliable evidence to show that a two-element Yagi aerial can provide a realizable gain of 4 to 5dB. Further, the NBS publication puts the maximum realizable gain of a three-element array as high as 7.1dB although again there is much solid evidence suggesting that some 6dB is about as much as one can achieve in practice. Despite its age, the Yagi aerial clearly does not readily yield up all of its design secrets!

The market place

In virtually every country except the USSR and some (but not all) the Eastern European countries, the amateur market is now dominated by Japanese products. One of the few exceptions to the general rule is, paradoxically enough, in the field of antennas where the Japanese-originated Yagi beams as well as multi-band vertical rods have come in the majority from two American firms: Hy-Gain Electronics and Mosley Electronics. But recently, according to *Time* magazine, Hy-Gain has filed bankruptcy papers and sent its 1,000 employees home, although still fighting to reorganize and stay in business.

The firm's problems seem to stem largely from its involvement with Citizens' Band equipment. In 1977 CB became in the United States a major loss-maker when the FCC authorized 40-channels at a time when stocks of 23-channel equipment were very high. Distributors slashed prices until 23-channel models were being offered at rock-bottom prices on a saturated market, and in the outcome Hy-Gain may not be the only casualty.

Meanwhile ARRL continues to bemoan the drying up of the one-off component suppliers, except at prices that reflect the distributors' view that the paper-work costs more than the profit margin. Disappearance from stockists' lists of the slower-moving items is proving a problem for US publishers, with "component lists" outdated almost before they appear in print. To get on the air at low cost, newcomers are increasingly having to turn to the second-hand market, as hardening rates of exchange continue to raise the price of Japanese equipment in many countries.

In the air

According to *IARU Region 1 News* there are now over 120 beacon stations in Region 1, of which over 20 operate above 1GHz. The use of these beacons for propagation studies is underlined by S. Canivenc, F8SH, the v.h.f. sporadic-E co-ordinator for IARU Region 1. On June 7 and 11, 1977, the French 50MHz beacon FX3VHF was heard by A. McClellan, VE1ASJ, at St John, Nova Scotia in Eastern Canada. Trans-equatorial reception of the beacon was reported on October 27 by Ray Cracknell, ZE2JV, at Salisbury, Rhodesia. Transmissions from FX3VHF are continuing in a southerly direction until May 15, 1978 when transatlantic tests are to be restarted. The beacon, on 50.104MHz, has a transistorized power amplifier providing 70 watts r.f. power and about 1kW e.r.p. During the summer of 1977 there were a number of 50MHz contacts over the 8500km path between Japan and California, and F8SH suggests these may have been due to three- or four-hop sporadic-E propagation.

The RSGB has stated that the authorities possess complete information on the "vandals" abusing GB3LO and that most of them are licensed amateurs. The society however emphasises that at some 70 other repeaters, now operational, virtually no problems are experienced.

A 50-yen postage stamp featuring an old horn loudspeaker and a Morse key was issued in Japan last autumn to commemorate the 50th anniversary of the first Japanese private experimental licence in September 1927. There are now over 465,000 licensed amateurs in Japan, although not all represent active stations.

In brief

A change of venue has been announced for the annual convention of the British Amateur Radio Teleprinter Group. It is to be held on Saturday, July 15, at Harpenden Public Hall, Harpenden, Herts, a venue chosen for easy access by rail or motorway. There will be trade stalls, picture tape factory, demonstrations, lectures, etc, and non-members of BARTG are welcome; from 1100 to 1700 hours .... The Welsh Amateur Mobile Rally is on Sunday, May 21 at the Barry Rugby Football Club, Myneth Duffan, Barry, South Glamorgan with more trade stalls than usual .... At the turn of the year there were a number of 1.8MHz two-way contacts between the UK and Japan with about ten Japanese stations logged between 1907.5 and 1912.5kHz .... The rising sun-spot number has brought good openings on 21 and 28MHz bands this winter .... A satellite ground station is being built at 4U1ITU, the amateur station located at the ITU Headquarters in Geneva .... Auroral openings appear to have been more frequent than usual this winter with a number of successful predictions .... The AMSAT Oscar D satellite tests in December were successful and (as Oscar 8) is due to have been launched in early March.

PAT HAWKER, G3VA

Electronic systems — 8

The transmission and reception of pictures

In previous articles we have seen how audio information may be communicated over vast distances. We are now going to consider the mechanisms for transmitting and receiving visual data, typically in the form of pictures. This important area is manifested in the many forms of television, and also in facsimile — for the transmission of press photographs and pictures from satellites showing weather situations.

WHILE this article is particularly relevant to television, it is perhaps more correct to use the term video to describe the graphic data and signals. Theoretically, a visual scene (picture) is composed of an infinite amount of detail. However, by using artificial aids such as the microscope and the telescope, more of this detail can be seen.

To represent this theoretical picture in all its detail would require an infinite number of picture elements, each capable of varying through a very wide range of intensities. In practice, the number of picture elements and the range of brightness of each element may be quite severely limited and yet still provide sufficient detail to give a satisfactory presentation of the original scene.

If the picture is to be transmitted, one way of doing it is to subdivide it into a grid pattern comprising a finite number of picture elements, as in Fig. 1. The average brightness of each element can be individually measured by a photosensor (light cell) and the output of each sensor connected to a receiver which produces a light output corresponding in position and intensity to that element in the original scene. To transmit a picture, a large number of sensors and receivers (each with their own transmission connection) would be needed, requiring a large number of parallel transmission paths. Consequently, this system is readily rejected at least on the grounds of the physical bulk of the equipment and its sheer cost.

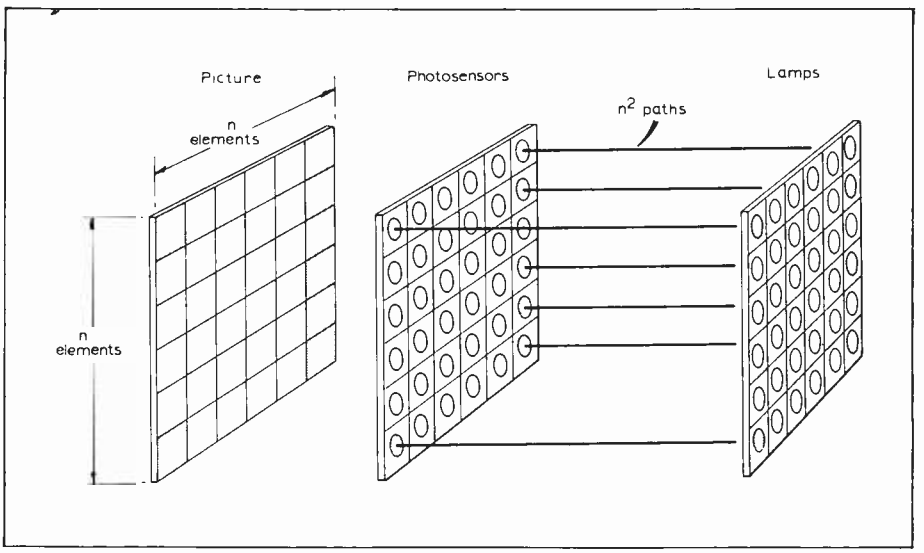
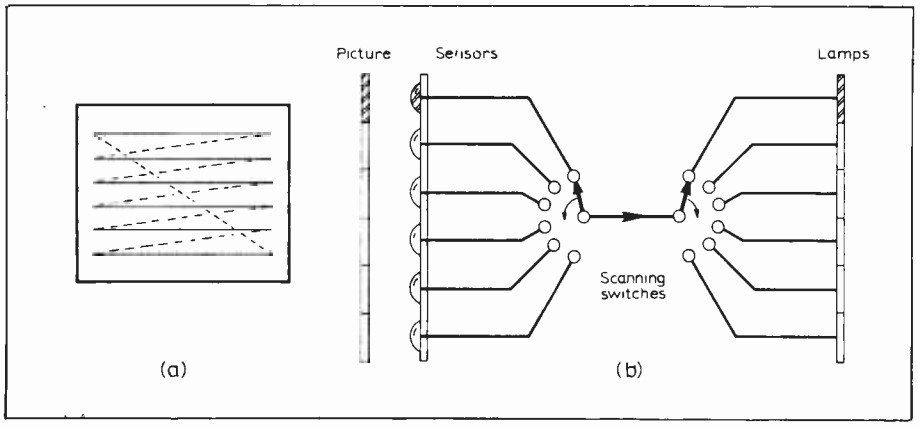


FIG. 1. Representation of parallel video transmission. Each element is independently sensed, transmitted and recreated.

FIG. 2. Simple illustrations of raster scanning. (a) shows the raster scan on a display. Dotted lines indicate a rapid jump. (b) shows the vertical scanning of a sequential video-transmission system. Switches on the sensors and lamps run in synchronism. Similar switches are required for the horizontal scan.



In practical visual systems, the picture elements are transmitted sequentially over a single intercommunication between transmitter and receiver by using a method called scanning. A simple illustration of this is given in Fig. 2. During a scan, the sensors for each picture element are interrogated one after the other in a regular manner which is typically of the form used with the written word, i.e. from left-to-right and top-to-bottom. At the end of each horizontal line there is a jump to the start of the next and at the end of the picture (bottom, right) the scan jumps back to the top left-hand corner to restart. The zig-zag path traced out during the scan is called a raster. The picture is reconstituted at the receiving end of the link by presenting the sequential brightness signal to an array of light generators in synchronism with the scan at the transmitting end.

One disadvantage of this transmission system is that it takes a considerable length of time to transmit a full picture and if a succession of pictures are required to convey the impression of motion, as in cine, it cannot be transmitted faster than a certain rate.

Television and cine rely on an important feature of the human eye,

namely, persistence of vision. This permits the impression of continuous motion without jerks or flicker when a section of pictures are presented in rapid succession to the eye. Indeed, each picture may be in a scanned form, as in television, such that even though the line structure traced by the scan may be clearly visible, the sequential addressing of the picture elements will be quite undetectable, providing the scan is sufficiently rapid.

Spatial resolution

If a picture is made up of ten horizontal lines, each containing ten elements, the resultant 100-element picture would have a very low resolution. For good results, a figure of at least 500 lines, with an equivalent horizontal definition, is considered necessary, but it is important to remember that the picture resolution required is a function of viewing distance and the screen size. It is only at and beyond a certain distance from the picture that the individual elements are unresolved and appear to give a continuous effect. Likewise, it is unnecessary and uneconomic to provide a higher definition than prescribed by a situation where a fixed or minimum viewing distance is dictated.

Scanning rate

Associated with the phenomenon of persistence of vision, there is a certain frequency at which a light may be flashed below which the light is seen to blink or flicker, and above which the light appears to be of constant intensity. This frequency is called the flicker-fusion frequency. Although its value depends on the intensity of the light source and varies from person to person, it is usually within the range 30 to 35Hz under normal television viewing conditions. See previous article, Part 7. Its relevance to visual systems lies in the fact that a scan must be performed at a rate above the flicker-fusion frequency to avoid a flickering image, which can be most irritating to the viewer. For this reason, a scanning rate of greater than 40 scans per second—often written as "scanning at 40Hz"—is ideal.

Although in Part 7 it was stated that the flicker-fusion frequency is approximately 70Hz, this figure is the worst case achieved under the conditions of intensity and ambient illumination which yield the highest figure. Visual presentation of information is highly subjective and a scanning rate of 40Hz does, under normal viewing conditions, prove to be acceptable.

Interlacing

We therefore have two requirements for the raster scan. It must comprise at least 500 scanning lines, and the total scan should be completed at least 40 times per second. The current European standards are in fact 625 lines at a scanning rate of 50Hz.

Here the use of the 50Hz mains frequency is intentional since the effect of any mains-borne interference such as hum tends to be minimised.

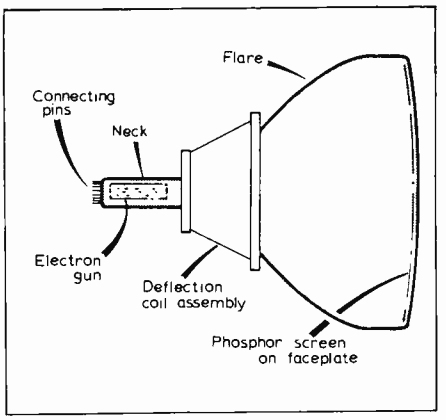


FIG. 3. Structure of cathode-ray tube.

Although the bandwidth requirements of television signals are considered later in this section, it is necessary at this stage to point out that the bandwidth of a tv signal characterised by 625 lines at 50Hz is approximately 12MHz. This high figure obviously limits the number of broadcast television channels and places severe performance requirements on the electronic circuitry. It would be advantageous on these counts to be able to reduce the bandwidth by, for example, reducing the scanning rate—provided that problems regarding flicker were not encountered. This may be achieved by a process called interlacing.

In an interlaced presentation the complete raster is produced by two successive scans, each providing half of the total number of picture lines. In a 2:1 interlaced scan, the scanning lines of one field interlace in the spaces between the lines of the other field. Each vertical scan of half the total number of lines is called a field, while each full picture, consisting of two fields, is called a frame. The field frequency is retained at 50Hz (in Europe) while the frame frequency, the total picture repetition rate, is now 25Hz. As a result the bandwidth of the video signal is halved to a figure of approximately 6MHz.

Interlacing allows the transmission and reception of good quality pictures within a practical bandwidth at an effectively flicker-free scanning rate. Although only half the picture information is presented at a 50Hz rate by interlacing, this 50Hz figure represents the flicker frequency in spite of the fact that the full frames are produced at the lower rate of 25Hz. Persistence of vision is such that each field is sustained for a short interval before totally decaying and the two fields are seen simultaneously in spite of the fact that they occur at intervals of 20 ms.

Visual display

The requirements for a display for a visual system are as follows. The display surface should ideally consist of a flat screen and, for most applications, should have a rectangular format. An exception is the radar display, of course. The screen should be capable of resolving a large number of picture elements (typically 500 × 500), addressable by horizontal and vertical scanning signals. Since the individual elements need not be defined, the active screen surface may be continuous. The light output from each element should be controllable by an intensity signal through a brightness range from total extinction to a maximum intensity appropriate to the application. If the visual system is to be commercially viable, the display, and its associated components, should be inexpensive and reliable.

The Cathode-ray tube

The cathode-ray tube (c.r.t.) satisfies the above requirements and has been recognised as the established visual display over the last few decades. A c.r.t. assembly consists of three integral parts: the screen, neck and flare, as shown in Fig. 3.

The screen, which is nearly rectangular, is coated on its inner surface with phosphor, a compound which emits light when it is bombarded by high velocity electrons. A narrow beam of electrons is generated in the electron gun housed in the tube neck and are accelerated to a very high velocity by connecting the phosphor screen to a high potential (16 to 20kV) relative to the electron gun.

When the electron beam strikes the phosphor screen it produces a bright spot, the intensity of which is controlled by the beam current (rate of flow of electrons) which is, in turn, sensitive to variations in the control potentials associated with the electron gun. For television and most other display purposes, the screen is rectangular in format with an aspect ratio (width-to-height) of 4:3, corresponding to the standard aspect ratio of television pictures. Earlier tubes had a 5:4 aspect ratio, for ease of manufacture, but a complete picture could not be correctly displayed without underscanning in at least one direction. Screen size is described by the diagonal dimension of the screen. □

This series of articles is based on an Advanced Level course for schools and is prepared in consultation with Professor G. B. B. Chaplin, University of Essex.

LETTERS TO THE EDITOR

STEREO FOR TELEVISION?

THE AUDIO systems most in use are those connected to television receivers (radio notwithstanding) and the lamentable output of these is well known. Stranger still is the lack of stereo for all those thousands of musical items televised every year. And lack of stereo may well be considered distortion in these days of i.cs when the price of a receiver is reviewed.

It is high time that a modified Zenith-GE pilot tone system be introduced. F.m. standards need not necessarily be maintained. A clean flat signal to some 11kHz with some 40dB of stereo separation would not make tv set design unnecessarily difficult. Considering decoder degradation some 1% distortion and 30 dB of separation could well be achieved at the receiving end and thus stay within the limits of the tolerable, and this with a reasonable signal-to-noise ratio.

I suggest your journal runs a competition for the best specification of a modified Zenith-GE system suitable for use with a 625-line tv system. It would surely highlight the receiver problems involved and could well bring decent tv audio one step nearer. May we all live to hear it.

Peter Hirschmann
Haifa
Israel

MYSTERIES OF SPORADIC E

PAT HAWKER wrote in your February issue about the mysterious Sporadic E. Readers might like to know what *has* been learned, from a combination of ground-based and rocket observations.

Sporadic E was first seen to occur in the way it does, that is as very thin intense layers of ionisation, by a British Skylark rocket flown from Woomera in 1958. By 1966 an association between these layers and sharp reversals in wind direction at high altitude had become recognised. Wind measurements in the very rarefied atmosphere up to 150km or so revealed that a surprising pattern of wind reversals with height can occur; what is more the measurements showed that the pattern often descends slowly over a period of hours, with, for example, a sharp wind shear first appearing above 150km height then moving downwards to below 100km before fading. The cause of this rather unexpected wind structure appears to be the propagation of atmospheric waves horizontally over great distances.

The sharp wind shears are at the root of the sporadic E layers, though in rather complicated a way. The winds, tenuous though they are at such heights, act to move the ions and electrons in the ionosphere across the Earth's magnetic field, but interactions then occur in such a way as to displace the plasma vertically. Where strong wind shears of the appropriate sense exist the plasma is squeezed into a thin concentrated layer, being moved downwards from above, upwards from below. As the wind pattern descends the layer descends too into an ever denser atmosphere, until finally at a height of about 100km it is brought to a halt.

In a very productive experiment at Woomera in 1971 a Skylark rocket was launched with a ground-based ionsonde showing a strong layer overhead. Instruments on the rocket measured the exact position of the layer and, something of a novelty, the ambient electric field as well; the wind structure was also charted, in better than usual detail. A very strong wind shear was found, but the layer was not quite where theory required until a correction was applied for the additional constraint imposed on the electrical charges by the electric field.

Sporadic E, then, owes its transient character to interactions between atmospheric waves, the ionospheric E layer and magnetic and electric fields. All but the magnetic field are constantly changing so that the right conditions for layer formation occur — well, sporadically. If the question is asked why the explanation has been so long in coming — I should explain that physicists the world over have contributed to the solution — the answer is that the region concerned, roughly 100-200km above the Earth's surface, is inaccessible to satellites and therefore to regular on-the-spot measurements.

One final point. Were the sporadic E layers to be composed simply of ionised atmospheric gases they wouldn't persist. They are, in fact, composed of ionised metallic atoms, mainly magnesium, silicon and iron, probably the remains of burned-up meteorites. The descending wind shears sweep up the metallic ions and bring them down as Sporadic E layers out of the thermosphere into the lower regions where atmospheric turbulence then churns them away into oblivion. Sporadic E layers seem to be the product of Nature's vacuum cleaning!

E. B. Dorling
Mullard Space Science Laboratory
University College, London
Holmbury St Mary
Surrey

QUESTIONS ABOUT FUSES

THIS is where I stand up and show my ignorance about fuses, perhaps to the amusement of the more knowledgeable ones. I was most interested to read Mr Connor's article in the January issue because, in my work mainly as a designer of electronic circuits and during my university training, I have not had to learn nor have been taught much about these humble components. I sometimes idly wondered how they behaved apart from the fact that they are likely to fuse if the rated current is exceeded. I have even been confused enough to believe that transient or anti-surge fuses, which I infer are better described as time-lag fuses, were designed to guard against transients. In future I shall try to remember that the obvious assumption that occurs to me because of the names is the wrong one.

I get the impression that, out of the various types, only a limited range (generally unmarked as to their speed of operation) is available to the general public or amateur constructor, presumably due to lack of demand. Perhaps a little technical advertising on behalf of the manufacturers might stimulate designers like myself to use fuses in less conventional applications, especially if they are now being developed successfully to protect semiconductor devices.

I would like to ask two questions of Mr Connor (or of his obliging expert Mr Newbury of Brush Fusegear) which other readers might also be interested in.

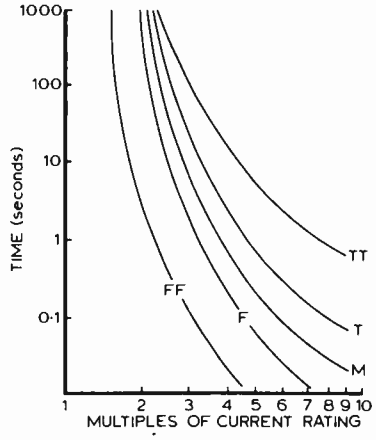
First, can he give me some typical examples of the range of speed characteristics available and how these speeds are defined when considering different types of I/t fusing characteristics?

Secondly, is it safe to use fuses in normally pulsed conditions (e.g. without premature ageing and failure) as long as the average power dissipation ($\propto I^2 t/T$) is below the rated value and the pulse width t is somewhat shorter than the pre-arcing time for current I? I suppose that in this case the speed of operation on a fault current could be limited by either average or pulsed power considerations assuming one effect to be dominant.

P. K. Cockings
Borehamwood
Herts

Mr Connor replies:

I would like to thank Mr Cockings for his letter, but would point out that it was not possible in a short article to cover the points he has raised. I assume his questions refer to miniature fuses of current ratings 32mA to 10A. These are covered by British Standard 4265 and IEC Specification No. 127 which give maximum and minimum pre-arcing times for class F and T types only. The accompanying figure, showing operating speeds of miniature fuses, is reproduced from a recent paper by P. G. Newbery and Prof. A. Wright ("Electric fuses," *Proc. IEE*, 124, 11R, Nov. 1977) which gives a review of all types of fuse at present in use and also refers to future developments. It will be seen that there is a wide difference in operating speed between the super-quick acting (FF) and the



super time-lag (TT) fuse. Intermediate speeds are obtained with the other classes which were referred to in the penultimate paragraph of my article. These differences are achieved by specially designed fuse elements and the wide choice in operating speeds should cover the requirements of most users.

Regarding pulsed loading, manufacturers would, I feel sure, be most reluctant to publish withstand curves for their fuses under pulsed loading conditions. I suggest, however, that most industrial and miniature fuses will withstand indefinitely pulses of 75% of the currents for the corresponding times shown on their t/I characteristic curves. For semiconductor fuses this factor may have to be reduced to 50%; manufacturers should be consulted in cases of difficulty.

I entirely agree with Mr Cockings's remarks regarding technical advertising and hope that his letter will provide the stimulus.

R. A. W. Connor
Felixstowe

RECORDINGS OF WIRELESS TRANSMISSIONS

RECENTLY I have acquired a number of recordings of wireless transmissions of about 1935-36. They are recorded on discs of approximately 7in diameter. The material has a "celluloid" quality, is transparent, and pliable. The recording appears to have been indented on the sides of a shallow groove (as distinct from being cut into that groove), and revolves at 78 r.p.m. It is difficult to get an intelligible playback, having regard to the warped nature of the discs.

Can anyone tell me how and on what machine these recordings would have been made, and the recommended method of playback?

Edward S. Walker
Walsall
West Midlands

IMPORTANCE OF LEVEL IN AUDIO ASSESSMENT

I WAS very interested in your report on the hi-fi rumpus in the February issue. I am a little worried, too, and can sympathise somewhat with the KEF, Quad, Armstrong, B & W group. After all, most of them have been in the field a long time and have gained a lot of experience the hard way. We are not born with experience. On the other hand, I have no doubt that the "youngsters" really did hear differences that others have said should not have been there.

Now because we all learnt at college that any sound level change less than 1dB is not generally audible, we tend to take that as a rough dividing line between good and otherwise. Any modern amplifier should have a response flat within a small fraction of a dB over the whole frequency range, but when tone controls containing pre-amplifiers are added into the chain this is very doubtful unless there is a "cancel" switch position. Centralized bass and treble controls are no guarantee of a truly flat response, and we have plenty of evidence that departures far less than a dB over the audible range can make very large subjective differences when we listen to music.

Adherence to a strict RIAA curve is also in doubt with many pickup-amplifier combinations.

Now our art has progressed to such high standards that tiny errors in, say, frequency response that we could safely ignore a few years ago because they were anyway swamped by other audible shortcomings can no longer be overlooked. Peter Walker and Peter Baxandall have often stressed the fact that you *will* hear differences apparently of quality in the sound if there is any difference in level between two systems being compared, even if the response curves really are identical and, of course, both systems running at levels well below limiting.

After all, 1dB is a voltage change of 12% and therefore a power change of getting on for 25%. A 1dB change when listening to a pure tone may not be very noticeable but listening to music with its whole range of frequencies with an ear whose frequency response varies with sound level is a very different thing. Now add to that the tiny deviations from RIAA responses and "level" tone control settings, no wonder we are at odds. Add further dubious contacts in plugs, sockets, switches and leads and it begins to be clear how very careful one must be before one passes judgment, especially in print. At the old Northern Polytechnic, now the Polytechnic of North London, we ran a series of evening courses on audio measurements some years ago. Our opening theme was always: "Are you measuring what you think you're measuring?"

Ralph L. West
Villeréal
France

THE FLIGHT FROM REASON

THE idea that humans have occult sense-faculties which transcend physical measurement is by no means confined to the reviewers of amplifiers: people near New York airport lately complained that Concorde's intolerable noise was of the kind that did not affect a noise meter. All such beliefs are irrational, but it is impossible to persuade those who hold them that they may be mistaken. The only thing one can do is to insist that they are not allowed to design their own subjective experiments, if only because their beliefs so often go with limited technical understanding. Equally, nobody should take any notice of what they say unless those skilled in the design of subjective experiments have been let loose on them: unless observers are kept quite separate from the equipment they are examining their results cannot be reliable.

I myself suffered similarly when scientists insisted that visual judgements of brightness contrast could never be reconciled with physical photometric measurements. For six years it was impossible to persuade them that their sophisticated statistical analysis could not compensate for the variations introduced by the erratic experimental conditions they had elected to adopt. But eventually pure chance made modifications essential, and it at once became clear that under correctly designed experimental conditions visual and physical measurements were identical. Even so, I am not certain whether the scientists really believe this . . . .

If readers think this last surprising, let them recall that Sir Arthur Conan Doyle was convinced that Houdini and Maskelyne were not really conjurers, but powerful mediums who prostituted their occult talents to make easy money.

P. C. Smethurst
Bolton
Lancs

AUDIO EQUIPMENT REVIEWS

IT IS SAD to see an internationally respected technical journal such as *Wireless World* descend to the level of village pump gossip. But given that gossip has a place in human affairs, the facts at least should be correct.

The news item "British hi-fi scene drama" in the February issue gives a very slanted view of a recent occurrence by suggesting obduracy, conspiracy and threats in matters of reviewing. So far as KEF Electronics is concerned, and I cannot speak for any other, there has been no change of policy. We continue to co-operate with the international consumer press and to provide products for *bona fide* tests on request. Several recently published reviews of KEF products bear witness.

In the matter of *Hi-Fi Choice*, staying out of a current large scale test of loudspeakers was my personal decision. I was initially asked to make laboratory facilities available for, and later to lend products to, a proposed test involving about sixty different pairs of loudspeakers. The timetable covered a period of six to eight weeks. I refused to accede to the first request on the grounds that it could have been unfair to our competitors. Argument about the veracity and validity of measurements and merit ratings would inevitably have arisen. In any case, our laboratories are in constant use and we could not tolerate the disruption. At the same time I objected to the proposed use of other manufacturers' facilities for similar reasons. It is my firm belief that the press should operate quite independently in the public interest.

So far as such large scale tests are concerned, I do not believe that they can be conducted fairly and effectively in present circumstances. Bearing in mind that we have an extremely experienced team at KEF Electronics, backed up by facilities of the very latest type, I would allocate a period of four or five months to this kind of evaluation. Yet we are seriously asked to believe that one man working with borrowed equipment and on a shoestring budget can accomplish a miracle in less than two months. I feel very strongly that such pseudo-scientific testing can only mislead the readers and serves no useful purpose in the long run.

I would like to make it clear that I am not against reviewing in the general sense. Competent evaluations fairly assessed can be both interesting and informative. However, when tests are carried out on an impossibly vast scale and taken to the point of de-

signating best buys, they become nonsense. In the case under discussion, even the name of the magazine is nonsensical since evaluation is concerned with matters of fact, whereas choice is subjective and must take account of the users' needs and circumstances.

Raymond E. Cooke
KEF Electronics Limited
Tovil
Kent

RADIO CLYDE IN SOUTH AFRICA

I WAS interested to read in your February issue (p.30) of Radio London's QSL report from South Africa.

Please find enclosed a postcard received here at Radio Clyde of a reception report also from South Africa. This seems even more remarkable since not only are we further north by approximately 400 miles but we broadcast on a frequency with a lot less power than that of Radio London. In fact our transmitter power is 2 kilowatts. Not only that, but we broadcast with a directional aerial which points in a north by north westerly direction.

Could the reception have been via two polar points?

John Lumsden
Radio Clyde
Glasgow

Editor's note: The postcard is from a Mr Edwin Rimmer of Cape Town. It refers to reception on 1151kHz on January 4 at 0115 to 0150 hours GMT, using a long wire aerial and an HMV receiver.

LINSLEY-HOOD CASSETTE DECK

I WAS interested to read Mr Linsley Hood's comments on the tape head types which are supplied with the Lenco mechanism. While laboratory testing a cassette deck which I had obtained as a kit (from Powertran Ltd) I discovered that the best frequency response that I could obtain using good quality tape, even with low bias levels and large amounts of pre-emphasis, was from 25Hz to 4kHz. The highest discernible frequency was 10kHz, being 11dB below the reference level which I took as being —20dB at 600Hz, which is a fairly standard recording level used by cassette deck manufacturers. A reference tape showed a similar frequency response on replay. The results of these experiments suggested that the tape head, which bore the legend "MC" followed by "B24-05", was at fault. I decided to purchase the head for a very high quality Tandberg machine, assuming that the quality of the head would also be good. A shortage of bias was eliminated by using the Stuart circuit which gives a very high, linear output. These modifications resulted in a frequency response —3dB at 13.5kHz, a considerable improvement.

During the above tests, what appeared to be a major design oversight came to light. In the original articles it is stated that the maximum record level at 660Hz should be given by 2.25V r.m.s. at the output of IC_3. The record pre-emphasis response requires a minimum of 16dB lift at approximately 14kHz. This is to give the same recorded flux on the tape at high frequencies as that at low frequencies, i.e. to offset "shortcomings in the tape and head characteristics". Since the record level meters are monitoring IC_3, any output in excess of 2.25V, as is required at high frequencies, will appear to the operator as an overmodulation when in fact the tape is nowhere near saturated. Hence we must assume that the overall record level when recording programme material is considerably reduced at all frequencies. Mr Linsley Hood admits this in his postscript and suggests in Fig. 7 that this reduction is about 3 decibels, but there is still a peak of 14dB at 10kHz.

This brings me to my second point, which is that the clipping level of the 741C operational amplifier when run on a power rail of 13.5V is only about 4V r.m.s. Thus even if the meters monitored the input, the record amplifier would not be capable of supplying the 14V r.m.s. or 31V peak-to-peak output which 16dB pre-emphasis requires.

When square-wave optimisation is attempted, a reasonable square wave can be recorded at 0dB. If the output of IC_3 is monitored at the same time, clipping of the "square-wave" overshoots can clearly be seen. The record level must be considerably lowered for this limiting to cease.

As to a solution, reducing the value of R_{26}, which appears to be a simple answer, is self-defeating as this reduces the head current at high frequency, requiring more pre-emphasis. A solution which I have adopted is to supply the record amplifiers and meter circuits with a negative rail and to short out R_{15}, which makes the output symmetrical about 0V, doubling the output range. Unfortunately the output from the replay amplifier to the meter must be disconnected.

These modifications improve the subjective quality quite considerably.

C. W. Beal
Bradford 7
West Yorkshire

Mr Linsley Hood replies:

The basic design specification which I set out to meet, for personal reasons, was that of a recorder which would operate from the 13.5V (nominal) output of a 12V battery. Using a 741 type operational amplifier in the "record" circuitry would therefore allow an output into a high impedance load of some 3V r.m.s. with low distortion.

The inductance of the heads was quoted as 130mH, which would have an impedance of 9.8kΩ at 12kHz, the intended upper frequency limit of the system, and the head saturation level was quoted as 0.126mA. Empirically the saturation level for several standard quality "low-noise" cassette tapes was found to correspond to a head current of 60μA at 660Hz. From these figures it appeared that a series resistor of 39kΩ for R_{26} would provide an adequate safety margin on head saturation or recording amplifier overload, while swamping the effects of recording head inductance at the highest intended operating frequency (phase lag less than 15°).

With the circuit values shown, therefore, the limit on tape remanent flux was imposed, as intended, by the characteristics of the tape itself, rather than by the circuitry of the recorder or the characteristics of the recording heads.

With regard to the effect of the recording pre-emphasis on the amplifier output, it is self-evident that in any system of this kind — where pre-emphasis is employed — if the programme material contains a uniform distribution of signal frequencies, the high frequency signals impose the recording level limit, and the low frequency ones will be present at a substantially lower level.

This is a fact of life — not a design shortcoming which I "admit". Fortunately, the recording level meters respond to the effective signal levels at the output of the recording amplifier, after pre-emphasis, and allow one to judge the extent to which one is overstepping the limits imposed by the flux saturation of the tape.

RADIO ON THE FLIGHT DECK

THANK YOU for the excellent articles by Alan Bramson (January and February), though I must take him to task on "the astonishing pace of aircraft radio development this past 20 years" — unless by "astonishing" he means "astonishingly slow." Doppler and inertial navigation, it must be agreed, fall within the period at least as far as their practical development is concerned but Decca Navigator, Omega, i.l.s. and Flight Director systems are all longer in the tooth than 20 years.

Decca was an immediately post-war development, though one is entitled to ask the connection between the pre-war "Chapman" method, GEE and Decca, all hyperbolic systems with the first two using pulses and the third continuous waves.

I.l.s. was well covered by your contributor, though mention might have been made of the disturbing characteristic of the normal glide slope to plunge to earth at about 150ft altitude.

A forerunner of the Flight Director systems was the Sperry "Zero Reader" which was on sale before 1950 and which combined attitude gyro, compass or directional gyro and i.l.s./v.o.r., really taking the sweat out of a manually-flown i.l.s. approach.

Omega, I suggest, is a tarted-up version of the wartime Loran and so falls outside the 20 years, at least in principle.

I must agree with Alan Bramson that "it would be a very unwise man who claimed an intimate knowledge of what the future holds for aircraft radio." *The* lesson of the last 33 years, I suggest, is that too much depends on international politics as opposed to technical/commercial merit which can be demonstrated, measured and judged by the laws of physics – and now we have yet another UK/USA battle on our hands, this time over a microwave landing system. All these wrangles not only impose delays in time but impose decisions based on entirely the wrong criteria. Thirty-one years ago we were capable of virtually touching-down on the same square of concrete, every time, after an automatic approach. Now we are back to square one and arguing over the ground radio equipment.

Astonishing progress indeed!

R. T. Townson, RAF (ret'd)
Reading, Berks.

Communications '78

An exposition of communications equipment and systems

THE fourth international communications equipment and systems exposition, Communications '78, is to be held at the National Exhibition Centre in Birmingham from 4 to 7 April. It will be inaugurated by HRH The Duke of Kent. In addition to an exhibition of equipment and systems, a four-day conference, on the themes of PTT telecommunications, fixed and mobile radio communications and defence communications, has been organised by the IEE in association with similar American and European organisations. (See News, March issue for further details.) The exhibition will be open daily from 9.30 a.m. to 6.00 p.m. (5.30 p.m. on the last day) and admission is free. Computer print-outs giving details of products, exhibiting companies and stand locations will be available, on request at the exhibition, to all visitors.

Grampian Reproducers Ltd, of Kingston-on-Thames, will be showing their new sound system, which recently won them a Ministry of Defence order worth £320,000. According to Grampian, a quantity of the systems will be used by the British Army at tattoos, displays and other military occasions where they need to provide their own facilities for broadcasting speech and music. The heart of the system is a 100W/100V-line mixer-amplifier which provides a protected, four-mixer input facility — typically two microphone and two auxilliary inputs. Each input has its own volume control, and the amplifier includes a wide range tone control for base and treble. An interlock facility, claimed by the makers to be a unique feature of the amplifier, enables two amplifiers to be used together to provide an 8-input/200W output capability. Included in the system are three microphones, having different response characteristics, four re-entrant horn units, four line-source column loudspeakers, and eight heavy-duty loudspeaker stands.

Facsimile telecopying equipment will be among the exhibits on the Siemen's stand. Included in these is a new telephoto transmitter, type TS1085, and a laser-based photo receiver, type TM4006, which will be on show for the first time in the UK. The TS1085 telephoto transmitter is a light-weight and compact machine for press, PTT and tv applications. It is suitable for a.m. or f.m. operation and includes a scanning system with an automatic "black signal" optimization facility. It also has built-in facilities for digital picture transmission and faster drum speeds. The TM4006 is capable of producing pictures of photographic quality. Since this receiver uses a laser technique it allows the development of dry pictures, as compared with most photo receivers which require the incoming picture to be developed wet.

Previously unpublished details of the Ministry of Defence's secure mobile tactical network, known as the Ptarmigan Project, will be disclosed at the Communications '78 conference. A discussion of the Ptarmigan Project will form the main topic for the conference's final day, which is devoted to defence.

About 100 papers are now being prepared by the IEE for the conference programme, including ones from Belgium, Canada, Denmark, France, Japan, Sweden and Yugoslavia.

The UK/PRC320 manpack, illustrated, is a lightweight h.f., s.s.b. radio station which was designed as part of the British Army's Clansman range of radio equipment. This equipment will be among the products on the Plessey stand. The company also plans to show other Clansman products including a u.h.f. a.m. manpack, a range of v.h.f. antennas, and a hand-driven generator for charging the batteries used in the Clansman radio manpacks. Other products on the stand will include h.f. s.s.b. and v.h.f. f.m. vehicle stations, a v.h.f. f.m. squad radio, weapon control systems, and a range of airborne radio equipment.

Picture shows a 19GHz digital radio transceiver which will be featured on the GEC Telecommunications stand. The antenna, transmitter and receiver are combined in a pole-mounting unit. Also on show will be digital radio systems for the 2GHz and 11GHz bands. In addition to these products, GEC will be putting particular emphasis on fibre-optic transmission and digital muldex and line systems for up to 140Mbit/s. The highlight on their stand will be the SL-1 business communications system. This is a PABX that combines the flexibility of stored programme control (the use of a computer to control telephone calls) with the versatility of digital switching.

List of exhibitors

Action Communication Systems
AEG-Telefunken (UK)
AEL Crystals
Aero Electronics
AIL Division of Cutler-Hammer
Air Call
Airtech
Ameeco (Personnel Services)
Andrew Antenna Systems
Antenna Specialists UK
Aspen Electronics
Audix Barkway Electronics
Aveley Electric

Bantex
Barry Research Corporation
Belling & Lee
Besson, A. P.
BICC
Bird Electronic Corporation
Boonton Electronics Corporation
Bunzl Telecomm. Services

C & S Antennas
Cable & Wireless
Cablewave Systems Inc.
Canadian Instr. & Electronics
Cathodean Crystals
Chase Electrics
Clarbrook Engineering Co.
Codex Corporation
Cole Electronics
Collins Group Rockwell Intern'l
Collins Radio Co. of England
Comelit, of GTE Telecomm's
Commercial Cable Co.
Comm's Access. & Equip.
Communications International
Computer and Systems Engineering
Computer Transmission
Consumer Microcircuits
Cooke Engineering
Cossor Electronics
Crystalate (Holdings)
Cyfas

Danbridge UK
Data & Control Equipment
Dataplex
Decca Communications
Defence Magazine
Delta Electronics Inc.
Derby Automation Consultants
Dictaphone Co.
Dielectric Communications
Digi-Log Systems Inc.
Digitech Data Industries
DMW Associates (Electronics)

Ebonestos Industries
Elcom Systems Inc.
Electro-Mechanics Company
Electronics Weekly
Elmi AS
Essco Collins
Euro-Electronic Instruments
Evans, F. W.

Farnell Instruments
Feedback Instruments
Ferranti
Financial Times
Francis & Lewis
Frederick Electronics Corp.
Frequency Electronics Inc.
Future Film Developments

GEC—Telecommunications
—Marconi Electronics
—Marconi Communication Systems
—Eddystone Radio
—Mobile Radio
—Marconi Instruments
—Marconi Space and Defence Systems
General Audio & Data Comm's
General Telephone & Electronics
Grampian Reproducers
Granger Associates
Green Electronics & Comm's
GTE Communications Products

Halcyon Communications
Harmer & Simmons
Harris –RF Comm's USA
Hatfield Instruments
Hayden Laboratories
Hewlett Packard
Highland Electronics
Home Office
Horizon House International

IAL Group
—Communications Services
—Computer Systems
—Data Communications
—Digital Systems
—Park Air Electronics
Ibex Telephones & Telecomm's
IBM UK
Imhof-Bedco
Informer Inc.
Inst. of Electrical Engineers
Interface International
International Broadcast Eng.
Intern'l Manag. & Operat. Sys.
Interphone
Interscan Comm. Systems
Interstate Electronics Corp.
IPC Electrical-Electronic Press
Italtel Societa Italiana Telecomm
ITT Business Systems

Jaybeam
Juniper Journals

Kabel und Metallwerke GHH AH
KDI Pyrofilm Corporation
Krone GmbH

LDV Electro Science Indistries
Lero Electronics
Lero Engineering
Lero Telecommunications Co.
Lion Systems Development
Logica

MCP Electronics
MEL Equipment Co.
Membrain
Metex Corporation
Microwave Associates
Millbank Electronics Group
Ministry of Defence
Minister Automation
Mitel
Monks, Keith (Audio)
Morse Equipment
Motorola
Motorola Electronics
Muirhead Data Communications
Mullard
Multitone Electric Co.

Narda Microwave Corporation
Neumann Comm. Systems
New Electronics
Newport Instruments
Norlin Communications
Nuclear & Silica Products

Olektron Corporation
Olivetti, Ing.C. & Co. SpA

Pacific Measurements Inc.
Panorama Antennas
Panorama Radio Co.
Petters Power Generation
Pilkington PE
Pirelli General Cable Works
Plantronics Inc.
Plantronics SA
Plessey Group
—Electronic Systems
—Avionics & Communications
—Radar
—EAE
—Project Ptarmigan
—Telecommunications
—Public Telecomm. Sys.
—Private Communication Systems
—Controls
—Aerospace
—Semiconductors
—Connectors
—Assessment Services
—Birkbys Plastics
Post Office Telecommunications
Precision Metal Spinnings
Pye Business Communications
Pye TMC

Racal Electronics
—Amplivox Comm's
—Antennas
—Automation
—Communications
—Data Instruments
—Datacom
—Group Services
—Milgo
—Tacticom
—Thermionic
—S. G. Brown Comm's
—Modern Aerials
Radio Systems (Enfield)
Radio Masts
Rank Telecommunications
Rathdown Industries
Raytheon Cossor Data Systems
Redifon Telecommunications
Roditi International Corp.
Rohde und Schwarz GmbH
RFL Electronics

Sagem
Salford Electrical Instruments
Scientific Control Systems
Security Systems International
SE Labs (EMI)
Service 800 SA
Shure Electronics
Siemens
Southcom International Inc.
South Midlands Comm's
Spectronics
Sperry Gyroscope
Spinner GmbH
Standard Telephones and Cables
Sunair Electronics
Systems Designers
Systems Reliability
Systron Donner

Tandberg Radiofabrikk AS
Tannoy Products
Technical Comm's Corp.
Technical Material Corporation
Technology for Comm's Intern'l
Tekelec Airtronic
Telecommunications
Telecommunications
Telemit Electronic GmbH
Telephone Rentals
Telepower Systems
Teleprinter Equipment
Telex-Verlag Jaeger & Waldmann
Thomson-CSF
Thorn-Ericsson Telecomm's
Toa Electric Co.
Transco Products Inc.
Transtel Communications
Trend Communications
Trio Laboratories
TRT
TRW-Composants Electroniques
—Electronic Functions
—Globe
—Semiconductors Inc.
—UTC Transformers
Tungstone Batteries

Uher

Vanderhoff Communications
Varta (GB)
Vero Electronics

Wandel und Goltermann
Watkins-Johnson
Webster Electronics
Westcom UK
Western Electronics (UK)
Whitton Press
Widney Dorlec
Wireless World

NEW PRODUCTS

Shortwave receivers

Two radio receivers, introduced by National Panasonic, have been designed specifically for shortwave listeners. The Model RF-2200 is an eight-band portable priced at £134.95. It covers frequencies in the medium-wave, shortwave and f.m. bands. Tuning is by a two-speed tuning knob coupled to a band dial having 10kHz divisions, and two crystal markers at 50kHz and 125kHz. Its double-superheterodyne circuit and wide-or-narrow bandwidth selection ensure high selectivity. A b.f.o. is also provided for the reception of s.s.b. and c.w. The Model RF-4800, illustrated, is suitable for the radio amateur's shack and is a ten-band communications receiver priced at £319.95. The tuned frequency is indicated on a l.e.d. digital display. The ten bands cover the long-wave band from 145 to 410kHz, the medium-wave band from 520 to 1610kHz and the shortwave band, split into seven smaller bands, from 1.6 to 27.3MHz. A meter allows the receiver to be tuned for optimal signal strength. Other features include an antenna trimmer, a gain control, a b.f.o. and mode selection. The maximum variation in frequency is claimed to be only 500Hz during any 30 minutes after the warm-up time. National Panasonic (UK) Limited, 107 to 109 Whitby Road, Slough, Bucks SL1 3DR.
WW301

Portable noise analyser

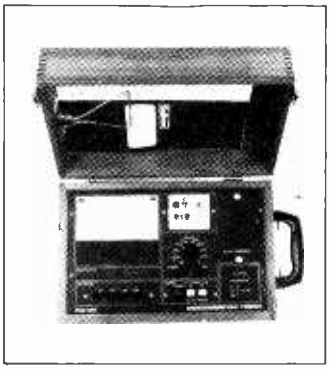
The SA-24 analyser has been designed primarily for the real-time analysis of noise and vibration. It is a portable instrument suitable for measuring the frequency distribution of noise, on-site. Twenty-five, or nine, frequency bands, according to the filter selected, are displayed on a c.r.t., and each band can be read directly in dB (normalized to a preset, calibrated datum). The display appears as vertical bars, each one representing the noise level of a discrete frequency band, so that a total graphic representation of the entire noise spectrum emitted from a test subject is obtained. A hold button freezes the display when it is required to observe the spectrum pattern in detail, while an automatic hold stops the display when analysis of impulsive noise or vibration is undertaken. The SA-24, made by Rion in Japan, can operate from its own internal, rechargeable batteries, an external 12V direct-voltage source, or from the mains, as required. Outputs may be recorded on a high-speed recorder. Computer Engineering Limited, Wallace Way, Hitchin, Herts.
WW302

I.f. filters

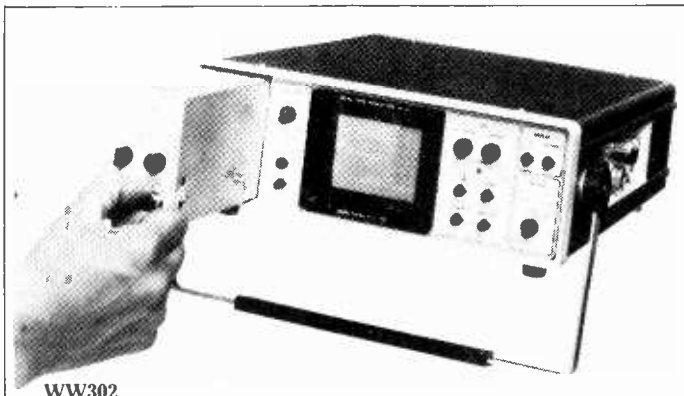
The Toko type LFY filter is a four section miniature ladder device encapsulated in a plastic case measuring 8 × 7 × 7mm. Centre frequency is 445 ± 1.0kHz and the bandwidth at —6dB is F_c ±3 or 6kHz minimum for the B and D types respectively. Type CFM2 is a two element ceramic filter measuring 7.5 × 3 × 9.5mm. Centre frequency is also 455 ±2kHz and the bandwidth at –6dB is 4, 6, 8, 19, 12kHz for versions A to E respectively. Centre frequencies of 452, 460, 468 and 470kHz are also available. Ambit International, 2 Gresham Road, Brentwood, Essex CM14 4HN.
WW303

Portable test equipment

Three precision measuring instruments, available from H. W. Sullivan Ltd, have been designed for both indoor and outdoor use. The model T2900, shown, is a portable, battery-powered megohmmeter which replaces the model 29A (the 20 million megohmmeter, as it was called). It may also be used as a picoammeter, d.c. voltage source or high input-resistance d.c. millivoltmeter. The instrument has eight ranges covering from 100kΩ to 100TΩ for test voltages of 100, 250, 500 and 1000V. Current measurements may be made from 100pa to 1mA full scale, in eight ranges. The second instrument, type 3335, is a d.c. millivoltmeter and null detector. It has three linear voltage ranges of 100μV, 1 mV and 10mV full scale and three logarithmic ranges. The full scale accuracy is ± 5% and the resolution on the most sensitive range is 2.5μV/mm of the mirrored scale. The third instrument, T1190, is a resistance bridge having an accuracy of ±0.1% and a range from 0.001 to 10MΩ. This bridge may be used for Murray and Varley loop tests and as an accurate decade resistance box. H. W. Sullivan Limited. Archcliffe Road, Dover, Kent CT17 9EN.
WW304



WW301



WW302

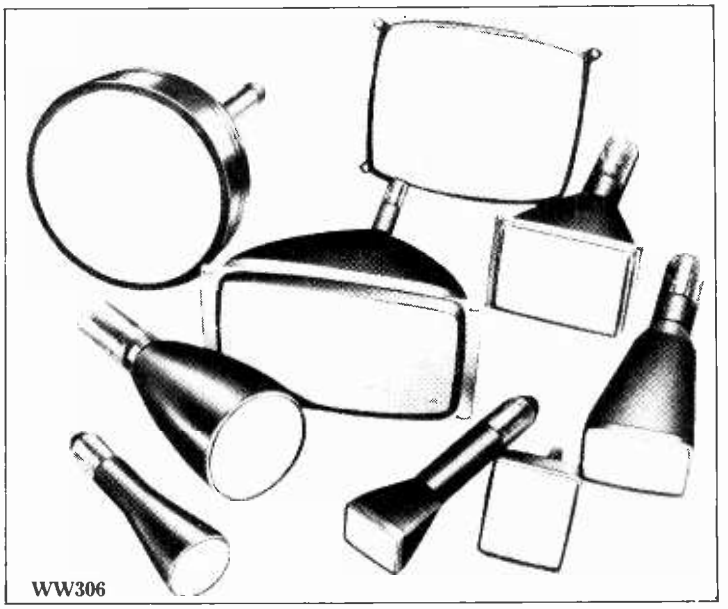
Audio test set

A test set, designated the TTI 1120, measures the transmission level, frequency, noise and weighted noise of audio frequency channels and systems. The set, which has been manufactured to CCITT specifications, includes a microprocessor and memory and, in addition to controlling measurement and transmit functions, tests all major instrument components automatically and gives the results on an alphanumeric display. This self-diagnosis takes only 12s. The unit's oscillator may be tuned over two bands (50Hz to 4kHz and 1kHz to 20kHz), or used in a fixed push-button mode at predetermined

frequencies. Level measurements are autoranging from −50 to +10.5dBm and the noise readings may be made from −90 to +10dBm. Wandel & Goltermann (UK) Limited, 40 to 48 High Street, Acton, London W3.
WW305

Cathode ray tubes

A comprehensive range of monochrome, industrial cathode ray tubes, introduced by Impectron Limited, is available with round or oblong screens in sizes from 1.5 to 23in. The tubes also come in a variety of neck sizes and deflection angles. Three different grades of resolution are also available. The first is a tv-grade having a maximum of 500 tv lines, the second is a medium-grade having between 500 and 700 tv lines, and the third is a high-grade having between 800 and 1000 tv lines. The choice of nine different phosphors allows a range of screen colours to be obtained. Impectron Limited, Impectron House, 23 to 31 King Street, London W3 9LH.
WW306


WW306

Robust digital multimeter

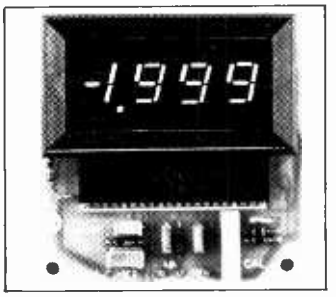
The model DA116, from Avo, is a general-purpose digital multimeter which is similar in mechnical design to an analogue instrument, in particular the well-known Avo model 8. It has a similar mode of operation to the model 8, and it is also very robust. The display is of the liquid crystal type, giving a long battery life, 13mm high characters and a wide field of view. It also has easily recognisable characters which, it is claimed, may be read in all ambient light conditions. The instrument employs large scale i.c.s. and its a.-to-d. converter is a single i.c. which uses a dual-slope technique with automatic zero correction. The DA116 enables voltage measurements to be made for both a.c. and d.c. from 200mV to 1kV full scale, and current measurements from 200μA to 10A full scale. In all cases the maximum display indication is 1999. All current ranges, except the 10A range, are protected by a 2A fuse located in the positive socket. Although the 10A range is unprotected it has a separate socket so that, even if it is damaged, it will in no way affect the rest of the multimeter. Two special ranges have been included in the meter. The first is a high-speed ohms range which is intended to speed up continuity testing. On this range the response time of the instrument and display is reduced by a factor of ten. The second special range can be used to test diode and transistor junctions under forward or reverse bias. On this range the display indicates the voltage drop across the junction for a nominal current of 0.5mA. There are also six ranges giving high-accuracy measurements of resistance up to 20MΩ. Four ordinary SP-11 zinc-carbon batteries are claimed to give life of well over 500h. The DA116 costs £99, including the clip-on case and test leads. Avo say that an additional carrying case and a 30kV d.c. probe will be available shortly. Avo Limited, Archcliffe Road, Dover, Kent CT17 9EN.
WW307

Miniature capacitors

Polyester-film and aluminium-foil capacitors, from Nortronic Associates Ltd, are available in values from 0.001 to 0.1μF, with minimum working voltages of 160V. These components are offered in tubular cases with axial, tinned copper leads welded directly to the extended foil. For protection, the capacitors have polyester sleeves and epoxy-sealed ends. This covering is unaffected by cleaning solvents, and body markings are permanent, say Nortronic. Nortronic Associates Limited, Arnold Street, Nantwich, Cheshire.
WW308

Digital panel meters

A range of 3½-digit panel meters is claimed by its makers, Lascar Electronics Ltd, to break new ground in terms of price, performance and physical size. The standard meter has auto-polarity, auto-zero and an accuracy of 0.1%. They are available with full scale readings of either ±1999mV or ±199.9mV, with both versions incorporating an overrange input indication — by suppressing the last three digits. Both types can be supplied with either 0.3 or 0.43in red l.e.d. displays, with or without mounting bezels. A programmable left-hand decimal point and a built-in 20-turn calibration preset are included, the latter being accurately set prior to despatch. The meter measures only 3 × 2¾ × ⅜in and is priced (for 100 off quantities) at about £17. Lascar Electronics Limited, P.O. Box 12, Module House, Billericay, Essex CM12 9QA.
WW309



U.h.f. transistors

Two u.h.f. transistors, types BFT92 and BFT93, are miniature versions of standard devices. Both transistors are p-n-p complements of the types BFR92 and BFR93, which have been available for some time. The devices, which are intended for u.h.f. and microwave amplification applications, have special connector tabs especially suited to thin and thick-film circuits. Brief details are as follows for the type BFT92 and BFT93 devices: intermodulation distortion, typically 60dB in each case; noise figure, typically 2.4 and 1.9dB; transition frequency, 18 and 5GHz respectively.
V_{CBO} (max), 20 and 15V; V_{CEO} (max.), 15 and 12V; I_C (max.), 25 and 35mA and P (total, max.), 180mW in both cases. Mullard Limited, Mullard House, Torrington Place, London WC1E 7HD.
WW310

A.c.-to-d.c. adaptor

An a.c.-to-d.c. adapter, suitable for both laboratory and do-it-yourself applications, can supply 3, 6 or 9V (direct) at up to 200mA from a 220 to 240V, 50Hz input. The appropriate voltage is selected by means of a three-position slide switch on the face of the unit. Supplied with the adaptor is a detachable connecting lead having a four-way connector which will fit most low-voltage coaxial and jack sockets. Two versions of the unit are available. One model has a flying lead for a mains plug and the other has integral square pins. Price of adaptor is about £2. C. Brandauer & Company Limited, 401 to 414 New John Street West, Birmingham B19 3PF.
WW311

D.i.l. instrumentation amp.

A high-performance, hybrid instrumentation amplifier, Micro Network's MN2200, is supplied in an 18-pin dual-in-line package. Characteristics of the amplifier include a common mode rejection ratio of 110dB, fixed gains of 1, 10, 100 and 1000, and a gain accuracy better than 0.01% for gains of 1 and 10 and better than 0.1% for gains of 100 and 1000. The input impedance is greater than 1000MΩ and the input offset current is less than 7nA. Pascall Electronics, who supply the device, say that, because the gain resistors in the package are laser trimmed during production, the offset drift with temperature of less than 2μV/°C can be guaranteed for practical operating conditions. The laser trimming also ensures a very low initial offset voltage of less than 200μV. Also included in the unit is a two-pole Butterworth filter which, by the addition of two external capacitors, can provide a 12dB per octave low pass filter having a user-selectable 3dB point. Pascall Electronics Limited, Hawke House, Green Street, Sunbury-on-Thames, Middlesex TW16 6RA.
WW312

SIDEBANDS by Mixer

Reactance

When a policeman accosts you as you drive along and asks you to blow up his balloon for him, what is he really doing, apart from applying the kiss of death to a perfectly good night out? Well, of course, he wants to know whether you've been bending the old elbow too much for safety.

But I think that the breathalyser is far too selective a test to be of maximum benefit. No one in full possession of their marbles would condone drunken driving, but there are those who can knock back four or five doubles without turning a hair and others who go cross-eyed after a couple of wine-gums. So why limit the elimination of incompetents to those suffering from alcohol indulgence? The breathalyser attacks only one cause of dangerous driving and is very leaden-footed in its approach.

Perhaps a better way would be a test for a direct cause of bad driving, caused by anything which reduces one's capabilities, including alcohol, but also illness, tiredness, old age, bad temper or just native dreaminess. The one thing that is common to these conditions is a slow reaction time and it would seem to be a relatively simple matter to provide each police car with a little reaction-time tester as an on-the-spot measure, to be followed by a visit to the local station for a more thoroughgoing test of reflexes. Maybe, even at the driving-test stage, candidates could be subjected to such a test, with a view to weeding out those whose future driving careers could profitably be abandoned.

The gadget could be made from three or four m.s.i. chips and a couple of seven-segment displays, battery-powered and pocketable. They shouldn't cost much more than a tenner and police would need no training in their operation. Furthermore, the result would be presented in numerical form.

Mystique-ism

Having spent far too much of Christmas cleaning out the carburettors on the monstrous, money-gobbling family totem that sometimes allows me to ride about in it, I felt reasonably sure, as I gazed with red-eyed hate at the thing, that this was still the trouble. Two hours of immobility on the A1, in biting cold, had not prepared me to face the thinly-disguised contempt of the garage mechanic as he had a quick look at the c.b. capacitor, consigned it to the gutter with a muttered oath and sent me on my way with a warning not to buy any more components made by people of non-European origin. That's almost what he said, at any rate. Apparently he had only to see the outside of the case to realize that it had developed an intermittent short.

Trembling with fury at the car, the mechanic, the weather and whoever invented fireproof pipe tobacco, I streaked down the A1 in a highly accident-prone frame of mind. Easing into top at around a hundred and eighty, or maybe it only seemed like that, I began wondering why electronics people don't put on a bit more of the style. That garage mechanic had me sized up as a Grade 1 moron within seconds of my calling the condenser a capacitor and obviously considered anyone who couldn't recognize a Hong Kong component as the seat of the trouble ought not to be out alone.

And yet, when he wants the radio repairing and explains that he's sure it's alright, really, because he's only tightened up all the loose screws, including the crumbly grey ones, he doesn't expect to be told he's an ignorant . . . .

When the gardener next door pityingly compliments you on achieving a well-nigh perfect lawn-clover fertilizer and dandelion propagator, does it not occur to him he is as a babe in arms when it comes to a quick rescue job on "Match of the Day"?

I suppose it applies to all of us. Maybe all mechanics, fitters, repairmen and what have you should be made to memorize a salutory thought, such as "Before you say what you're thinking, how are you on brain surgery?".

Decline and fall

All designers, but particularly those in electronics, will recognize the feelings of frustration, fury, depression and, sometimes, relief, when overtaken by events. I suppose it's always been the way of the world — the hairy little chap beavering away at carving a wheel from the living rock must have been a bit put out when he saw them being mass produced from tree trunks. But the pace seems to be hotting up now and when one has slogged away for a year or so to design the best low-drift, low-noise, high-input-Z instrument amplifier ever seen, one is very apt to lose one's gruntle when an integrated circuit to do the same job is announced just as the design is nearing completion. It's even the same with i.cs. Use a couple of dozen m.s.i. chips to do a job and you can bet your life that sooner or later someone will produce an l.s.i. chip to do the same job, only more so. All this is extremely vexatious if one is the designer concerned, but more to the point is the waste of effort. There aren't so many good engineers around that their work can be allowed to drain away.

One can hardly expect the makers of i.cs to lose a couple of years' selling lead by announcing their development programme. So it seems that, when designers become too annoyed by being continually up-staged, they will cease to design discrete, s.s.i. or m.s.i. circuitry and the whole of electronic circuit design will pass to those employed by the makers of little black things with legs.

Anyone want to buy a soldering iron?

Time of reckoning

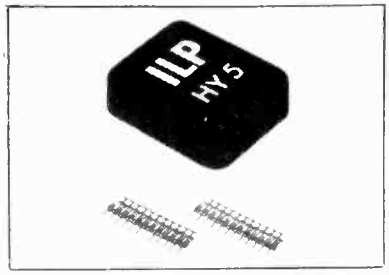
A few years ago, when pocket calculators really hit the fan, and predictions of an innumerate future for our descendants were rife, the debate became fairly heated. Calculators were good if you thought they would instil an interest in arithmetic and bad if you considered them only a way of avoiding it. Now, the talking seems to have stopped, and I am left wondering whether the O-level candidates of 1978 exhibit any marked arithmetical differences to those of 1972 or 1973. To those who claimed that constant use of a calculator would atrophy children's reasoning powers and expose them to disaster if caught calculatorless came the reply that these devices are only an extension of log. tables and the slide rule — both very respectable calculating aids. Not only that, it was said, but you had only to let a youngster loose with a calculator and in no time at all he would develop an inquiring and perspicacious mind. Well, I wonder. Admittedly, my own boy discovered the pattern of sevenths and ninths for himself, but he was so overcome with emotion that he must have decided his calculator was possessed. At any rate, he hasn't used it since.

Are children still taught their "times" tables? My own weren't, I remember, but I suspect that was because their teacher didn't know them either and was far too engrossed in implanting the rudiments of binary notation and Boolean algebra into their pathetically trusting little minds. There must now be a number of school leavers in that locality who can see that 1 and 1 make 10, but who aren't terribly sure about two and two. My wife, who teaches infants, bless her, tells me that the educationists' search for a method of avoiding educating children is gradually calming down a bit and that they are now floating less than a foot off the ground. When their feet touch, that's when I shall stop being resentful at paying my rates.

15—240 Watts!

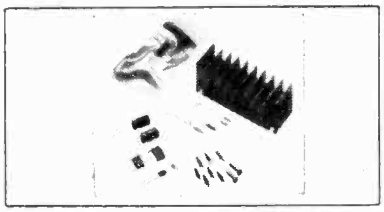
HY5
Preamplifier

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



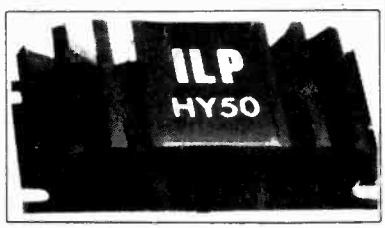
HY30
15 Watts into 8Ω

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



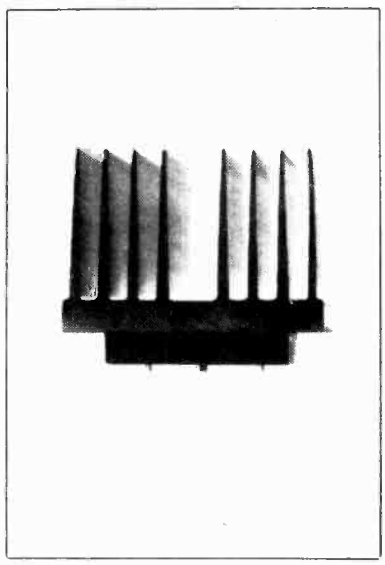
HY50
25 Watts into 8Ω

The HY50 leads I.L.P.'s total integration approach to power amplifier design. The amplifier features an integral heatsink together with the simplicity of no external components. During the past three years the amplifier has been refined to the extent that it must be one of the most reliable and robust High Fidelity modules in the World.
FEATURES: Low Distortion — Integral Heatsink — Only five connections — 7 Amp output transistors — No external components.
APPLICATIONS: Medium Power Hi-Fi systems — Low power disco — Guitar amplifier.
SPECIFICATIONS: INPUT SENSITIVITY 500mV.
OUTPUT POWER 25W RMS in 8Ω LOAD IMPEDANCE 4-16Ω. DISTORTION 0.04% at 25W at 1kHz.
SIGNAL/NOISE RATIO 75dB. FREQUENCY RESPONSE 10Hz-45kHz — 3dB.
SUPPLY VOLTAGE ± 25V. SIZE 105·50·25mm.
Price £6.82 + 85p VAT P&P free



HY120
60 Watts into 8Ω

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

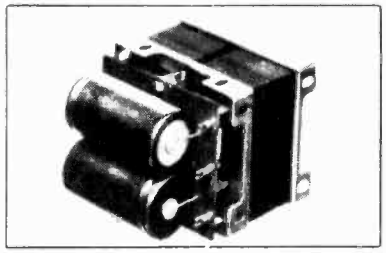


HY200
120 Watts into 8Ω

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

HY400
240 Watts into 4Ω

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



POWER SUPPLIES

PSU36 suitable for two HY30's **£5.22** plus 65p VAT P/P free.
PSU50 suitable for two HY50's **£6.82** plus 85p VAT P/P free.
PSU 70 suitable for 2 HY 120's **£13.75** plus £1.10 VAT P/P free.
PSU90 suitable for one HY200 **£12.65** plus £1.01 VAT P/P free.
PSU180 suitable for two HY2000's or one HY400 **£23.10** plus £1.85 VAT P/P free.
B1 **48p** plus 6p VAT.

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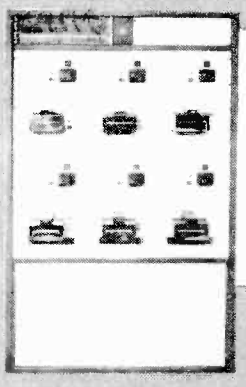
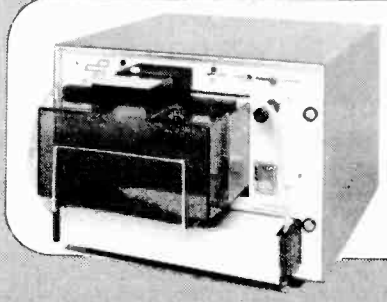
If International Telecommunications is your line you should see our 'CAT'.



1

Torn Tape Relay Console
Typical of our custom building capability.



Model 770 Paper Tape Punch
5 or 8 level code.
Up to 600 Baud.
High reliability.

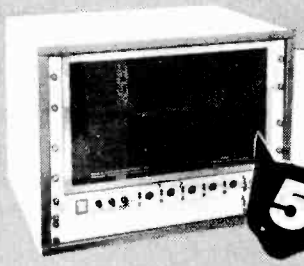
2

3

Model 724
Dual Head Transmitter with automatic heading and numbering.

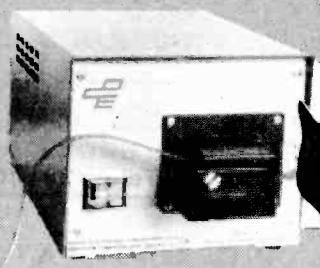
Edi-Tel V.D.U.
For telegraph message preparation and editing.
5 unit code.
4,000 character storage.

4



5

Model 730 and 731
Teleprinter line and message switching systems.



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Model 754 Auto Transmitter
Universal 5, 6 or 8 level code.
50-1200 Baud.
Full/half/quarter rate, self clock. Built in signalling supply.

7

Code Converters Models 752, 772, 710.
Available with tape reader, tape punch or direct on line. ASCII, Baudot, TTS, EBCDIC to/from conversion.

Model 750
Teleprinter tape to Morse Code converter (illustrated).

Model 723
Single Head Transmitter.
With auto heading and numbering

8

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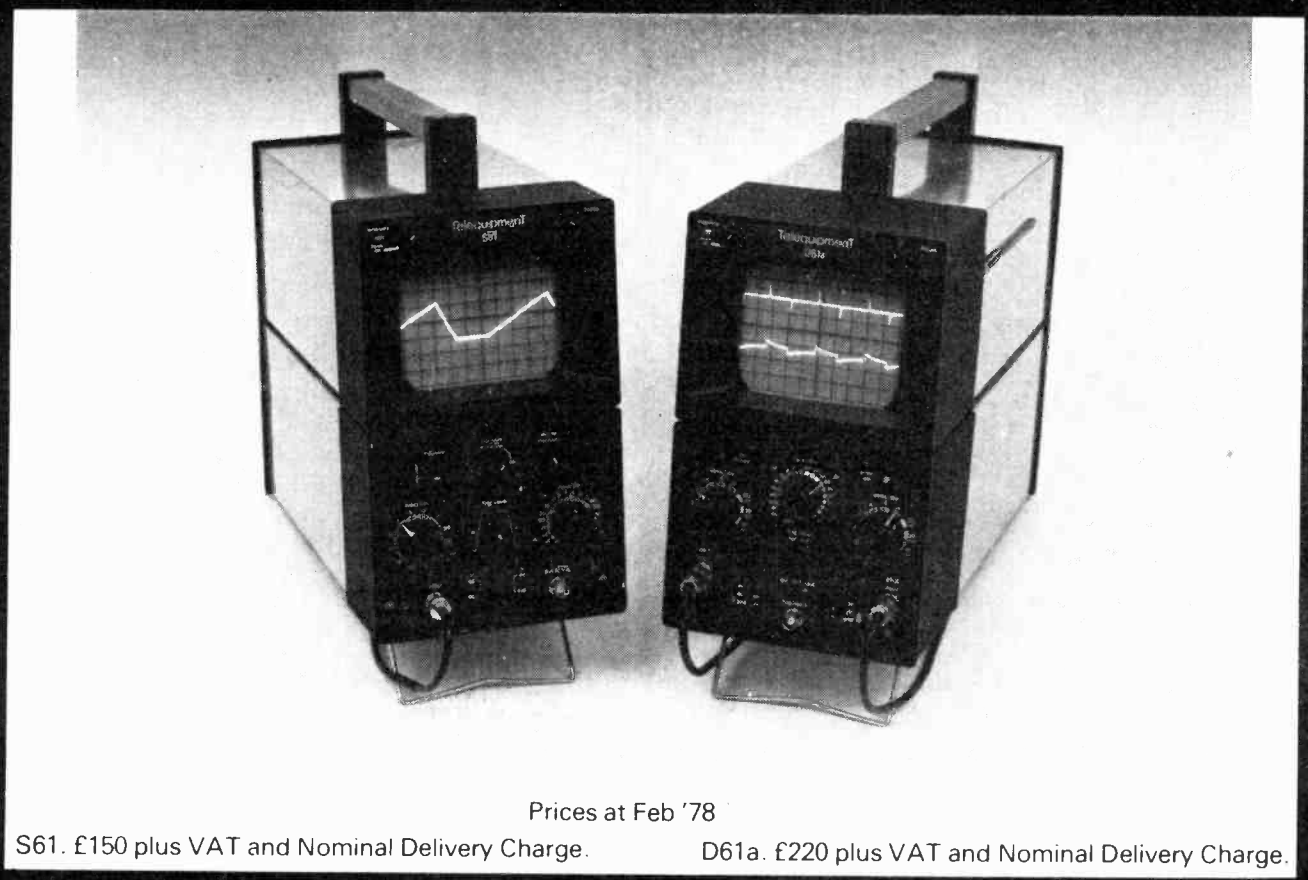

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S61. £150 plus VAT and Nominal Delivery Charge.

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When it comes to deciding on a general purpose oscilloscope for the laboratory or the service department, you have a choice between single or dual trace models and medium or high bandwidth.

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THE DYNAMIC DUO

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

A novel feature is that the amplifier is automatically switched on or off by sensing the power line of the radio/tape unit hence alleviating the need for an on/off switch.

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

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

C15/15
15 Watts per channel into 4Ω
Distortion 0.2% at 1KHz at 15 watts
Frequency response 50Hz - 30KHz
Input Impedance 8Ω nominal
Input sensitivity 2 volts R.M.S. for 15 watts output
Power line 10 - 18 volts
Open and Short circuit protection
Thermal protection
Size 4 × 4 × 1 inches

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

Data on S15
6" Diameter
5¼" Air Suspension
2" Active Tweeter
20oz Ceramic magnet
15 Watts R.M.S. handling
50 HZ - 15KHz frequency response
4Ω Impedance

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

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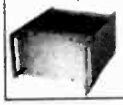
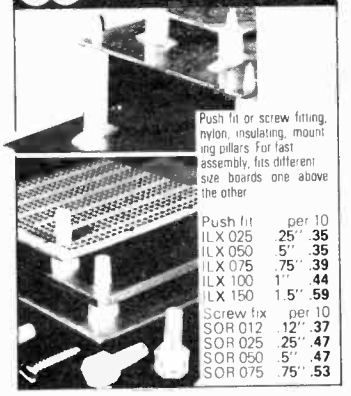
Adds sophistication to any equipment

In anodised aluminium with top and bottom panels grained black P.V.C.



	L	B	H	
BC2/121	432	268	89	23.01
BC2/222	219	268	89	16.63
BC3/121	437	268	133	25.24
BC3/222	219	268	133	18.61

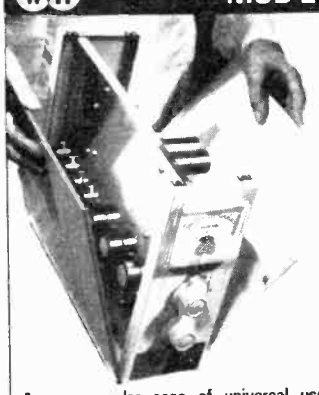
ILEX & SORREL



Push fit or screw fitting, nylon, insulating, mounting pillars. For fast assembly, fits different size boards one above the other

Push fit	per 10
ILX 025	.25" .35
ILX 050	.5" .35
ILX 075	.75" .39
ILX 100	1" .44
ILX 150	1.5" .59
Screw fix	per 10
SOR 012	.12" .37
SOR 025	.25" .47
SOR 050	.5" .47
SOR 075	.75" .53

MOD-2



A very popular case of universal use

Modular design. Stores flat. Chassis fixes between front and back panels of PVC/aluminium. Covers of PVC/steel. Cheap enough for production, ideal for development work.

MD2 A	9.05	MD2 I	14.51	MD2 Q	12.98
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MD2 E	10.90	MD2 M	10.67	MD2 U	17.92
MD2 F	12.80	MD2 N	11.48	MD2 V	16.77
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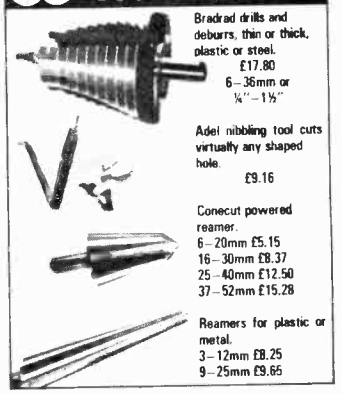
MD2 H	12.36	MD2 P	11.36	MD2 X	24.10

Send for catalogue

Prices are correct at time of going to press. Prices are one off inc P&P, but not VAT. Discounts for quantities.

Note new address

CUTTING TOOLS



Bradrad drills and deburrs, thin or thick, plastic or steel.
£17.80
6–36mm or ¼"–1½"

Adel nibbling tool cuts virtually any shaped hole.
£9.16

Conecut powered reamer.
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16–30mm £8.37
25–40mm £12.50
37–52mm £15.28

Reamers for plastic or metal.
3–12mm £8.25
9–25mm £9.65

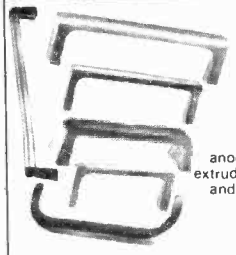
KNOBS

Send for Mentor Catalogue

Hundreds of knobs to choose from

West Hyde stock thousands of knobs: collet, screw fixing, plastic, aluminium, fluted, textured, smooth, wing, pointer, insulated, slow motion, digital, crank handle, heavy-duty, contemporary, dual, diamond turned. With shafts 3 mm to 10 mm and diameters from 8 mm to 58 mm. See catalogue for prices

HANDLES



West Hyde have a wide range of high quality handles in nylon, chromium, anodised, flush, extruded, carrying and heavy duty.

Chromium from **81p** Extruded from **2.19**
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Pivoting from **4.37**
Flush precision from **5.28**
V. heavy duty from **8.25**

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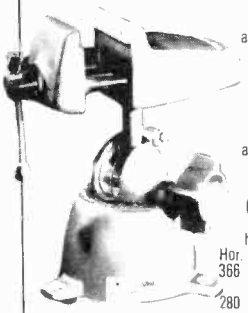

The Panavice has a 180° tilt action and turns a full circle locking in any position. Has a unique system of interchangeable components in world wide use. (See catalogue)

303 Vert. vice head **8.44** 304 Hor. vice head **9.05**
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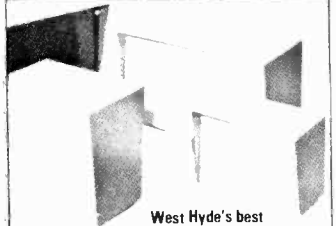
West Hyde have the greatest range of instrument cases

CONTIL



West Hyde's best selling case, strong, rigid and smart

	L	B	H	
CON 755	178	127	127	8.68
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CON 867	203	152	178	10.30
CON 177	305	178	178	11.86
CON 161	406	305	178	16.36
CON 191	489	267	267	22.53
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Best selling range of Textured blue acrylic steel eyebrow cases. Front panels white or PVC/aluminium, also unpainted up to size 1277

SWIFT

Swiftcase wins industrial design award at Hanover

A case for good looks, strength and efficiency. Particularly suitable for applications needing power dissipation.

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SWF 212	432	268	88.9	18.70
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SWF 312	432	268	133.4	22.26
SWF 322	219	268	133.4	17.74

CONTIL WOODEND

Leather textured PVC steel body with polished teak ends.

Two wooden ends and two tie bolts, result in a simple, light, inexpensive case. A toroidal transformer of 130W is available to fit. Ideal for Hi Fi applications and domestic and office equipment

	L	B	H	
WEC 801	202	240	80	12.80
WEC 802	417	240	80	14.97
WEC 803	550	240	80	16.29

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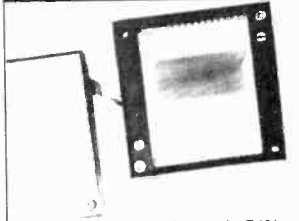
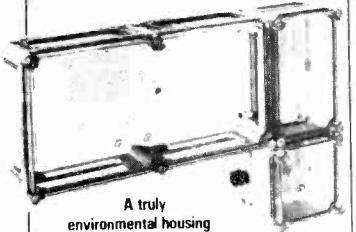


The ready-made DIN case you have been waiting for

Heavy aluminium extrusions lock rigidly together providing, heat dissipation, screening and strength, with provision for 16 P.C. boards and quick component mounting. To order: *See catalogue*

DIN 217	6.01	DIN 215	7.10	DIN 914	10.07
DIN 213	6.25	DIN 912	8.19	DIN 915	11.01
DIN 214	6.57	DIN 913	9.01		

ENCASE



A truly environmental housing

EnCase solves your waterproof and dustproof problems and because of its chemical resistance is ideal as the process industries. The polycarbonate is virtually unbreakable. Covers clear PC. Case – glass filled PC. Gaskets (screws incl, gland plates (hinges available)

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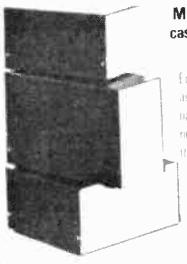
ENC B	280	190	130	11.56
ENC C	380	190	130	15.40
ENC D	280	280	130	16.03
ENC E	380	280	130	20.51
ENC F	560	280	130	28.51
ENC G	560	380	130	39.29

SAMOS



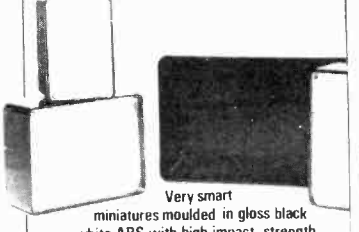
Miniature PVC/steel cases with hundreds of uses

Equipment can be assembled in the lower half which is flanged for rigidity, completed, tested, then the top cover is sprung into place.

Moulded plug in feet included

	L	B	H		L	B	H	
S1	50	100	50	1.36	S5	100	125	75	2.24
S2	100	150	50	1.56	S6	150	125	75	2.63
S3	150	100	50	1.74	S7	200	125	75	2.32
S4	50	125	75	1.96					

MINOS

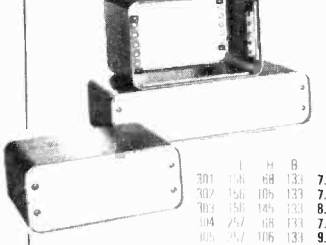


Very smart miniatures moulded in gloss black or white ABS with high impact strength

Front panels in aluminium, white PVC/steel or moulded. Guides for P.C.Bs, dividers or screens, also internal pillars for 'P' clips. Recess on the back for decals etc.

		L	B	H	
MIN 020	100	85	50	.73
MIN 025	135	85	50	.85
MIN 030	135	100	50	.94
MIN 040	200	130	65	1.77

MOD-3



	L	H	B	
301	156	68	133	7.19
302	156	106	133	7.39
303	156	145	133	8.59
304	257	68	133	7.85
305	257	106	133	9.19
306	257	145	133	10.99

Attractive gloss blue PVC/Steel cases of wrap-round construction. Removable front and back panels give full access. Grey PVC/steel panels accept Letraset. Supplied with W.H. self adhesive feet. Black cases also available, slight extra cost.

All West Hyde cases are available with substantial discounts for quantities. Most cases have discounts at 5, 10 and 25 off with discounts up to 25% at 100 off.

NOTE NEW ADDRESS

Prices include P & P and are less 10% if collected on first two price breaks on cases only. Send for catalogue. Prices correct at press date.

WEST HYDE DEVELOPMENTS LIMITED, Unit 9, Park Street Industrial Estate, AYLESBURY, BUCKS. HP20 1ET. Phone: Aylesbury (0296) 20341. Telex: 83570

WW—080 FOR FURTHER DETAILS

TTLs by TEXAS

7400	16p	74107	36p
74H00	28p	74109	89p
74S00	63p	74110	55p
74LS00	30p	74111	90p
7401	18p	74116	200p
7402	18p	74118	84p
7403	18p	74120	120p
7404	23p	74121	32p
74H04	36p	74122	54p
7405	25p	74123	76p
7406	43p	74125	73p
7407	43p	74126	70p
7408	25p	74128	75p
7409	27p	74132	70p
7410	18p	74136	75p
74H10	28p	74141	75p
7411	24p	74142	320p
7412	25p	74145	90p
7413	36p	74147	190p
7414	75p	74148	160p
7416	33p	74150	140p
7417	36p	74151	72p
7420	18p	74153	85p
7421	40p	74154	150p
7422	22p	74155	90p
7423	37p	74156	90p
7425	30p	74157	90p
7427	37p	74159	190p
7428	36p	74160	120p
7430	18p	74161	120p
7432	36p	74162	120p
7437	36p	74163	120p
7438	36p	74164	120p
7440	19p	74165	220p
7441	75p	74166	160p
7442	70p	74167	340p
7443	140p	74170	250p
7444	140p	74172	720p
7445	120p	74173	160p
7446	100p	74174	120p
7447	85p	74175	85p
7448	80p	74176	120p
7450	18p	74177	120p
7451	20p	74179	160p
7453	20p	74180	110p
7454	18p	74181	298p
7460	18p	74182	82p
7470	36p	74184	160p
7472	30p	74185	150p
7473	34p	74186	920p
7474	34p	74190	160p
74LS74	56p	74191	160p
7475	45p	74192	120p
7476	36p	74193	160p
7480	50p	74194	120p
7481	95p	74195	95p
7482	90p	74196	120p
7483	90p	74197	120p
7484	110p	74198	250p
7485	120p	74199	250p
7486	34p	74221	160p
7489	320p	74251	140p
7490	40p	74265	90p
7491	85p	74278	290p
7492	55p	74279	140p
7493	40p	74283	190p
7494	90p	74290	150p
7495	70p	74293	150p
7496	84p	74298	200p
7497	340p	74365	150p
74100	120p	74366	150p
74104	65p	74390	200p
74105	65p	74393	225p

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CD4017AE	100p
CD4018AE	110p
CD4019AE	52p
CD4020AE	120p
CD4022AE	100p
CD4023AE	22p
CD4024AE	80p
CD4025AE	22p
CD4026AE	170p
CD4027AE	65p
CD4028AE	98p
CD4029AE	120p
CD4030AE	55p
CD4035AE	131p
CD4040AE	120p
CD4042AE	90p
CD4043AE	100p
CD4046AE	140p
CD4047AE	100p
CD4049AE	63p
CD4050AE	57p
CD4054AE	120p
CD4055AE	140p
CD4056AE	135p
CD4059AE	600p
CD4060AE	130p
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CD4516AE	112p
CD4518AE	130p
CD4520BE	100p
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CD4560BE	250p

MEMORIES

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2107	1000p
2112-2	300p
2114	1500p
2708	2500p
2716	4000p
6810A	400p
8080A	1200p
8212	200p
8224	400p
8228	700p
8245	450p
8251	800p
8255	800p
8T28	225p
AY-5-1013	600p
AY-5-2376	1100p
RO-3-2513	800p
X887	1360p

OP. AMPS

1458	Dual Op. Amp Int. Comp.	8 pin DIL	70p
301A	Ext. Comp.	8 pin DIL	36p
3130	COSMOS/Bi-Polar MosFet	8 pin DIL	100p
CA3140	BIMOS	8 pin DIL	100p
CA3160	Int. Comp.	8 pin DIL	200p
LM318N	High speed	8 pin DIL	200p
LM324N	Quad. Op. Amp.	14 pin DIL	120p
LM348N	Quad. Op. Amp.	14 pin DIL	125p
NE531V	High slew rate	8 pin DIL	140p
NE543K	Servo Amp.	TO99	200p
3900	Quad. Op. Amp.	14 pin DIL	70p
709	Ext. Comp.	8/14 pin DIL	36p
741	Int. Comp.	8/14 pin DIL	22p
747	Dual 741	14 pin DIL	70p
748	Ext. Comp.	8/14 pin DIL	36p
776	Programmable Op. Amp.	TO-5	180:

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★AY-1-0212	Tone Generator	16 pin DIL	600p
★CA3028A	Diff. Cascade Amp.	TO5	95p
★CA3046	5 Transistor Array	14 pin DIL	80p
★CA3048	Quad. Low Noise Amp	16 pin DIL	200p
★CA3053	Diff. Cascade Amp.	TO5	70p
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★LM389N	Aud. Amp +3 Trs. Array	18 pin DIL	160p
LM3911N	Temp Controller	8 pin DIL	150p
★MC1310P	FM Stereo Dec.	14 pin DIL	190p
★MC1351P	Lim/Det. Aud Preamp	14 pin DIL	97p
MC1495L	Multiplier	14 pin DIL	450p
★MC1496L	Bal. Mod/Demod.	14 pin DIL	100p
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NE567	PLL Tone Dec.	8 pin DIL	200p
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★SN76008	10W Amp in 4 ohms	5 pin Plastic	250p
★SN76013N	Pwr Aud Amp with int HS	16 pin DIL	140p
★SN76018	10W Amp in 8 ohms	5 pin Plastic	250p
★SN76023N	Pwr Aud Amp with int HS	16 pin DIL	140p
★SN76033N	Pwr Aud Amp with int HS	16 pin DIL	230p
★SP8515	Prescaler 450MHz ÷ 10	16 pin DIL	675p
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★TAA661B	FM IF Amp-Limiter/Det.	QIL	120p
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★TBA810	7W Audio Amp.	QIL	100p
★TBA820	2W Audio Amp.	QIL	60p
★TCA940	10W Audio Amp.	QIL	200p
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ZN1034E	Precision Timer	14 pin DIL	200p
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DL707 Red/Green	140p	TIL313	110p
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FND 357	120p	TIL330 ÷ 1	140p
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Drivers: 75491 **84p**. 75492 **96p**. 9368/9370 **200p**

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1A100V TO5	80p	4A/400V	Plastic	63p
1A400V TO5	90p	★MCR101 0.5A/15V	TO-92	35p
3A400V Stud	100p	2N3525		
7A400V TO5+HS	90p	5A/400V	TO-66	120p
12A400V Plastic	160p	2N4444		
16A100V Plastic	160p	8A/600V	Plastic	185p
16A400V Plastic	180p	★2N5060		
16A600V Plastic	220p	0.8A/30V	TO-92	34p

TRANSISTORS

AC125	35p	BFY50	22p	2N3055	65p
AC126	25p	BFY51	22p	2N3439	67p
AC127	25p	BFY52	22p	2N3442	140p
AC128	25p	BFY90	90p	★2N3565	30p
AC141	20p	BRY39	45p	★2N3643	48p
AC142	20p	BSX19	20p	★2N3644	48p
AC176	25p	BSX20	20p	★2N3702	12p
AC187	25p	★BU105	140p	★2N3703	12p
AC187K	30p	BU108	250p	★2N3704	12p
AC188	25p	★BU205	200p	★2N3705	12p
AC188K	30p	★BU208	300p	★2N3706	12p
AD149	49p	★MJE340	65p	★2N3707	12p
AD161	45p	MJ481	175p	★2N3708	12p
AD162	45p	MJ491	200p	★2N3709	12p
AF114	30p	MJ2501	225p	2N3773	300p
AF115	30p	MJ2955	120p	2N3866	90p
AF116	30p	MJE2955	130p	★2N3903	18p
AF117	30p	MJ3001	225p	★2N3904	18p
AF127	25p	MJE3055	70p	★2N3905	20p
AF139	43p	★MPSA06	30p	★2N3906	18p
AF239	48p	★MPSA12	50p	2N4036	70p
BC107/B	9p	★MPSA56	32p	2N4058	15p
BC108/B	9p	★MPSU06	62p	★2N4059	10p
BC109/B	10p	★MPSU56	78p	★2N4060	13p
BC109C	12p	OC28	140p	★2N4123	22p
★BC117	22p	OC35	140p	★2N4124	22p
★BC147	9p	OC36	140p	★2N4125	22p
★BC148	9p	★OC71	20p	★2N4126	22p
★BC149C	10p	★R2008B	200p	★2N4289	20p
★BC157	11p	★R2010B	200p	★2N4401	27p
★BC158	10p	★TIP29A	40p	★2N4403	27p
★BC159	11p	★TIP29C	55p	2N4427	90p
★BC169C	12p	★TIP30A	48p	★2N5087	27p
★BC172	11p	★TIP30C	60p	★2N5089	27p
BC177	18p	TIP31A	52p	2N5191	85p
BC178	17p	TIP31C	52p	2N5194	90p
BC179	18p	TIP32A	58p	2N5296	55p
★BC182	12p	TIP32C	82p	★2N5401	50p
★BC183	12p	TIP33A	90p	2N6034	160p
★BC184	13p	TIP33C	115p	2N6107	55p
BC187	30p	TIP34A	115p	2N6247	190p
★BC212	11p	TIP34C	160p	(Comp to 2N3055)	
★BC213	10p	TIP35A	225p	2N6254	130p
★BC214	14p	TIP35C	290p	2N6292	65p
BC461	36p	TIP36A	270p	40290	250p
BC478	30p	TIP36C	340p	40360	40p
★BC516	60p	TIP41A	65p	40361	45p
★BC517	65p	TIP41B	70p	40362	45p
BCY70	18p	TIP41C	78p	40364	120p
BCY71	22p	TIP42A	70p	40409	80p
BCY72	18p	TIP42B	78p	40410	85p
BD131	63p	TIP42C	82p	40411	300p
BD132	85p	TIP2955	78p	40636	130p
★BD135	48p	★TIS93	30p	40594	100p
★BD136	50p	★ZTX108	10p	40595	110p
★BD139	52p	★ZTX300	13p	40871	80p
★BD140	58p	★ZTX500	15p	40872	84p
BDY56	200p	2N457A	190p		
BF115	22p	2N697	22p	**FETs**	
BF167	23p	2N698	45p	★BF244B	36p
BF170	23p	2N706	20p	★BF256B	70p
BF173	25p	2N708	20p	★MPF102	45p
BF177	26p	2N918	40p	★MPF103	40p
BF178	28p	2N930	18p	★MPF104	40p
BF179	33p	2N1131	18p	★MPF105	40p
BF180	33p	2N1132	18p	★2N3819	25p
BF184	22p	2N1304	75p	★2N3820	50p
★BF194	10p	2N1305	75p	2N3823	57p
★BF195	9p	2N1306	75p	★2N5245	40p
★BF196	14p	2N1307	75p	★2N5457	40p
★BF197	15p	2N1308	75p	★2N5458	40p
BF200	32p	2N1309	75p	★2N5459	40p
BF257	32p	2N1613	25p	★2N5460	70p
BF258	36p	2N1711	25p	★2N5485	40p
BF259	45p	2N1893	30p		
BF337	30p	2N2102	55p	**MOSFETs**	
★BFR39	30p	2N2219	20p	3N128	96p
★BFR40	30p	2N2222	20p	3N140	95p
★BFR41	30p	2N2369	14p	3N141	95p
★BFR79	30p	2N2484	30p	3N187	180p
★BFR80	30p	2N2904/A	25p	3N201	80p
BFR81	30p	2N2905/A	25p	3N204	80p
★BFR88	30p	2N2906/A	24p	40603	63p
BFX29	30p	★2N2926R	7p	40673	90p
BFX30	34p	★2N2926B	7p	40841	80p
BFX84	30p	★2N2926O	10p	**UJTs**	
BFX85	30p	★2N2926Y	12p	★TIS43	34p
BFX86	30p	★2N2926G	12p	2N2160	120p
BFX87	30p	2N3053	22p	2N2646	48p
BFX88	30p	2N3054	65p	★2N4871	65p

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75107	180p	81LS97	170p	9322	150p
75182	200p	81LS98	170p	9324	150p
75324	400p	9302	175p	9334	175p
75325	400p	9308	315p	93417	400p
75450	85p	9310	275p	93427	400p
75451	72p	9312	160p	93436	650p
75452	72p	9314	165p	93446	650p

DIODES

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OA47	9p
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OA90	9p
OA91	9p
OA95	8p
OA200	8p
OA202	10p
IN914	4p
IN916	9p
IN4148	4p
RECTIFIER	
★BY100	25p
★BY126	12p
★BY127	10p
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IN4002	5p
IN4004	6p
IN4005	6p
IN4007	7p
IN5401	13p
IN5404	18p
IN5407	23p
ZENER	
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★400mW	9p
★1W	18p

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★1A 200V	30p
★1A 400V	32p
★1A 600V	36p
★2A 50V	30p
★2A 100V	35p
★2A 200V	40p
★2A 400V	45p
★3A 200V	60p
★3A 600V	72p
★4A 100V	84p
★4A 400V	90p
6A 50V	90p
6A 100V	96p
6A 200V	108p
6A 400V	120p
10A 400V	270p
25A 400V	400p

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Plastic

Amp	Volts	
3	400	85p
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6	500	107p
10	400	120p
10	500	140p
15	400	160p
15	500	180p
40430		130p
40669		130p
DIAC		
BR100		30p

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5V	7805	115p	5V	7905	160p
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15V	7815	115p	15V	7915	160p
18V	7818	115p	18V	7918	160p
24V	7824	115p	24V	7924	160p

LM309K 1 Amp 5V TO3 **140p** T8A6258 12V 0.5A TO5 **120p**
LM309H 100mA 5V TO5 **75p** LM323K 3A 5V **700p**

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TL470 2V to 30V 100mA TO-92 **70p**

100mA TO92

+5V	70p
+12V	70p
+15V	70p
−5V	80p
−12V	80p

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8 pin **13p**, 14 pin **14p**, 16 pin **15p**, 18 pin **36p**, 22 pin **40p**, 24 pin **50p**, 28 pin **60p**, 40 pin **75p**.

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This is first-grade 1/16" board coated with positive resist. The sensitised surface is protected with removable light-proof adhesive film making it possible to handle boards in normal lighting and to cut to exact size prior to exposure

Standard board 204mm x 114mm	£1.50
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Developer — **40p**. Ferric Chloride — **75p**

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Approx 3.18mm thick — Single-sided **£1.25** square foot; Double-sided **£1.50** square foot

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Approx 1.0mm thick — Single-sided **£1.50** square foot; Double-sided **£1.75** square foot

FOTOLAK Light-sensitive lacquer

Positive resist in handy aerosol form. Just spray board, allow to dry, place positive of required circuit on sensitised surface, expose, develop and etch. **You** can produce your own perfect circuits within minutes rather than weeks! Widely accepted by industry as the perfect medium for all prototype work. One can will coat 1-1½ square metres of board **£1.80** per can inclusive

Computer Boards containing:

21 ICs, 24 Diodes, resistors, capacitors	£1.00
17 ICs, 26 Diodes, 3 Reed relays, etc	£1.00
8 BC107B, 8 BCY 70, approx. 80 other components, 2 for	£1.00
Copper-clad paxolin 245mm x 150mm x 1/16" Pack of 10 sheets	£2.50
Edge Connectors 18 x 2" Pack of 10	£1.00
Vero Boards 90mm x 90mm x 1", pack of 8	£3.00

Colour convergence controls, 10 assorted **£1.00;** 1N4005, 15 **£1.00;** Plastic 8C108C, 10 **£1.00;** 1N4148, 20 **£1.00;** BY126, 10 **£1.00;** **MEU 22 (PUJ) 8 £1.00**, MJE 340, 4 **£1.00;** 2N3053 equiv., 10 **£1.00;** Silicon diodes, 100 **£1.00;** Zener BXY88 type zener, untested, 200 **£1.00;** Resistors, assorted 100 **£1.00;** Capacitors, s/mica, ceramic etc., 100 **£1.00;**

3,000 reels 10" diameter ½" magnetic tape, used once only, all in excellent condition, packed in individual tins and cardboard outers. **OPEN TO OFFERS!!**

12 Volt Fluorescent Lighting

12" 8-watt fittings	£3.75
21" 13-watt fittings	£5.00
Complete with tube	
Inverter transformers	£1.00

SPECIAL OFFER!!! Orders over £10 **£1 Credit voucher** included for each £10 value of order **£15 Credit voucher** included with £100 orders!!!! This offer is for a limited period only! Order today!

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POSTAGE AND VAT INCLUDED

369 ALUM ROCK RD. B'HAM B8 3DR

NEW PRODUCTS!

NRDC-AMBISONIC UHJ

SURROUND SOUND DECODER

The **first ever** kit specialy produced by Integrex for this British NRDC backed surround sound system which is the result of 7 years' research by the Ambisonic team. W.W. July, Aug., '77.
The unit is designed to decode not only UHJ but virtually all other 'quadrophonic' systems (Not CD4), including the new BBC HJ 10 input selections.
The decoder is linear throughout and does not rely on listener fatiguing logic enhancement techniques. Both 2 or 3 input signals and 4 or 6 output signals are provided in this most versatile unit. Complete with mains power supply, wooden cabinet, panel, knobs, etc.

Complete kit, including licence fee **£45.00** + VAT
or ready built and tested **£61.50** + VAT

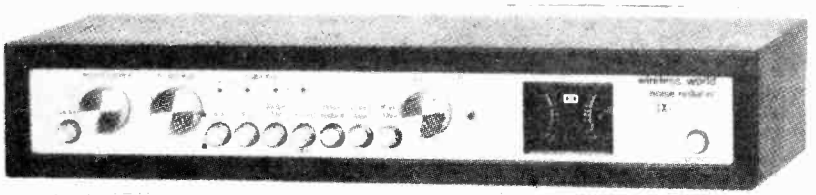
INTRUDER 1 RADAR ALARM

With Home Office Type approval
As in "Wireless World", designed by Mike Hosking, 240V ac mains operated and disguised as a hardbacked book. Detection range up to 30 feet.

Complete exclusive designer approved kit **£46.00** + VAT
or ready built and tested, **£54.00** + VAT

Wireless World Dolby™ noise reducer

Trademark of Dolby Laboratories Inc.



Featuring:
- switching for both encoding (low-level h.f. compression) and decoding
- a switchable f.m. stereo multiplex and bias filter
- provision for decoding Dolby f.m. radio transmissions (as in USA)
- no equipment needed for alignment.
- suitability for both open-reel and cassette tape machines.
- check tape switch for encoded monitoring in three-head machines.

Typical performance
Noise reduction better than 9dB weighted.
Clipping level 16.5dB above Dolby level (measured at 1% third harmonic content)

Harmonic distortion 0.1% at Dolby level typically 0.05% over most of band, rising to a maximum of 0.12%

Signal-to-noise ratio: 75dB (20Hz to 20kHz, signal at Dolby level) at Monitor output

Dynamic Range >90db

30mV sensitivity

Complete Kit **PRICE: £39.90** + VAT

Also available ready built and tested ..... **Price £54.00** + VAT

Calibration tapes are available for open-reel use and for cassette (specify which) ..... **Price £2.20** + VAT

Single channel plug-in Dolby™ PROCESSOR BOARDS (92 x 87mm) with gold plated contacts are available with all components ..... **Price £8.20** + VAT

Single channel board with selected fet ..... **Price £2.50** + VAT

Gold Plated edge connector ..... **Price £1.50** + VAT *

Selected FETs **60p** each + VAT, **100p** + VAT for two, **£1.90** + VAT for four

Please add VAT @ 12½% unless marked thus *, when 8% applies (or current rates)

We guarantee full after-sales technical and servicing facilities on all our kits, have you checked that these services are available from other suppliers?

Buy it with Access · EUROCARD · BARCLAYCARD · master charge THE INTERBANK CARD

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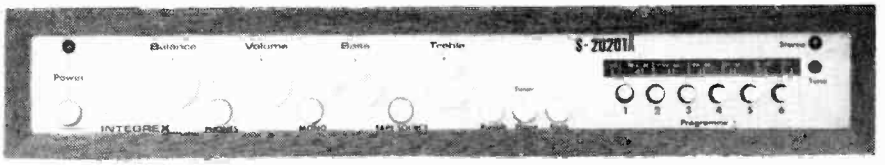
INTEGREX LTD.

Portwood Industrial Estate, Church Gresley,
Burton-on-Trent, Staffs DE11 9PT
Burton-on-Trent (0283) 215432 Telex 377106

INTEGREX

S-2020TA STEREO TUNER/AMPLIFIER KIT

SOLID MAHOGANY CABINET



A high-quality push-button FM Varicap Stereo Tuner combined with a 24W r.m.s. per channel Stereo Amplifier.

Brief Spec. Amplifier Low field Toroidal transformer, Mag, input, Tape In/Out facility (for noise reduction unit, etc.), THD less than 0.1% at 20W into 8 ohms. Power on/off FET transient protection. All sockets, fuses, etc., are PC mounted for ease of assembly. Tuner section uses 3302 FET module requiring no RF alignment, ceramic IF, INTERSTATION MUTE, and phase-locked IC stereo decoder. LED tuning and stereo indicators. Tuning range 88—104MHz. 30dB mono S/N @ 1.2μV. THD 0.3%. Pre-decoder 'birdy' filter.

PRICE: £58.95 + VAT

NELSON-JONES STEREO FM TUNER KIT

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

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

Compare this spec. with tuners costing twice the price.

Mono £32.40 + VAT
With ICPL Decoder £36.67 + VAT
With Portus-Haywood Decoder £39.20 + VAT

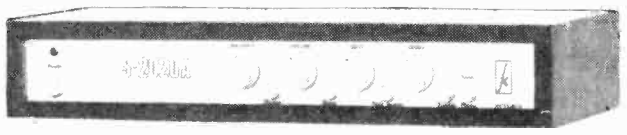
STEREO MODULE TUNER KIT

A low-cost Stereo Tuner based on the 3302 FET RF module requiring no alignment. The IF comprises a ceramic filter and high-performance IC Variable INTERSTATION MUTE. PLL stereo decoder IC. Pre-decoder 'birdy' filter Push-button tuning

Sens. 30dB S/N mono @ 1.2μV
THD typically 0.3%
Tuning range 88—104MHz
LED sig. strength and stereo indicator

PRICE: Stereo £31.95 + VAT

S-2020A AMPLIFIER KIT



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

Power 'on/off' FET transient protection.

Typ Spec. 24+24W r.m.s. into 8-ohm load at less than 0.1% THD. Mag. PU input S/N 60dB. Radio input S/N 72dB. Headphone output. Tape In/Out facility (for noise reduction unit, etc.). Toroidal mains transformer

PRICE: £33.95 + VAT

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

BASIC NELSON-JONES TUNER KIT	**£14.28** + VAT	**PHASE-LOCKED IC DECODER KIT**	**£4.47** + VAT
BASIC MODULE TUNER KIT (stereo)	**£16.75** + VAT	**PUSH-BUTTON UNIT**	**£5.00** + VAT

PORTUS-HAYWOOD PHASE-LOCKED STEREO DECODER KIT . . . . . **£8.00** + VAT

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

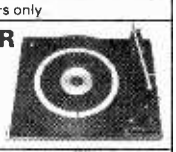
BSR HI-FI AUTOCHANGER
STEREO AND MONO £21.50 Post 75p

Plays 12", 10" or 7" records. Auto or Manual. A high quality unit backed by BSR reliability with 12 months' guarantee. A.C 200/250V. Size 13½-11¼in 3 speeds. Above motor board 3¾in. 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

PORTABLE PLAYER CABINET
Modern design. Rexine covered Vynair front grille. Chrome fittings Size 17 x 15 x 8in. approx **£4.50** Post 75p
Motor board cut for BSR or Garrard deck

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 **£7.50**
Model 'B' Size 16 x 13¾ x 7in
Extra large plinth & cover teak wood base. Size 20"x17½"x9" **£18.50.** Callers only

BSR SINGLE PLAYER



ideal replacement or disco deck with cueing device and stereo ceramic cartridge. 3 speeds Large turntable, modern design
£15.50 Post 75p

ELAC HI-FI SPEAKER 8in. TWIN CONE

Dual cone plastic roll surround. Large ceramic magnet 50-16,000 c/s. Bass resonance 40 c/s 8 ohm impedance 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.**

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. **£11.25;** Stereo. **£18.** 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.

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

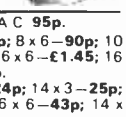
E.M.I. 13½ x 8in. SPEAKER SALE!

With twin 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 D C **95p.** 6V D C **85p.** 240V A C **95p.**
BLANK ALUMINIUM CHASSIS. 6 x 4—**70p;** 8 x 6—**90p;** 10 x 7—**£1.15;** 12 x 8—**£1.35;** 14 x 9—**£1.50;** 16 x 6—**£1.45;** 16 x 10—**£1.70. ANGLE ALI.** 6 x ¾ x ¾in—**15p.**
ALUMINIUM PANELS. 6 x 4—**17p;** 8 x 6—**24p;** 14 x 3—**25p;** 10 x 7—**35p;** 12 x 8—**43p;** 12 x 5—**30p;** 16 x 6—**43p;** 14 x 9—**52p;** 12 x 12—**68p;** 16 x 10—**75p.**
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.** GP93 **£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
£17 Post 35p
Kit of parts to build a 3 channel sound to light unit 1,000 watts per channel
Easy to build. Full instructions supplied Cabinet **£4.**
Will operate from 20MV to 100 watt signal

R.C.S. LOW VOLTAGE STABILISED POWER PACK KITS
£2.95 Post 45p
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

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

R.C.S. GENERAL PURPOSE TRANSISTOR PRE-AMPLIFIER — BRITISH MADE
Ideal for Mike, Tape, P.U., Guitar, etc Can be used with battery 9-12V or H.T. line 200-300V d.c operation. Size 1¾ x 1¼ x ¾in Response 25 c/s to 25 kc/s 26 dB gain **£1.45**
For use with valve or transistor equipment Post 30p
Full instructions supplied Details S.A.E

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 50p

250-0-250V 70mA, 6 5V, 2A	£3.45
250-0-250V 80mA 6 3V 3 5A, 6 3V 1A or 5V 2A	£4.60
350-0-350V 80mA 6 3V 3 5A 6 3V 1A or 5V 2A	£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	£1.40
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	£1.00	12V 100mA	£1.00
20V 3 amp	£2.45	12V 30V 40V 2 amp	£2.75
30V 5 amp and 17V 0-17V 2 amp	£3.45	40V 2 amp	£2.95
0.5 8 10 16V ½ amp	£1.95	20V 1 amp	£2.20
9V 3 amp	£2.75	20V-0-20V, 1 amp	£2.95
24V 3 amp + 48V ½ amp	£3.50	30V-0-30V 2 amp	£7.00
30V 1½ amp	£2.75	2 of 18V, 6 amp	£9.00
		12-0-12V 2 amp	£2.95

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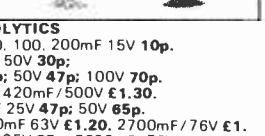
12V 1½ amp Half Wave Selenium Rectifier **25p**

R.C.S. BOOKSHELF SPEAKERS

13 × 10 × 6in
50 to 14,000 cps
8 watts rms 8 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.**
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5000mF 6V **25p;** 12V **42p;** 35V **85p.** 5600mF/76V **£1.75**
MANY OTHER ELECTROLYTICS IN STOCK

SHORT WAVE 100pF air spaced gangable tuner. **95p.**
TRIMMERS 10pF, 30pF, 50pF, **5p.** 100pF, 150pF. **15p.**
CERAMIC, 1pF to 0.01mF. **5p.** Silver Mica 2 to 5000pF. **5p.**
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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. ¼W, ½W, 1W, 20% **2p;** 2W, **10p;** 10Ω to 10M
HIGH STABILITY. ½W 2% 10 ohms to 6 meg. **12p.**
Ditto 5% Preferred values 10 ohms to 10 meg. **5p.**

ELECTRO MAGNETIC PENDULUM MECHANISM
1.5V d.c operation over 300 hours continuous on SP2 battery, fully adjustable swing and speed Ideal displays, teaching electro magnetism or for metronome, strobe, etc **95p** Post 30p.

BAKER MAJOR 12" £15.00
Post £1.00

30-14,500 c/s. 12in. double cone, woofer and tweeter cone together with a BAKER ceramic magnet assembly having a flux density of 14,000 gauss and a total flux of 145,000 Maxwells. Bass resonance 40 c/s. Rated 25W. NOTE 4 or 8 or 16 ohms must be stated.

Module kit, 30-17,000 c/s with tweeter, crossover, baffle and instructions. **£19.00** Post £1.60 each
Please state 4 or 8 or 16 ohms.

BAKER "BIG-SOUND" SPEAKERS. Post £1.00 each

'Group 25'	'Group 35'	'Group 50/15'
12in 30W **£12.00** 4 or 8 or 16 ohm	12in. 40W **£14.00** 4 or 8 or 16 ohm	15in 75W **£26.00** 8 or 16 ohm

BAKER LOUDSPEAKER, 12 INCH. 60 WATT. GROUP 50/12, 4 OR 8 OR 16 OHM HIGH POWER. FULL RANGE PROFESSIONAL QUALITY RESPONSE 30-16,000 CPS MASSIVE CERAMIC MAGNET WITH ALUMINIUM PRESENCE CENTRE DOME **£21.00** Post £1.60

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
For 6½in. speaker and tweeter 12x8x6in. **£5.80** Post 75p
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.**
De Luxe Horn Tweeters 3-18kc/s. 30W 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.
PIEZO ELECTRIC HORN TWEETER. Handles up to 100 watts No crossover required. **£7.95.**

Plastic Construction Box with brushed ali facia. 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. **£75** £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.

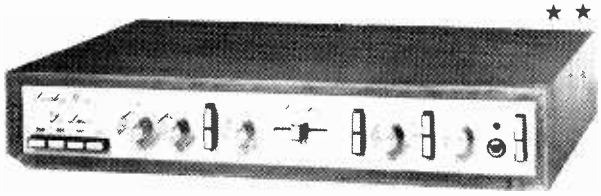
MONO PRE-AMPLIFIER. Mains operated solid state pre-amplifier unit designed to complement amplifiers without low level phono and tape input stages This free-standing cabinet incorporates circuitry for automatic R.I.A.A equalisation on magnetic phono input and N.A.B equalisation for tape heads. Power ON/OFF. 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

RADIO COMPONENT SPECIALISTS
337 WHITEHORSE ROAD, CROYDON
Open 9-6. Wed. 9-1. Sat. 9-5 (Closed for lunch 1.15-2.30)
Radio Books and Components Lists 10p. (Minimum posting charge 30p.) Cash prices include VAT. (We accept Access or Barclaycard. Phone your Order) **Tel. 01-684 1665**

AUDIO KITS OF DISTINCTION FROM POWERTRAN

NEW! DE LUXE EASY TO BUILD LINSLEY-HOOD 75W AMPLIFIER



AVAILABLE AS SEPARATE PACKS
PRICES IN OUR FREE CATALOGUE

SPECIAL PRICE FOR COMPLETE KIT £99.30

The standard model of our kit for Mr. Linsley Hood's 75 watt design has for a long time offered exceptional performance at a very modest cost with high quality high power ready built units of comparable quality generally being over three times the price.

Features of the amplifier include very low distortion (less than 0.01%), 75W rms per channel power output, rumble filter, variable slope scratch filter, variable transition frequency tone controls, tape monitoring facilities and individually adjustable inputs. This model is based on 5 circuit boards which not having the controls mounted on them can, if desired, be effectively used separately in high performance audio systems not based on our metalwork.

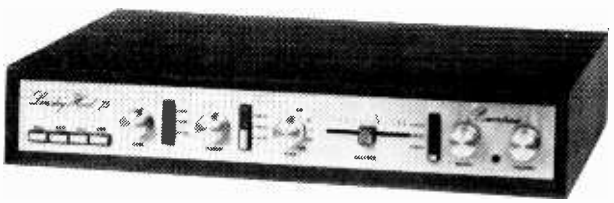
Our new De Luxe model uses 14 boards which interconnect with gold plated contacts and are designed to have the potentiometers and switches mounted upon them. This system almost eliminates internal wiring, making installation after their assembly delightfully straightforward, and as each board can be easily removed in seconds from the chassis, checking and maintenance is so simple that even newcomers to electronics will be able to cope competently with the kit. Additional features of our new model are inclusion of the latest circuit improvements, generously sized heat sinks for heavy duty use, even in tropical climates, and metal oxide resistors throughout for long term stability and reliability.

PACK PRICES FOR STANDARD KIT

Pack	Price
1. Fibreglass printed circuit board for power amp	£1.15
2. Set of resistors, capacitors, pre-sets for power amp	£2.50
3. Set of semiconductors for power amp	£6.50
4. Pair of 2 drilled, finned heat sinks	£1.10
5. Fibreglass printed-circuit board for pre-amp	£1.90
6. Set of low noise resistors, capacitors, pre-sets for pre-amp	£4.10
7. Set of low noise, high gain semiconductors for pre-amp	£2.40
8. Set of potentiometers (including mains switch)	£3.50
9. Set of 4 push-button switches, rotary mode switch	£5.40
10. Toroidal transformer complete with magnetic screen/ housing primary: 0 117-234 V: secondaries: 33-0-33 V, 25-0-25 V	£12.95
11. Fibreglass printed-circuit board for power supply	£0.85
12. Set of resistors, capacitors, secondary fuses, semiconductors for power supply	£5.40
13. Set of miscellaneous parts including DIN skts., mains input skt., fuse holder, interconnecting cable, control knobs	£6.20
14. Set of metalwork parts including silk screen printed fascia panel and all brackets, fixing parts, etc.	£8.20
15. Handbook	£0.30
16. Teak cabinet 18.3" x 12.7" x 3.1"	£10.70

2 each of packs 1-7, 1 each of packs 8-16 inclusive are required for complete stereo amplifier. Total cost of individually purchased packs £92.80

STANDARD LINSLEY-HOOD 75W AMPLIFIER



SPECIAL PRICE FOR COMPLETE KIT £79.80

WIRELESS WORLD FM TUNER

SPECIAL PRICE FOR COMPLETE KIT £70.20

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

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.D. 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. Teak cabinet 18.3" x 12.7" x 3.1"	£10.70

One each of packs 1-14 inclusive are required for complete stereo cassette deck. Total cost of individually purchased packs £83.00

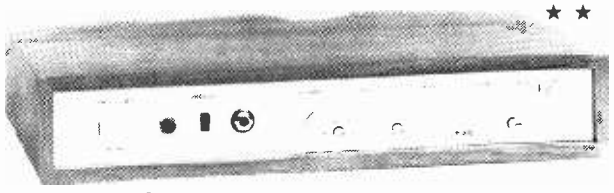
Matsushita WY 436 AZ head (optional extra) £4.50 (free with compete kit)

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 back ground. Push button switches are used to provide a choice of equalization time constants, a choice of bias levels and also an option of using an additional pre-amplifier for microphone use. The mechanism used is the Goldring-Lenco CRV, a unit distinguished in its robustness and ease of operation. Speed control and automatic cassette ejection are both implemented by electronic circuitry. This unit which is powered by a toroidal transformer and uses metal oxide resistors throughout offers an excellent match for the Wireless World Tuner and the Linsley-Hood 75 Watt Amplifier. 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!

Pack	T20	T30
1. Set of low noise resistors	£1.60	£1.70
2. Set of small capacitors	£2.60	£3.40
3. Set of power supply capacitors	£2.20	£2.50
4. Set of miscellaneous parts	£3.50	£3.50
5. Set of slide, mains, P.B. switches	£1.50	£1.50
6. Set of pots., selector switch	£2.80	£2.80
7. Set of semiconductors, ICs, skts.	£7.25	£7.75
8. Toroidal transformer—240V prim. e.s. screen	£5.60	£7.20
9. Fibreglass PCB	£3.50	£3.90
10. Set of metalwork, fixing parts	£5.20	£6.20
11. Set of cables, mains lead	£0.40	£0.40
12. Handbook	£0.25	£0.25
13. Teak cabinet 15.4" x 6.7" x 2.8"	£4.50	£4.50

One each of Pack 1-13 are required for complete stereo amplifier. Total cost of individually purchased packs T20+20 £40.90, T30+30 £45.60.

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

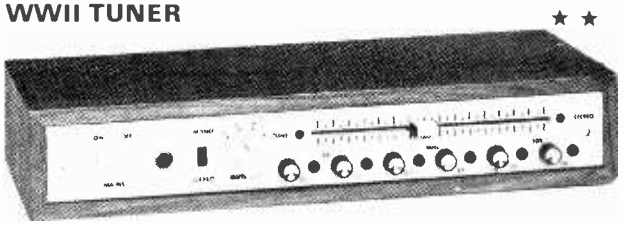
T30+30 KIT PRICE £38.40

EXPORT A SPECIALITY!

Our Export Department can readily despatch orders of any size to any country in the world. Some of the countries to which we sent kits last year are shown in this advertisement. To assist in estimating postal costs our catalogue gives the weights of all packs and kits. This will be sent free on request, by airmail together with our 'Export Postal Guide' which gives current postage prices.

EXPORT ORDERS: No minimum order charge! Prices same as for U.K. customers but no Value Added Tax charged. Postage charged at actual cost plus 50p documentation and handling. Please send payment with order by Bank Draft, Postal Order, International Money Order or cheque drawn on an account in the U.K. Alternatively for orders over £500 we will accept Irrevocable Letter of Credit payable at sight in London.

WWII TUNER

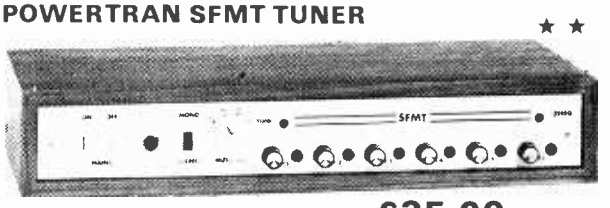


SPECIAL PRICE FOR COMPLETE KIT £47.70

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. The frequency meter of the more advanced model has been omitted and the mechanics simplified however the circuitry is identical and this kit offers most outstanding value for money. Facilities included are switchable afc, adjustable, switchable muting, LED tuning indication and both continuous and push-button channel selection (readily adjusted by controls on the front panel).

POWERTRAN SFMT TUNER



PRICE FOR COMPLETE KIT £35.90

AVAILABLE AS COMPLETE KIT ONLY

The requirement was a simple, low cost design which could be constructed easily without special alignment equipment but which still gives a first class output suitable for feeding any of our very popular amplifiers or any other high quality audio equipment. Not finding a suitable published circuit, the requirement was met by design and development work in our own laboratories and this tuner, which uses a pre-aligned front end module can be set up with the aid of nothing more sophisticated than a multi-meter. A phase-locked-loop is used for stereo decoding and controls include switchable afc, switchable muting and push-button channel selection (adjustable by controls on the front panel). This unit matches well with the **T20+20** and **T30+30** amplifiers.

INTERNATIONAL POWERSLAVE 200 watt AMPLIFIER

NEW!

COMPLETE KIT AS FEATURED IN ELECTRONICS TODAY INTERNATIONAL

Super-Fi performance for studio/monitoring/h-fi use with the inherent reliability and ruggedness for the most demanding group/disco applications.

Features

- ★ over 200W rms continuous from each of 2 totally independent DC coupled amplifiers — over 800W peak power!
- ★ highly original fully complementary high linearity o/p stage utilizing the inherent symmetry of no less than 4 differential pairs!
- ★ ultra low feedback (an incredible low 14dB overall!) together with super high slewing rate (20/μS) banish ricochet effects and TID!
- ★ distortion only 0.03% at FULL power 1KHz rising to only 0.07% at 10KHz (how many high power amplifier producers dare to quote at this frequency?)
- ★ independent stabilized power supplies driven by custom designed TOROIDAL transformers
- ★ inherent reliability — monster heat sinks for cool running at the hottest venues — electronic open and short circuit protection — 4 rugged power transistors/amplifier — each 250W rating
- ★ professional quality — metal oxide resistors, cermet adjusters, fibre glass boards, sturdy 19" rack mounting cabinet complete with sleeve and feet for free standing work too
- ★ easy to build — plenty of working space with ready access to all components, minimal wiring, extensive instructions suitable for both experienced constructors and newcomers to electronics — can be purchased one channel at a time
- ★ value for money — quality and performance comparable with ready-built amplifiers costing over £600!

PSI 4001 SLAVE MODEL

OVER 800W PEAK POWER!

PSI 4002 STUDIO MODEL

Pack	Price
1. Fibre glass printed circuit board for power amp	£4.20
2. Set of capacitors, metal oxide resistors, thermistor, cermet pre-sets for power amp	£6.40
3. Set of semiconductors for power amp with mounting hardware, cooling tabs	£27.60
4. Pair of monster black drilled heat sinks, transistor mounting bracket	£6.90
5. Toroidal transformer. Primary 0-117V-234V. Secondaries 42-0-42V, 0-15V, 0-15V. Electrostatic screen	£19.20
6. Set of all parts for stabilized power supply including fibre glass printed circuit board, mounting bracket, semiconductors, resistors, capacitors, etc	£20.50
7A. Set of all parts for buffer/overdrive unit including fibre glass printed circuit board, semiconductors, resistors, capacitors, controls — required for PSI 4001 only	£3.00
7B. Set of parts for peak power meter including professional quality meter, fibre glass printed circuit board, components, controls — required for PSI 4002 only	£11.50
8. Set of all miscellaneous parts including sockets, illum. mains switches, fuse holders, fuses, cut-outs, cable, etc	£12.10
9. Cabinet, including chassis, anodised silver on black panels, fixing parts etc. Please state whether Sleeve or Studio model required	£27.50
10. Handbook £0.50 or free on request when ordering any of above packs.	
2 each of packs 1-7 (A or B). 1 each 8, 9 and 10 are required for complete 200 + 200W professional amplifier.	
Total cost of individually purchased packs	PSI 4001 £216.80
	PSI 4002 £232.20

SPECIAL OFFER PRICES FOR COMPLETE KITS — (PSI 4001 £205.00 — PSI 4002 £220.00)

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
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
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
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
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
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

SQ QUADRAPHONIC DECODERS

These state of the-art circuits described by CBS are offered as kits of superior quality with close tolerance capacitors, metal oxide resistors and Fibreglass PCBs designed for edge connector insertion. Further information on these kits is given in our FREE CATALOGUE.

M1 Basic matrix decoder	£5.90
L1 Full logic decoder	£17.20
L2A Full logic decoder with variable blend	£22.60
L3A As L2A but with high performance discrete component front end (or with carbon film resistors)	£30.10 £25.90
SQM1 30 Decoder complete with 30W rear channel amplifiers. Complete kit matches T30+30 amplifier	£40.75

Value Added Tax not included in prices
UK Carriage FREE

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 May 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 at current rate if changed).

SECURICOR DELIVERY: For this optional service (U.K. mainland only) add £2.50 (VAT inclusive) per kit.

SALES COUNTER: If you prefer to collect your kit from the factory, call at Sales Counter (at rear of factory). Open 9 a.m.-4.30 p.m. Monday-Thursday.

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

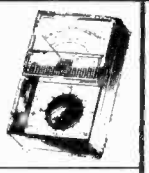
DEPT. WW4

POWERTRAN ELECTRONICS

PORTWAY INDUSTRIAL ESTATE, ANDOVER
ANDOVER HANTS SP10 3NN (0264) 64455

SERVICE TRADING CO

WHY PAY MORE?!



MULTI RANGE METERS Type MF15A A.C./D.C volts 10 50 250 500 1000 Ma 0-5 0-10 0-100 Sensitivity 2000V 24 range. diameter 133 x 93 x 46mm Price **£6.50** plus 50p P&P (**£7.56** inc VAT & P)

TRIAC.

Raytheon tag symmetrical Triac Type Tag 250/500v 10 amp 500 piv Glass passivated plastic triac Swiss precision product for long term reliability **£1.25** P&P 10p (**£1.46** inc VAT & P) (inclusive of date and application sheet) Suitable Diac **22p.**

0 to 60 MINUTES CLOCKWORK TIMER.

Double pole 15 amp 230AC Contacts (no dial) **£1.50**. P&P 30p (**£1.94** inc VAT & P)

MERCURY SWITCH

Size 27mm x 5mm 10 for **£5.00** (inc VAT **£5.72**) Min quantity 10

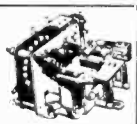
CONTACTOR

Mfg by Hendrey Relays. type C2839 220/250 AC ops. Contact 4C/O at 20 amp at 440 volts AC. price **£6.00** P&P 75p (**£7.29** inc VAT & P)

230 VOLT AC FAN ASSEMBLY

Powerful continuously rated AC motor complete with 5 blade 6½" aluminium fan. New reduced price **£3.00** P&P 65p (**£3.94** inc VAT & P)

21-WAY SELECTOR SWITCH with reset coil



The ingenious electro mechanical device can be switched up to 21 positions and can be reset from any position by energising the reset coil 230/240v A.C. operation. Unit is mounted on strong chassis. Complete with cover. Price **£5.50** P&P 75p (**£6.75** inc VAT & P)

VORTEX BLOWER AND VACUUM UNIT

Dynamically balanced to fully enclosed 9" rotor with max air delivery of 1.5 cubic metres per min. Max static pressure 600mm W.G. Suction or blow from 2 side-by-side 37mm I.D. circular apertures fitted to base of unit. Powerful continuously rated 115v a.c. motor mounted on alloy base with fixing facilities. Dimensions: Length 22cm x width 25cm x height 25cm.

These units are ex-equipment but have had minimum use. Fully tested prior to despatch. Price **£12** + £1.50 P&P (**£14.58** inc VAT & P) Suitable transformer for 230/240v a.c **£6** + £1 P&P (**£7.56** inc VAT & P)

CENTRIFUGAL BLOWER

Mfg. by Smiths Industries 230/240v a.c. Miniature Model Series SE7200. Size 95mm x 82mm x 82mm. Aperture 38mm x 31mm. 12 c.f.m. **£2.75.** Post 50p (**£3.51** inc. VAT & P).

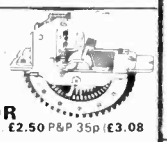
Smith type FFB 1906 022 220. 240v A.C. Aperture 10x4½cm overall size 16x14cm Price **£3.75** p&p 75p (inc VAT **£4.86**). Other types available phone for details.

NI-CAD BATTERY

	Height (mm)	Width (mm)	Length (mm)
35 AH 1.2v Metal	219	75	29

Postage 30p per unit

UNISELECTOR SWITCH



4 bank 25 way 75 ohm coil. 36-48v D.C. operation. Ex **new** equipment. **£4.25,** P&P 75p. Total price inc VAT. **£5.40.**

MINIATURE UNISELECTOR

12v. 11 way 4 bank (3 non-bridging, 1 homing). **£2.50** P&P 35p (**£3.08** inc VAT & P)

MICRO SWITCHES

As illustrated but fitted with 1" Lever. 10 for **£2.00** P&P 30p (**£2.48** inc VAT & P)

Sub-miniature Burgess type v 41 1. 10 for **£2.50** P&P 30p (**£3.02** inc VAT & P).

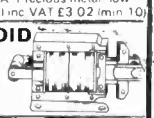
50 for **£10.00** post paid (**£10.80** inc VAT & P)

Type 3 115M 906T 10 for **£2.50** post paid (**£2.70** inc VAT & P)

BF lever operated 20a c/o. mf. Unimax USA. 10 for **£4.00** plus 50p P&P (min. order 10) (**£4.86** inc VAT & P).

D.P. C/O lever m/switch. mfg by Cherry Co. USA. Precious metal low resistance contacts. 10 for **£2.50.** P&P 30p. Total inc VAT £3.02 (min 10).

NEW HEAVY DUTY SOLENOID



Mfg. by Magnetic Devices. 240v. A.C. Operation approx. 20lb pull at 1.25". Price **£7.00** P&P 75p (**£8.37** inc VAT & P)

Similar to above approx. 10lb pull **£3.50** P&P 60p (**£4.43** inc VAT & P)

230-250 VOLT A.C. SOLENOID

Similar in appearance to illustration. Approximately 1½lb pull. Size of feet 1⅜" x 13/16". Price **£1.00** Post 25p (**£1.35** inc VAT & P)

24 VOLT D.C. SOLENOIDS

UNIT containing **1 heavy duty solenoid approx. 25 lb. pull** at 1 in travel. 2 solenoids of approx 1 lb. pull at ½ in. travel. 6 solenoids of approx 4 oz. pull at ½ in. travel. Plus 1 24V D.C. 1 heavy duty 1 make relay. Price **£3.00** Post £1.00 (**£4.32** inc VAT & P)

ABSOLUTE BARGAIN

240 A.C. SOLENOID OPERATED FLUID VALVE

Rated 1 p.s.i. will handle up to 7 p.s.i. Forged brass body, stainless steel core and spring ½ in. b.s.p. inlet outlet. Precision made. British mfg.

PRICE **£2.75** Post 50p (**£3.57** inc VAT & P)

VARIABLE VOLTAGE TRANSFORMERS

INPUT 230 v. A.C. 50/60

OUTPUT VARIABLE 0/260v. A.C.

BRAND NEW. All types.

200W (1 Amp) fitted A/C volt meter	**£12.50**
0.5 KVA (Max. 2½ Amp)	**£15.00**
1 KVA (Max. 5 Amp)	**£19.50**
2 KVA (Max. 10 Amp)	**£32.00**
3 KVA (Max. 15 Amp)	**£39.50**
4 KVA (Max. 20 Amp)	**£60.00**

Carriage extra

LT TRANSFORMERS

0-12v/24v at 1 amp **£2.50** p&p 50p (**£3.24** inc VAT & P)

0-15v at 1 amp + 0-15v at 1 amp. 3vv 1 amp **£2.50** p&p 50p. **£3.24** inc VAT & P.

25-0-25v at 2½ amp **£4.50** p&p 75p (**£5.67** inc VAT & P)

0-12v/24v 10 amp **£12.35** p&p £1.50 (**£14.96** inc VAT & P)

0-4v/6v/24v/32v at 12 amp **£13.00** p&p £1.50 (**£15.66** inc VAT & P)

0-12v at 20 amp or 0-24v at 10 amp **£12.00** p&p £1.50 (**£14.58** inc VAT & P)

0-6v/12v/17v/18v/20v at 20 amp **£14.00** p&p £1.50 (**£16.74** inc VAT & P)

0-6v/12v at 20 amp **£11.85** p&p £1.00 (**£13.88** inc VAT & P)

Other types in stock, phone in enquiries

COMPRESSOR,

precision built by Emerson USA. Horizontally opposed twin head diaphram type producing 20lbs. Plus P.S.I. per head 3.5 plus C.F.M. Output virtually pulse free. Powered by 110v A.C. motor size 30x23x15cm. Weight 7 kilos. **Price £20** p&p £2.00 (inc VAT **£23.76).**

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230 volts AC 3 digits mfg. Veeder Root type LL/144L **£1.75** P&P 25p (**£2.16** inc VAT & P)

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Tiny precision built 3 rpm USA motor size only 1 x 1. 100 volt AC op. supplied with resistor for 230 volt AC price **£2.37** p&p 20p. 4 for **£5.40** post paid.

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Test to I.E.E. spec. Rugged metal construction, suitable for bench or field work, constant speed clutch. Size L. 8 in. W. 4 in. H. 6 in., weight 6 lb.

500 VOLTS 500 megohms

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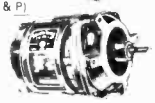
100 R.P.M. 115 lbs. ins.!!

115 lb. ins. 110 volt 50Hz 2.8 amp. single phase, split capacitor motor. Immense power. Continuously rated. Totally enclosed. Fan cooled. In-line gearbox. Length 250mm. Dia. 135mm. Spindle Dia. 15.5mm. Length 145mm. ex-equipment tested **£12.00** Post £1.50 (**£14.58** inc. VAT & P). Suitable transformer 230/240 volt **£8.00** Post 75p (**£9.45** inc. VAT & P).

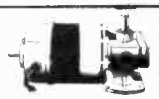
BODINE TYPE GEARED MOTOR



(Type 1) 71 r.p.m. torque 10 lb. in. **Reversible** 1/70th h.p. cycle 38 amp. This U.S.A. motor is offered in with transformer for 230/240v AC input. Price type **£6.25** Post 75p (**£7.56** inc. VAT & P) or less transformer **£3.75** Post 65p (**£4.75** inc VAT & P). (Type 3) 71 r.p.m. 230 volt A.C. Continuously rated. Non reversible **£6.50** Post 75p (**£7.83** inc. VAT & P).

28 r.p.m., 20lb. inch approx. 115v a.c. Reversible similar to above drawing. Mag. by Wynstruments. Price **£4.75** + 75p p&p. Total inc. VAT £5.94 inc. transf. 230/240v a.c. **£7.25** + p&p £1. Total inc. VAT £8.91.

FRACMO



96 rpm 50lb. ins. 24 v. AC. reversible. 0.7 amp. stall length 35mm. 1¼" bore. weight 6 kilos 600 grams. Price **£15.00** P&P 1.50 (**£17.82**).

PARVALUX GEARED MOTOR

Type 50/18 24 v. AC. reversible. 60 rpm. 30lbs. inch. Price **£15.00** P&P 1.50 (**£17.82** inc. VAT).

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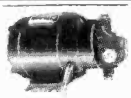
200/240v a.c. motor. 2850 rpm. 480w approx. 1/3 hp. driving a centrifugal pump with 1½" inlet and outlet delivering approx. 40 galls. per min. at 10ft. head. Ideal for pumping or circulating any non corrosive light viscosity liquid. Dozens of uses in industrial labs. etc. Note this pump is not self priming. Price **£15** + 75p P&P (**£17.01** inc. VAT & P).

CITENCO 19 RPM



FHP motor type C 7333. 15 220/240v a.c. 19 rpm reversible motor. torque 14.5 kg. Gear ratio 144:1. Brand new. incl. capacitor. our price **£14.25** + £1.25 P&P (**£16.20** inc. VAT & P).

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General Electric 230v A.C. 1 600 r.p.m. 0.25 amp. Complete with anti-vibration mounting bracket and capacitor. O/A size 110mm x 95mm. Spindle 5/16" dia. 20mm long. Ex-equipment tested. **£3.00** Post 50p (**£3.78** inc. VAT & P).

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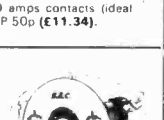
A.C. MAINS TIMER UNIT



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EBC33	0.50	GZ32	0.65	UABC80	0.60		
EBF80	0.50	GZ33	3.50	UBF80	0.55		
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ENF89	0.50	GZ37	2.50	UBL1	1.00		
EC52	0.40	KT66	4.00	UBL21	0.75		
ECC81	0.55	MH4	1.00	UCC85	0.50		
ECC82	0.50	ML6	1.00	UCF80	0.80		
EBC83	0.50	OA2	0.55	UCH81	0.60		
ECC84	0.45	OB2	0.60	UCL82	0.75		
ECC 85	0.50	PABC80	0.40	UF41	0.80		
ECC86	1.25	PC85	50	UL41	0.75		
ECC88	0.60	PC86	0.85	UL84	0.75		
ECC189	0.80	PC88	0.75	UM80	0.60		
ECF80	0.50	PC900	1.25	UY82	0.55		
ECF82	0.45	PCC84	0.45	UY85	0.50		
ECF801	0.75	PCC89	0.55	VR105/30	1.80		
ECH34	0.95	PCC189	0.65	VR150/30			
ECH35	1.50	PCF80	0.50		1.25		
ECH42	0.85	PCF82	0.40	X66	0.75		
ECH81	0.45	PCF84	0.65	X61M	1.50		
ECH84	0.95	PCF86	0.65	Z800U	3.00		
ECL80	0.60	PCF200	0.90	Z801U	3.50		
ECL82	0.55	PCF201	0.90	Z900T	1.50		
ECL83	1.20	PCF801	0.55	1A3	0.60		
ECL85	0.55	PCF802	0.65	1L4	0.30		
ECL86	0.55	PCF805	1.80	1R5	0.55		
EF36	0.75	PCF806	0.85	1S4	0.40		
EF37A	1.50	PCF808	1.00	1S5	0.40		
EF39	2.90	PCH200	0.80	1T4	0.40		
EF40	0.70	PCL81	0.60	1X2B	1.10		
EF41	0.75	PCL82	0.65	2021	0.55		
EF80	0.40	PCL84	0.70	2K25	9.00		
EF83	1.50	PCL86	0.70	2X2	0.80		
EF85	0.45	PCL805/85		3A4	0.60		
EF86	0.55		0.75	3D6	0.40		
EF91	0.65	PD500	2.25	3D21	20.00		
EF92	0.75	PFL200	0.85	3E29	5.50		
EF95	0.45	PL36	0.80	3S4	0.50		
EF183	0.55	PL81	0.75	3V4	0.85		
EF184	1.60	PL82	0.50	5B/254M	6.50		
EF804	2.00	PL83	0.50	5B/255M	6.50		
EFL200	0.75	PL84	0.65	5B/258M	6.50		
EH90	0.60	PL504	1.10	5R4GY	1.10		
EL32	0.60	PL508	1.30	5U4G	0.95		
EL34	2.20	PL509	2.40	5V4G	0.65		
EL37	3.00	PL802	2.80	5Y3GT	0.65		
EL41	0.80	PY33	0.60	5Z3	1.00		
EL81	0.70	PY80	0.60	5Z4G	0.70		

PLUMBICON TUBES TYPE XQ.1020R

Mullard—£150 each

5Z4GT	0.75	6X5GT	0.55	95A2	2.20		
6AB7	0.60	6Y6G	0.95	723A/B	9.00		
6AC7	0.60	6Z4	0.65	803	6.00		
6AH6	0.70	6-30L2	0.90	805	18.00		
6AK5	0.55	7B7	0.80	807	1.00		
6AK8	0.40	7V4	0.80	813	8.50		
6AL5	0.40	9D2	0.60	829B	5.50		
6AL5D	0.65	9D6	0.75	832A	4.50		
6AM5	1.60	11E2	11.00	866A	2.80		
6AM6	0.65	12A6	0.60	931A	6.00		
6AN8	0.85	12AT6	0.45	954	0.50		
6AQ5	1.30	12AT7	0.55	955	0.50		
6AQ5W	0.85	12AV7	0.50	956	0.50		
6AS6	0.80	12AV6	0.70	957	0.90		
6AT6	0.75	12AX7	0.50	1625	1.00		
6AU6	0.40	12BA6	0.50	1629	0.70		
6AV6	0.50	12BE6	0.60	2051	1.00		
6AX4GT	0.80	12BM7	0.60	5763	2.00		
6AX5GT	1.00	12C8	0.55	5842	6.50		
6B7	0.75	12E1	4.25	5933	3.00		
6BA6	0.40	12J5GT	0.40	6057	0.85		
6BE6	0.50	12K7GT	0.60	6060	0.85		
6BG6G	1.00	12K8GT	0.70	6064	0.85		
6BJ6	1.10	12Q7GT	0.50	6065	1.20		
6BQ7A	0.60	12SC7	0.55	6067	1.00		
6BR7	2.30	12SH7	0.70	6080	3.50		
6BW6	2.80	12SJ7	0.55	6146	3.80		
6BW7	1.00	12SQ7	0.55	6146B	4.20		
6C4	0.40	12Y4	0.40	6360	2.00		
6C6	0.55	14S7	1.00	8020	5.50		
6CH6	3.00	19AQ5	0.75	9001	0.40		
6CL6	0.75	19G3	10.00	9002	0.55		
6D6	0.50	19G6	6.00	9003	0.70		
6EA8	0.80	19H5	17.00	9004	0.40		
6F8G	0.75	20P3	0.60	9006	0.40		
6F12	0.65	20P4	1.10				
6F17	1.00	25L6GT	0.80	**C.R. Tubes**			
6F33	4.20	30C15	1.00	DG7-5	15.00		
6M6	4.20	30C17	1.10	DG7-32	18.00		
6J4WA	1.75	30C18		DG13-2	22.00		
6J5	0.75	see PCF805		MW13-35			
6J5GT	0.55	30F5	1.00		35.00		
6J6	0.50	30FL2	1.20	VCR139A			
6J7	0.75	30FL12	1.20		10.00		
6J7G	0.50	30FL14	1.00	3BP1	8.00		
6K7	0.50	30L15	1.00	88J	9.00		
6K7G	0.35	30L17	1.00	88L	9.00		
6K8GT	0.55	30P12	1.00	5FP7	10.00		
6L6M	1.90	30PL1	1.00	CV1526	10.00		
6L6GT	0.90	30PL13	1.10	SE3A/B31			
6L7G	0.65	30PL14	1.10		15.00		
6SA7	0.55	35L6GT	0.80	**Special Valves**			
6SG7	0.75	35W4	0.60	CV2339	45.00		
6SJ7	0.70	35Z4GT	0.70	K301	7.00		
6SJ7GT	0.50	50C5	0.70	KRN2A	6.00		
6SK7	0.60	50CD6G	1.20	725A	25.00		
6SL7GT	0.75	75	1.00	BR189	250.00		
6SN7GT	0.75	75C1	0.80	2J/52A	75.00		
6SQ7	0.75	76	0.80	CV5228	17.50		
6V6GT	0.75	78	0.75	Plumbicon			
6X4	0.60	80	0.75		150.00		
				P863B	20.00		
				2C39A	9.00		

POSTAGE: £1-£2 20p; £2-£3 30p; £3-£5 40p; £5-£10 60p; over £10 free.

VIDECON TUBE TYPE P863B
English Electric—£20

MARCONI SIGNAL GENERATORS

TF 2400/1 Frequency Converter up to 510MHz.
TF 894 A Audio Tester 50cs to 27kHz 2W into 15. 3Ω
AIRMEC
MODULATION METER 210A. 2·5-300MHz. AM 0-100%FMD+100kHz in 4 ranges.
HF WAVE ANALYSER 853 from 30kHz to 30MHz
VHF WAVE ANALYSER 248 Freq from 5MHz to 300MHz.
TF 801 D/1/S SIGNAL GENERATOR. Range 10-485MHz in 5 ranges. R F output 0·1 V-1V. Source C.M. 50Ω output impedance. Internal modulation at 1KHz at up to 90%
TF 801 B/2. Spec as for 8010 but minor circuit differences. Few only left.
TF 995 A/1 or A/2 or A/2M or A5 SIGNAL GENERATORS. Very high class AM/FM 1·5MHz to 220MHZ. Detailed spec and price on application
TF 995/3S with additional amplifier to give extra high output between 1·5 and 6 Mc/s
TF 144 H SIGNAL GENERATOR
HIGH FREQUENCY SPECTRUM ANALYSER. MARCONI TYPE 1094A/S. Basic Freq. range 3 to 30 Mc/s and with LF unit from 100Hz to 3 MHz. Measures relative amplitudes up to 60dB
TF1041 B VALVE MULTIMETER. DC voltage from 300mV to 1 000V. AC voltage from 300mV to 300V at up to 1,000MHz
TF1370 R.C. OSCILLATOR FOR SQUARE & SINE WAVE. Freq —31·6V rms. **TF1066 FM/AM SIGNAL GENERATOR.**

MARCONI TF 867 SIGNAL GENERATOR

Range 15KHz to 30MHz. Output 0·4 μV to 4V at 13 or 75 ohms. Impedance with termination (supplied). Built in crystal check facility with handbook. CT478, CT479, QT480 Signal Generators frequency from 1·3 KMS up to 11kMS. output up to 1mV CW and imp. mod.

LEVEL OSCILLATOR TYPE REL 3W29. Frequency from 0·3 to 1200Kc/s. Mod. ext. output from +16dB to —60dB. Impedance output 75, 140, 600 ohms.
36' AERIAL MASTS consisting of 6 sections 6' 8" × 2¼" dia. Complete with all accessories to erect and instal.
AVO CT 160 VALVE TESTER
LOW RESISTANCE HEADPHONES TYPE CLB £1.50. 40p postage. VAT 12½%.
AR88 D & LF SPARES. We hold the largest stock in UK. Write for list.
RF METERS. 0 to 8 amps. 2¼" dia. USA, brand new **£1.50.** P&P 25p.
TELEPHONE TYPE "J" tropicalised
10 LINE MAGNETO SWITCHBOARDS
CABLE LAYING APPARATUS No. 11. New production P.O.A.

FOR EXPORT ONLY

TRANSMITTER RECEIVER. Transmitter Type M9 receiver Type M17 with fixed frequency. Range 240MHz
RCA ET4336, 2 Mc/2·20 Mc/s. 350W, also modified version of increased output to 700W
Collins 231D 4·5kW. 3MHz-24MHz. 10 channel. Auto or manual tuning.
53 Transmitter
Mullard C11, High power installation. 1000W. Technical details and prices available on request.

VALVES AND TRANSISTORS

A lot of these valves are imported and prices vary for each delivery, so we reserve the right to change prices for new stock when unavoidable. Telephone enquiries for valves, transistors, etc., retail 749 3934; trade and export 743 0899.

RHODE & SCHWARZ

2-g DIAGRAPH TYPE 2DU 30·420MHz 50Ω. Directly measures multiterminal networks, phase shift, phase angle with complementary. POWER SIGNAL GENERATOR TYPE SMLM high freq resolution, internal external mod. up to 3v out.
FREQUENCY SYNTHESIZER TYPE XUA. 30Hz-30MHz with FREQUENCY INDICATOR TYPE FKM 15·30MHz, 30·100MHz.
UHF SIGNAL GENERATOR TYPE SMLM from 30 to 303MHz.
UHF SIGNAL GENERATOR TYPE SLSD from 300 to 300·940MHz.
FREQUENCY INDICATOR TYPE FKM from 30 to 1,000MHz.

TEKTRONIX

545A. Bandwidth DC to 30MHz.
570 CHARACTERISTIC CURVE TRACE
517A OSCILLOSCOPES wide band high voltage cathode ray oscilloscope designed for observing and photographically recording wave form having extremely short rise times.
DANA EXACT FUNCTION GENERATOR MODEL 121. Frequency range 0·2Hz to 2MHz (7 ranges) voltage controlled to 10V sweep generator 1ms to 10 sec.
TEKSCAN ELECTRONIC SYSTEM ANALYZER MODEL 9990. Frequency range 10MHz to 300MHz with market controls
FURZEHILL SENSITIVE VALVE VOLTMETER TYPE V200A full scale from 10mV to 1000V in 6 steps with output amplifier
TRAINING SET for Radio Operators with 10 key terminals and control frequency and volume
EDDYSTONE COMMUNICATIONS RECEIVER MODEL 730/1A. Frequency from 500kc/s to 28Mc/s
HIGH VACUUM VARIABLE CAPACITORS — ceramic envelope — UC 100A/20/150 = VMMHC 1000 60·1000pF 20kv·150A RF max = 27MHz
TEST SET FT2 for testing Transceivers A40, A41, A42 and CPRC26
UNIVERSAL WIRELESS TRAINING SET No 1 Mk 2 YA 8316 to train 32 operators simultaneously on key and phone. Complete installation consists of 3 kits packed in 3 special transit cases
HARNESS "A" & "B" CONTROL UNITS "A" "R" "J1" "J2." Microphones No 5, 6, 7 connectors, frames carrier sets etc

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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			
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			
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			
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

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.

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 **£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.

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 90-100-110-120v 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 13amp 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 **£10** carr £2.

SPECIAL OFFER OF HEAVY DUTY L.T. TRANSFORMER FRACTION OF MAKER'S PRICE

FOSTER Pri 240v sec 24v 200amps. Open type terminal connections **£60** ex stores.
HIRST Pri 240v sec 12v 200 amps **£35** ex stores.
GARDNERS Pri 200-220-240v sec 25v 30A twice will give 25v 60 amps or 50v 30 amps. C core type table top connection **£30** ex stores.
Pri 220-240v sec 100-0-100v 8 amps C core type **£25** carr £3.

HEAVY DUTY HT TRANSFORMERS

GARDNERS Pri 200-220-240v Size tapped 300-250-0-250-300v 4 amps (DC rating) open type **£30** ex stores.
COSSOR Pri 240v 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. PARMEKO Pri 240v sec 1875v 60M/A and 500v 31M/A. Potted type **£5.75** carr £2.

HT TRANSFORMERS BY FAMOUS MAKERS ALL PRIMARIES 240v

Open type tag connections.
Type MT33 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. 5·6·3v 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. MT8. Sec 350-0-350v 120M/A 6·3v ct 4A. 5v 2A or 6·3v 1A **£4.50** pp £1. MT7. Sec 350-0-350v 100M/A 6·3v 3·5A 5v 2A or 6·3v 1A **£4.00** pp £1.

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.

HOWELLS L.T 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 30-0-30v 10A **£17.50** carr £3.

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 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.

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.

GEC L.T TRANSFORMERS ALL PRIMARIES 220-240v

G.P.O. spec. Sec tapped 59·61·63·65·67·69v 10A **£10** carr £2. Sec tapped 58-63-69-74v 3A **£4.50.** carr 75p. Both types terminal block connections.

POTTED HT TRANSFORMERS BY FAMOUS MAKERS ALL PRIMARIES 240v

No 1 Sec. 400-0-400v 400M/A **£7.50** carr £2. No 2 Sec. 408 200-0-200 408v 408 taps rated at 165M/A. 200v taps rated at 500M/A **£5.50.** carr £2. No 3 330-0-330v 200M/A 6·3v 6·6A 5v 3A **£4.75** carr £1·50. No 4 300v 37M/A. twice 4v 1A, 4v 0·3A 4kv DC wkg **£3.** pp £1. No 5 630-0-630v 105M/A 4v 2A 5v 2A **£4.95.** pp £1·50.

L.T. SMOOTHING CHOKES

4·8M/H 10 amps **£4.** pp £1. 150M/H 3 amps **£3.50.** pp £1. 100M/H 2 amps potted type **£4.** pp £1. 13M/H 1·5 amps potted type **£1.50.** pp 50p. 2+2M/H 12 amps **£4.** carr £1. C core types 10M/H 25 amps **£8.50** carr £2. 18M/H 10 amps **£4.50.** carr £1·50.

AC WKG BLOCK CAPACITORS BY FAMOUS MANUFACTURERS

MFD	Volts	Price
Q25	1500vAC	**50p**
Q75	440vAC	**50p**
1	470vAC	**60p**
1·25	360vAC	**65p**
2	400vAC	**75p**
2·4	360vAC	**75p**
2·5	360vAC	**75p**
2·7+0·1	700vAC	**£1.25**
3	440vAC	**£1.00**
3·5	250vAC	**£1.00**
4	250vAC	**£1.00**
5	360vAC	**£1.25**
6	440vAC	**£1.50**
7·2	440vAC	**£1.50**
8·4	250vAC	**£1.00**
15	250vAC	**£1.75**

PP up to 2·5MFD **25p,** 2·7 to 15MFD **50p**+8% on total.

OIL FILLED BLOCK CAPACITORS TCC-DUBILIER. FRACTION OF MAKER'S PRICE

MFD	DCV WKG	Price	Postage
10	450v	**50p**	25p
8	800v	**£1**	35p
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
1	1500v	**40p**	35p
1	1000v	**35p**	15p
1	600v	**30p**	10p

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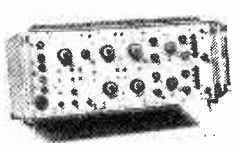
Modular Pulse Generator PG.52. System of 5 signal generating & processing units. Repetition freqs up to 20MHz & output pulses to 20V (50Ω). Rise & Fall times 5 nsec Its versatility enables the production of complex pulse & ramp waveforms not obtainable from conventional pulse generators **£425.00**

PG55 High Power Double Pulse Generator. Produces ±50V into 50Ω with rise time variable between 12ns and 100ns. Main pulse width continuously variable 100ns to 100ms in decade steps with a 10 1 fine control Rise Time 12ns up to 3 5MHz, variable to greater than 100ns Fall Time, less than 15ns Delay prepulse to main pulse 0 1µs to 100ms in decade steps with a 10 1 fine control Repetition rate continuously variable 1Hz to 5MHz Amplitude positive or negative from earth 0.4V to 50V into 50Ω in six ranges with vernier control. External triggering **£150.00**

Double Pulse Generator PG5002D. Main pulse width 0.1usec to 1sec Rise time 12nsecs Amplitude 8mV to 50 volts Repetition rate 0 1Hz-1MHz **£150.00**

Double Pulse Generator PG.56. Pulse Amplitude 0 1V-10V Sq. wave 0-10V Rise Time 10nsec (typically) . **£100.00**



Pulse Generator PG59 (Type CT600). Produces a pulse controllable in frequency, width, amplitude, delay and rise and fall times Also produces prepulse and gate outputs Repetition frequency 1Hz to 10MHz Pulse width 25nsec to 1sec Rise and fall times 12nsec to 1 sec Delay 25usec to 1sec Trigger. Internal, external and single shot **£595.00**

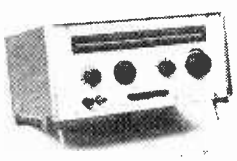
LR100X-Y Plotter. Specification. Main frame. Frequency response 1Hz. Plug-in amplifiers, LR120 general purpose amplifier LR121 time base Full specification on request **£235.00**

R.F. Signal Generator B4B7. 30kHz-30MHz O/p 1µV to 100mV Output z —75Ω Int Mod 400Hz 0-80% Provision for Ext. Mod Audio o/p 0-10V at 400Hz into 600Ω **£165.00**

AF Signal Generator H1E. Specification. Frequency range. 15Hz-50KHz AF Output, Sine Wave 200µV to 20V r m s ±2 dB Square Wave 1 4mV to 14V peak to peak approximately **£80.00**

Signal Generator J3. Frequency range 10Hz to 100kHz Sine & Square output Metered o/p . . . **£150.00**

Signal Generator J4. Frequency range 10Hz to 100kHz Sine and square o/p **£140.00**



Wide range oscillator SG 67A. Frequency range 1Hz to 1MHz Sine and square wave **£95.00**

Low Distortion Oscillator SG 68A. 1 5Hz-150kHz. Output waveforms Low distortion — <0 01% (40Hz-20kHz). Low distortion — <0.05% (20kHz-150KHz) Square wave Typically 600Ω impedance Max output 4V (r m s) Battery operated **£175.00**

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Frequency Counter TC16. 5Hz-80MHz. 5 digit display. 1MHz crystal Frequency and count functions **£110.00**

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Timer Counter TC18. Specification, Frequency Measurement Input 1 10Hz to 100MHz Input 2 10MHz-512MHz Both inputs direct counting Sensitivity 35mV r.m.s to 40MHz 50mV r m s at 100MHz Input 2 sensitivity 35mV r m.s 40MHz to 400MHz, 50mV r.m.s. to 512MHz Display 6 digit dot matrix L E D **£245.00**

Timer Counter TC22. Measures Frequency DC-100MHz 6 digit, time, period, period average, count, totalise, pulse width, ratio **£275.00**

40MHz Frequency Divider TCD40. Range 1-40MHz. Divide by 100, 40, 10, 4 or 1. 50Ω impedance. Input sensitivity 50mV r.m s to 10V . . . **£30.00**

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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 10-10⁵ 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**

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 11B2A 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 wave **£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**

Dual Trace Portable Oscilloscope 485. DC-350MHz. Sensitivity 5mV-5V/Div. Input impedance 1MΩ or 50Ω, Time base ranges 1ns-0 5s/Div on A and B, Time base modes A B intensified, delayed sweep, alternate sweep . . . **£2,900.00**

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 B trigger pulse intervals . . **£450.00**

General Purpose Oscilloscope 515A. DC-15MHz. Single trace 50mV-20V/cm **£185.00**

TV Waveform Monitor 525 £165.00

Portable Battery/Mains Oscilloscope 212. DC-500kHz Dual Trace 1mV-50V/Div **£585.00**

Plug In Unit Power Supply 132 £120.00

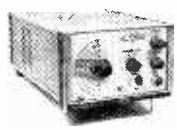
Spectrum Analyser Plug In 3L10 (for 560. and 564 series 'scopes). 1-36MHz **£415.00**

4-Trace Plug In Unit "M" (for use with 530, 540 & 580 series) . **£250.00**

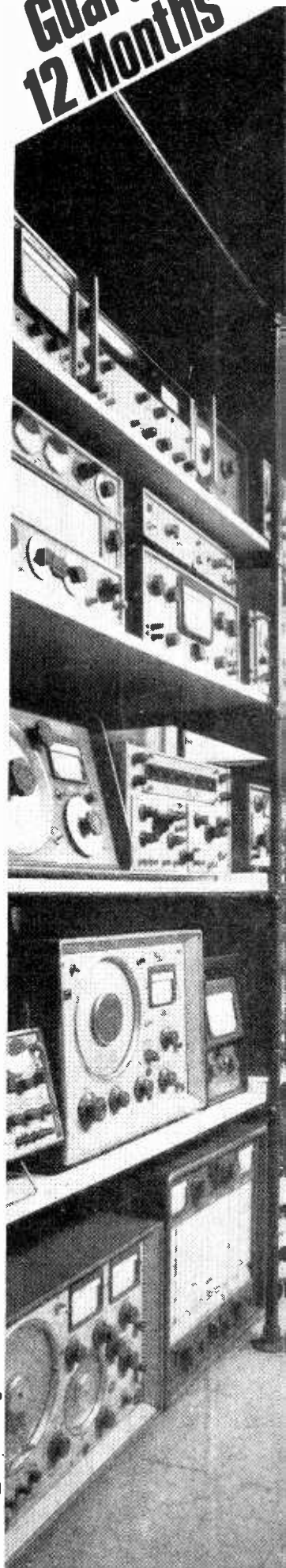
Differential Plug In Unit "W" £325.00

Oscilloscope Camera Unit C12 £190.00

Digital Readout Oscilloscope 567. Choice of plug-ins available Mainframe price **£610.00**



Constant Amplitude Signal Generator 191. 350kHz-100MHz Sine wave 5mV-5 5V constant amplitude 50kHz Amplitude reference . **£350.00**



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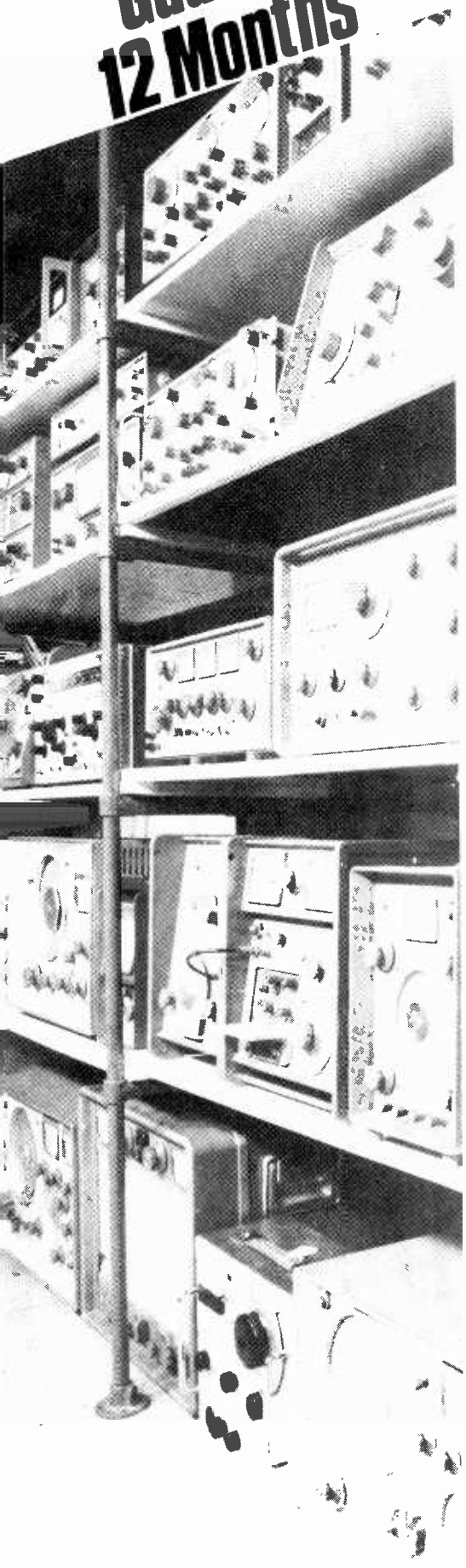

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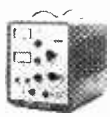
True R.M.S. Voltmeter 3400A. 1mV-300V (12 ranges) dB range −72-+52 dBm Frequency range 10Hz to 10MHz **£415.00**

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 **£400.00**



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 bandwidth Sweep Delay **£550.00**

Programmable Step Attenuator 355E. DC-1000MHz 0-12 dB in 1dB steps Unused **£60.00**

Portable Oscilloscope 1707A. DC-75MHz Solid State Dual Trace 10mV/div Sweep delay **£825.00**

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 10Hz-10MHz **£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**

FLUKE

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 10⁷ for one year Freq storage Full spec on request **£2650.00**

Frequency Synthesiser 6160A/DX. 4MHz 30MHz in 1Hz steps Output 1V into 50Ω Stability ±1 part in 10⁷ in 24 hours Full spec on request UNUSED. BARGAIN PRICE **£675.00**

Meter Calibrator 760A. Spec for DC Voltmeters −0 001V to 1kV Accuracy 0 1% Resolution 100μV DC Ammeters −1μA to 10A Accuracy ±0 25% Resolution 1μA AC Voltmeters −0 001V to 1kV 60Hz and 400Hz Accuracy ±0 25% Resolution 100μV AC Ammeters −1μA to 10A 60Hz and 400Hz Accuracy ±0 25% Ohmeters −0 to 10MΩ 0 1% of setting +0 5MΩ Resolution 1Ω Full spec on request **£2150.00**

Reference Divider 750A. Used for calibration of precision DC Voltmeters Voltboxes. DC Calibrators etc The equipment is a 10ppm (0 001%) divider with switched input taps ranging from 1100 to 1 1V and switched output taps ranging from 1100V to 0 1V **£980.00**

Industrial Counter Totaliser 1941A. 5Hz-40MHz 40mV sensitivity R P M measurement **£150.00**

Communications Counter 1920A. 5Hz-520MHz 15mV sensitivity 9 digit LED display **£400.00**

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 Input sensitivity 25mV BRAND NEW **£175.00**

GENERAL RADIO

Frequency Meter & Discriminator 1142A. Frequency Range 3Hz to 1 5MHz Accuracy ±0 2% Can be used with a recorder to produce records of frequency change and drift **£235.00**

Standard Frequency Multipliers. Type 1112 series. Providing microwave range standard freqs Output 20mW Output impedance 50Ω Low noise and excellent phase stability
Type 1112A **£520.00**
Type 1112B **£495.00**

Radio Frequency Bridge 1606A. 400kHz to 60MHz a generator & detector is required **£390.00**

Wave Analyser 1900A. C/w Graphic Level Recorder 1521B Spec 1900A 20Hz-50kHz 3 band widths 3, 10 and 50Hz Tracking averages 30mV-300V f s d Input impedance 1MΩ 3 meter speeds Spec 1521B 4 5Hz-200kHz. 1mV sensitivity Linear dB plot of r m s ac-voltage level 20 40 or 80dB range **£2000.00**

Electronic Voltmeter 1806A. AC+DC voltage 9 resistance ranges ±2% accuracy Wide frequency range — up to 1500MHz **£175.00**

Adjustable Attenuator 874 GAL. 100MHz to 4GHz 120 dB range 50Ω Impedance BRAND NEW **£150.00**

METRONIX (POLAND)

Wide Range Multimeter UM11. 100 000Ω/V DC volts 150mV-1500V f s d AC Volts 1 5-1500V f.s d (31 6K/V) DC current 10μA to 15A f s d AC Current 0-15A Supplied with Test leads & Carrying Case BRAND NEW Full specification on request **£29.50**

Function Generator G432. 1Hz-1 1MHz Sine Square & Triange BRAND NEW Full specification on request **£79.50**

RADIOMETER

Stereo Signal Generator SMG1C. Solid state, pushbutton operation. Full specification on request **£350.00**

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Multiminor Mk. IV. Supplied with leads & plastic carrying case **£14.00**

Multimeter model 7 ..... **£40.00**

Leads, prods & croc clips for models 7, 8 & 9 **£4.50 set**

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100MHz Single output Pulse Generator PM5775. Specification on request **£800.00**

100MHz Double Output Pulse Generator PM5776. Specification on request **£900.00**

50MHz Pulse Generator PM5712

£495.00

Specification on request

50MHz Pulse Generator PM5715. Specification on request **£600.00**

Low Frequency Generator PM5105. 10Hz-100kHz sine & Square wave **£156.00**

Sine & Square Wave Oscillator PM5125. 10Hz-1MHz **£145.00**

U.H.F. TV Generator PM5525A. 470-850MHz Can be modulated with black & white as well as colour TV **£95.00**

RACAL

Freq. Period Meter 9520. 5Hz-10MHz **£110.00**

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)

Distortion Meter D566B. Solid State 10Hz-1MHz 0 03%-100% incorporation also millivoltmeter **£305.00**

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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TELEQUIPMENT

Portable Oscilloscope D75. DC-50MHz at 5mV/Div Dual Trace Delay/Mixed Sweep **£575.00**

MARCONI INSTRUMENTS

Signal Generator TF867. 15kHz-30MHz o/p 0.4μV-4V Int & Ext mod Supplied with Terminating Unit **£185.00**

F.M./A.M. Signal Generator TF995B/2. Frequency Range 200kHz to 22MHz in five bands Output 0 1μV-200mv Output 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**

F.M./A.M. Signal Generator TF995B/5. This is the current narrow-deviation model for v h f mobile radio testing It differs from the TF995B/2 in the following respects - Tuning Controls Combination of Fine Tuning and calibrated Incremental Frequency controls permits rapid and accurate bandwidth measurement Modulation (F M) Normal deviation continuously variable from 0-5kHz and 0 to 15kHz in all bands. Greater deviation is obtainable on most bands Modulation (A M) Internal AM 400Hz, 1kHz or 1 5kHz, 0-50% External AM 100Hz to 100kHz, 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**

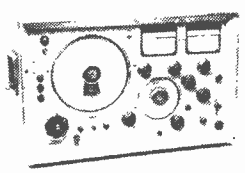
Solid State Signal Source 6058B Frequency range 8-12 5GHz Internal and external modulation Min O/p 20mW Frequency Stability (short term) 0 003% Output Impedance 50Ω **£530.00**

Microwave Sweep Oscillator 6600A. Together with Plug in Oscillator 6619 Frequency range 1 7 to 4 2GHz Output Impedance 50 **£2500.00**

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**

A.M. Signal Generator TF801D/1/S. Special military version of TF801D/1 having fully sealed meters and carrier on/off switch The electrical specification is similar to the TF801D except for extended carrier and modulation frequency ranges as shown below Frequency Range 10MHz to 485MHz in five bands Modulation External AM 30Hz to 50kHz 0-90% **£450.00-£600.00**

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**

Oscillator TF1247 (can be used with Q Meter TF1245) 20MHz-300MHz **£350.00**

A.M. Signal Generator TF801D/8S. Same spec as TF801D/1S + freq. counter o/p facility **£695.00**

F.M./A.M. Signal Generator TF995A/2M. 1 5 to 220MHz 2μV to 200mV int & Ext A M Int F M at 1kHz deviation 0-75kHz **£375.00-£475.00**

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**

A.F. Signal Source TF2000. 20Hz to 20kHz Extremely low distortion 111dB attenuator -0 1dB steps **£325.00**

Phase A.M. Signal Generator TF2003. 0 4-12MHz **£150.00**

Two-Tone Signal Source TF2005R. The instrument comprises two identical low-distortion a f oscillators and a monitored attenuator unit to form a compact test set for the measurement of inter modulation distortion using the methods recommended by S M P T E and C C I F Frequency Range 20Hz-20kHz in six bands (each oscillator can be adjusted and used independently) Harmonic Distortion Less than 0 05% between 63Hz and 6kHz when using unbalanced output Generally less than 0 1% under other conditions Intermodulation Below 80dB with respect to the wanted signal Amplitude Reference Level Up to +10dBm from each oscillator Output Attenuator 111dB in 0 1dB steps **£415.00**

Colour Gain and Delay Test Set TF2904. 625 line N T S C or P A L Sub carrier frequency 4 43MHz Impedance 75Ω Used to measure relative gain and delay between luminance and chrominance channels **£495.00**

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**

L.F. Extension Unit TM6448. For use with Spectrum Analyser OA 1094A series 100Hz to 3MHz **£200.00**

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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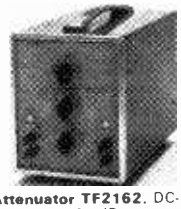

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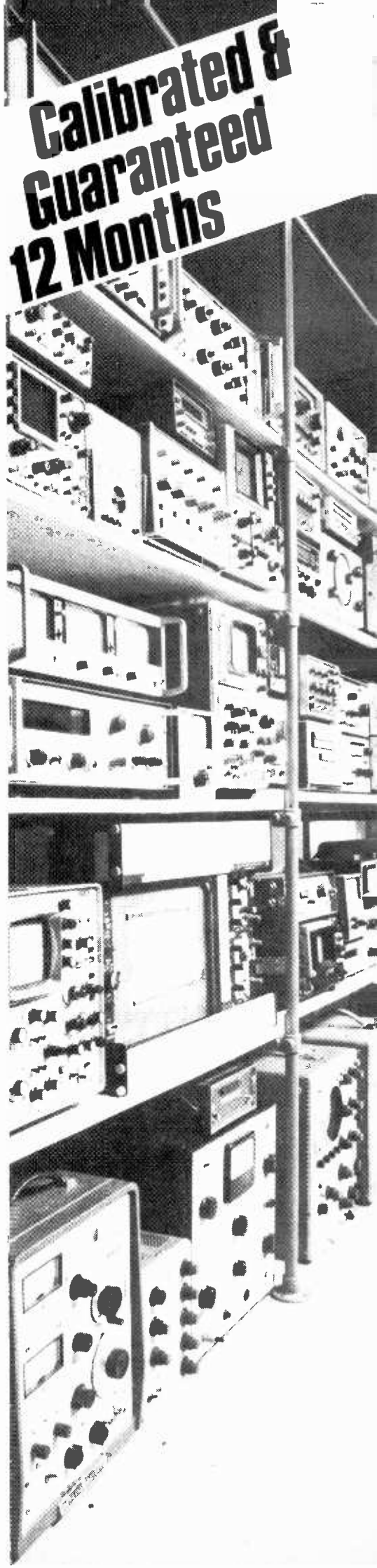

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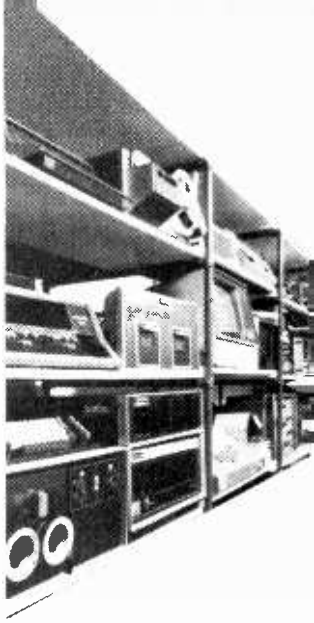

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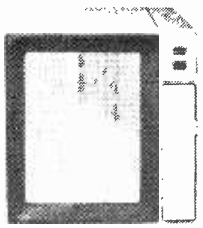

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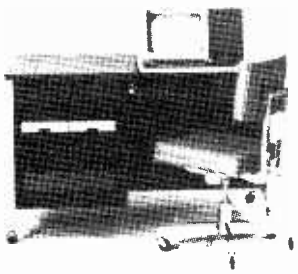

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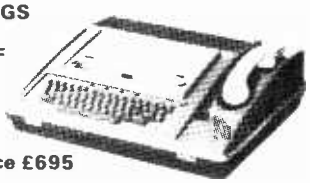

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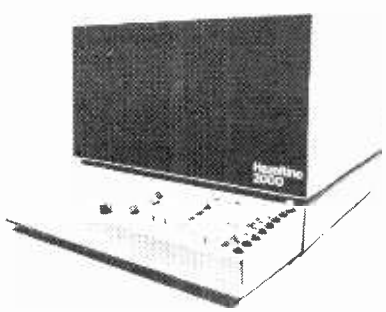

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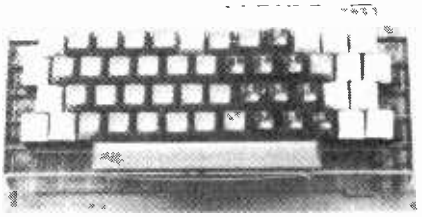

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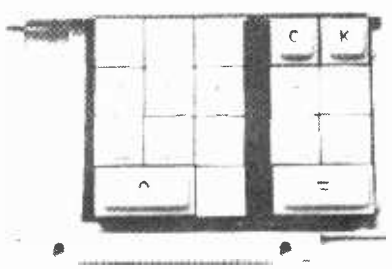

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2022	9V-0-9V 100mA	**90p***
2023	12V-0-12V 100mA	**95p***

1 AMP MAINS Primary 240V

No	Secondary		Price	
2026	6V-0-6V	1 amp	**£2.50***	P. & P. **45p**
2027	9V-0-9V	1 amp	**£2.00***	P. & P. **45p**
2028	12V-0-12V	1 amp	**£2.60***	P. & P. **55p**
2029	15V-0-15V	1 amp	**£2.75***	P. & P. **66p**
2030	30V-0-30V	1 amp	**£3.45***	P. & P. **86p**

STANDARD MAINS Primary 240V
Multi-tapped secondary mains transformers available in ½ amp, 1 amp and 2 amp current rating. Secondary taps are 0-19-25-33-40-50V.

Voltages available by use of taps
4, 7, 8, 10, 14, 15, 17, 19, 25, 31, 33, 40, 50, 25-0-25 V.

No	Rating	Price	
2031	½ amp	**£5.50***	P. & P. **86p**
2032	1 amp	**£6.60***	P. & P. **86p**
2033	2 amp	**£8.40***	P. & P. **£1.10**

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TO18 SIM TO 2N706/8

BSY27/28/95A. All usable devices. No open and shorts.

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Appointments

Advertisements accepted up to 12 noon Monday, April 3, for the May issue, subject to space being available.

DISPLAYED APPOINTMENTS VACANT: £7.50 per single col. centimetre (min. 3cm).
LINE advertisements (run on): £1.10 per line, minimum three lines.
BOX NUMBERS: 50p extra. (Replies should be addressed to the Box Number in the advertisement, c/o Wireless World, Dorset House, Stamford Street, London SE1 9LU.)
PHONE: Eddie Farrell on 01-261 8508
Classified Advertisement Rates are currently zero rated for the purpose of V.A.T.

Sony Broadcast Technology Centre to be established in the UK

Sony Broadcast announce the setting-up of a new Technology Centre in the UK to provide the necessary field support to their Marketing Division in system planning, special projects, installation and commissioning, as well as to participate in longer-term research and development programmes in co-operation with Sony, Tokyo and the newly-created Sony Technology Center in Palo Alto, California, USA.

As a result of this decision, several vacancies will shortly become available for **enthusiastic and versatile engineers experienced in video tape recording and editing, digital video and audio, ENG and allied technologies.** The engineers we are seeking will probably be in the age range 25–35, hold a degree in electrical engineering or an equivalent qualification, be keen to travel when necessary, have a background in industry or broadcasting, and enjoy working at the forefront of television technology, either individually or as a member of a team. An ability in other European languages would be a considerable advantage.

The search for suitable premises is being centred on the Basingstoke, Reading, Woking, Camberley areas at present, but it may be necessary to ask successful candidates to work out of Vianen, near Utrecht in Holland, for a few months whilst more permanent accommodation is being arranged. In this case, accommodation would be provided and generous overseas allowances paid.

Attractive salaries and, where appropriate, relocation expenses will be paid to the successful candidates.

Applications, which will be treated in strict confidence, should contain full details of qualifications, experience and salary required, and be addressed to:

Howard Steele
Managing Director
Sony Broadcast B V I O
Postbus 100
Vianen (ZH)
Holland

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7954

A CHALLENGING CAREER IN T.V.

Join Audio + Video Ltd in London's West End. If you are capable of maintaining RCA and Ampex quad VTRs, RCA and Rank telecines, TBCs and other associated equipment, then we would like to meet and talk to you. Now that we have just taken delivery of a Marconi DICE standards convertor, the position we are offering is even more interesting. A good working knowledge of helical scan machines would be a definite asset.

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(7999)

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METRO RADIO has a vacancy for a

SENIOR AUDIO ENGINEER

(GRADE ILR1)

Applicants should have a good education background with relevant technical experience.

Please send full details of education and career to:

Station Engineer
METRO RADIO
Newcastle-Upon-Tyne
NE99 1BB

(7995)

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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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Kingston area **£4,000 p.a. salary**

A young, experienced person (22-30) capable of good prototype wiring and construction with the ability to fault find at a low technology level. Experience in the layout of P.C. Boards desirable. We are a small company and the ability to work well without supervision is necessary. Ex-apprentice preferred.
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AUDIO VISUAL EQUIPMENT LTD.
73 Surbiton Road, Kingston, Surrey
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(8021)

RESOURCEFUL ENGINEER

required by the London International Film School to maintain enormous range of audio, film and video equipment — 50 years of electronic history, from enormous bottles to teeny ICs. Not much money but terrific job satisfaction plus good hours, long holidays, friendly people, own workshop, use of company pushbike, etc.

Apply to:

The Administrator
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(7998)

Electronics Engineers on the move

INVEST 5 MINUTES IN YOUR FUTURE

DESIGN, TEST, Q. A; FIELD SERVICE, MANAGEMENT, ETC.

Take advantage of the best opportunitfes being offered in the Electronics Industry from amongst over 3000 U. K. Companies with whom we deal. We are seeking all categories of Electronics Engineers for equipment ranging from computers to communications.

By returning the application form below, your job requirements will be matched against our clients' numerous vacancies, many of which are not advertised. Your application will be treated in strict confidence and no approaches will be made to existing employers or to any other companies you care to specify. Please remember, our service is completely FREE to applicants.

So don't delay - act now to give yourself the best chance of finding the perfect job.

If you wish to discuss any aspect of the Electronics job market, you are welcome to phone anytime. Please ask for Brian Cornwell.

Capital Appointments Ltd. 29/30, Windmill St. London, W.1. ☎ 01-637 5551

PLEASE WRITE IN BLACK INK.

NAME: ADDRESS:

Tel: (Home): (Office):

Date of Birth: Place of Birth: Nationality now: If not British, is a Work Permit req'd?

Marital Status: Car Driver: Car Owner:

Type of Position required: Approx. Salary level:

Please indicate areas in which you are prepared to work:

Cent. London		S.Coast		E.Midlands	
S.E. London		West Country		W.Midlands	
S.W. London		N. E. Engld.		E.Anglia	
N.E. London		N. W. Engld.		Wales	
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Home Counties: N.W. | N.E. | S.W. | S.E.

Are you a houseowner? Are you willing to relocate?

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State of health:

Notice Period required: Availability for Interview:

EDUCATION:

Secondary School Qualifications:

College or University Qualns:

Any Professional Membership:

INDUSTRIAL EXPERIENCE:

Period of Employment	Company & Location	Products	Job Title	Responsibilities	Reason for leaving	Final Salary

ELECTRONICS PROFILE: Indicate extent of experience- A-Extensive; B-Moderate; C-Limited; If Nil experience, leave blank.

Telephone Eqpt.	Data Commns.	Radio/Hi-Fi/T.V.	Broadcast Eqpt.
Digital/Logic	Analogue Eqpt.	Software/Programming	Minis/Microprocessors
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Phototypesetting	Servo-mechs.	Components-Active	Components-Passive
Production Eng.	Electrical Eng.		

Others - Please state.

Please indicate any Companies you do not wish us to contact.

If you wish to detail further aspects of your experience or job requirements, please enclose on a separate sheet.

Land a good job

Your Radio Officer's qualifications can mean a lot here on shore

If you're thinking of a shore-based job, here's where you'll find interesting work, job security, good money, and the opportunity to enjoy all the comforts of home where you appreciate them most – at home!

The Post Office Maritime Service has vacancies at Portishead Radio and some of its other coast stations for qualified Radio Officers to undertake a wide variety of duties, from Morse and teleprinter operating to traffic circulation and radio telephone operating.

To apply, you must have a United Kingdom Maritime Radio Communication Operator's General Certificate or First Class Certificate of Proficiency in Radio-telegraphy or an equivalent certificate issued by a Commonwealth Administration or the Irish Republic. And, ideally, you should have some sea-going experience.

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For further information, please telephone Andree Trionfi on 01-432 4869 or write to her at the following address: ETE Maritime Radio Services Division (L690), ET17.1.2, Room 643, Union House, St. Martins-le-Grand, London EC1A 1AR.

Post Office Telecommunications

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 ELLIOTT 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-Elliott Avionic Systems Ltd.,
22-26 Dalston Gardens, Stanmore, Middlesex HA7 1BZ. Tel: 01-204 3322.

7917

TELSEC

We are a small company manufacturing the widest range of X-ray spectrometers within the United Kingdom and we require two dedicated people in our Technical Services Department.

ELECTRONICS TEST ENGINEER

To join a team working on the testing and setting up of computerised spectrometers. Qualifications to HNC level is desirable with experience of instrumentation or computers.

SERVICE ENGINEER

For installations, commissioning and after sales service on our complete range of instruments. This will involve extensive travel throughout the U.K. and Europe and a company car is provided. A proven record in our, or other related field is required with a good practical background.

Salaries for both posts will be excellent with a good pension scheme and four weeks holiday.

Applications to:

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Telsec Instruments Ltd.,
Sandy Lane West, Littlemore
Oxford OX4 5JX

(7966)

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has vacancies for:

ELECTRONIC ENGINEERS

to work in the fields of:

a. H.F./V.H.F./U.H.F. communications equipment design and development.
b. General circuit design, analogue and digital.

Appointment will be in the grades of Higher Scientific Officer and Scientific Officer for which the minimum academic qualification is HNC or equivalent. For Higher Scientific Officer 5 years post-qualification experience is required except for candidates with First or Second Class Honours degree when this is reduced to 2-year postgraduate experience.

Salaries are

Scientific Officer £2593-£4032
Higher Scientific Officer £3746-£4976

Also required are

ELECTRONIC DRAUGHTSMEN/WOMEN

Minimum qualification is Ordinary National Certificate or equivalent but preference will be given to more experienced candidates with higher qualifications.

Lower Salary Scale **£2875-£3951** for minimum qualifications
Higher Salary Scale **£3951-£4447**

All above salary scales include Phase I & II Supplements.

For application forms apply to:

The Administrative Officer
H.M. GOVERNMENT COMMUNICATIONS CENTRE
Hanslope Park
Hanslope
Milton Keynes, Bucks MK19 7BH

(7953)

Electronics Technicians

Saudi Arabia
£14,600 tax free per two year contract

At major airports throughout Saudi Arabia, Lockheed Aircraft International has responsibility for the maintenance and operation of a wide range of advanced radar and radio communications installations. Keeping them in first-class operational order is a vital task and we can, therefore, offer you an opportunity to carry out interesting and challenging work in a fascinating overseas environment. We're looking for Technicians to carry out station and base maintenance on the following equipment:

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To maintain VHF/UHF ground/air communication systems and radio navigational equipment such as ILS, TACAN and CADF. Sound relevant maintenance experience is required, preferably including some knowledge of point-to-point VHF and HF SSB systems.

ATC or Ground Radar

To maintain long range surveillance and precision approach radars, antennae and display systems in control tower installations. Several years' relevant radar maintenance experience on long range surveillance or approach radars is required together with some knowledge of SSR and IFF equipments. **Technicians with airborne radar experience will also be considered and appropriate conversion training given.**

Radio Relay

To service and repair a variety of VHF/UHF, SHF and TROPO communications equipment and associated multiplex systems. Cross training in TROPO and multiplex can be provided. Good relevant experience, covering multiplex and microwave equipment is required.

As a Technician with Lockheed Aircraft International you will be able to earn £14,600 tax free for a two year contract. In addition, you will receive free bachelor accommodation, free food and laundry, free medical care and life insurance and two free flights home to the UK per year.

So, if you have the necessary experience and are looking for an interesting job with high earnings, phone The Recruitment Officer on 01-572 9844 or 01-572 9899 or write to him at International Aeradio Ltd., Aeradio House, Hayes Road, Southall, Middlesex. Quote Ref. 062.

IAL LOCKHEED INTERNATIONAL

7960

Engineering Opportunities

Pye Business Communications Limited, a member of the Pye Group of Companies – part of the international Philips organisation – markets, installs, commissions and services a wide range of communications equipment.
The Engineers appointed to the following positions will enjoy the excellent employment conditions associated with a major company.

FIELD MAINTENANCE ENGINEER
— **Southern Area**, preferably resident in Greater London, to work on Intercom and CCTV systems, Radio and Inductive Paging equipment.
— **Scotland**, should reside in the Glasgow/Edinburgh area, to work on Intercom, CCTV, Private Telephone and Public Address systems, Radio and Inductive Paging equipment.

INSTALLATION & COMMISSIONING ENGINEER
— **Southern Area**, resident North of the Thames, for Private Telephone systems, Intercom and Public Address systems and Paging Equipment.

A Final C. & G. Telecommunications Certificate, ONC or equivalent is essential for the above vacancies, together with a current driving licence. Company cars will be provided.

PABX INSTALLATION & COMMISSIONING ENGINEER
— **UK Area**, for Philips UH900 and UH200 exchanges. City and Guilds Final Certificate in Telecommunications is desirable, and experience in the installation and commissioning of electro-mechanical PABX exchanges. The position involves travel throughout the UK and regular absence from home during the week. A company car is not provided but realistic mileage and subsistence allowances are offered.

Please apply to:
Mrs. Ann Macnab, Personnel Manager,
Pye Business Communications Limited,
Cromwell Road, Cambridge CB1 3HE
Telephone Cambridge 45191

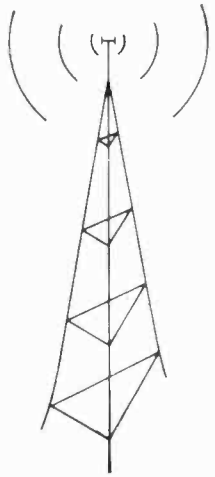
PYE **Pye Business Communications Ltd**

A member of the Pye of Cambridge Group

7963

Are You Interested In

Radio Communications



and do you have practical experience in this field

if you have City and Guilds Intermediate Certificate in Electronics or Telecommunications; ONC; or an equivalent qualification

then the Metropolitan Police Office has a job for you as a Radio Technician.

vacancies are at our depots in South London

we offer
Good pay, Excellent prospects
Secure employment
4 weeks holiday, Day release

For further information and an application form please apply to: The Secretary, Room 213/WW/RT, 105 Regency Street, London SW1P 4AN, or telephone 01-230 3122 (24-hour answering service).

(7977)

Electronic Engineers

Hunting Geology and Geophysics Limited is engaged in Mineral and Energy Exploration and Consultancy. Vacancies exist for engineers able to assume responsibility for the preparation and operation of sensing and recording systems designed to map earth resources from the air. Duties will involve flying and overseas service, normally on a bachelor basis, for approximately six months a year.

The openings could suit development engineers wanting greater variety and capable of problem solving by equipment modification and interfacing.

Applicants should hold at least HNC qualification and must be willing to turn a hand to the practical aspects of base and field teamwork.

Application to:
The Personnel Manager,
HUNTING SURVEYS & CONSULTANTS LTD.,
Elstree Way,
Borehamwood,
Herts. WD6 1SB.

7973

ELECTRONICS TECHNICIAN

required to assist with the servicing, maintenance and design of a wide range of scientific equipment. Computer interphasing experience essential.

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(8019)

PRODUCTION TEST TECHNICIAN

required for work on our range of commercial metal detectors. Must have at least five years' experience in testing, fault finding and mechanical and electrical inspection, and be prepared to work at a fast production pace.
We offer good wages, three weeks' holiday plus sickness benefits, and work that is interesting and rewarding.
Excellent opportunity for right person with small expanding company
Application form from

YOUNG ELECTRONICS LTD.
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London NW5 4BA
Telephone: 01-267 0201

(7996)

Logic Engineers

STC need Logic Engineers to work on the design problems which arise during commissioning and testing of TXE4A Telephone Exchanges. The System uses both wired logic and programme controlled processors, designed with T.T.L. and M.O.S.L.S.I. components.

Applicants should have a degree or HNC in electronic engineering, and at least two years experience in logic design. Experience of telecommunications or real time control systems would be useful but is not essential.

These vacancies are at New Southgate which is situated on the outskirts of North London with easy access to Central London or rural Hertfordshire. We are part of a large well established and pleasantly situated location with all the facilities and amenities this implies.

We offer competitive benefits and very real prospects of advancement for the right man or woman.

Telephone or write to: Mike Randal (Department 32210), Standard Telephones and Cables Limited, Switching Main Exchange Products Division, Oakleigh Road South, New Southgate, London N11 1HB. 01-368 1200 Ext. 3066.

STC Changing the face of communications worldwide

7957

ELECTRONICS ENGINEERS

Ricardo have an international reputation in internal combustion research and development and are Consulting Engineers to the majority of the world's engine manufacturers. They urgently require Electronics Engineers for highly varied and challenging instrumentation work. Current projects include the design and implementation of automated engine test bed systems. future projects will involve the application of microprocessors to engine control.

Applicants should preferably have a B.Sc. in electronics with a few years' experience. A good theoretical knowledge and some experience of modern digital techniques is essential.

Salary will be in the range £3500-£4850 and the appointments offer excellent fringe benfits including bonus and non-contributory pension schemes. free life assurance and generous assistance with relocation where necessary.

Apply in writing or telephone
Mr. R. Barrow
Personnel Manager
Ricardo & Co. Engineers (1927) Ltd.,
Bridge Works, Shoreham by Sea,
West Sussex BN4 5FG
Tel: (07917) 5611

RICARDO

(7980)

ENGINEER

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Ideally, applicants should be conversant with colour telecine operation.

Salary in the range of £5000 to £5500.

The company operates profit-sharing and pension schemes.

For more information please contact:

Malcolm Syers
DPBS Limited
67 Brompton Road
London SW3 1EF
Telephone: 01-589 4595

(8002)

THE UNIVERSITY OF HULL

VISION/LIGHTING SUPERVISOR AUDIO VISUAL CENTRE

Applications are invited for the above post which is available immediately. Candidates should have an HNC or equivalent qualification, and relevant experience in operations and maintenance in broadcast and/or educational television. Salary will be in the Grade 7 scale for University Technical Staff (£4,254 x 4 increments — £4,782).

Applications, giving details of age, qualifications, experience, and the names of two referees, should reach the Personnel Officer, University of Hull, HU6 7RX by 14 April. Further particulars are available.

(7967)

BROMPTON HOSPITAL

Senior Medical Electronics Technician

to undertake work involving maintaining, installing, and developing medical electronic equipment. A knowledge of ultrasonics and microcomputer based systems would be a distinct advantage.

Applicants should have a good general knowledge of electronics and be qualified to H.N.C. (Electrical and Electronic Engineering) standard or equivalent.

Salary will be on the scale £3,776-£4,708 according to experience.

Further information from Physicist in charge, Mr. R. B. Logan-Sinclair, Tel. 01-352 8121, Ext. 4252.

Application forms and job descriptions from Miss J. A. Jenks, Personnel Manager, Brompton Hospital, Fulham Road, London SW3 6HP. (Tel. as above, Ext. 4357)

7978

LATIN AMERICA

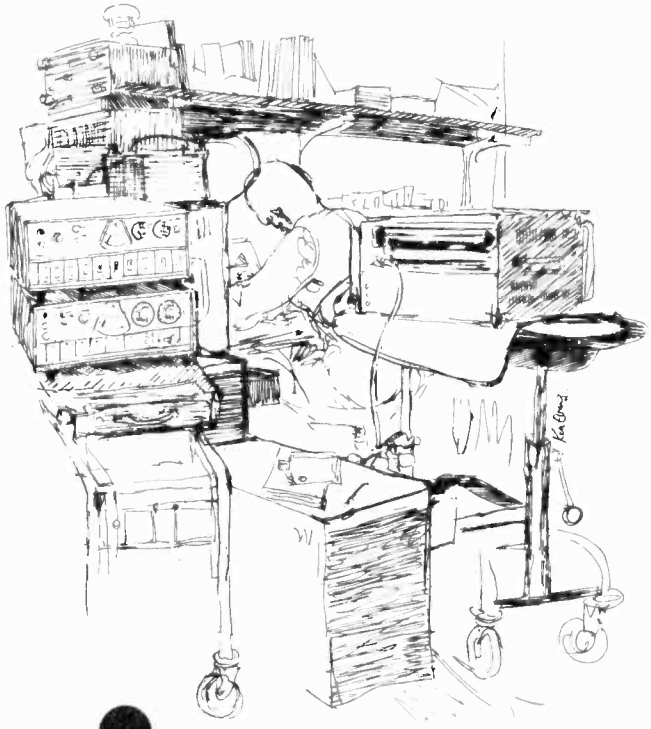
RADIO ENGINEER

Required to work with the Radio Schools Federation in Guatemala. Responsibility for implementing an in-service training programme for local technicians in small rurally-based radio stations which promote adult education among impoverished Indian communities.
A British Volunteer Programme post; intensive Spanish language training provided. For further information write with details of curriculum vitae to:

CIIR Overseas Volunteers
1 Cambridge Terrace
London NW1 4JL

(7997)

Marconi Instruments



ELECTRONIC TECHNICIANS

Opportunities for the experienced and sometimes inexperienced in St. Albans and Luton.
Work situations range from fault finding on PCB's and components, to batch product testing of equipment that utilise very advanced techniques including microprocessors and the repair/calibration of all manner and types of test instruments.
Attractive salaries and, where appropriate, relocation are offered for the right candidates.
Further information may be obtained in confidence from John Prodger
Marconi Instruments Limited,
Longacres, St. Albans, Herts. tel: St. Albans, 59292

A GEC-MARCONI ELECTRONICS COMPANY

(7982)

mi

OVERSEAS APPOINTMENTS

ELECTRONICS TECHNICIANS

Petty-Ray is one of the leading Companies in the field of oil exploration and due to our ever increasing workload require single personnel, in the age range 21-25, who are looking for a varied and interesting career working overseas.

You should be educated to H.N.C/O.N.C. in Electronics or C & G Radio and T.V. Technician level. On appointment you will be assigned to one of our field crews either in Africa or the Middle East for on the job training in the operation and maintenance of digital seismic recording equipment.

Candidates must be in possession of a current driving licence.

We offer a good starting salary which is tax free. Food and accommodation will be provided and rest leaves are generous.

GEOSOURCE

If you would like to have more information about these positions

Please write giving brief career details to the Personnel Officer.

Petty-Ray Geophysical Division

3-5 The Grove Slough Berkshire SL1 1QG

(7974)

We pay top salaries for the right engineers
Starting at £4000 p.a. for Bench Engineers
Increasing appreciably for Field Service Engineers

London's largest independent radio-telephone company is expanding fast! We have built a reputation for reliable efficient service. If you have the capability we need you urgently.

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

FRANK CODY ELECTRONICS LTD.
require
AN ELECTRONICS ENGINEER

with some experience of V.H.F. and U.H.F. R/Ts for interesting work on our range of Marine and land mobile communications and navigation equipment.

Frank Cody Electronics Ltd.
40 Sunbury Cross Centre
Sunbury-on- Thames
Middlesex TW16 7AZ
Tel: Sunbury-on-Thames 88705

(8023)

Design and Development Engineers

HF and Satellite Communications

International Marine Radio Co. Ltd., part of Standard Telephones and Cables Ltd., is the leader in the field of maritime HF communications and is now advancing into the satellite era.

Here is an important opportunity to join an expanding team engaged in the design and development of HF and satellite communications equipment for the marine field. The work requires familiarity with modern solid state technology in one or more of the following areas:

Small signal linear circuit design
TTL/ECL digital techniques
Micro processor software and hardware design
HF receiver and transmitter design

The positions offer first class career opportunities for both male and female engineers qualified to degree/HNC standard and with two-five years experience. There are also several openings for newly qualified graduates to obtain invaluable experience at an early stage in their careers.

Please write with brief career details or telephone Jonathan Smith, International Marine Radio Co. Ltd., Peall Road, Croydon CR9 3AX. Tel: 01-684 9771.

STC Changing the face of communications worldwide

7956

TEST ENGINEERS

When reliability matters, people come to Pye

When the 1952 expedition, led by Sir John Hunt, made the first successful ascent of Everest, they carried with them Pye portable radiophone equipment – equipment with a long reputation for efficiency and reliability under arduous conditions.

Part of that reliability comes from the quality of the design and the components used, but the final seal is set by the highly skilled men and women who check our UHF/VHF systems to our very exacting specifications prior to delivery.

If you already have experience of fault diagnosis, alignment and testing of electronic equipment, especially communication equipment, perhaps gained in the Armed Forces, then why not get in touch and find out for yourself exactly why people come to Pye.

There's not room to tell you all the details here, but we can assure you of a competitive salary, company stability, job security and satisfaction, well equipped workshops and a variety of equipment, using both IC's and transistor.

Openings are available at Haverhill, Suffolk and at Cambridge, both extremely pleasant places to live, with key-worker housing available at Haverhill. In addition, considerable assistance is provided for those moving from other parts of the country.

Write or phone (reversing charges if necessary) to:
Catherine Dawe, Pye Telecommunications Ltd, Colne Valley Road, Haverhill, Suffolk CB9 8DU Tel: Haverhill 4422.
or Clare Barton, Pye Telecommunications Ltd, St. Andrews Road, Cambridge CB4 1OW Tel: Cambridge 58985

Pye Telecommunications Ltd

7969

ARE YOU IN MF/HF RADIO?

If so, then my client, the rapidly expanding marine equipment division of one of Britain's most respected engineering groups, wants to meet you. We are looking for a

Radio Communications Engineer

based Birmingham **up to £5,000**

This newly-created post is tailor-made for a young engineer (ideally late 20s) with an HNC and at least 3 years' medium frequency radio communications experience.

Your role will be to develop their medium frequency marine communications receiver, from testing stage, through to initial production. This will involve you in fault finding and design modification, with some digital electronics as the project progresses.

PER Professional & Executive Recruitment

Telephone: Anita Blakemore on 021-236 6971

Applications from both men and women are welcome

UNIVERSITY OF SURREY

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(7968)

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and

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(7975)

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(7958)

CITY OF LONDON POLYTECHNIC

DEPARTMENT OF BIOLOGICAL SCIENCES

ELECTRONICS TECHNICIAN GRADE 5

The City of London Polytechnic requires as soon as possible an Electronics Technician for the design and construction of electronic physiological and neurophysiological apparatus for teaching and research, together with day-to-day servicing of the neurophysiological teaching laboratory, and supervision of the electronics workshop. Candidates should possess an H.N.C in an appropriate field

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(7992)

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(7964)

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(8004)

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(7961)

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(8022)

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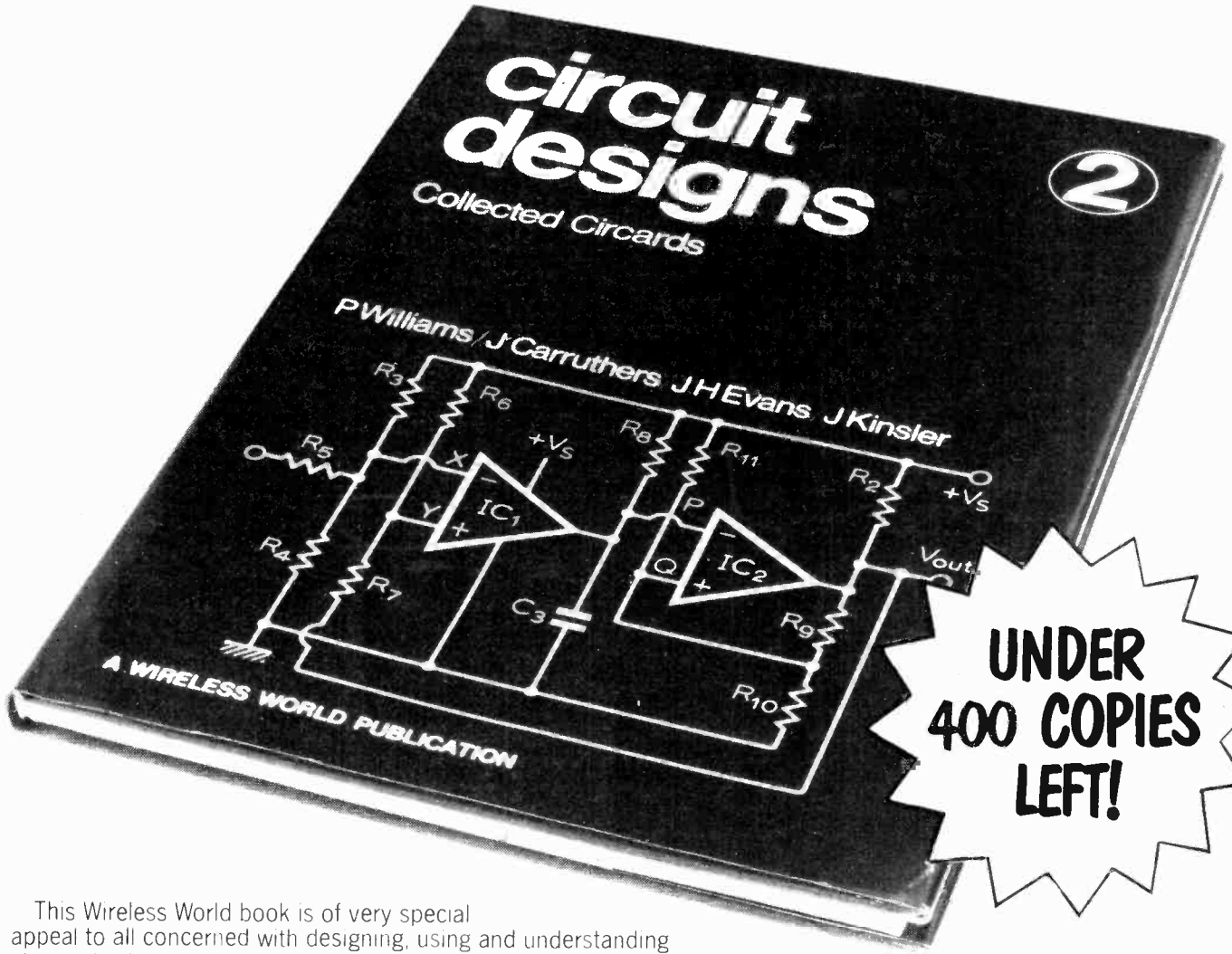

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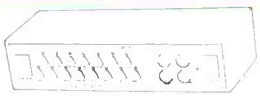

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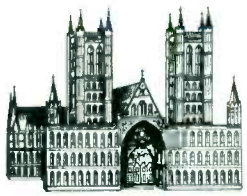

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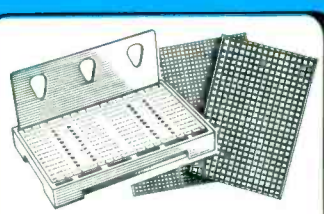

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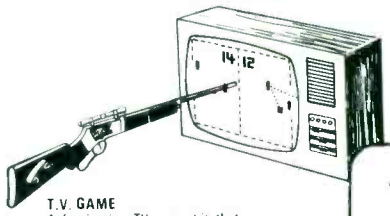

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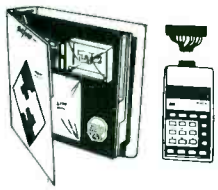

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Even if tin prices stabilised, a change from 60/40 alloy to Savbit Solder could save you £100/tonne, ensure a better job...

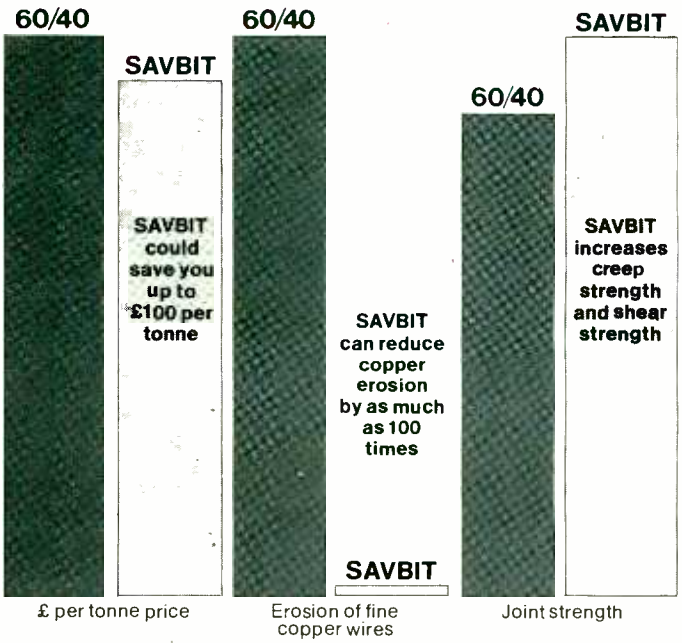
The reason is that Multicore Savbit not only solves the problem of fine copper wires and thin foils deteriorating during soldering, but also contains less tin than 60/40 alloy. **We make both so we are just offering to alleviate your rising metals costs.**

During normal soldering, a dissolving action causes the wire to weaken and embrittle – often to break during subsequent field use.

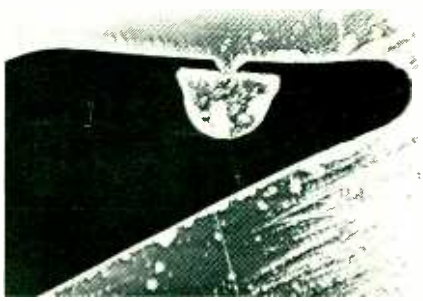
Savbit, however, is a rosin based, 5-core wire solder comparable in joint quality to standard high performance alloys, but capable of dramatically inhibiting the copper dissolving action.

As this diagram shows,* compared with a 60/40 alloy, Savbit can reduce the dissolution of copper by as much as 100 times. Yet wetting rate, flow, conductivity and capillary force are almost identical – with creep strength and shear strength actually increased.

*(Indicative of product advantages only; not to scale)



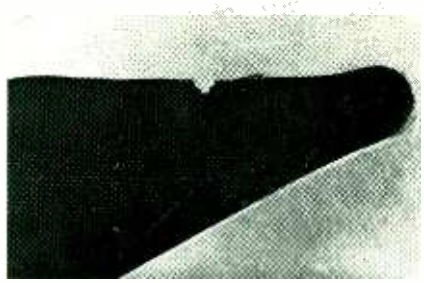
...and more



Cracked iron-plated bit, after 40,000 simulated operations using 60/40 Solder.

Some people think Savbit alloy is only usable with plain copper soldering iron bits, but this isn't true.

As these photographs illustrate dramatically, Savbit also saves significantly on the cost of iron-plated soldering iron bits, which have a copper core. This is exposed through cracks in the plating.



Cracked iron-plated bit, after 40,000 simulated operations using SAVBIT Solder.

Add this advantage to the increased reliability and joint quality Savbit offers, and you'll understand why more and more 60/40 users are making the change – and profiting. The Ministry of Defence have given a special new Approval No. DTD 900/4535A for Savbit alloy with ERSIN 362 flux to be used in lieu of Solders to B.S. 219 and B.S. 441.

ERSIN Multicore

For full information on Savbit or any other Multicore products, please write on your company's letterhead direct to:

Multicore Solders Limited,
Maylands Avenue, Hemel Hempstead, Herts. HP2 7EP.
Telephone: Hemel Hempstead 3636. Telex: 82363.