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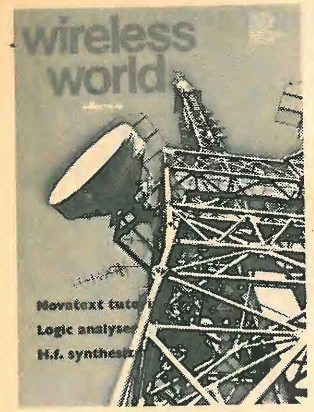

Front cover shows aerial of Niederhorn television transmitter operated by Swiss PTT on v.h.f. and u.h.f. colour. Photo: The Hamer-Smith Swiss collection.

IN OUR NEXT ISSUE

Home computer. **The start of a series on the construction and use of a microcomputer, which uses a novel language and which is designed for mathematical problem solving.**

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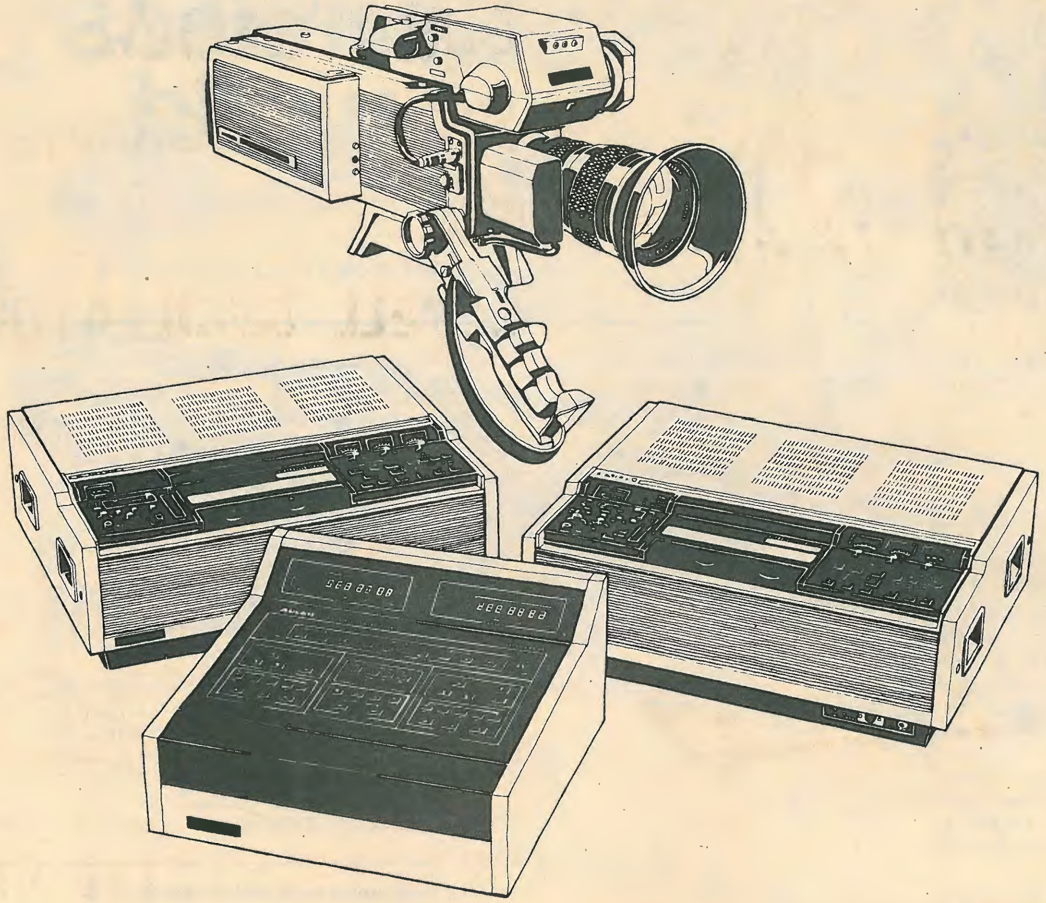
ELECTRONICS/TELEVISION/RADIO/AUDIO

MARCH 1979 Vol 85 No 1519

From Bell & Howell, exclusive distributors of JVC video products to the educational, industrial and institutional markets in the UK and Eire.



JVC.
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SUPERSHIELD.

Choose video equipment with all these names in mind.

Above: a new, complete and outstanding video system from JVC. One three-tube colour camera, of studio quality but portable. Two *editing* U-format video cassette recorders. One automatic editing control unit. Designed to meet broadcast requirements, and therefore excellent in any other application, they should be seen in action before deciding how to re-equip a video production centre which aims at the highest standards (though by no means at the highest current price).

At the other end of the comprehensive JVC range is low-cost equipment for surveillance and similar tasks. Between the extremes: a wide choice of b/w and colour cameras and recorders (reel-to-reel and U-format). And now, of course, VHS – VHS made by the people who invented and developed it, JVC.

For leaflets about JVC video products or, still better, a demonstration, use the coupon. We'll also send you a leaflet on Fuji video tapes, worth reading about because their exclusive Beridox coating is so good for the picture.

We'll also tell you about the third name in our headline, Supershield. This is a new and, we believe, unique guarantee, covering all video and audio-visual products made or distributed by Bell & Howell (excluding only camera tubes, tapes and projector lamps). For two years after purchase, Supershield gives free technical advice, free parts *with no labour charges*, and (in mainland Great Britain) free collection from your premises to one of our Supershield workshops and free delivery back to you when the job is done. JVC plus Bell & Howell was already a strong combination. JVC plus Bell & Howell plus Supershield, plus a national network of first-class dealers, should be unbeatable.

Please tick squares, fill in your name, clip coupon to your letterhead and mail in an unstamped envelope to Bell & Howell A-V Ltd, Freepost, Wembley, HA0 1BR.
Leaflets, please, on:

☐ JVC video products generally ☐ JVC VHS ☐ Demonstration arrangements

Name

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WW 3 79

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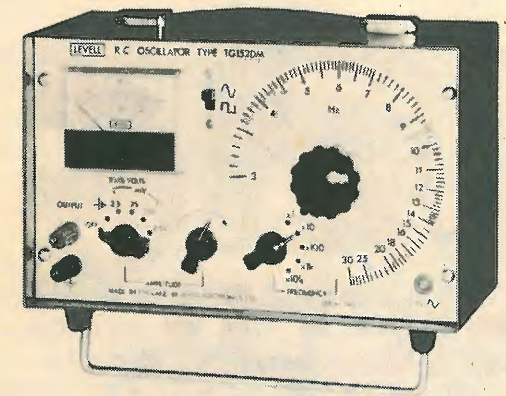
SYNC INPUT	±1% freq. lock range per volt r.m.s.
METER SCALES	TG200M, DM & DMP only. 0/2V/ 0/7V & −14/+6dBm.
SIZE & WEIGHT	260 × 130 × 180mm. 4.3kg with batteries.

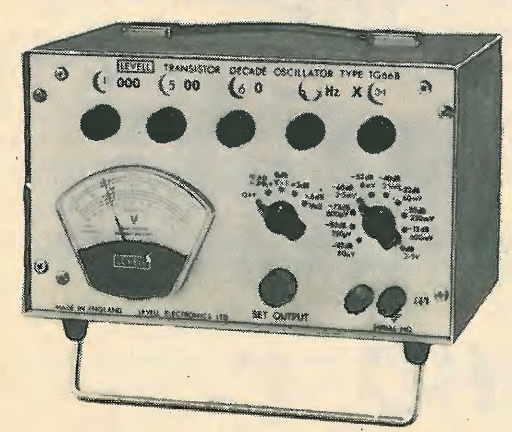
TG200	TG200D	TG200M	TG200DM	TG200DMP
£85	**£90**	**£105**	**£110**	**£115**



FREQUENCY	3Hz to 300kHz in 5 decade ranges.
ACCURACY	±2% ±0.1Hz to 100kHz. Increasing to ±3% at 300kHz.
SINE OUTPUT	2.5V r.m.s. down to <200μV
DISTORTION	<0.2% from 50Hz to 50kHz. <1% from 10Hz to 200kHz.
SQUARE OUTPUT	2.5V peak down to <200μV.
SYNC. OUTPUT	2.5V r.m.s. sine.
METER SCALES	0/2.5V & −10/+10dB on TG152DM.
SIZE & WEIGHT	260 × 130 × 180mm. 3.4kg with batteries.

TG152D Without meter **£68**

TG152DM With meter **£85**



FREQUENCY	0.2Hz to 1.22MHz on four decade controls.
ACCURACY	±0.02Hz below 6Hz. ±0.3% from 6Hz to 100kHz. ±1% from 100kHz to 300kHz. ±3% above, 300kHz.
SINE OUTPUT	5V r.m.s. down to 30μV with Rs = 600Ω.
DISTORTION	<0.15% from 15Hz to 15kHz. <0.5% at 1.5Hz and 150kHz.
METER SCALES	2 Expanded voltage and −2/+4dBm
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TG66B Battery model **£225**

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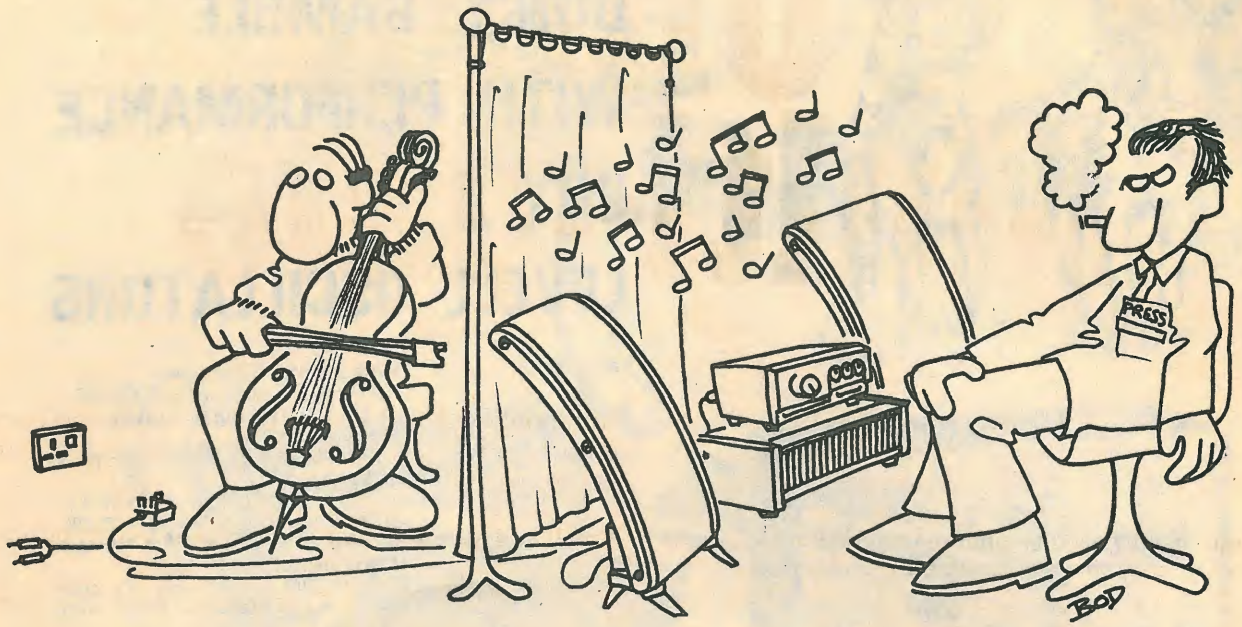

Artistic licence?

We at QUAD go to a very great deal of trouble to ensure that with a QUAD 33 in the Cancel position, the voltage delivered to your loudspeakers is a virtually exact RIAA transfer of the voltage the pickup will produce into a stated passive load. Nothing added – nothing taken away.

A visiting journalist recently suggested that we should not do this. Final adjustment should be done by ear, he said.

What an opportunity!

After all we know that if we add a little warmth with a subtle boost in the lower middle and balance this with an ever so gentle hump in the quack region (2-3kHz), we can make most programmes sound superficially more impressive. Come to that, why not change the 3180µS to 5000µS adding a little more 'heft' that most people will fall for. We could even make a special model for the boom and tizz brigade.

Been to any live concerts recently ?

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WW—042 FOR FURTHER DETAILS

The Ultimate Multi-mate

It's easy to see why Philips new PM 2517 digital multimeter is called The Ultimate Multi-mate. No other DMM comes anywhere near its combination of laboratory performance and handy form - for such a handy price. Take a look at some of the features it packs in.

Full 4-digit display giving higher resolution than 3½ digits for 80% of measurements. Parameter readout, too.

Choice of LED or LCD display - choose the one that suits you, the price is the same. Mains unit supplied free with LED version.

Autoranging with manual override. Average auto response time less than two seconds.

True RMS rather than "average" detection. The Ultimate Multi-mate measures non-sinewave AC signals more accurately.

High accuracy - necessary to make full use of those four digits. An impressive 0.2% of reading ±0.05% of scale on d.c. volts.

Current to 10A via a separate input is standard, not optional, on the PM 2517.

Overload protection that is so comprehensive you have to try very hard to do any damage, even with mains and TV booster voltages.

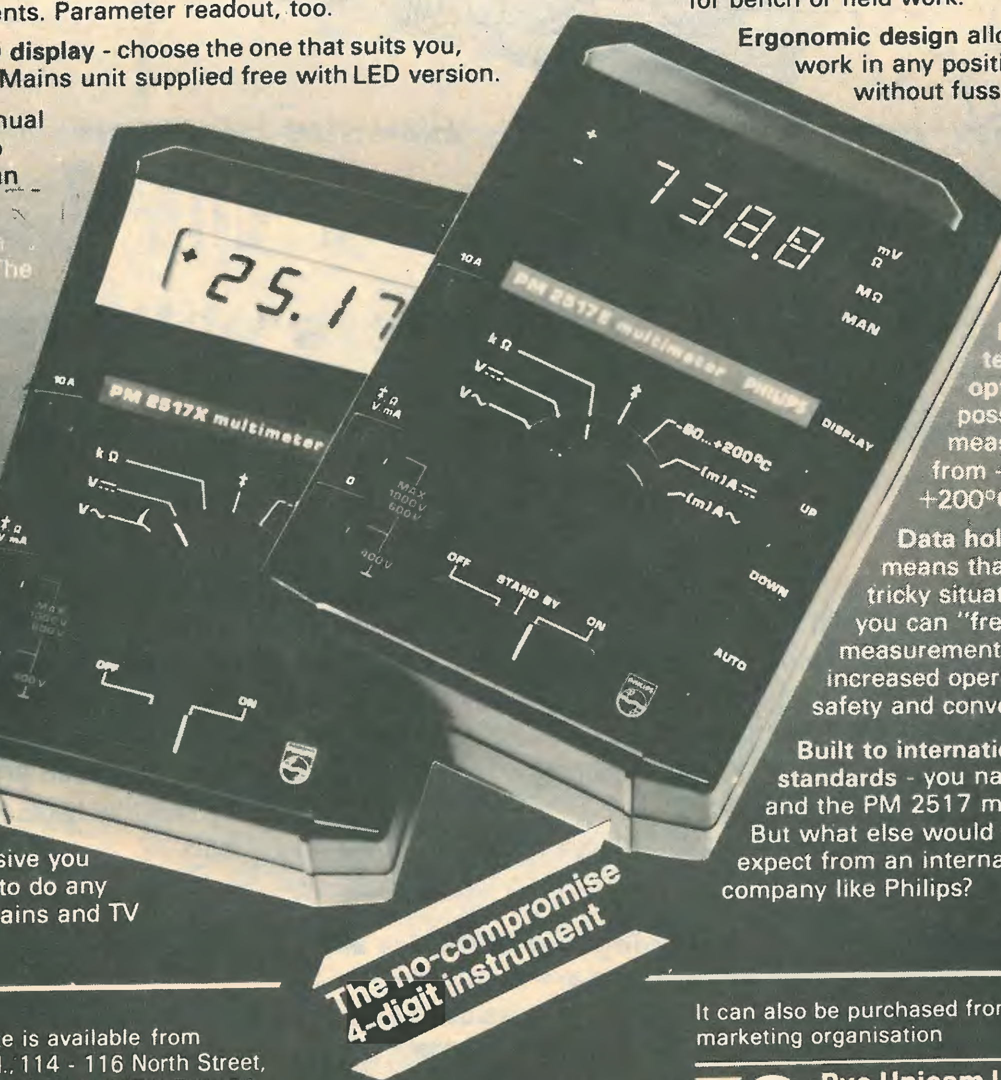
Small and sturdy construction makes this DMM ideal for bench or field work.

Ergonomic design allows it to work in any position without fuss or fumble.

Low-cost temperature option makes possible measurement from —60 to +200°C.

Data hold option means that in tricky situations you can "freeze" measurements for increased operator safety and convenience.

Built to international standards - you name them and the PM 2517 meets them. But what else would you expect from an international company like Philips?



The Ultimate Multi-mate is available from
Wessex Electronics Ltd., 114 - 116 North Street, Downend, Bristol BS16 5SE. Tel: (0272) 571404;
Rank Radio International, Watton Road, Ware, Herts. (Tel: Ware 3966);
and Philips Service Centres
('phone 01-686-0505 for the address of your nearest branch).

It can also be purchased from the U.K. marketing organisation

Pye Unicam Ltd
Philips Electronic Instruments Dept
York Street, Cambridge, England CB1 2PX
Tel: Cambridge (0223) 58866 Telex: 817331

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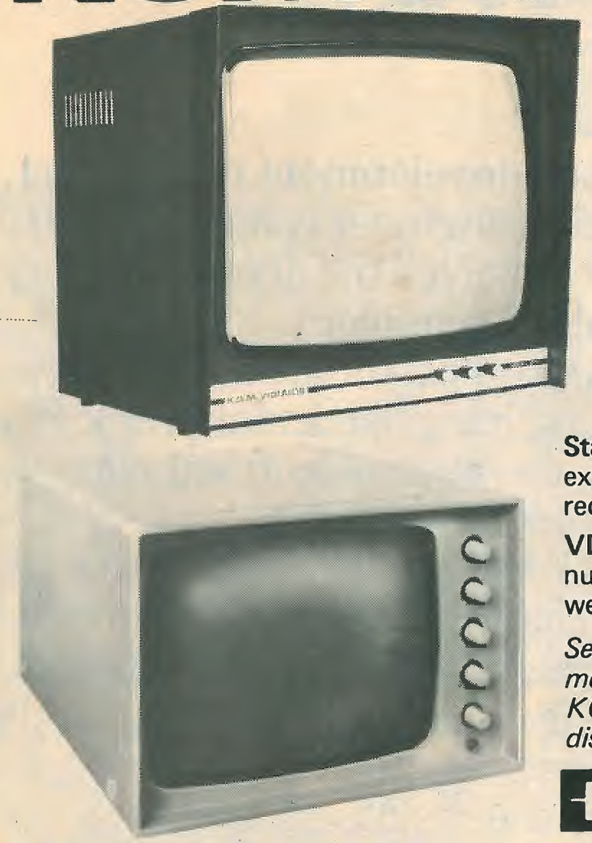
WW—082 FOR FURTHER DETAILS

KGM TV MONITORS the big choice



Type 224 — the ruggedized monitor for those really demanding situations — extremes of weather, temperature, vibration and frequent change of site.

Standard KGM monitors range from 12" — 24". Our long experience of CCTV enables us to meet almost any special requirement.

VDU's — visual display units have also been supplied in large numbers to suit customers' requirements. Tell us your needs and we will gladly quote.

Send for your data sheets on the full range of CCTV monitors and cameras designed and manufactured by KGM. KGM also supply an extensive range of ancillaries and distribution units.

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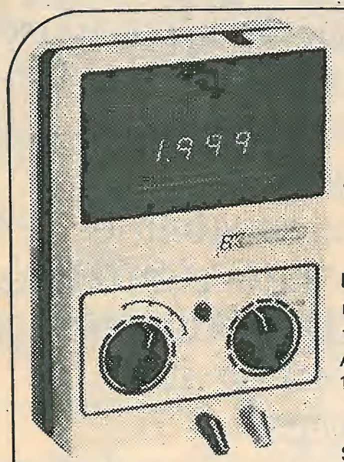

2810 3-1/2 Digit Portable DMM with.5% Accuracy

FEATURES: 3½ digit easy to read LED display · 0.5% typical DC accuracy · Autozeroing · 100μV, .01Ω, 1mA resolution · 10 ohm range and control to zero lead resistance · Selectable High-/Low-power ohms on four ranges · Fully overload protected.

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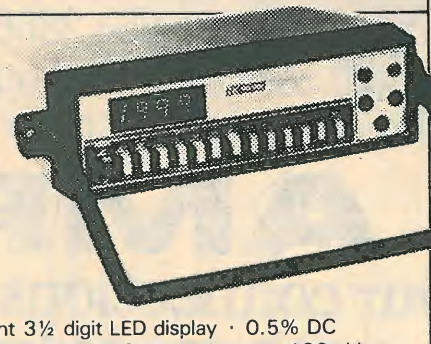
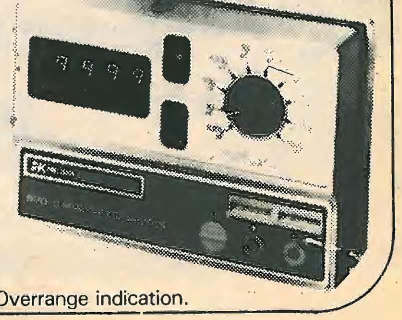
2830 New 3-1/2 Digit Lab DMM



FEATURES: Bright 3½ digit LED display · 0.5% DC accuracy · 100μV, 100nA, .01Ω resolution · 100mV AC and DC ranges · Selectable high-/low-power ohms · Autozeroing · Autopolarity · Completely overload protected · AC operation standard, DC power pack optional · Protected against RF interference · Built-in 10 amp current range.

820 New Portable Digital Capacitance Meter



FEATURES: Measures capacitance to 1 Farad in 10 ranges · Resolves to 0.1pF on lowest range · 4 digit easy-to-ready LED display · 0.5% accuracy · Special lead insertion jacks and banana jacks · Fuse protected · Uses either rechargeable or disposable batteries · Overrange indication.

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

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

You'll like our other design features too. Low force spring contacts. Gold flash or full gold plating on the contacts as you wish. Terminals for wire wrapping or soldering. Many options; pitches of .100" (2.54mm)—modular connector, .150" (3.81mm), .156" (3.96mm) and .200" (5.08mm).

Contact: Connector Sales, Ferranti Limited, Professional Components Department, Dunsinane Avenue, Dundee DD2 3PN, Scotland.
Telephone: 0382 89321 Telex: 76166
Distributors: Giltech Components Ltd., 22 Portman Road, Battle Farm Industrial Estate, Reading, Berks RG3 1ES
Telephone: 0734 582131

FERRANTI
Connector Capability

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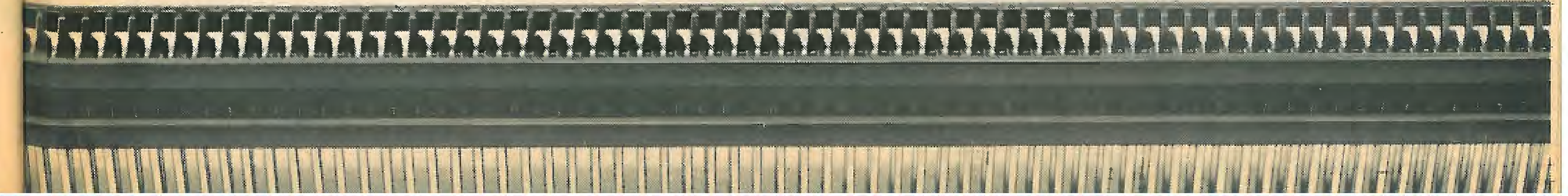
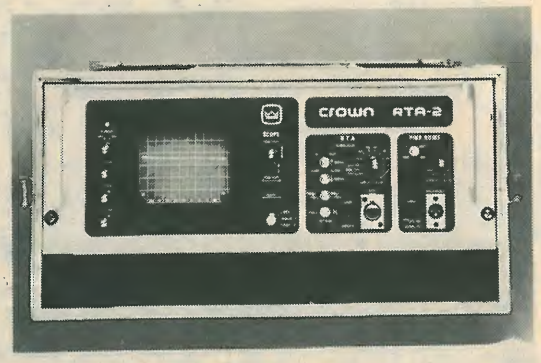


New from AMCRON

Real Time Analyser RTA2



The Amcron RTA2 Real Time Analyser is designed as much for use as a production tool as it is for on-site audio analysis of theatres, and recording studios. A flight case is available.

- ★ 5" CRT Display
- ★ Internal Pink Noise Source
- ★ ⅓ or 1 octave Display
- ★ Frequency range 20 - 20kHz
- ★ Outputs for X-Y Recorders
- ★ Compatible with any microphone
- ★ Price £1,960 ex. VAT

POWER AMPLIFIER D75

The AMCRON D75 power amplifier replaces the previous model D60. Employing completely new type circuitry it offers also many new features but without any increase in the price.

- ★ New Amcron IOC comparator.
- ★ Balanced XLR input connectors.
- ★ Signal Presence indicators.
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- ★ 45 watts into 8 ohms per channel.
- ★ Price £230 ex. VAT.

Other AMCRON products include:

DC300A amplifier 500 watts/chan.	£550
D150A amplifier 200 watts/chan.	£350
VFX2A Electronic Variable Filter	£270
EQ2 Equaliser	£599
IC150A Pre-amplifier	£260
IMA Intermodulation Distortion Analyser unit	£610

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Tel. Saxmundham (0728) 2262/2615

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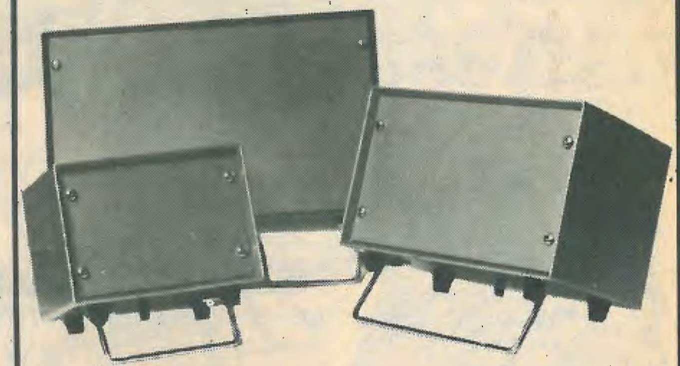
MINICASES



Type	Overall Dimension Width	Height	Depth	Case no vents	Case with vents	Chrome leg
21	6½"	4½"	4½"	—	5.88	1.15
22	8½"	5½"	5½"	—	6.50	1.15
23	10½"	6½"	6½"	—	7.70	1.30
24	12½"	7½"	7½"	—	8.45	1.30
25A	6½"	4½"	4½"	5.60	6.20	1.30
25B	6½"	4½"	6¼"	6.00	6.60	1.30
26A	8¾"	5¾"	6¼"	7.90	8.50	1.30
26B	8¾"	5¾"	8¼"	8.25	8.85	1.30
27A	12¼"	7½"	5½"	8.65	9.35	1.30
27B	12¼"	7½"	8"	9.35	10.05	1.30
28A	14"	10½"	6½"	10.20	10.90	—
28B	14"	10½"	8½"	11.15	11.85	—
29A	10"	4"	6"	7.15	7.75	1.30
29B	10"	4"	8"	7.53	8.13	1.30
30A	12"	5"	6"	7.80	8.50	1.30
30B	12"	5"	8"	8.15	8.85	1.30
31A	14"	6"	6"	8.50	9.20	1.30
31B	14"	6"	8"	8.93	9.63	1.30
61	15½"	7½"	9½"	—	13.00	—
62	17½"	8½"	9½"	—	15.00	—
63	16½"	9½"	9½"	—	15.00	—
64	15½"	7½"	12½"	—	15.00	—
65	17½"	8½"	12½"	—	17.15	—
66	16½"	9½"	12½"	—	17.15	—

Postage & VAT extra

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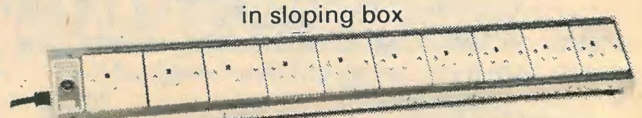

Type 13A/10SW **£27.50.** P&P £1.85 + VAT

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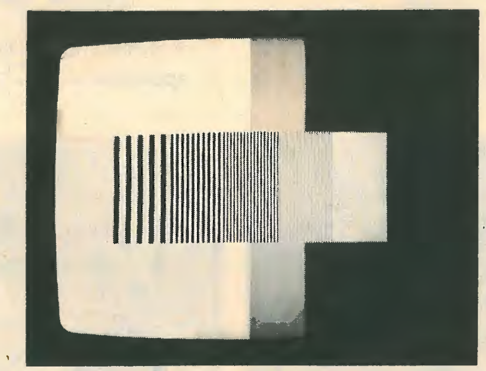
WW—017 FOR FURTHER DETAILS

The professionals' colour pattern generator

Over 20 patterns to CCIR or RTMA standards

- **Full RF coverage: TV IF, Band I-III- IV and V.**
- **Electronic tuning and choice of six preset channels.**
- **Synchronisation according to TV standard, also obtainable as composite and frame sync.**
- **Adjustable Video, calibrated chroma/burst and variable RF amplitude.**
- **Internal/external video and sound modulation.**



Linearstaircase signal with 8 identical steps combined with definition pattern of 5 vertical bars at 0.8 - 1.8 - 2.8 - 3.8 and 4.8 MHz.

This pattern generator is the finest available for precise measurement and alignment work on video equipment including domestic TV receivers, VCR's, VTR's, VLP's, closed circuit and cable TV installations.
Service technicians, video development engineers, TV broadcast staff and lecturers will all appreciate the quality and ease of use of this compact but very versatile pattern generator. More than 20 patterns are available on six channels frequencies using instant touch-button selection. The RF, video and trigger outputs are superior to many other portable generators and closely resemble those transmitted from your local TV station.

Find out more about the PM 5519 and the rest of the Philips audio and video service equipment range by requesting our new Service Brochure.

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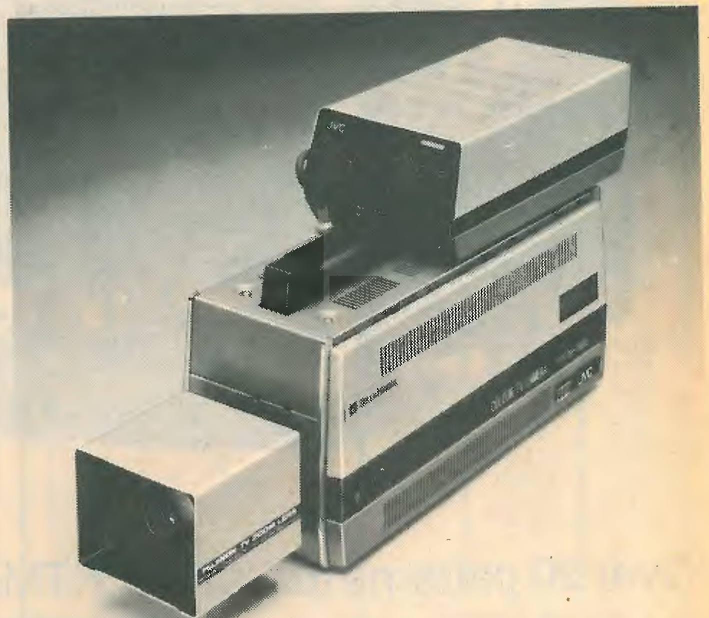
WW — 083 FOR FURTHER DETAILS

Buying video equipment?

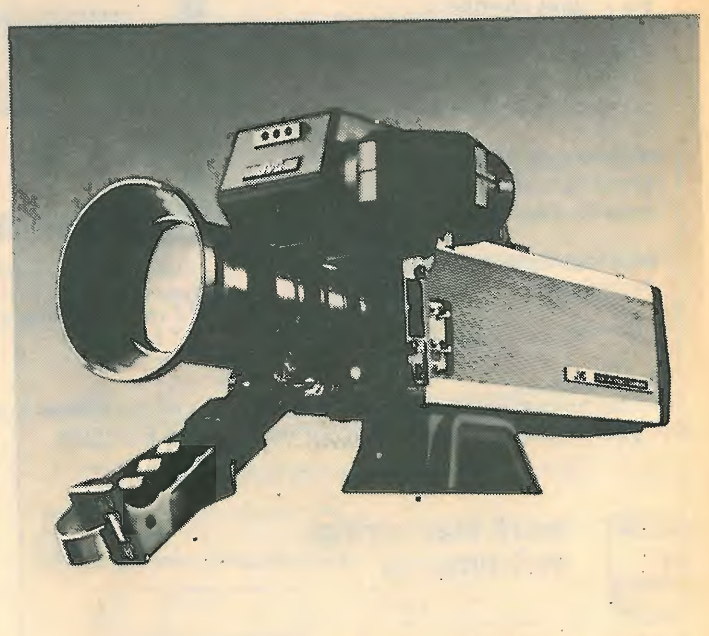
Then talk to someone who picks horses for courses better than most.

The JVC VHS recorder and GC3300 camera form an economical colour system for duties like rôle playing and product demonstrations.



A three-tube colour camera with a wide range of applications: JVC's NU1800.

Fuji video tapes–among the world's finest–are a comprehensive range extending from VHS to broadcasting.



The outstanding new JVC CY8800, truly portable but with a 'studio' standard of performance.

Before making a purchasing decision, talk to one of Bell & Howell's specialist video dealers. You'll find he's a specialist with some special qualities. He knows everything worth knowing about the JVC and other video products distributed by Bell & Howell, as you'd expect. He also knows which of these products, or which combination of them, is likely to be best for whatever video job you have in mind.

Indeed, he'll even resist the temptation to sell you any kind of video equipment if your message can be conveyed just as well by a tray of slides plus a cassette of audio tape. Conversely, he'll have the courage to start talking in four figures, or maybe five, if a substantial investment is what you've got to make.

And, when the decision has been made and the order placed, you have a guarantee of highly skilled free advice on anything to do with the equipment you buy. That's part of the exclusive new Bell & Howell Supershield warranty, which also guarantees free replacements or repairs, with no labour charges, for two years from the date of purchase.*

First-class video equipment. First-class advice. The support of a first-class (and, we believe, unique) guarantee. For all of these, just contact one of the Bell & Howell specialist video dealers whose names and addresses you can obtain by using the inquiry service or writing in an unstamped envelope to Bell & Howell A-V Ltd, Freepost, Wembley, Middlesex, HA0 1BR (01-903 5411).

*This two-year warranty even includes video heads and excludes only video tapes and camera tubes. In mainland Britain, too, we collect and deliver free when guarantee service is required.

BELL & HOWELL
Information systems. For work, education and entertainment.

CR8500LE, JVC's new U-format recorder, designed for assemble and insert editing and with important special features.

One of the current JVC range of ¾ in. U-format video cassette recorders, with full remote control.

A JVC configuration for U-format recording on location, based on the CR4400 portable recorder and two-tube GC4800 colour camera.

The JVC accessory range extends from simple vision switches to effects and mixing units–and beyond.

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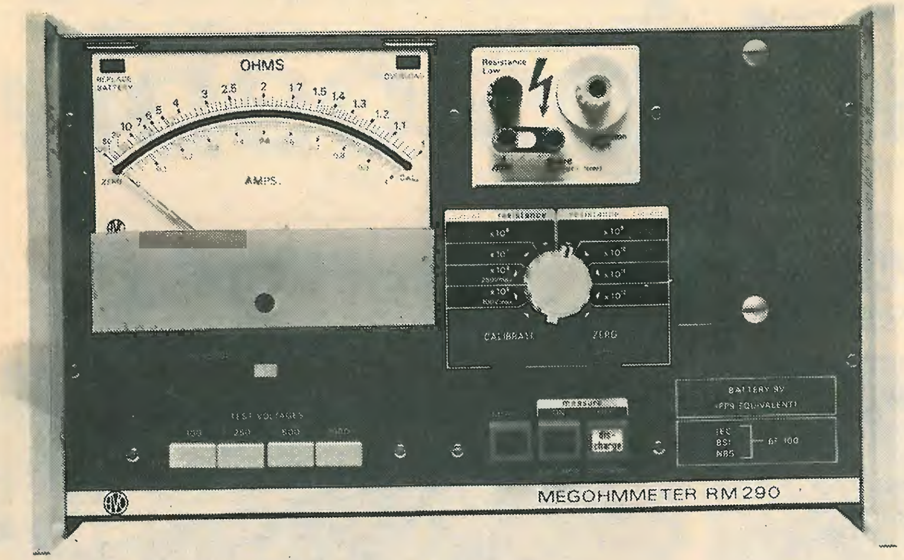

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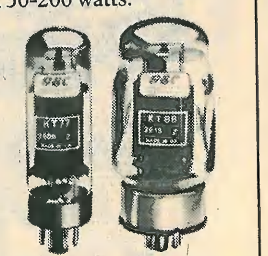

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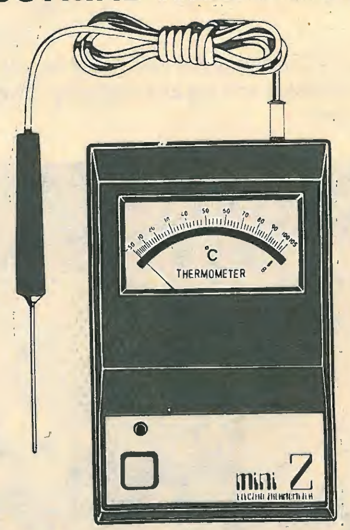

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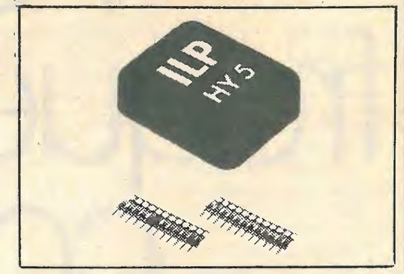
15—240 Watts!

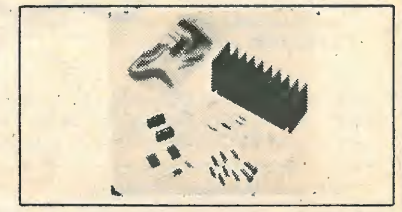
HY5
Preamplifier

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 £6.27 + 78p 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 £6.27 + 78p VAT. P&P free.

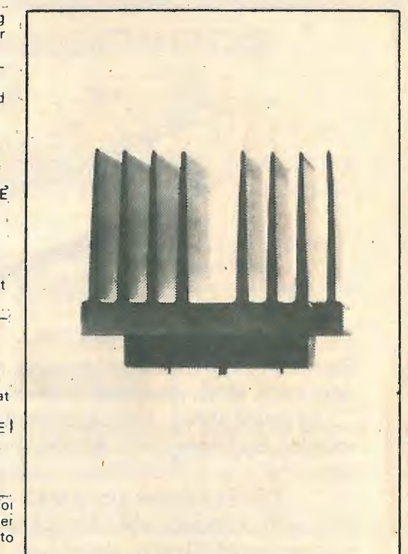


HY50
25 Watts into 8Ω

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 £8.18 + £1.02 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 £19.01 + £1.52 VAT. P&P free.

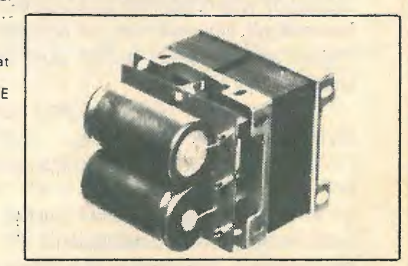


HY200
120 Watts into 8Ω

The HY200, now improved to give an output of 120 Watts, has been designed to stand the most rugged conditions, such as disco or group while still retaining true Hi-Fi performance.
FEATURES: Thermal shutdown — Very low distortion — Load line protection — Integral Heatsink — No external components.
APPLICATIONS: Hi-Fi — Disco. — Monitor — Power Slave — Industrial — Public address.
SPECIFICATIONS:
INPUT SENSITIVITY 500mV.
OUTPUT POWER 120W RMS into 8Ω. LOAD IMPEDANCE 4-16Ω. DISTORTION 0.05% at 100W at 1kHz.
SIGNAL/NOISE RATIO 96dB. FREQUENCY RESPONSE 10Hz-45kHz — 3dB. SUPPLY VOLTAGE ±45V.
SIZE 114 x 100 x 85mm
Price £27.99 + £2.24 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 £38.61 + £3.09 VAT. P&P free.



POWER SUPPLIES

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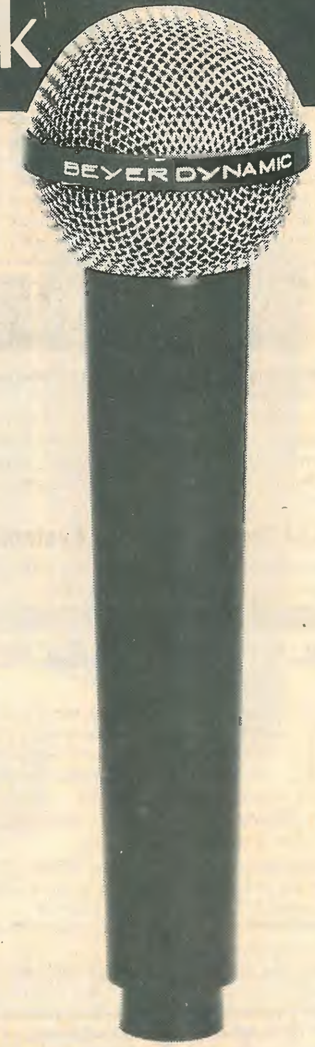

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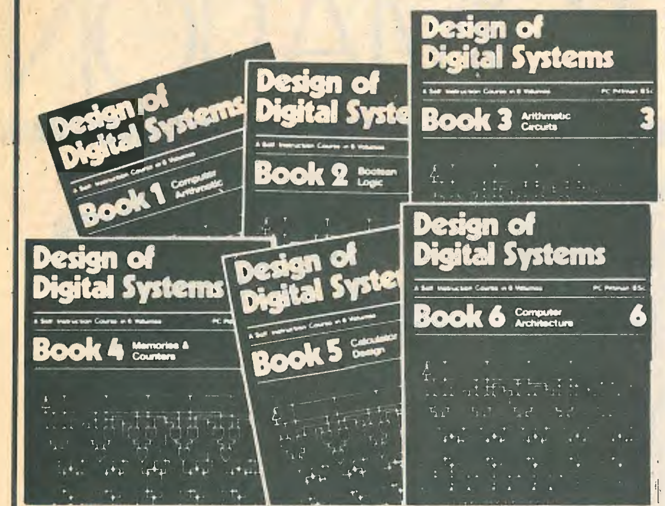
New teach-yourself courses



In the years ahead the products of digital electronics technology will play an important part in your life. Calculators and digital watches are already commonplace. Tomorrow a digital display could show your vehicle speed and petrol consumption; you could be calling people by entering their name into a telephone which would automatically look up their number and dial it for you.

These courses were written by experts in electronics and learning systems so that you could teach yourself the theory and application of digital logic. Learning by self-instruction has the advantages of being faster and more thorough than classroom learning. You work at your own pace and must respond by answering questions on each new piece of information before proceeding.

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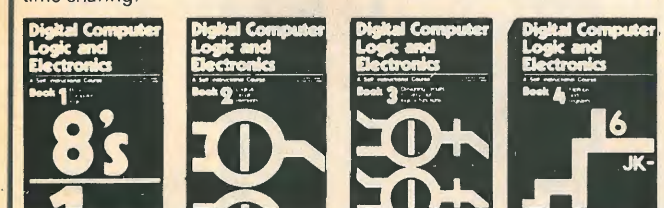
Design of Digital Systems is written for the engineer seeking to learn more about digital electronics. Its six volumes — each A4 size — are packed with information, diagrams and questions designed to lead you step-by-step through number systems and Boolean algebra to memories, counters and simple arithmetic circuits, and finally to a complete understanding of the design and operation of calculators and computers.

The contents of Design of Digital Systems include:

Book 1 Octal, hexadecimal and binary number systems; conversion between number systems; representation of negative numbers; complementary systems; binary multiplication and division.
Book 2 OR and AND functions; logic gates. NOT, exlusive OR, NAND, NOR and exclusive-NOR functions; multiple input gates; truth tables; De Morgans Laws; canonical forms; logic conventions; Karnaugh mapping; three-state and wired logic.
Book 3 Half adders and full adders; subtractors; serial and parallel adders; processors and arithmetic logic units (ALUs); multiplication and division systems.
Book 4 Flip flops; shift registers; asynchronous and synchronous counters; ring, Johnson and exclusive-OR feedback counters; random access memories (RAMs) and read only memories (ROMs).
Book 5 Structure of calculators; keyboard encoding; decoding display data; register systems; control unit; program ROM; address decoding; instruction sets; instruction decoding; control program structure.
Book 6 Central processing unit (CPU); memory organisation; character representation; program storage; address modes; input/output systems; program interrupts; interrupt priorities; programming; assemblers; computers; executive programs; operating systems and time sharing.



Digital Computer Logic and Electronics is designed for the beginner. No mathematical knowledge other than simple arithmetic is assumed, though the student should have an aptitude for logical thought. It consists of four volumes — each A4 size — and serves as an introduction to the subject of digital electronics. Everyone can learn from it — designer, executive, scientist, student, engineer.

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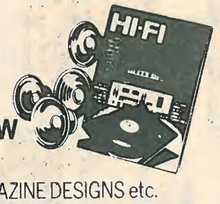

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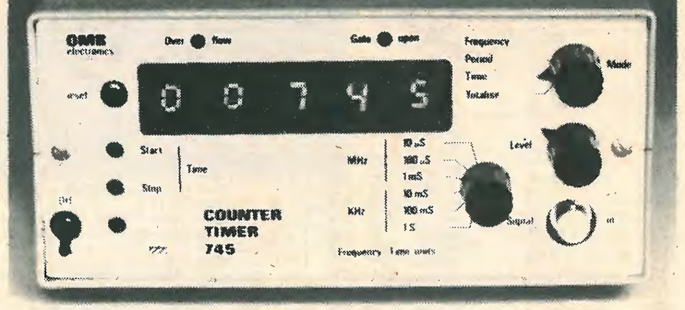

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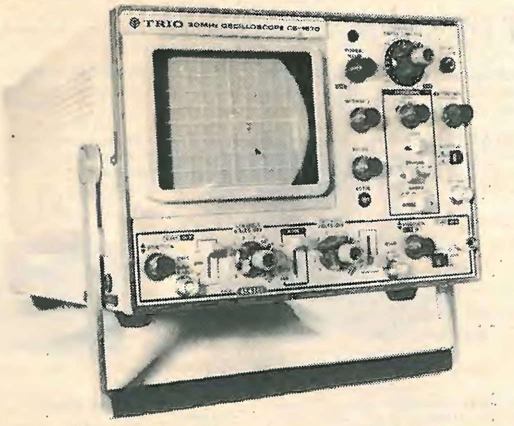

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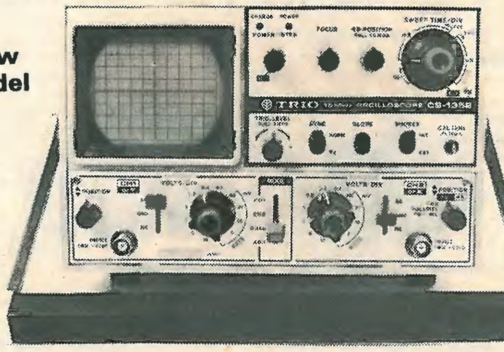

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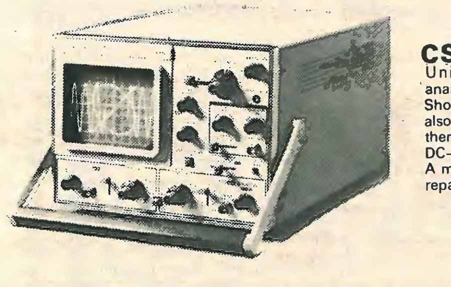

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Performing blights

It is not open to question that goods sold by retailers should be capable of fulfilling the purpose for which they are meant — they should be of "merchantable quality". Most people need no urging to insist that this law should be observed; a faulty pair of shoes or a watch that gains or a tape recorder that doesn't are quickly returned whence they came and instant action demanded.

Usually, the fault is obvious: if a pair of shoes lets the water in, one can be reasonably sure there is a hole in them; a book with pages missing is an affront to the eye and a bag of crisps containing nothing but little blue packets brooks no argument.

Times are changing rapidly, more so than ever before, and the words "high technology" are bandied about and taken to mean, in our own industry, "clever electronics". Domestic tape recorders, amplifiers and tuners are not in the same class as industrial equipment, computers and the like when judged by the height of their technology, but on the domestic scene they are clever enough to be the least-understood kind of hardware ever found in the average person's home.

Of course, radios and record players have been around for many years, but all they have been expected to do (by this mythical "average person") is to produce a large enough amount of "mellow" music. Now, the possession of an array of satin chrome and teak, high-quality equipment comes a good second to the bed and dining table when setting up house.

The choice of the equipment, when not made on appearance alone, is often prompted by the scanning of reviews in the magazines devoted to high-fidelity sound — and very thorough some of them are. But an ominous note is sounded in many reviews seen in these magazines to the effect that adjustments have not been properly carried out by the makers, drastically reducing the quality of reproduction — and this is on equipment lent by makers, not bought in shops. On tape recorders, for example, head alignment is frequently a cause for complaint, as are the amount of bias current and Dolby level adjustment.

It does not seem possible for most users to investigate the finer points of performance themselves, which means they are totally in the hands of the maker/retailer organization. Since it would be unrealistic to suppose that, when sold, every single piece of equipment is at the peak of its potential, it must be assumed that there are instruments in service which are not performing as well as they might, the reasons for which the user is at a loss to explain, even supposing he can detect the shortcomings.

It would probably increase the price of equipment to an unacceptable level to expect that each instrument be subjected to a stringent examination of every facet of its specification, and since it seems probable that many purchasers would not be greatly upset by a signal-to-noise ratio of 57dB instead of 58dB, it would be unwarranted. But is there, perhaps, scope for specialist organizations to "breathe on" equipment, at a price, to make sure it is performing up to its capabilities? In an ideal world, this sort of thing would not be needed, but it seems to be an increasingly rare experience to buy a complicated object — a car, music-centre, house — and be completely happy with its performance. Exhortations from public to manufacturers appear to have negligible effect. It might be better and cheaper, of course, for the maker to do no testing at all, the specialist taking over completely: the maker couldn't then charge for work which hasn't been done.

Low-cost logic analyser

Simple, yet flexible design with discrete l.e.d. display

by B. C. Adams

As digital i.cs and systems get larger and more complex, so the problems of testing and de-bugging also become more difficult. To keep pace with these problems, costly commercial analysers have been designed to maintain the systems. This design offers several useful features and enables the constructor to build a versatile, yet economical logic analyser.

THE PROBLEMS INVOLVED in testing and function checking digital equipment are exactly the same for the amateur constructor as they are for industry except that the cost of a commercial logic analyser is prohibitive to the constructor. Faced with this problem, I designed a reasonably simple analyser which can provide almost any information that may be required from a logic system. With a little experience and ingenuity the user can overcome most diagnostic problems.

Introduction

A block diagram of the analyser is shown in Fig. 1. The instrument is a self-contained unit which comprises four main sections, a 16-bit parallel data input latch, a sample channel and display matrix, a hexadecimal comparator, and a trigger input with control logic.

In operation, the analyser monitors a number of different signal points and displays their state. If a particular section is triggered, the data is stored. All inputs are interfaced to the internal logic via comparators which provide a high input impedance, compatability with high level or t.t.l. logic, and permit the threshold transition level to be controlled. The 16-bit parallel latch outputs are taken to a row of l.e.d.s which indicate the 0 to 1 state of each input. The latch can be used, for example, to sample a data bus at a predetermined time or in the event of a fault, which can be especially useful when debugging microprocessor machine-code programs.

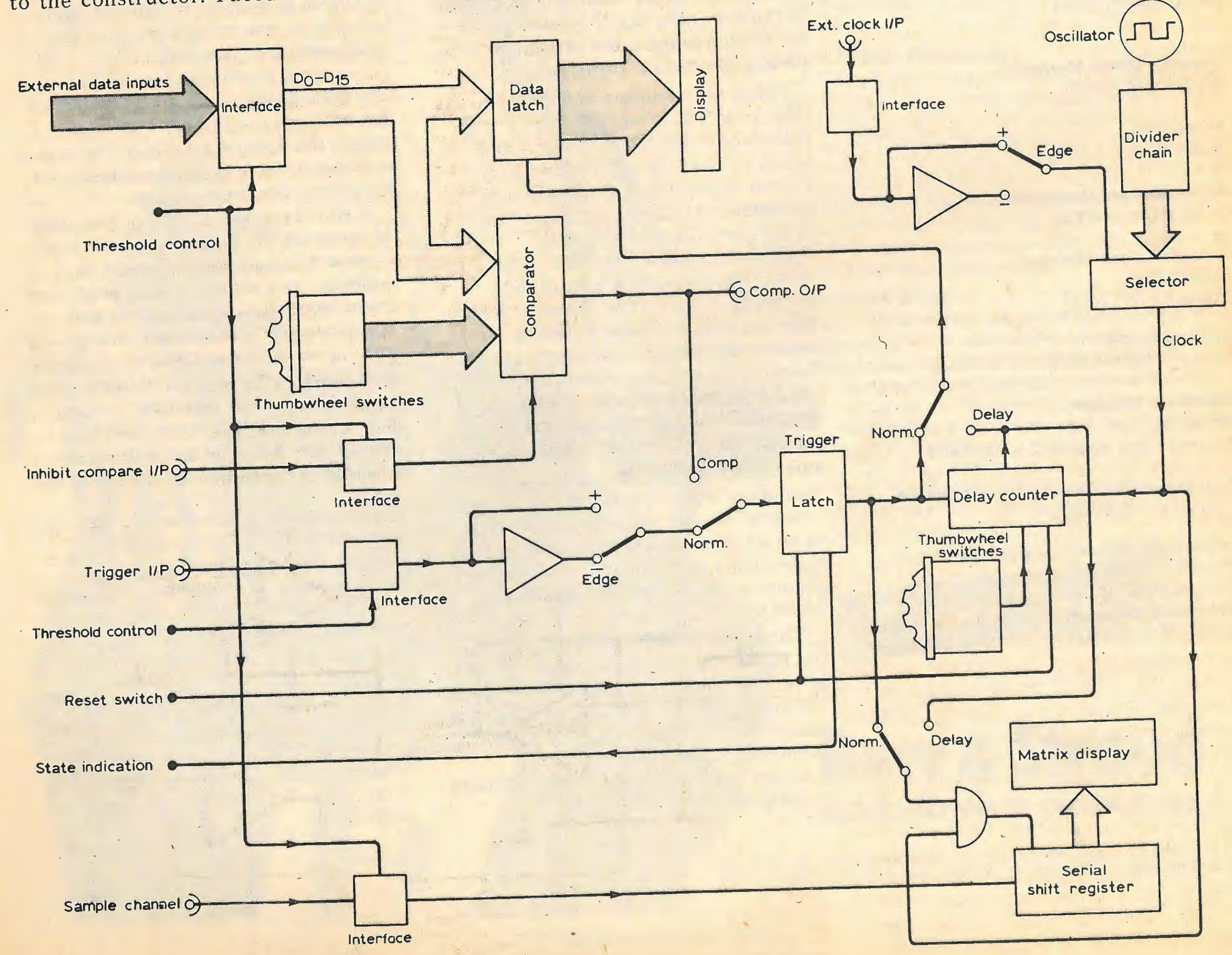


Fig. 1. Block diagram of the analyser which comprises four basic sections. All external inputs are interfaced to the logic by comparators.

The sample channel can be used to store and display any sequential input signal by loading it into a 32-bit serial shift register at a preselected clock rate. The contents of the register can then be continuously displayed on an l.e.d. matrix. When a trigger signal occurs, the sample clock is inhibited and the display matrix indicates the states of the 32 previous input pulses. By using the external sample clock input, a data-domain rather than time-domain display can be generated which is necessary when monitoring synchronous logic.

A 16-bit hexadecimal comparator continuously compares the data-latch inputs with a hexadecimal code set on thumbwheel switches. A true output is generated when the latch input code equals the hexadecimal code, and this can be used either as an external control signal, or switched internally to the trigger input. Many microprocessors use hexadecimal coding for their machine code instructions, so the analyser can be triggered by a particular machine instruction and store data from, for example, a peripheral at a time related to that instruction. An input is provided which can inhibit the compare output, during a change in state of the parallel data inputs, until they have settled.

The data latch and sample channel can be individually controlled by the external trigger input which has a separate logic threshold control, and provision for positive or negative-edge triggering. The trigger signal is detected by a latch, and the state of the latch is displayed by an l.e.d. which flashes when a correct trigger signal has been received. In addition to signals from the trigger latch, control may also be derived from a delay counter which generates a signal a preselected time after the trigger latch has changed state. This delay mode is useful because it allows any combination of pre-trigger and post-trigger information to be stored by the data latch and sample channel. The delay is set by a 0 to 99 thumbwheel switch, and is the thumbwheel setting multiplied by the sample rate selection.

Specification
Data inputs, sample channel and compare/inhibit input

Propagation delay for low to high	70ns
Propagation delay for high to low	95ns
Input resistance	90kΩ
Transition threshold	1.5 to 10V
Transition hysteresis	0.175V
Maximum input	+1·2V
Minimum input	−2V
Trigger input as above except for	
Propagation delay from trigger signal to disable signal	70ns
Transition threshold	1.5 to 10V
Delay mode	Selectable from 0 to 99 times the selected clock period or external input period
Clock	
Source	Internal oscillator or external input
Clock period selection	20ns to 20ms
External input	The same as data input except for threshold which is fixed at 2.2V.

Circuit description

The main requirements for the input interface are that it should be high impedance, fast, and should allow control of the 0 to 1 to 0 transition threshold. The external sample-clock input is similar, but with a preset transition threshold. It is also necessary for the interface to accept both t.t.l. and high level logic inputs. The circuit in Fig. 2 shows the SN2710 comparator which was chosen for its speed and its ability to drive t.t.l. This device does, however, have a relatively high input current requirement which restricts the input impedance. To overcome the inherently low hysteresis of the comparator, about 175mV of feedback hysteresis is added by R_3.

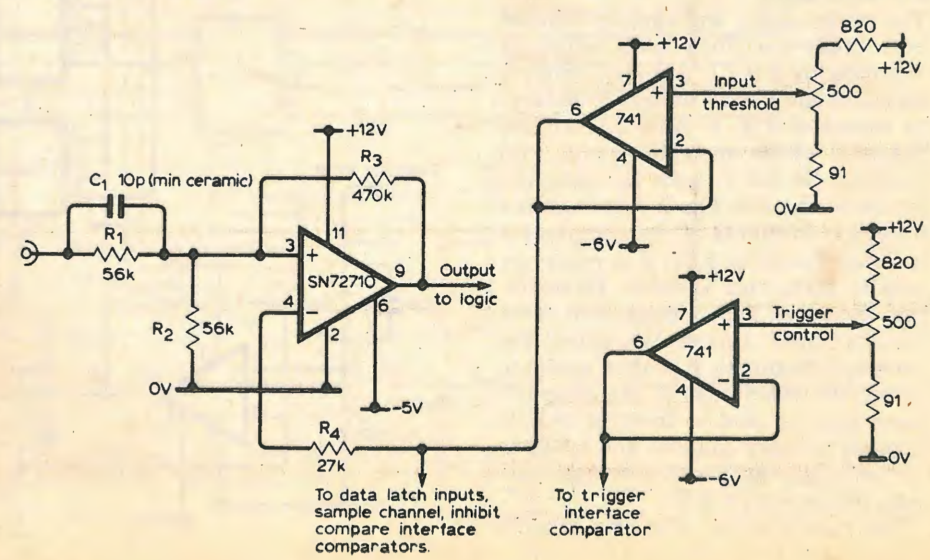
A combination of input resistance and intrinsic shunt capacitance of the comparator tends to increase the propagation delay, but this has been partly overcome by the addition of a speed-up capacitor C_1, which provides some input overdrive for each edge of the input waveform. The reference voltage for each comparator is derived from a common op-amp via separate source-impedance matching resistors. It is essential that a well-stabilized voltage is used for the variable threshold levels, because power supply ripple can cause incorrect transition switching.

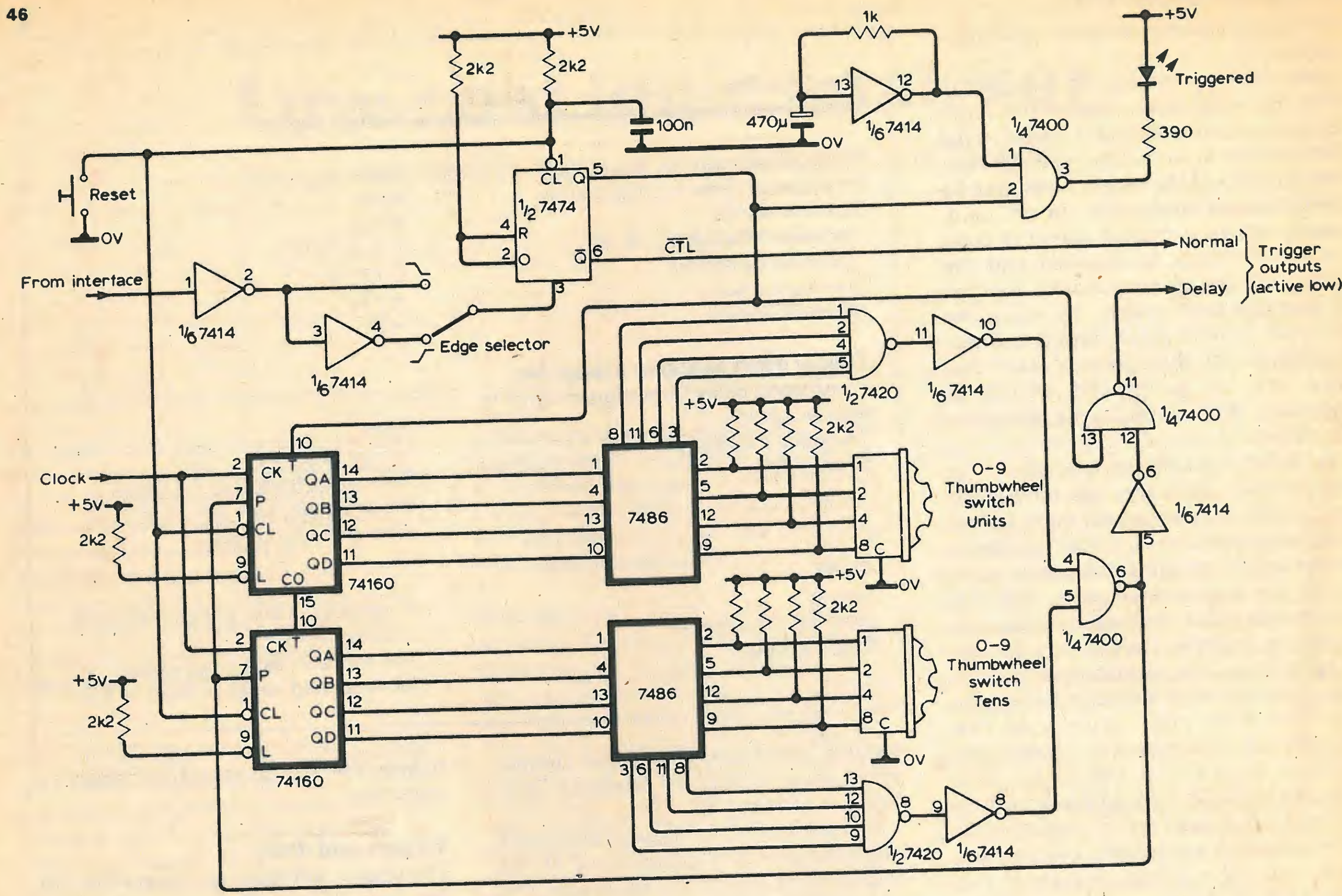
Low power Schottky t.t.l. is used to limit the load on each comparator, and to keep the total propagation delay to a minimum.

Fig. 2. Interface comparator and threshold level controls. Resistor R_3 provides about 175mV of feedback to increase the hysteresis.

Trigger and delay

The trigger and delay circuit is shown in Fig. 3. The trigger channel is interfaced with its own threshold control, and the signal is used to clock a D type flip-flop connected as a latch. The output of the latch is used to gate a low-frequency oscillator which drives the trigger indicator lamp and delay counter. As shown, the latch can be reset using the clear input, and positive or negative-edge triggering is achieved via two inverters. Once the latch has been triggered, the CTL output goes high and enables the two synchronous decade counters. The count is compared with the thumbwheel switch setting by exclusive-OR gates, and the gated outputs are decoded when the counter value reaches the required number. The counters are then disabled by taking their inputs low. The delay and the CTL signals can both be used for switch selection to the sample channel and the





▲
Fig. 3. *Trigger and delay circuit. The counter clock may be fed from the clock and divider chain in Fig. 4, or from the external input.*

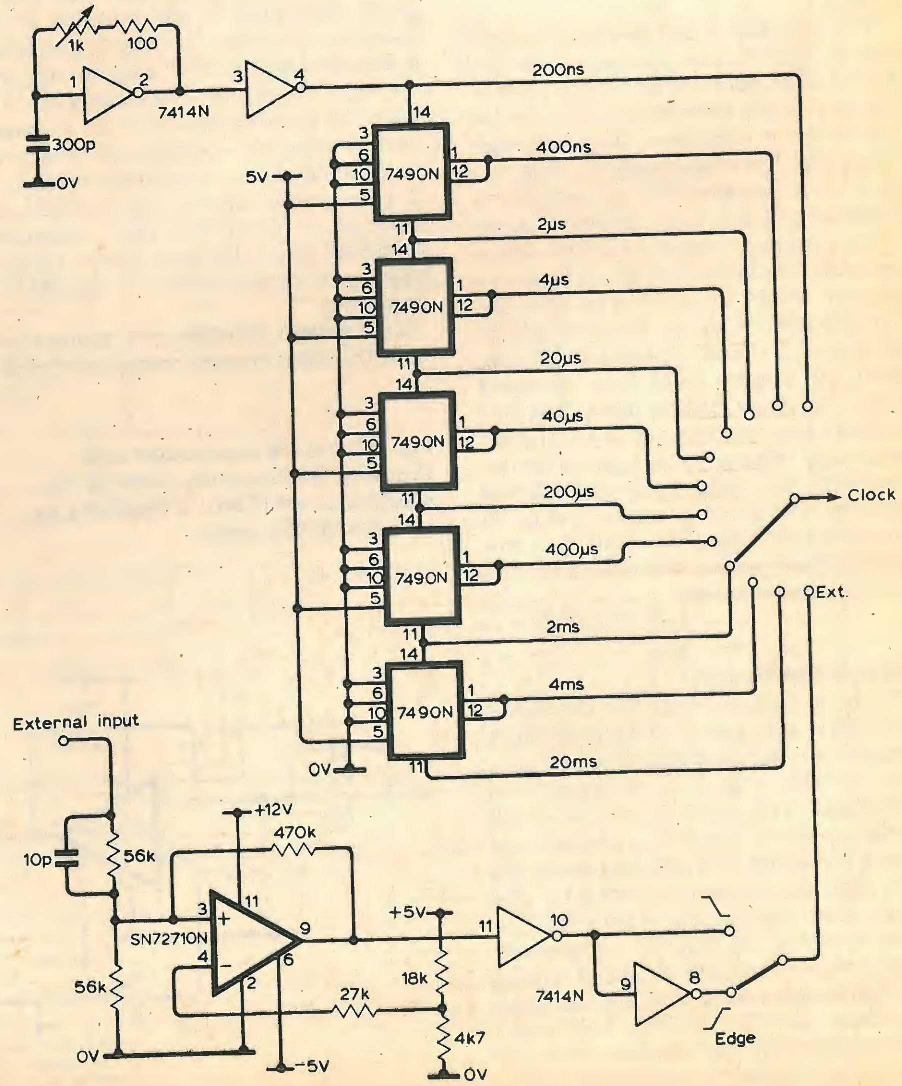


Fig. 4. *Clock generator and external input.* ▶

data latch disable inputs. The counter clock period may either be derived from the internally generated clock and divider chain in Fig. 4, or from the external input, in which case the delay counter can be used to trigger a data section after a pre-determined number of pulses at the trigger input.

Internal clock generator and external input

The trigger-delay and sample-channel both require a clock train which is supplied by a t.t.l. Schmitt trigger oscillator and a chain of decade dividers as shown in Fig. 4. Alternatively an external clock may be used, and provision for this is made by using the interface circuit in Fig. 2. Although the transition threshold of the comparator is shown preset at 2.2V, it is relatively easy to make this variable. However, this should be kept independent from the data-input threshold control for maximum flexibility. It is often useful to determine which edge of the external-input signal is used to drive the sample channel or delay counter, and a switch for selecting the positive or negative-edge has been included.

The total number of clock outputs available, including the external source, is twelve and on the prototype these are selected by a 1-pole 12-way rotary switch connected to the clock inputs of the sample-channel and delay-counter which are linked. It is just as easy, however, to allow both clock inputs to independently select a clock line by using two rotary switches.

Data latch inputs and hexadecimal comparator

The data-latch and l.e.d. display circuitry is shown in Fig. 5. The interface comparator outputs in Fig. 1 directly drive the hexadecimal comparator and the bistable latches. The latch outputs each control an individual l.e.d. which is positioned on the front panel directly above the corresponding data input socket.

While the enable input is at logic 1, the latch output will follow the data input condition, and when the enable is taken to a logic 0, the latch output will hold the logic state which was present

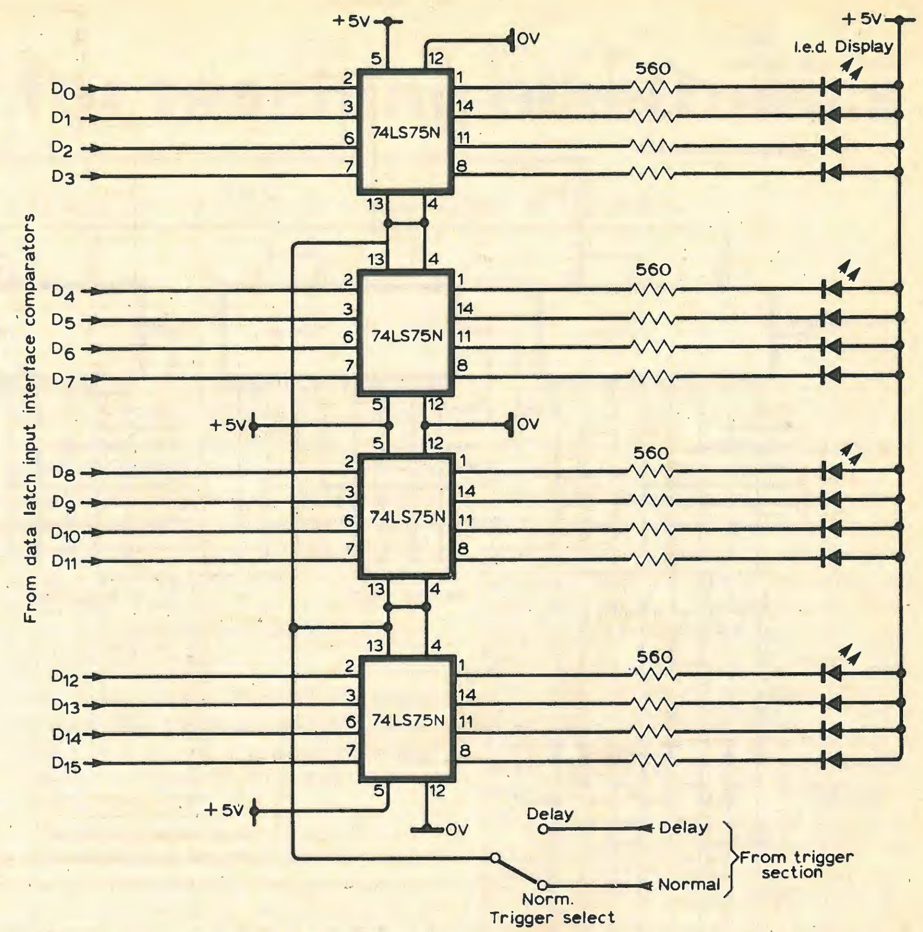
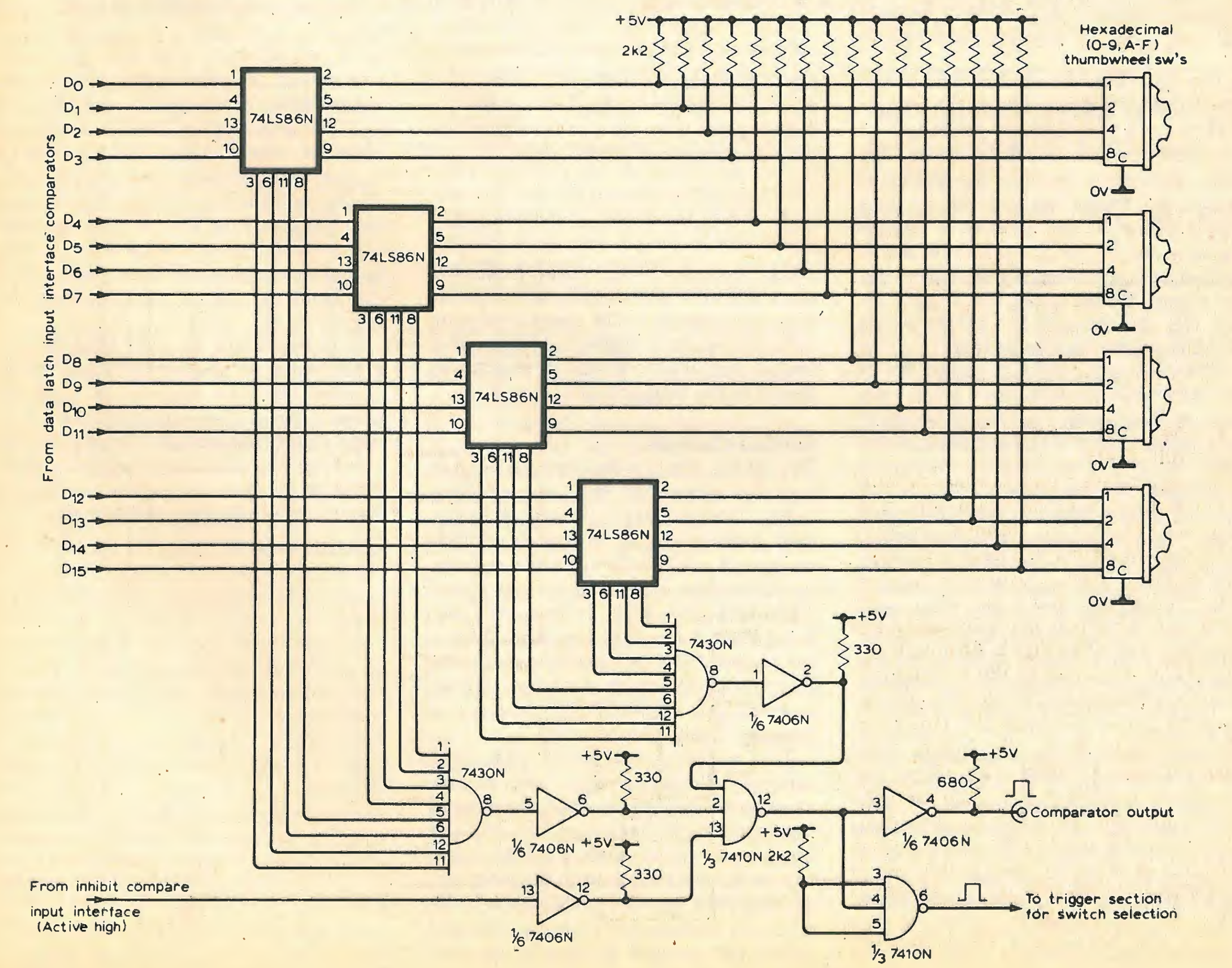


Fig. 5. *Data latch and display. Because the 74LS latches have a low output current capability, a reduced l.e.d. current of about 5.5mA is used.* ▶

Fig. 6. *Hexadecimal comparator.*
▼



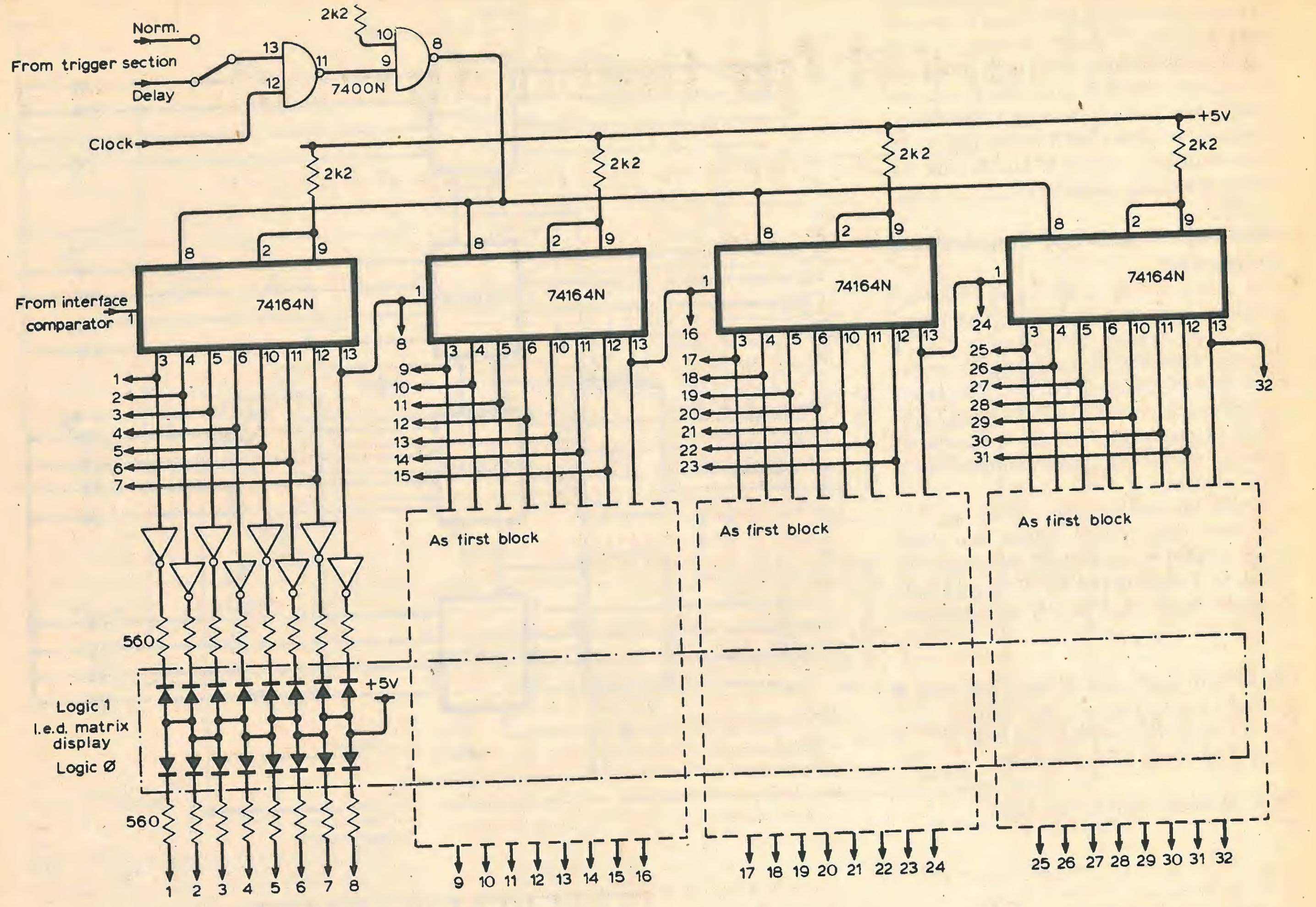


Fig. 7. *Sample channel and display matrix. In the prototype, two spare NAND gates were used as inverters. All other inverters are 7400N types.*

at the time of the transition. The latch-enable signal is derived from the trigger section and a switch is provided to select either normal or delay mode. The data-latch therefore has the ability to sample and freeze the state of the data inputs either at the time of a trigger signal occurring, or at a pre-determined time or operational point after the trigger signal. By disabling the trigger input, the l.e.d. display can be used as a 16-bit real time logic indicator.

The low output current capability of the 74LS series necessitates a lower l.e.d. current than would normally be used, and in this case it is about 5.5mA. However, this has proved to be quite acceptable. By using the Q latch output, an l.e.d. that is illuminated indicates a logic 1 and vice versa. The circuit has been designed to show 16 bits of data, although this can easily be expanded or reduced in blocks of four bits depending on the user's requirements. It should be noted that extra control signal buffering will be required if further bits are added.

The hexadecimal comparator section is shown in Fig. 6. The comparator continuously compares the logic state of the data inputs with a hexadecimal-coded binary value set on the thumb-wheel switches. This signal can be used as a control for either external use or as a trigger command, and also as a signal to be displayed on the sample channel. The compare/inhibit input, which uses the standard interface, disables the compare-output when taken high, and thus inhibits unwanted comparisons from the exclusive-OR gates. An open collector output is taken to a front panel socket and also to a switch which can feed it to the trigger input.

Sample channel

The 32-bit sample-channel store uses four 8-bit series shift-registers as shown in Fig. 7. Input data is presented to the shift register via an interface comparator, and clocked through the register on the positive edge of each clock cycle. Therefore, the register contains the input logic states that appeared during the previous 32 clock periods. By disabling the clock when a trigger signal occurs, the register will store the previous 32 bits of input data.

The register contents are continuously displayed on an l.e.d. matrix as shown. The top row of the matrix represents logic 1 register bits, and the bottom row represents logic 0. By using the external clock input, the combination of shift register and display forms a time or data domain storage channel which can be used for displaying one-shot pulses or pulse trains. Use of the trigger-delay mode enables the channel to store and display events occurring after the trigger signal. By delaying 16 sample clock periods, the first half of the display will show the state of the sample channel input for the 16 clock periods before the trigger signal, and the second half of the display will show the state of the input for the 16 periods after the trigger signal.

It is important to note that for an input pulse or change of state to be clocked into the register, it must be present for at least one positive clock edge. For this reason, it is always advisable to have a clock sampling frequency of at least five times the expected frequency of the input waveform.

to be continued

New format for teaching electronics

"Novatexts" are a breakaway from conventional textbooks

by Peter Williams Ph.D., Paisley College of Technology

TEXTBOOKS HAVE NOT CHANGED their format in our generation — nor in the last. There are good reasons for this: the format has been successful for so long that there have to be. Conventionally the work is divided into chapters of roughly equal length, each chapter dealing with a single subject. Within each chapter there is a variety of information. In engineering and science at least four types are distinguishable: diagrams, figures and graphs; text, often describing the diagrams and linking them to the analysis; mathematical material developing the theoretical background; examples either practical or numerical. The last category can be extended to include data on particular devices or systems, references to related topics and so on. It is possible without diminishing its importance to describe this section as "house-keeping", a collection of useful functions that vary from occasion to occasion, e.g. some chapters lend themselves to worked examples, while others benefit from reference to manufacturers' data.

On each subject the reader is presented with this range of information, that, fully absorbed, leads to a balanced judgement. It is at this point that the approach can be challenged. It assumes implicitly that each reader is in need of all the information all the time. In some cases certain sections are indicated as being of advanced level, or of being subsidiary to the main theme, but that all the types of information are necessary does not appear to be questioned.

Consider the order in which the material is presented: the text introduces a topic, followed by a circuit diagram, a graph or a scale drawing. Some aspect of the material is then analysed, perhaps with a worked example and the text resumes. The pattern, or sometimes the lack of it, is repeated throughout each chapter, the aim being to provide a logical and coherent development of the whole subject at a level appropriate to the readers. The material is presented sequentially, and the reader is constrained to follow that sequence if he or she is to benefit most from the efforts of the author.

★ ★ ★

The proposition underlying the new approach is simple: that at any given time the information needed by a reader is less than that presented by the author. (This does not conflict with the truism that the need is always more than any author can provide.) The proposition is that different types of information are appropriate to different users, and to the same users at various times. The following illustrations may help to make the case:

- —a technician asked to produce a piece of test equipment would find a diagram of a circuit or a scale-drawing helpful, particularly if backed up by a worked example.
- —a student meeting a subject for the first time would need a description of the principles well before the rigours of the mathematical analysis became important.
- —during a second-level course the general principles should have been absorbed leaving the analysis as the key section though with reference to explanatory material to fill gaps in the memory.
- —a working engineer coming on an unfamiliar topic would welcome a visual summary of the subject in diagrammatic or graphical form; this would show the degree of relevance of the material and whether the text and analysis merited further study.

This is the case for the separation of a subject into separate types of information. It is not argued that this should always be done, but that it is an alternative of say diagrams, text analysis, examples. The weakness is that the physical separation onto different pages makes it almost as difficult to find the explanation of a diagram or the equations referred to in the text. There appears to be no way of juggling the information in a book to meet these requirements. This is because there is the hidden and apparently reasonable assumption that each sub-division of the book needs a number of pages. To a reader of this journal it will be clear that the format allows a far greater amount of material on the page. As a rough guide a WW page of text has 1200 to 1600 words depending on the type-size. By comparison, a novel has about 220 to 300 words per page with comparable figures for many text books. This shows the intensive nature of the information available in an A4 journal format — a 300-page text book can be accommodated in less than 60 pages, which is comparable to the editorial matter in a single issue of the journal.

The importance lies not in the value-for-money aspect but in the fact that a double-page spread is equivalent to perhaps a dozen pages of conventional text books. This represents a short chapter, and readily encompasses single topics within a longer chapter. The topic can now be presented at one sitting as it were and the format chosen is shown on page 50. The presentation is series-parallel rather than purely serial in that each of the four types of information appears sequentially but with the four streams of information in parallel. The first time reader can scan the left-hand column and perceive the nature and scope of the topic at a glance. Even before the details are gleaned from the text, the development of the ideas should be clear and the reader should know whether the text analysis or examples are most likely to meet his needs. Thus students, engineers, teachers and technicians can select the types of information they need in the most convenient order.

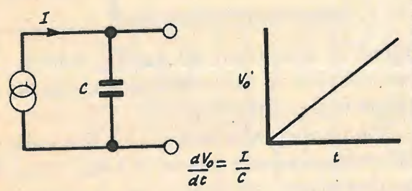
"Different types of information are appropriate to different users, and to the same users at various times."

Because the data streams are parallel, it is easy to cross-refer from diagram to text, to relate the analysis to the diagrams and so on without having to turn pages. To facilitate this a further constraint has been accepted: the text has generally been broken down into paragraphs of 150 to 250 words, with each paragraph related to the adjacent diagram. The diagrams, figures and graphs have been selected to assist this division. It is not thereby implied that all diagrams are of equal importance but the attempt has been made to partition the left-hand page into units of comparable length. This is neither possible nor desirable for the analysis, since certain equations apply to more than one diagram, while some diagrams may require several equations.

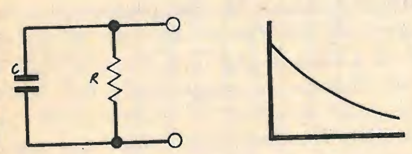
continued on page 88

Capacitor charging and discharging

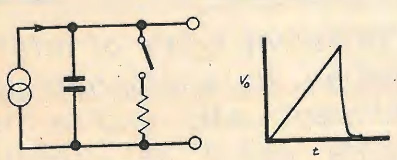
Linear Ramp: Constant Current



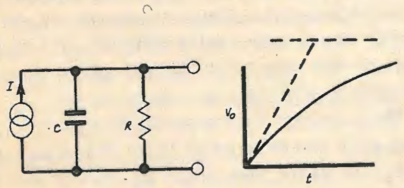
Capacitor Discharge



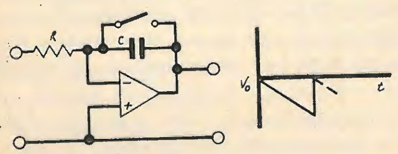
Sawtooth Generation



Ramp Non-Linearities



Op Amp Sawtooth Generator



Ramp, sawtooth and triangular wave generators, astables, monostables and pulse generators all depend on one simple fact: when a capacitor accumulates charge from some source of current its voltage changes. Further, the rate at which the voltage changes is directly proportional to the magnitude of the current. The variety of these circuits and their applications tends to obliterate this common property. It is very helpful to return to the behaviour of a single capacitor connected to a current source, a resistor, or both. In this way both the ideal behaviour and the departures from the ideal can be identified before considering the many versions that have been proposed for the above functions. A perfect current generator sustains a defined current into any load including that of a capacitor regardless of the terminal voltage. (Because most practical generators approximate to voltage sources, the behaviour, of current sources may appear less obvious, and a formal restatement of this basic property helps to avoid confusion.) The capacitor has the property that charge and voltage are proportional, Q= CV, provided that the capacitance C remains constant. Observing that current is the rate of flow of charge then the relationship between current and rate-of-change of voltage follows.

If a capacitor is charged to a given voltage and then has a resistor placed in parallel with it, that charge is dissipated. The higher the terminal voltage the greater the initial current flow and hence the rate at which the charge is lost. Hence the slope of the voltage waveform is steep at first, progressively diminishing as the voltage falls. The voltage is asymptotic to zero and the point at which the capacitor is said to be 'discharged' is thus arbitrary — for practical purposes, a final voltage of 1-10% of the initial value might be used. (In some cases the presence of a constant-current term in the model of the active devices used results in the capacitor voltage genuinely passing through zero). The property that the rate-of-change of voltage is proportional to the voltage itself leads to an exponential relationship between voltage and time. In this the resistor and capacitor always appear in the relationship as a product and it is convenient to write τ = CR where τ is referred to as the time constant of that portion of the circuit. A complex circuit has many time constants but it is often possible to evaluate the effects of each separately.

The two previous voltage waveforms can now be joined together to provide a pattern that if repeated continuously is described as a saw tooth waveform. It consists of a linear slope or ramp followed by a rapid, but not necessarily linear, return to zero or some very low value. A single cycle of this waveform can be obtained by switching the capacitor from the current generator to the resistor. This would leave the current generator open-circuit for part of the time, and by analogy with a short-circuited voltage generator this state of afairs can be seen as undesirable. As the discharge is required to be very rapid the current flow in the resistor is much greater than that from the source and it is more usual to leave the current generator connected. This raises the minimum value of the final output to IR, but provided IR$\ll V_{o(max)}$ this is no great disadvantage. The switching is simple in this form, consisting only of a single-pole switch. If the switch is operated at pre-determined instants the generator is said to be triggered and such a ramp-generator is the basis of oscilloscope time-bases. Alternatively, a level-sensing circuit can be used to activate the switch when the ramp reaches some particular voltage (free-running mode).

No perfect current generator exists, and the imperfection is most often that of a constant parallel resistance. This includes any leakage resistance of the capacitor and the input resistance of the following stage, as well as the finite output resistance of the generator. The current in the resistor is still much less than that from the generator if the circuit is to have any pretence of being a ramp generator, but the gap progresively closes as the output voltage increases. Hence the output departs from the ideal linear ramp. The error can be calculated either in terms of the difference between the actual and ideal voltages at any instant or in terms of the difference in the slopes. As the purpose of such a calculation is often to compare the relative merits of different arrangements it matters little which is used; the slope error is easier to calculate and is used in the following section. The actual error is usually obtained by expanding the exponential equation and taking account of the low-order terms in the expansion. In circuits involving active devices, the effect of finite voltage and current gains are shown to be equivalent to additional resistive losses.

A practical and widely-used form of sawtooth generator uses an operational amplifier. The configuration is that of an inverting integrator, and with a constant input voltage, the current in R is constant, assuming a true virtual earth corresponding to infinite voltage gain. Departures from this assumed condition are discussed later. The input current of an operational amplifier is finite, small and almost independent of the signal condition. It may be either positive or negative depending on whether npn or pnp transistors form the input stages. This current either increases or decreases the capacitor current by a small but constant fraction, leaving the ramp linear but with a slightly modified slope. Any voltage offset of the input devices modifies the voltage across R, providing a similar slope error. The inverting nature of the stage results in a negative-going output ramp for a positive input voltage. It is the virtual earth behaviour resulting from the very large voltage gain that allows the constant input voltage to produce a proportional and constant charging current. It also allows the output voltage to be nearly equal to the capacitor voltage while the output can be loaded without any significant change in the capacitor current.

Capacitor charging: constant-current

THEORY

The voltage built up across a capacitor when charged from a constant-current source follows from the basic relations

$$Q=CV$$
$$I=dQ/dt$$
$$\frac{dV}{dt}=\frac{1}{C}\frac{dQ}{dt}=\frac{I}{C}$$
$$\text{and } V=\int_{t_1}^{t_2}\frac{I}{C}\,dt$$

For I constant, and V_1 the initial value of V

$$V=\frac{I}{C}(t_2-t_1)+V_1$$

In many practical circuits the initial voltage across the capacitor is zero giving

$$V=It$$

The discharge cycle would be similar, with a constant current discharge; in most cases the discharge is through a resistor. Let the initial voltage be V_1, with the current flowing *into* the capacitor still I

$$\frac{dV}{dt}=\frac{I}{C}=-\frac{V}{CR}$$

For convenience write CR=τ the *time-constant* of the CR network

$$\frac{dV}{dt}=-\frac{V}{\tau}$$

Hence $V=V_1\exp -t/\tau$

with $V\to V_1$ for $t\to 0$

and $V\to 0$ for $t\to\infty$

There are two conditions of interest in which both resistive and constant current terms are present. In the first, the resistor switched into the circuit to discharge the capacitor is normally so low that the constant current has a negligible effect on the duration of the discharge. It limits the absolute lowest output to IR.

The second condition considers the effect of stray leakage or load resistances that disturb the linearity of the charging cycle.

$$\text{Then}\frac{dV}{dt}=-\frac{V}{\tau}+\frac{I}{C}=\frac{1}{C}(I-V/R)$$

The slope departs from the original value of I/C more and more as V increases, with a fractional error of (V/R)/I corresponding to V/V_{max} where V_{max} is the theoretical maximum voltage output if all the current were flowing in the leakage resistance R. The analysis can also be carried out by converting into the corresponding voltage generator form and treating it as a standard RC timing circuit with a corresponding large drive voltage (IR), with the output as only a small portion at the bottom of the experimental charging cycle.

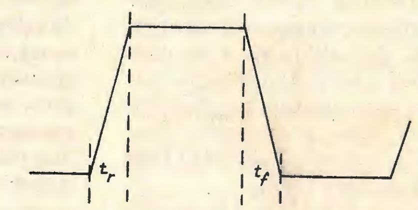
The information can be applied to the op.amp sawtooth generator shown. To a first order for high-gain op.amps, the capacitor current depends on V/R and the input bias current. The latter is independent of the output voltage to a first order i.e. modifies the output slope to be proportional to $(V/R-I_{bias})$ without disturbing the linearity.

EXAMPLES

1. An operational amplifier has a compensating capacitor of 30pF into which its first stage can deliver a maximum current of ±20μA. Calculate the slew rate i.e. the maximum rate-of-change of voltage across the capacitor

$$\frac{dV_C}{dt}=\frac{d(Q/C)}{dt}=\frac{1}{C}\frac{dQ}{dt}=\frac{I}{C}$$
$$\frac{dV_C}{dt_{max}}=\frac{I_{max}}{C}=\frac{20.10^{-6}}{30.10^{-12}}V/s$$
$$=0.67\times10^{-6}V/s$$
$$=0.67V/\mu s$$

2. An amplifier is loaded by a stray capacitance of 10pF and is to reproduce 10V peak-peak square-waves at a 10MHz clock-rate. What should the peak current-capability of the amplifier be, if the rising and falling edges are to occupy less than 10% of the total time?



$$t_r+t_r<\frac{100ns}{10}$$

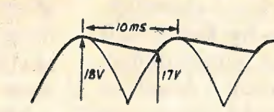
i.e. $t_r=t_f<5ns$

$$\text{As before}\frac{dV}{dt_{max}}=\frac{I_{max}}{C}$$
$$\frac{10V}{5ns}=\frac{I}{10pF}$$
$$I_{max}=\frac{10\times10\times10^{-12}}{5\times10^{-9}}=20\times10^{-3}A$$

Hence the amplifier output current must be at least 20mA.

3. A 1mF capacitor in a full-wave rectifier power supply is charged to a peak voltage of 18V. If the voltage is to decay by <1V between successive peaks, estimate the minimum value of load resistance that can be used (i) using the exponential decay equations; (ii) by the approximate method of assuming the discharge current is constant at its peak value. Assume mains frequency 50Hz.

(a) Capacitor discharges almost for a half cycle i.e. ≈10ms



$$17=18\exp(-10^{-2}/R\times10^{-3})$$
$$\frac{10}{R}=\ln\left(\frac{18}{17}\right)$$
$$R=175\Omega$$

(b) For linear decay 1≈18/R

$$\Delta V=1V$$
$$\Delta t=10ms$$
$$\frac{\Delta V}{\Delta t}=\frac{I}{C}$$
$$\frac{1}{10^{-2}}=\frac{18}{R.10^{-3}}$$
$$R\approx180\Omega.$$

WORLD OF AMATEUR RADIO

Sun-spots, sweepers and buried clocks

Although the approaching sun-spot peak is clearly going to be a high one, it now seems that it may not reach the bumper figures (over 200) predicted a few months ago: the sudden "recession" last summer seems to have had a lasting effect. Nevertheless, prospects for 50MHz and similarly high frequencies producing long-distance contacts are good. A series of s.s.b./c.w. contacts between KH6EQI in Hawaii and a number of Australian stations took place last Autumn, for the first time in 20 years.

Martin Harrison, G3USF, recently appealed for co-operation from British amateurs in collating more information on "sweepers and creepers," the unexplained natural emissions that sweep across finite bands of frequencies (often in the region 20 to 30MHz but sometimes much lower). Ted Cook, ZS6BT in Johannesburg, South Africa has recently forwarded to me a tape cassette providing many excellent examples of these curious and distinctive signals. So far, although a number of theories have been tentatively put forward, there is no entirely satisfactory explanation of these phenomena, first observed by Gerson and Gossard in 1958 (see WoAR, February 1978).

R. H. Dicke of Princeton University has recently put forward the idea that despite the apparently large and random variations in the periodicity of the sunspot cycles (cycles varying from 7.3 to 17.1 years have been recorded) the Sun appears to have the ability to "remember" and re-adjust to the correct spacing between maxima — almost as though there were an accurate chronometer buried deep in the Sun. His explanation for the apparent variations is that the transport of the magnetic field from the deep interior to the surface requires a long time and is subject to irregularities.

Band plan problems

The system of voluntary band-planning, introduced into Europe by the RSGB some 30 years ago and subsequently endorsed by the International Amateur Radio Union, has long been recognised as a highly desirable, if not essential, means of separating non-compatible transmission modes. However the increasing number of modes and specialised communication techniques (virtually unknown when the system was set up) is making it difficult to modify and extend band planning so that it satisfies everybody. One finds, for example, grumbles with the present situation on the popular 144MHz band. Some users are seeking specifically a.m. as well as n.b.f.m. "channels" and there have been problems with overlapping "satellite" and "emergency" allocations. A major problem is that frequent modifications to a v.h.f. band-plan can prove costly for stations not using frequency-synthesizer techniques, owing to the cost of new crystals.

Then again, on h.f. most r.t.t.y. operation is within the "telegraphy" sections of the various bands, though this does not seem to have been recognised by the writers (G3VYV, G8IAT and G4GQO) of the "Letter to the Editor" in the January issue who were apparently "stunned" by my suggestion that this mode can (and does) have high interference-potential. They did not seem to grasp that this referred to those using manual telegraphy, where one would find it extremely difficult to "notch out" an r.t.t.y. transmission, whatever may be the case with 'phone transmissions.

From all quarters

One of the less desirable aspects of amateur radio is that it seems to make its adherents more likely to receive unwanted "chain letters" promising to bring in thousands of dollars to those foolish enough to send money to the name at the top of the list and then forward copies of the letter to about 20 other people. A reader sent me (for inspection I hasten to say) a recent copy of one of these pests with their appeals or warnings against "breaking the chain." Pulling the chain on them is more appropriate.

Special event callsigns in the series GB2, GB3 or GB8 plus two or three letters are available through the RSGB provided that application is made at least one month before the event. However, once a particular callsign has been alotted to a group, the same call will not be issued to another group for a different event. The special prefix "GT" is being authorised during the Isle of Man Millenium for use between June 30 and July 8 (inclusive). Normal prefix for the Isle of Man is "GD."

The Japanese scientists — M. Morimoto, H. Hirabayashi and J. Jugaku — have pointed out that if intelligent civilisations are common throughout the Galaxy, they must have formed a community using communication and must be sending radio beacon signals. They suggest it is possible to specify not only the most likely frequency on which to listen (4829.659MHz, the spectral line of formaldehyde) but also the directions to be searched.

The Swedish farmer-amateur Lars-Erik Johansson, SM4AQL keeps his station on the air (and his farm running) from an ambitious cow-powered methane digester cum electric generator. The reactor, at any one time, contains some 22,000 gallons of slurry formed from the output of 50 cows and 40 heifers, providing 4,000 litres of fresh slurry daily and producing some 70 cubic metres of methane gas each day.

While a number of amateurs have been puzzled at why some Japanese-made amateur radio equipment seems to sell at relatively much lower prices in the U.S.A. than in the UK, rather fewer (Rev G. C. Dobbs, G3RJV of the G-QRP-Club is an exception) have remarked on the extraordinary difference between what the Post Office now charges for International Reply Coupons (25p each) and what it is prepared to give for them.

The BARTG newsletter has pointed out that amateurs using s.s.b. rigs for r.t.t.y. often have power amplifiers working at well under 50 per cent efficiency and that even the old and often discarded a.m./c.w. rigs have uses, other than as boat anchors: their Class C power amplifiers and large power units designed for high duty cycles can provide potent r.t.t.y. signals.

In brief

Application has been made for the operation of the first two 24GHz beacon stations on the Isle of Wight and Alderney . . . National events announced for 1979 include: March 10, National VHF Convention at The Winning Post, Twickenham, Middlx; May 11-12, RSGB Amateur Radio Exhibition, Alexandra Palace, London; August 5, National Mobile Rally, Woburn Park; September 15, RSGB H.F. Convention, Birmingham; and September 22, Scottish V.H.F. Convention, Dundee . . . Bert Mathews, G6QM of Cheltenham has died — he was a sub-manager of the RSGB QSL Bureau for over 30 years . . . Denis Campbell, G13TAC, a radio and electronics officer aboard the cable ship "Mercury" has been keeping a daily schedule from the Bermuda area with his father, G130LJ . . . North Midlands Mobile Rally, organised jointly by The Midland Amateur Radio Society and Stoke-on-Trent Amateur Radio Society will take place on Sunday, April 29 at Drayton Manor Park, near Tamworth.

PAT HAWKER, G3VA

Electronic organ tone system — 5

Vibrato, noise, expression pedals and stop control

by A. D. Ryder, M.A., Ph.D., F.I.E.E.

This article completes the section on tonal variations, and concludes the electronic organ tone system by describing further optional additions together with some general notes.

Table 13 Third and fifth harmonic cross-keying. The table shows manual frequencies for the first octave of each cross-keyed rank.

Played	CK1	C'K1	DK1	D'K1	EK1	FK1	F'K1	GK1	G'K1	AK1	A'K1	BK1
Keyed	F1.5	F'1.5	G1.5	G'1.5	A1.5	A'1.5	B1.5	C03	C'03	D08	D'03	E03
Hz	65.48	69.38	73.50	77.87	82.50	87.40	92.60	98.11	103.9	110.1	116.7	123.6

Played	CK2	C'K2	DK2	D'K2	EK2	FK2	F'K2	GK2	G'K2	AK2	A'K2	BK2
Keyed	G'2.5	A2.5	A'2.5	B2.5	C05	C'05	D05	D'05	E05	F05	F'05	G05
Hz	129.8	137.5	145.7	154.3	163.5	173.2	183.6	194.5	206.0	218.3	231.3	245.0

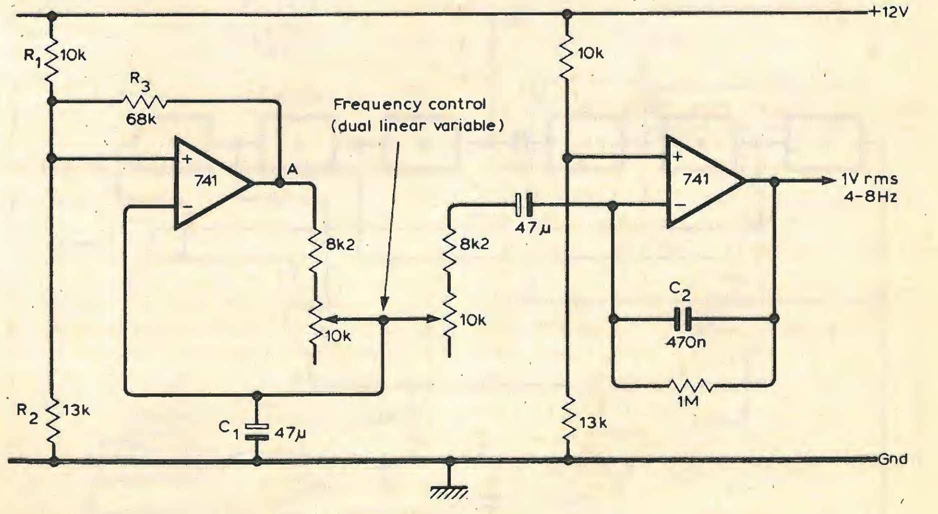
MODIFIED FILTERING may also be useful with cross-keyed ranks (see below), otherwise only octave harmonics are available.

For use with modified filtering, the harmonic content of the SQB signal may be increased by combining octavely-related divider outputs to produce an unequal mark-to-space ratio signal for gating. It is preferably to use OR or NAND functions rather than their inversions to minimise the d.c. component. For example, the NAND of 65.4, 131 and 262Hz provides a 1:7 pulse with a fundamental of 65.4Hz for which the first 16 harmonics are listed in table 12 with a saw-tooth for comparison.

Because the third harmonic of F1, for example, is nearly equal in frequency to C, with accurate equal temperament, an out-of-tune rank may be built up using ¾F1, for C1, ¾F'1 for C'1 and so on, which contrasts usefully with in-tune stops. This requires keying signals KB in Fig. 14 to be cross-linked (or separately generated). For example, the KB signal from manual C1, normally at 65.40Hz, must drive a gate on the F card supplied from the $1.5f_0$ divider output at 65.48Hz, and so on with these gates feeding a separate set of buses. A similar scheme is possible using the fifth harmonic where the much larger frequency difference produces noticeable beats similar to a celeste. The lowest note of a celeste rank is usually tenor C, and the appropriate frequency is available at $2.5f_0$ on the G' card. Table 13 shows the linking pattern for both arrangements. The same principle could be applied using the 7th and 9th harmonics to create larger frequency-differences. To provide the necessary frequencies, the reference input in Fig. 47 would be $12f_0$ or $24f$ with p.l.l. circuit components modified accordingly.

As the ear is insensitive to pitch at high frequencies, the 8th harmonic signal may be extended beyond EK5 by using 6th harmonic frequencies and so on. This is equivalent to the breaking back of a mixture. The transistor gate in Fig. 13 can function as a mixer because of the low input resistance at the base, but its usefulness is limited to octave combinations due to transient effects during keying. To build up a mixture rank, separate gates are preferable although they may use a common SQB set and filter. For comprehensive mixtures, it is necessary to expand to two sets of cards.

Fig. 48. *Low impedance sinewave source for vibrato. The potentiometer may be remotely mounted and connected with twisted wire.*



Vibrato

The term vibrato is used here for frequency modulation at 4 to 8Hz with a pk-to-pk amplitude of up to one semitone, 100 cents, though much smaller amplitudes, down to five cents or less, are useful. Sinusoidal modulation is preferable for large amplitudes. As noted in part 2, f.m. may be applied directly to the gate-card generators and, if a common signal is used, normal vibrato is produced. A 100 cent swing requires about 0.7V r.m.s. at the vibrato inputs. The use of independent signals is considered in the next section. Fig. 48 shows a low impedance sinewave source suitable for normal vibrato. In the trigger circuit, R_1 or R_2 may be trimmed for an equal mark-to-space ratio at A, i.e., for minimum second harmonic. Resistor R_3 or C_1 sets the

Table 12 Harmonic components as a percentage of the fundamental.

Harmonic No	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1:7 pulse	100	92	81	65	48	31	14	0	11	19	22	22	19	13	7	0
Sawtooth	100	50	33	25	20	17	15	13	11	10	9	8	7	7	7	6

frequency range of the control, which may be remotely mounted using twisted wire. The output level may be increased up to about 2.5V r.m.s. by reducing C_2.

Vibrato applied at the generators will affect all three departments and all frequencies. Vibrato to an individual department offers more flexibility, and helps a solo stop, for example, to stand out distinctively. It is sufficient to consider the h.f. channels only, because a pipe organ vibrato or tremulant has little effect on the bass pipes. Frequency modulation can be achieved by passing the signal through a bucket-brigade delay device, such as the Mullard TDA 1022 or Reticon SAD 1024, and modulating the clock frequency. The phase Ø of the output, relative to the input, depends on the line delay *D*, and because the frequency corresponds to *dØ/dt*, the output frequency varies as *dD/dt*. For sinusoidal modulation, the peak frequency deviations occur at the zeros of the modulating signal, where its slope is a maximum, and so have an amplitude proportional to both the frequency and amplitude of the modulation. Also, because *D* is a number of clock periods, e.g. 256 periods, it is the clock period rather than its frequency which should be linearly related to the modulating signal.

The circuit in Fig. 49 shows a period-modulated oscillator based on Circard 15-16, with a current mirror for constant-current charging of the 470p timing capacitor. The modulation amplifier provides the necessary low-impedance drive to pin 5, and has a gain inversely proportional to frequency so that the peak *dD/dt*, and thus the signal frequency deviation, is independent of the modulation input frequency. The clock excursions are greatest at low modulating frequencies, and the working point of pin 5 is set by the 7k5/8k2 divider to maximise the linear range. The adjustment can be trimmed by using a p.l.l. with a suitably short loop

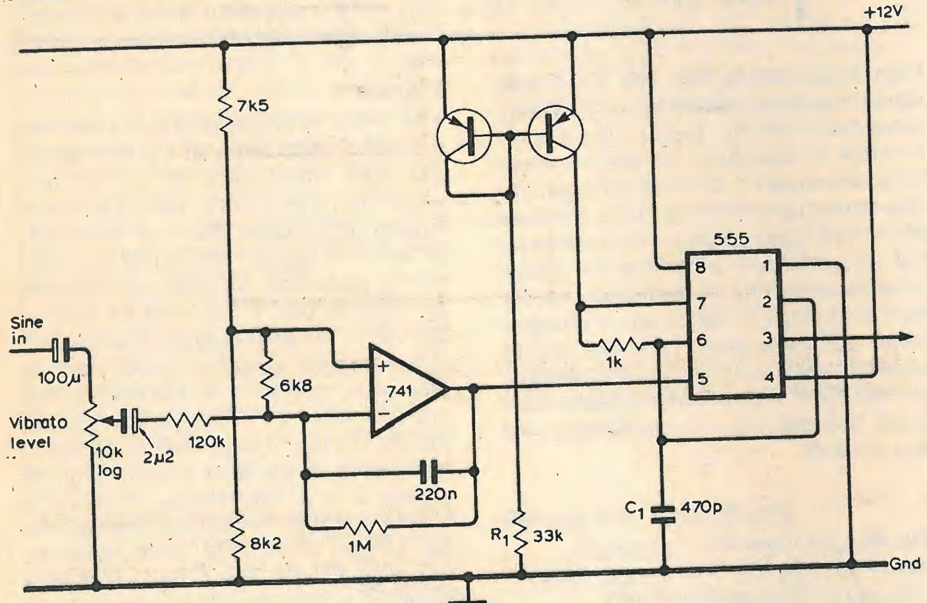


Fig. 49. Period-modulated oscillator. The oscillator frequency is controlled by the voltage at pin 5 and R_1C_1

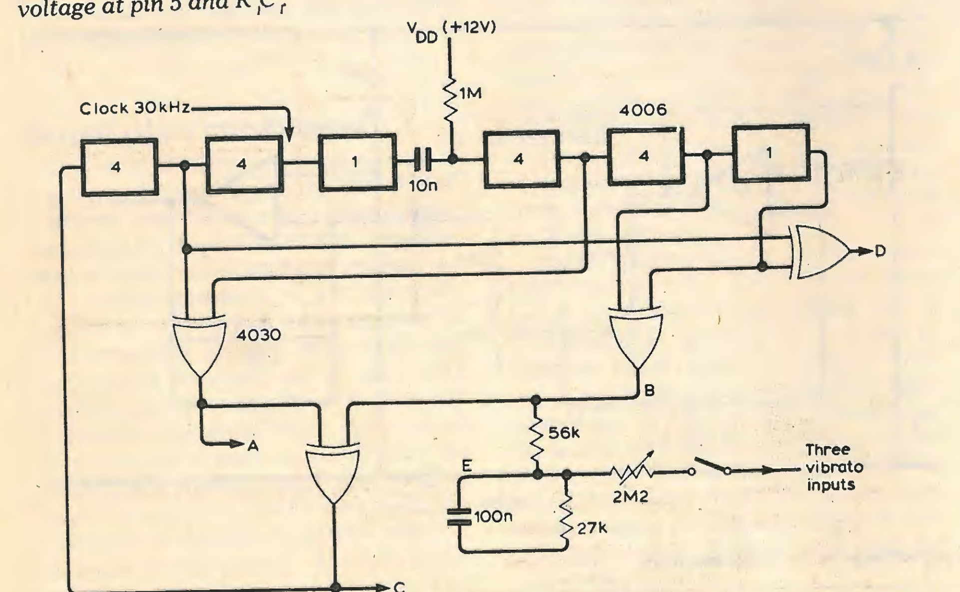


Fig. 50. P.r.b.s. generator with additional output. The capacitance coupling avoids persistence of the all-zeros condition. The output network shown at B is repeated for outputs A, C and D.

time-constant to derive the effective modulation waveform, and with a signal of say 8kHz as a carrier. The oscillator frequency is controlled by the voltage at pin 5 and R_1, C_1. The 6k8 resistor reduces the charging time of the input blocking capacitor at switch-on.

Bucket-brigade devices need two-phase clock signals, and manufacturers' data sheets show suitable circuits for deriving these from an input of twice the required clock frequency. The circuit values in Fig. 49 are for a 100 kHz clock, which requires the oscillator to run, unmodulated, at 200 kHz. Using a delay of 256 clock periods, the required modulation input is then about 1 V r.m.s. for 50 cents pk-to-pk f.m. Deeper modulation up to about 100 cents can be used, but the low-frequency limit is 4 to 5 Hz at this level. Although it entails correspondingly wide excursions, a relatively high clock frequency minimises a.f. noise from the device, and raises the frequencies of spurious output signals, so that a second-order output filter with a corner frequency of 12kHz is satisfactory. Care should be taken to set the signal input bias to the centre of the linear range, and r.f. bypassing at the input may also help to reduce noise.

In general, organ pipe harmonics fluctuate in phase with respect to the fundamental, and this effect can be simulated using a modulated and an un-modulated channel with a passive 6 dB/octave crossover at say 1 kHz, so that the modulated channel predominates at h.f. Separate speakers allow reflected sound to smooth out the comb-like frequency response which is produced if a delayed and undelayed channel are mixed electronically. Various other effects are possible by cyclic variation of channel gain, etc.

Noise: quasi-chorus

A pseudo-random binary sequence (p.r.b.s.) noise generator with a cycle length of 2^{18}-1, approximately 262,000 is shown in Fig. 50. Using a clock frequency of about 30 kHz, the signal at any output is substantially uniform over the a.f. range, and the periodicity of about 8½s is unnoticeable. The clock may be derived from the 1 MHz crystal by using a division of 32, or from pin 3 of the 240 divider in Fig. 37, about 29 kHz.

A noise-jitter chorus effect can be produced by applying band-limited noise signals to the gate-card vibrato inputs, and the circuit in Fig. 50 provides four time-shifted versions of the p.r.b.s., each of which may be used to modulate three adjacent semitones. The network shown at D has a 3 dB frequency of about 100 Hz, and also sets the mean level at E to +2V, which avoids transient frequency shifts when the switch is operated.

For use as a noise bus for mixing into stop combinations, the p.r.b.s. signal needs to be gated, by key operation, with an amplitude following roughly an

r.m.s. characteristic. Fig. 51 shows a basic circuit where Tr_2 corresponds to the p-n-p transistor in Fig. 33, and the noise gate is an inverted form of those in Fig. 13. Again, the time-shifted outputs of Fig. 50 can provide substantially uncorrelated signals for different stops or departments.

Expression pedals and amplitude modulation

The usual pipe organ expression pedal, which controls the swell department only, allows a greater variety of effects than if the whole organ were enclosed in a swell-box, and this arrangement can be adopted with the present design, with pedals for the other departments if required. A wide-range pedal is hard to control musically, and 15 or 20 dB is about right. The MC3340P electronic attenuator can provide a simple noise-free control, and although it introduces some low-order distortion at higher attenuations, this is not a serious drawback. The main difficulty is in the scaling, and each device needs individual calibration. Fig. 52 shows the basic connections. The gain depends on the pin 2 voltage, and is controllable by an external resistance R_c. The gain reaches a maximum of about ×4 when R_c is zero. If this is defined as 0 dB, the gain varies more or less linearly with R_c between about −6 dB, ($R_c=R_6$,) and −26 dB, ($R_c=R_{26}$). These two values must be found by trial, and also the open-circuit voltage *E* at pin 2, and R_e, the value of R_c which pulls down the pin 2 voltage to *E*/2. Typical values are $R_6=7k\Omega$, $R_{26}=12k\Omega$, $E=5.3$ V, $R_e=4.7k\Omega$. Resistance R_c can consist of a fixed 7kΩ resistor in series with a 5kΩ variable which is controlled by the pedal. In practice, however, the choice of pedal resistor is restricted. Fig. 53 shows a simple pedal linkage with an approximately linear action over an arc of 90°. This operates a wire-wound variable resistor which gives, for example, a swing R_V of 3.3kΩ with a 10kΩ variable resistor. In general, it is necessary to scale down the effective value of R_e, and hence R_6 and R_{26} to suit the available R_v, by a factor s, which in this case is 3.3/5.0 or 0.66. Fig. 54 shows two additional resistors R_a, and R_b, which are used for this purpose. Assuming a 12V supply, the values are

$$s=\frac{R_V}{R_6-R_{26}}, R_f=s\,.\,R_6$$

$$R_a=\frac{12\,.\,s\,.\,R_e}{E(1-s)}, R_b=\frac{E\,.\,R_a}{(12-E)}$$

For a 15dB range, R_{21} is measured and used in place of R_{26}.

The MC3340P may also be used for amplitude modulation tremulant by applying the modulation to pin 2. However, if an expression pedal is used as well, the modulation sensitivity necessarily varies with the pedal setting. To compensate for this, C_1 is increased to say 47μF to have a dominatingly low reactance. The modulation is applied to

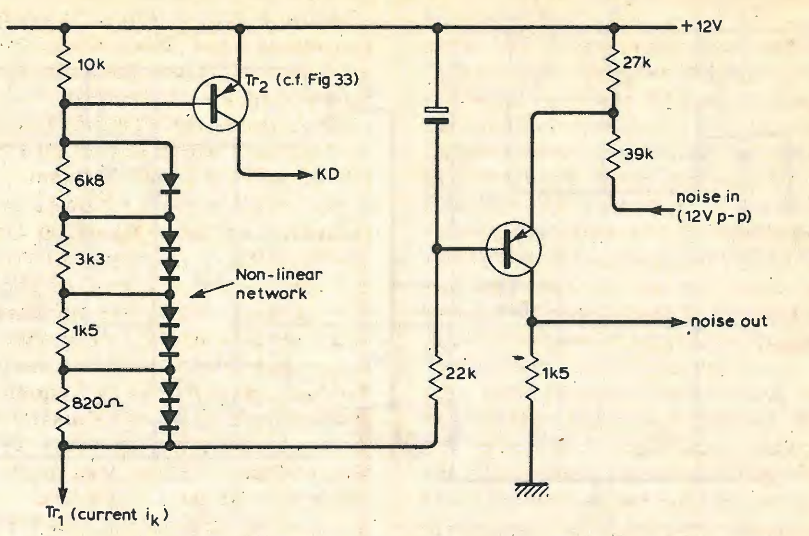


Fig. 51. Basic noise gating. The current i_k is proportional to the number of keys operated, and the noise output amplitude is required to vary as $\sqrt{i_k}$.

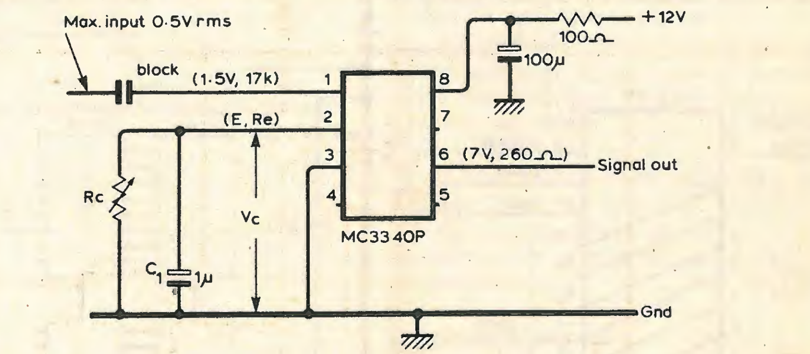


Fig. 52. Basic electronic attenuator. The figures in brackets show open-circuit d.c. voltages and internal resistances.

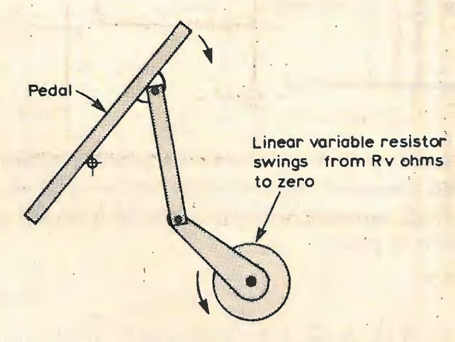


Fig. 53. Expression-pedal linkage. This arrangement provides an approximately linear action over an arc of 90°.

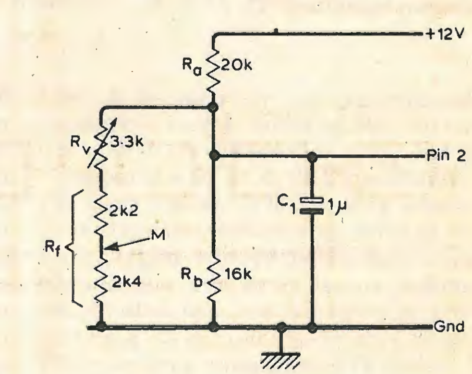


Fig. 54. Modified control network.

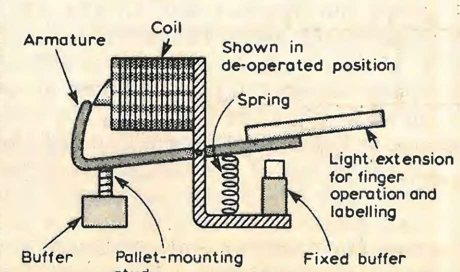


Fig. 55. Pallet-magnet with tab extension.

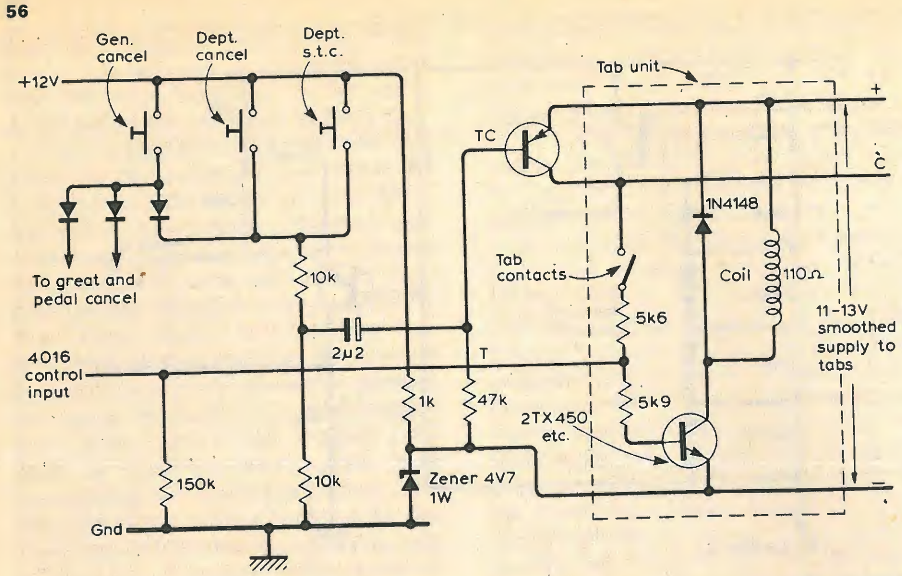


Fig. 56. *Stop tab circuit and swell department cancelling.*

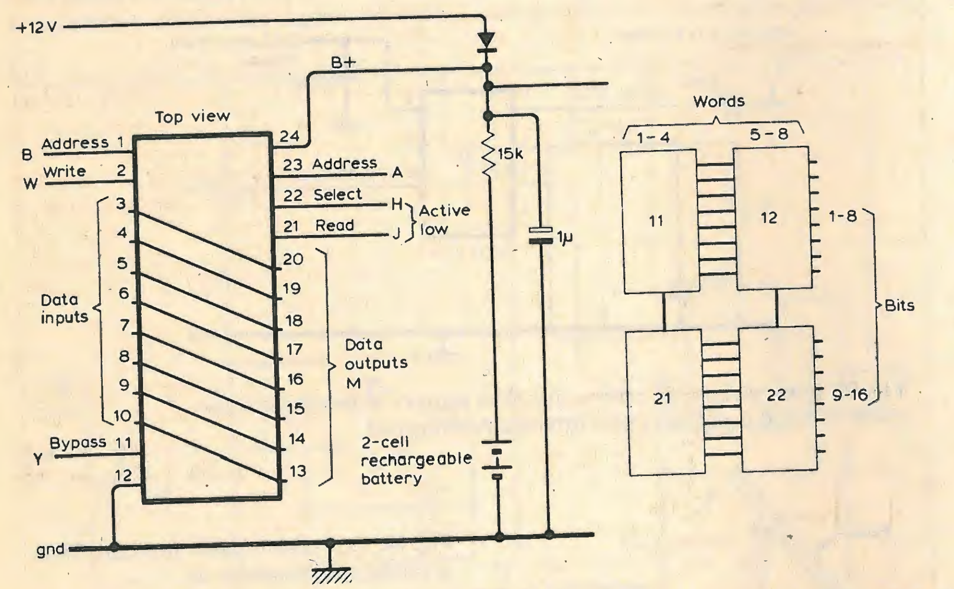


Fig. 57. *Pin connections for the 4036 and battery. The insert shows a block diagram of the four packages for one department, and these are wired as follows, B+, gnd, A, B, J, W and Y – common to all four. 11-12, 21-22, outputs and inputs, (pins 13 to 20) – common in pairs. 11-21, 12-22, H, – common in pairs.*

approximately the mid-point of R_f, so that the voltage swing at pin 2 increases as the gain increases. At 6 Hz, a modulation of 2 dB pk-to-pk will require an input at M of 100 to 150 mV r.m.s. If two or three independent channels are to be controlled by one pedal, the simplest course is to link additional variable resistors, because individual devices vary widely in gain for a given V_c value. The calibration process will then allow reasonable tracking.

Stop control

The use of 4016 devices, as previously mentioned, allows switching of stops and couplers via unscreened leads from the console stop-tabs. Each 4016 control input should have a pull-down resistor, to ground, of 150kΩ. The form of stop-tab described is an adaptation of the widely used pipe-organ pallet-magnet, shown in Fig. 55, which requires about 0.11 A at 12V. Although inefficient magnetically, it is designed for silent operation, and the shape allows parts to be attached, in particular a finger tab and light wire contacts to close in the operated position. Also, the fixed buffer may be replaced by one mounted on a stiff spring which can be depressed by extra finger pressure to operate further contacts for second-touch cancelling, s.t.c. This is only necessary for speaking stops, not couplers, and all s.t.c. contacts for one department are in parallel.

In the circuit of Fig. 56 the switching action causes the tab to remain up or down as moved by the finger. The voltage at T with the tab on is 9 to 10V, the negative rail of the tab supply being nominally 4.7V positive to ground. For s.t.c. purposes, the cancel signal is differentiated, and t.c. only interrupts the C line for about 40 ms. The t.c. circuit is repeated for the other departments, and the general-cancel piston activates all three.

The main purpose of magnetically operated or motorised tabs is to permit them to be controlled in combination by pistons (buttons) arranged for thumb or foot operation, and the automatic movement of the tabs keeps the player informed. The circuit in Fig. 56 permits the same T line to be used for both stop and tab control because a momentary connection of T to + 12V will operate the tab, and a momentary ground will release it.

The 4036 memory can be used in a simple parallel configuration to store and execute combinations, and a small battery allows them to be retained with the mains power off. The 4036 stores four words of 8-bits, and this description assumes that 16-bits (stops, couplers, etc.) are used per department, and that it is required to store eight combinations or words. Four are selectable by departmental pistons, c.p., and four by general pistons, g.p., which control all departments at once, using 12 packages in all. Couplers are included because of their tonal importance in the present design, although this is not universal practice.

Each combination is stored, or changed, by capture. It is set up manually on the tabs, and then allocated to a particular c.p. or g.p. by holding in that piston while simultaneously operating a separate capture button. This results in a write operation at the corresponding memory address. Fig. 57 shows one 4036 package, and the interconnection of four to produce 16 output lines. These are connected to the T lines of the department tabs, and two select lines, H1-4 (packages 11, 21) and H5-8 (packages 12, 22) which are in effect address lines together with the common address lines A and B. As Fig. 58 shows, the addresses are allocated to the c.p., B high, and g.p., B low, in two groups of four.

The memory control is shown in Fig. 59. With no piston operated, lines J, high, W and Y, low, are inactive and the M outputs take the potential of their T lines. Operation of a piston generates a memory address/select, and simultaneously a low at J via the two left-hand 4093 sections, which cause the address contents to be read onto the T lines, and drive them high or low to set the tabs accordingly. Holding in a capture button sets Y high, and prevents a subsequent J low from causing a read-out. Instead, operation of a piston then switches all four 4093 sections, and the high or low states of the T lines are written into the address from the inputs because the outputs remain floating. The c.r. couplings and trigger action delay the write pulse until the address lines are stable, and ensure that it terminates before the piston is released. The 4093 devices are supplied from the battery so that the memory outputs float, J high, with power off, and the T lines do not draw current. Battery drain

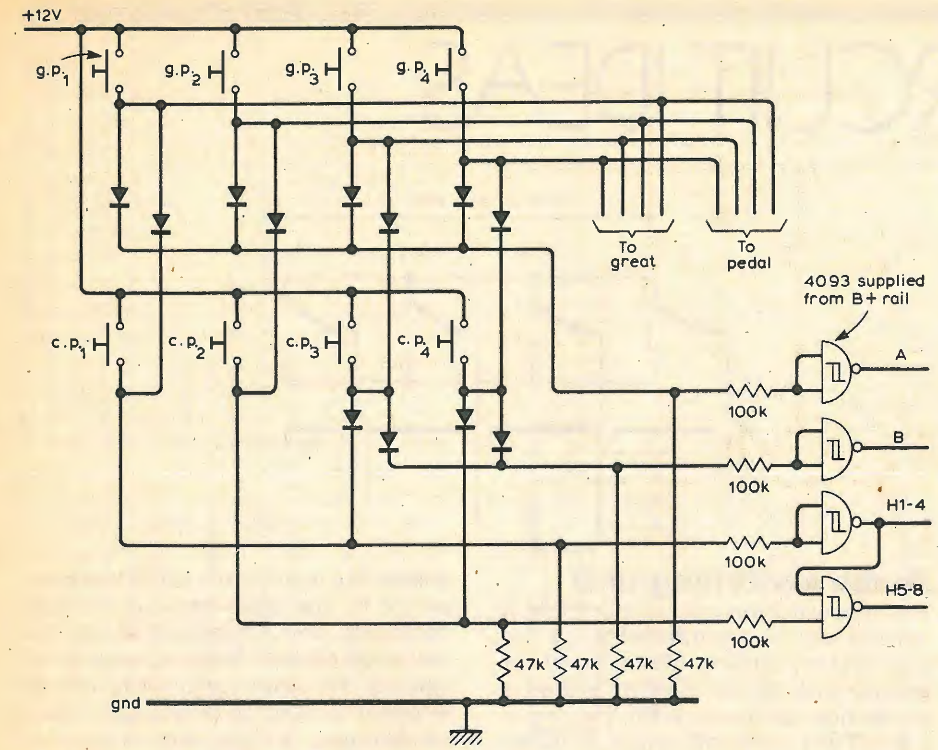


Fig. 58. *Addressing for swell department. The other departments are similar, with common connections to the general pistons.*

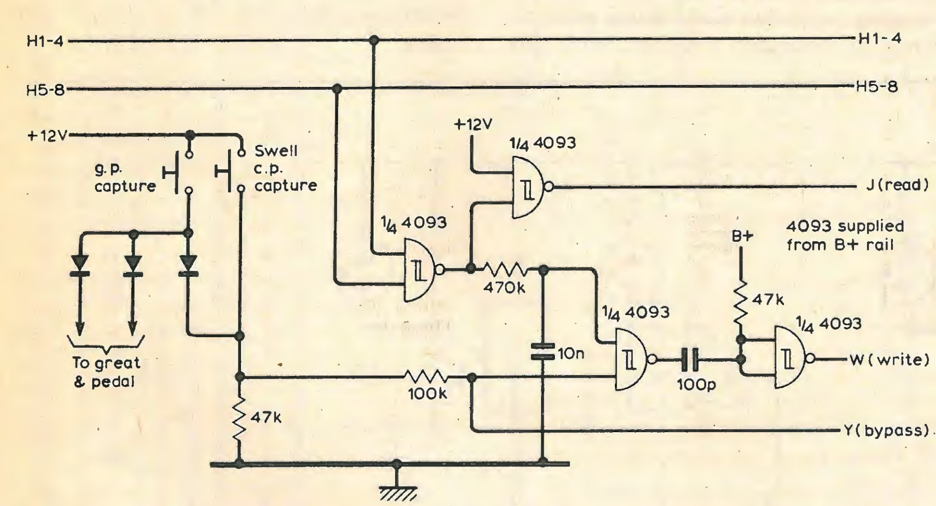
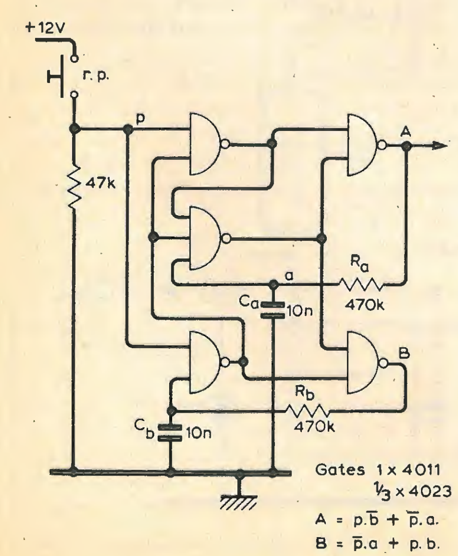


Fig. 59. *Memory control for the swell department.*



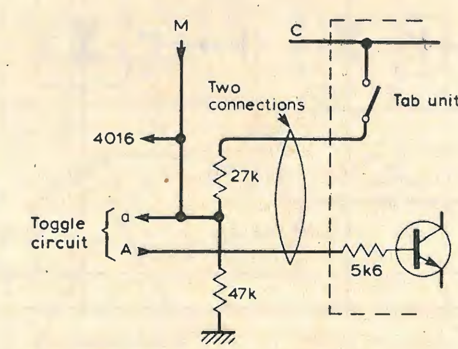


Fig. 61. *Tab control by the toggle circuit. Components R_a, and C_a are omitted from Fig. 60.*

◀

Fig. 60. *Toggle circuit.*

is only nanoamps, and the smallest cell size is suitable.

The two or three most used couplers, such as great-to-pedal, are often made available also from reversible pistons, r.p., push-on, push-off. This function requires some form of toggle or divide-by-two circuit. For example, a flip-flop preceded by a trigger circuit to produce a clean signal from the piston contacts. The circuit in Fig. 60, however, is more economical. A counter cell must have four distinct states, which requires two memories, A and B, and if p is the signal to be counted, the basic logic is,

$$A = p.\bar{B} + p.A \quad B = \bar{p}.A + p.B$$

In package counters, switching races are controlled by additional gates. In Fig. 60, which is a manipulation of the basic logic to minimise the package count, they are avoided by the RC delays. These delays also permit the latching action to be slowed sufficiently to immunise the toggle from contact bounce and interference. This allows direct connection to the r.p.

To use this circuit with a tab, the feedback path from A to a is arranged via the tab itself, which provides a delay, as shown in Fig. 61, and two connections are brought back from the tab unit. Manual tab operation, or a pulse from the memory, leaves the toggle appropriately set so that a subsequent r.p. actuation produces the expected result. □

Acknowledgement

The advice on tonal variations given by Mr E. L. Jones of Hiykon Ltd is gratefully acknowledged, and the p.r.b.s configuration of Fig. 50 is also due to him.

A 30 min cassette recording of the prototype is available for £2.00 c.w.o. A set of 15 special printed circuit boards (12×E01, 3×E02) is also available for £117.32 c.w.o. Both items are post free in the UK, and delivery is about 2 weeks and 4 weeks respectively.

Purchasers of these will also receive supplementary component and procurement details. Hiykon Ltd, Woodside Croft, Ladybridge Lane, Heaton, Bolton, BL1 5ED.

CIRCUIT IDEAS

Thyristor touch tuning

The use of thyristors as the switching elements in a touch-tune unit simplifies the circuit and gives improved reliability over conventional designs. Initially the s.c.r. in channel 1 is on due to the 10nF capacitor, and tuning potentiometer R_1 is activated. If the s.c.r. in channel 2 is triggered, 30V is dropped across R_2 and R_1 momentarily has a voltage drop of $VC_1C_2 + VR_2$, i.e. 60V. As the cathode of SCR_1 is now more positive than the anode, the holding current is zero and the thyristor is therefore turned off, which leaves R_2 as the active potentiometer. Triggering any other s.c.r. will repeat this process. The circuit includes neon channel indicators which were chosen for their low current consumption. The high voltage supply was obtained by tripling the 30V supply. Alternatively, l.e.d. indicators can be used as shown.

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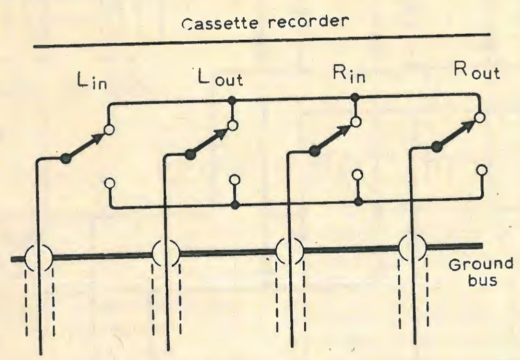
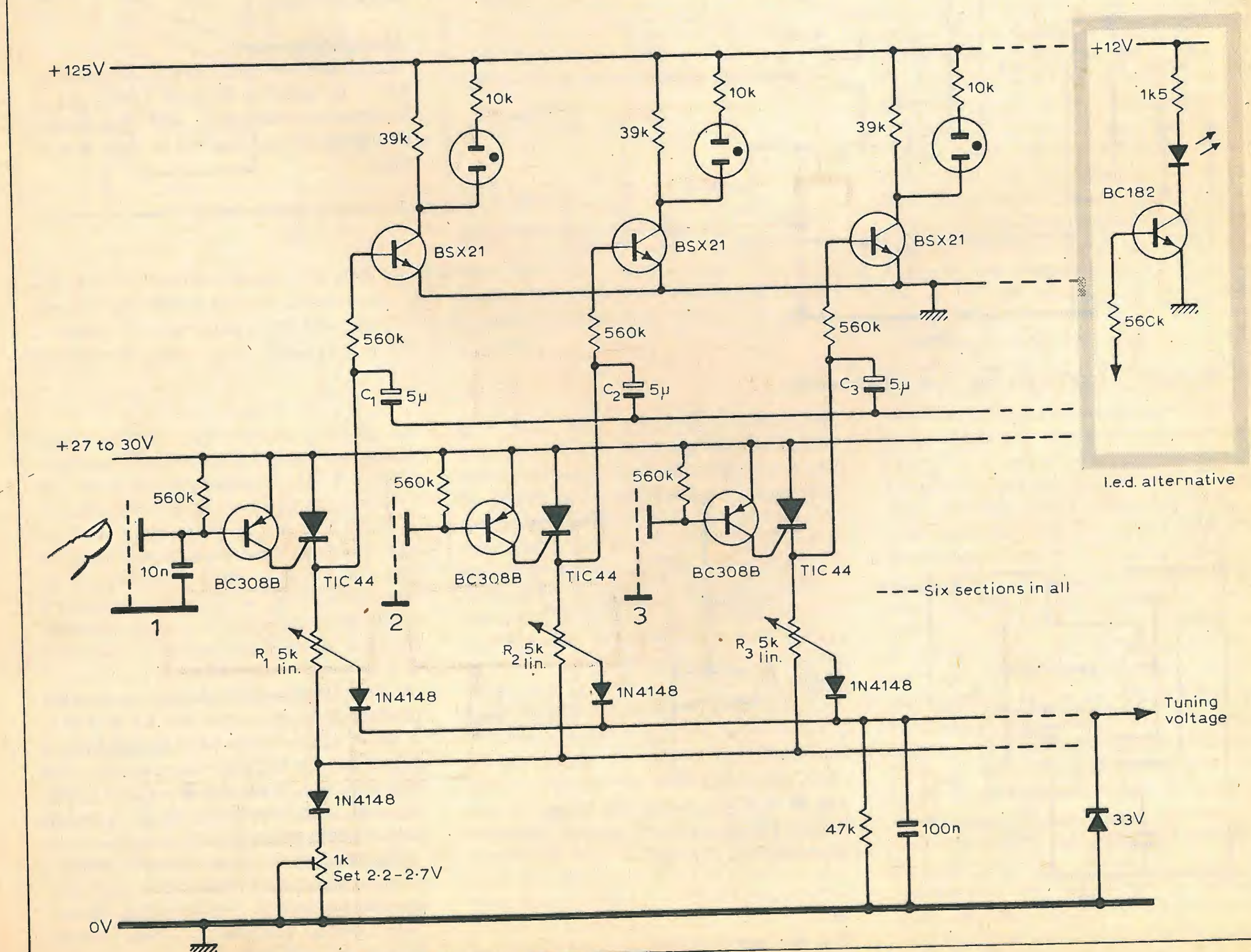
Kempsey
Worcester



Audio switching unit

A simple switching unit suitable for hi-fi systems can be constructed using the bus system shown. Each input or output, such as the cassette recorder connections in the diagram, requires a 1-pole 2-way centre off switch. Switches for the inputs and outputs of each piece of equipment should be grouped together and labelled. Any switches in the up position are connected together, similarly, switches in the down position are also connected together. With this system any input or output can be connected to any other input or output. Obviously, some connections should not be attempted, such as tape-in to tape-out. For some applications it may be useful to label the two switch buses left and right, or input and output. It is also useful to supplement the buses with jack sockets so that temporary leads can be patched into the unit.

F. A. B. Smith
Washington D.C.
U.S.A.

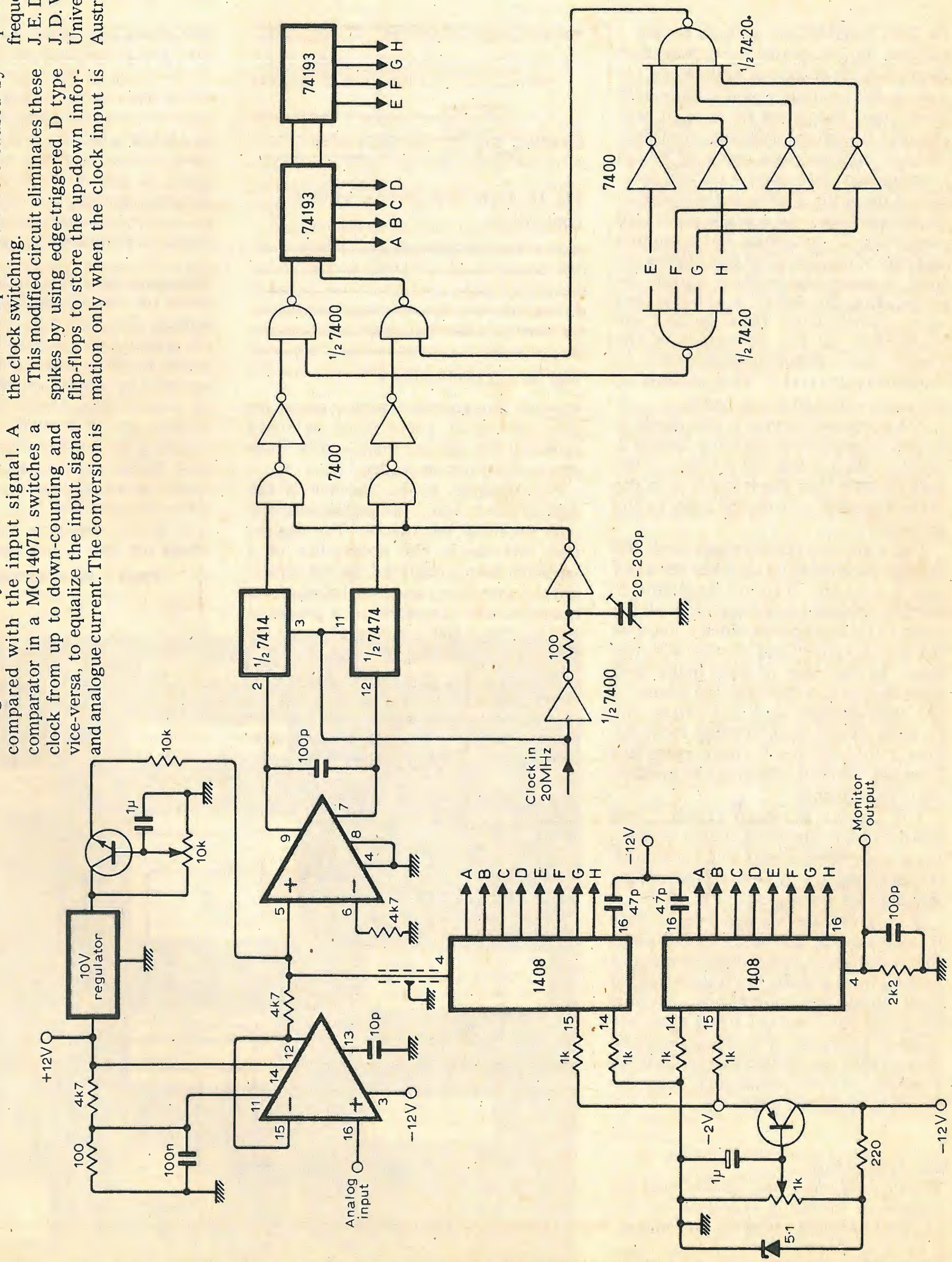


Continuous d-to-a converter

In Motorola's data library a d-to-a converter is shown where an up-down counter output is converted to an analogue current by an MC1408L, and compared with the input signal. A comparator in a MC1407L switches a clock from up to down-counting and vice-versa, to equalize the input signal and analogue current. The conversion is monitored with a second d-to-a converter. After trying this circuit we discovered large random spikes in the monitor output which were caused by the clock switching.

This modified circuit eliminates these spikes by using edge-triggered D type flip-flops to store the up-down information only when the clock input is low. The counter output is also used to switch off the counter just before it runs off-scale. The design now gives a satisfactory monitor output up to around 40kHz with a system delay of 1μs irrespective of input amplitude and frequency.

J. E. Dahl
J. D. Whitehead
University of Queensland
Australia



Computer buses — 2

Read/write control and contention for possession of the bus

by **Ian H. Witten,** M.A., M.Sc., Ph.D., M.I.E.E.

Department of Electrical Engineering Science, University of Essex.

IN THE EXAMPLES quoted, device 1 has sent data to device 2. Suppose that device 2 is the processor and device 1 is a store. Since the store will usually hold more than one word of data, it will respond to several different combinations of address lines, each of which combinations addresses a certain location of the store. Typically, there will be 16 address lines, and a single store unit may have 2^{12} locations, each holding one byte of data. So 12 of the 16 lines are used to select the location within the store, and the other 4 address the storage device itself. Thus, device 2 will respond to all the addresses in the range, say <0010000000000000> to <0010111111111111>. This presents no problems with address decoding.

The processor, device 1, also needs to be able to read from the store, device 2. In this case, it is still the initiator of the data transfer, but the transfer is in the other direction – from the store to the processor.

There are two relationships here: the master/slave relation between devices 1 and 2, and the receiver/transmitter relation. Device 1 is the master in all the cases so far considered, since it initiates the bus activity; and device 2 is the slave. In the case of data being sent from device 1 to device 2, the former is the transmitter and the latter the receiver, whereas in reading from device 2 into device 1 these roles are reversed, without affecting the master/slave relationship.

The choice between reading and writing is accomplished simply by adding a read/write control line to the bus, which is held low by device 1 for reading and high for writing, as in Fig. 19.

If only one device can ever initiate transfers along the bus – in the sense that a processor can initiate reading or writing from a store, but a store cannot itself initiate these operations – we now have all the control lines that are needed. However, if there are several devices that can initiate bus activity, for example, several processors, some interesting problems arise.

Bus contention

At any time, only one device must be capable of initiating transfers on the bus. This device is called the bus master. If several devices are potential bus masters (imagine several processors on the same bus), there must be some protocol for passing mastership from one to the other as needed.

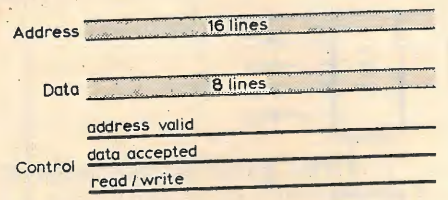


Fig. 19. *Asynchronous bus, without contention.*

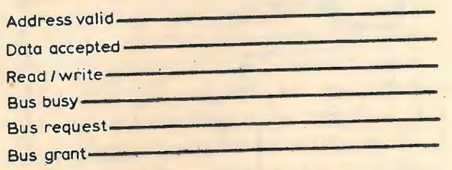


Fig. 20. *Bus control lines.*

For example, in the absence of the dashed line in Fig. 1, the processor is the only potential bus master. The dashed line introduces the possibility of a transfer being initiated by an input/output interface, and the interface in question will therefore be a potential bus master. Table 1 summarizes which devices are potential masters.

The ideal bus structure is one where every potential master uses the same protocol to communicate with other devices, and none is in overall charge. This increases the reliability of the system, since any device can fail without disrupting bus activity that does not involve it. If, on the other hand, just one of the devices had responsibility for the organisation of the bus, its failure could be catastrophic. We will stray from this ideal in the following two sections in order to see how existing computer systems operate their buses, but return to it later to examine more unconventional "distributed" bus protocols.

Bus controller. "Bus contention" occurs when two devices both desire bus mastership. The best cure for contention is prevention! A "bus busy" control line is added to show when the bus is active, asserted by the bus master throughout its mastership. There is normally no mechanism to prevent a device from hogging the bus for ever: it is assumed that device designers understand the importance of leaving the bus free whenever possible.

A device requests mastership only when the bus is not busy. Suppose it does so by asserting "bus busy". This by itself may seem an adequate protocol for transferring mastership but, unfortunately, it is not. If two devices simultaneously assert "bus busy", they will each think they have the bus to themselves, resulting in collisions. Hence there must be a protocol for requesting bus mastership, and having it granted by a central authority – the bus controller. A "bus request" and a "bus grant" line are introduced for this purpose. The controller monitors "bus busy" and "bus request", and issues grants when appropriate. Fig. 20 shows the control lines so far.

Table 1. Potential bus masters

		Potential bus master
Processor		yes
Store		no
i/o interface	Slow device (e.g. teletype)	no
	Fast device (e.g. disk)	yes

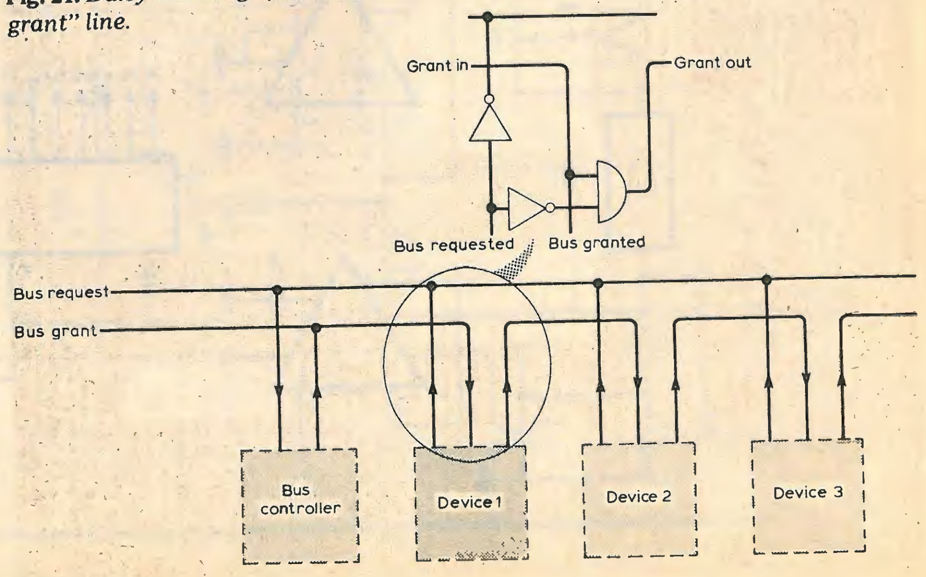


Fig. 21. *Daisy-chaining of the "bus grant" line.*

However, the "bus grant" line as described does not completely solve the problem. Each device requesting the bus will see the grant line being asserted, and each will think that it is now bus master. One way out is to "daisy-chain" the "bus grant" line through the devices, as in Fig. 21. A device, seeing "bus grant", will only pass the signal on to the next device if it itself does not want the bus. Hence a device has priority over all other devices which are further away from the controller than it, when contention occurs.

Fig. 21 also shows the circuitry which controls the daisy-chaining. When a device wants mastership, it takes the "bus requested" signal high, signalling a request on the "bus request" line. Note that this line cannot be tri-state, since there is no way of preventing simultaneous bus requests, and more than one tri-state gate cannot actively drive the same line at the same time. It is the only bus line we have introduced that must be wired-AND, and an open-collector gate is shown driving at low to signal a request. If the "grant in" line is asserted, it is routed through the "grant out" line provided the bus has not been requested. If it has, the grant chain is broken and the device achieves mastership.

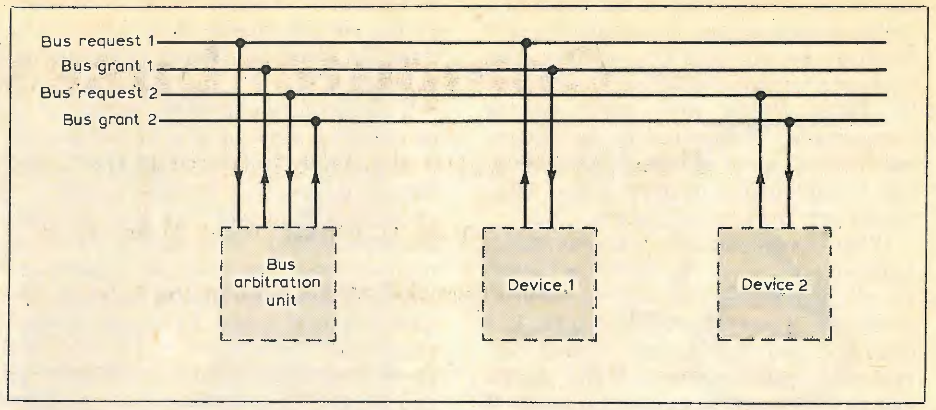


Fig. 23. *Bus control with an arbitration unit.*

A summary of the protocol necessary for a device to gain and relinquish bus mastership is given in Fig. 22, in which the bus is used for a single "send" operation during mastership. Although the protocol is quite complicated, we have seen how each step is necessary if the bus is to perform its job correctly.

Bus arbitration. An alternative to daisy-chaining the "bus grant" signal is to have separate "bus request" and "bus grant" lines for each device, as shown in Fig. 23. When contention occurs, the bus controller can select one of the contending devices and give it alone mastership by asserting its grant line. In this case, the controller is in a position to impose a priority structure on devices using programmed priority levels, and is often called a bus arbitration unit.

The disadvantage of bus arbitration is that the number of lines increases by two for each device added. However, the delays inevitably associated with a long daisy-chain are avoided. In practice a compromise solution is sometimes adopted, with say 8 priority levels, 8 "bus request" and "bus grant" lines, and several devices daisy-chained within each priority level.

Distributed buses. In general, if several identical autonomous devices are connected to a single bus, in a system with no protocol, bus controller or arbitration unit, there is no way of guaranteeing that two or more of them do not try to use it at the same time. However, if such "collisions" can be detected, it is possible to devise protocols for retransmission which ensure that the information gets through eventually.

Although it should be possible to detect collisions by looking for the neither-high-nor-low logic level that occurs when two tri-state gates, both enabled, are fighting for the bus, in practice distributed buses usually use serial transmission. So far, the bus has been considered as a parallel collection of wires, where the address, data and control information is presented in parallel, one wire for each bit of the information. However, if the bus wires are expensive, it is more attractive to use one line only for the information, and transmit the bits one after another on this one wire. This is the case, for example, when radio is used as the bus medium: to transmit 32 bits in parallel requires 32 different radio frequencies to be reserved for the bus, and radio bandwidth is a scarce resource. (The cost of duplicating the radio receiver and transmitter 32 times for each device connected to the bus is not negligible either!)

To detect collisions using serial transmission, some error-checking information is sent with the data. For example, one might send each transmission twice, and the receiver could check that they were the same. It is

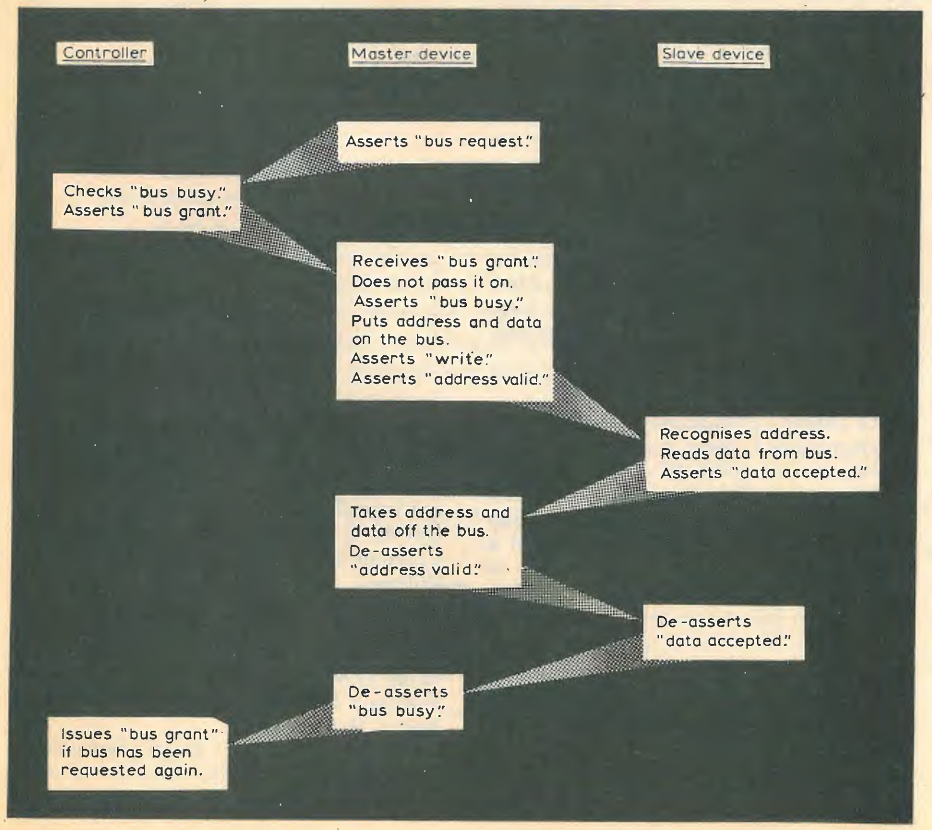


Fig. 22. *Protocol for gaining bus mastership and sending data.*

extremely unlikely that in the event of a collision when two transmitters are driving the bus simultaneously, the duplicate versions will check correctly. In fact, there are much more economical collision-detection mechanisms than double transmission, but we need not be concerned with them here: the principle is enough.

When a receiver sees a transmission addressed to it, it sends a "data accepted" or "acknowledgement" message. However, if a collision has occurred and the transmission is corrupted, it remains silent. If the sender has not received acknowledgement of his transmission after a reasonable time, he should assume that it has collided, and re-transmit it. However, if two senders collide on a transmission, it is important that they should not time out after exactly the same interval and collide when sending again, and so on ad infinitum! This situation is avoided by the simple expedient of making the time-out internal random (within suitable bounds).

If an acknowledgement is corrupted by colliding with another transmission, it will simply fail to be received. The device which was expecting the acknowledgement will then time-out and transmit again. This means that the receiver will see the same message twice, and care should be taken to ensure that this does not have any harmful effects. For example, each message could be numbered, so that the receiver can simply discard the second message after acknowledging it.

The scheme described is used in the Aloha network of computers in the Hawaiian islands. Note that no attempt is made to detect if the bus is busy before sending: this means that collisions can be expected fairly often and much of the bus's bandwidth will be used for re-transmissions. (One way of calculating just how much – under very simple assumptions – is given as an Appendix.) A more sophisticated mechanism is for the sender to listen to the bus before transmitting, to see if it will cause a collision by interfering with another transmission. This is analogous to the "bus busy" information described earlier. While this can be expected to reduce substantially the frequency of collisions, it will not eliminate them altogether since two devices may still decide to send at exactly the same time. A further refinement is for the sender to monitor its transmission itself and check that the bits it "hears" are trhe same as those it sends. If there is a discrepancy, this indicates a collision and it should cease transmitting at once. However, this is not feasible in the case of radio, since locally transmitted signals tend to swamp the local receiver and so collisions are not detected locally.

The author

Ian H. Witten graduated with a B.A. in mathematics from the University of Cambridge, England, an M.Sc. in computing science from the University of Calgary, Canada, and a Ph.D. in electrical engineering science from the University of Essex, England. He was a Commonwealth Scholar at Calgary during 1969-1970 and has been a lecturer in the Department of Electrical Engineering Science at Essex University since then.

His research interests span the field of man-machine systems; he has specialized in the fundamental problems of machine learning, and in computational phonetics – the science of speech synthesis by computer. He is the author and co-author of about 35 technical publications, including several on speech synthesis.

During a sabbatical year in 1977, he worked at the University of Canterbury, New Zealand, on learning machines, at the University of Calgary on speech synthesis by computer, and at Bell-Northern Research, Montreal, on speech analysis.

Dr. Witten is on the Editorial Board of the International Journal of Man-Machine Studies, and recently, as a consultant to the Open University, participated in the development of a new course entitled "The Digital Computer."

Appendix

Suppose d devices are attached to a distributed bus, each of which sends m messages (excluding re-transmissions) per second. All messages take T seconds to transmit. A synchronous or interlocked bus could handle the traffic provided the total time for dm messages was less than 1 second, i.e. provided $dmT<1$.

Now let the re-transmission rate be r re-transmissions/sec. In 100 seconds, there will be $100d(m+r)$ messages sent (including re-transmissions). These will occupy a total of $100d(m+r)T$ seconds which must, of course, be less than 100, and during the remaining $100-100d(m+r)T$ seconds the bus will be unused. Hence the probability of a message requiring re-transmission is $100d(m+r)T/100$. Now since there are r re-transmission for m real messages, the re-transmission rate can also be expressed as r/m.

Hence $r/m = 100d(m+r)T/100$, from which

$$r = \frac{dm^2T}{1-dmT}$$

We observed above that $100d(m+r)T$ must be less than 100 seconds, since the bus cannot be used more than full-time. Hence

$$d\left(m + \frac{dm^2T}{1-dmT}\right) < 1,$$

$$\text{or } \frac{dmT}{1-dmT} < 1,$$

$$dmT < 1/2$$

This shows that the maximum number of messages that can be originated under the distributed bus organization is only half that which the bus could handle if control were centralized.

Actually, these calculations are rather simplified. In real life, even a bus with centralized control cannot necessarily handle the traffic if dmT is close to 1, because this is the average load – the peak load will be higher. If messages are generated stochastically, then the performance of a centralized bus will depend on whether messages can be queued by the devices that originate them. For example, suppose a device wants to send a message, but the (centralized) bus is busy. It must wait for the bus to become free. If, while it is waiting, another message appears which must be sent as well, the device needs to be able to queue the two messages. If it can't, then a message will be lost and so the bus must be overloaded. If it can, how many message can be queued? Two? Two hundred? This is one of the parameters that will affect the performance of a bus with centralized control. In the most optimistic case, where an unlimited number of messages can be queued by each device if necessary, the centralized bus will be able to operate provided $dmT<1$. Statistical calculations show that the Aloha distributed bus becomes saturated if dmT *grows as big as* $1/2e$ (Abramson, 1970). Thus the distributed bus can handle about 20% of the traffic that a centralized bus can.

Further reading

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Antennas and propagation — 2

Further developments in antenna technology

by R. Ashmore

Part one gave extracts based on some of the papers presented at the Antennas and Propagation Conference, held at the Institution of Electrical Engineers in London recently. Topics covered included a systems engineering approach to antenna design, satellite communications and the amateur radio service. This second part continues where Part one left off, with the discussion on amateur antennas, based on the paper[4] by Les Moxon, G6XN.

A RECENT analysis showed that at least 80% of the h.f. stations contacted used relatively small antennas on rotary beams. These had closely-spaced half-wave elements providing about 6dB gain (relative to a dipole). This kind of antenna, on the popular DX bands, gives considerable directivity because of the narrow bandwidths. Even smaller beams are needed, but methods of size reduction so far employed have used lossy devices such as loading coils of resonant feed lines. Les Moxon therefore gives consideration to design optimization on the smaller antennas with a view to achieving increased efficiency.

Large beam antennas commonly used in commercial installations operate on an additive principle in that the gain and the volume of space occupied by the array are proportional to the number of elements. In contrast, the smaller amateur beams use a subtractive process where energy is concentrated in the wanted direction by arranging that cancellation is less complete in that direction than in the unwanted directions.

Mr Moxon gives an example of a beam antenna comprising two parallel, closed-spaced dipoles fed in antiphase to give a figure-of-eight directional pattern. This pattern is readily converted into a cardioid by introducing a phase shift corresponding to the spacing. Provided all the available power is radiated, the gain, 4.2dB for both of the above cases, will be independent of size. The practical realization of obtaining higher gains using more than two elements is extremely difficult because of the low radiation resistances, narrow bandwidths and close tolerances inherent in the subtractive method of beam formation, but the two-element design above allows considerable reduction in size without loss of effective gain.

The useful bandwidth of the smallest beam tried was found to be less than 100kHz but the required coverage of 350kHz was achieved by separately feeding each element through appropriate networks located at the transmitter.

In developing the small antenna it was found that to tune shortened elements to resonance without introducing losses, it was necessary to use as much capacitive loading as possible. The resulting concentrations of metal at the ends of the elements produced very severe capacitance overcoupling of the elements, effectively preventing the beam from operating. This difficulty was overcome by neutralizing the excess coupling using two additional wires to provide antiphase capacitance coupling between the ends of the elements.

Restricted space often goes hand-in-hand with height limitations, so it may not be enough just to reduce the size of the antenna. Where ranges are short the need can usually be met by vertical polarization for ground-wave communication or horizontal polarization for high-angle, sky-wave working. However, where longer ranges are required the use of steep ground slopes, if available, is the simplest solution, otherwise vertical polarization may provide the only answer. In the latter case, cancellation of the direct wave by the ground-reflected wave is incomplete so that a modest DX communication capability, almost independent of height, can be achieved.

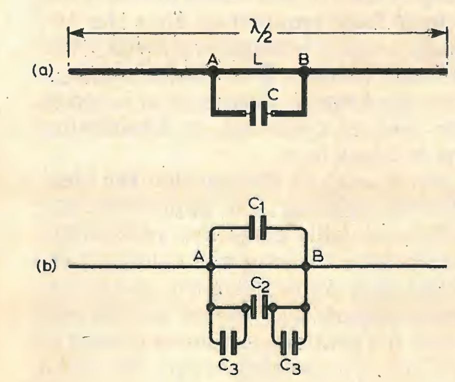

Fig. 2. (a) *A linear resonator for a λ/2 dipole. This will enable simultaneous operation at the design frequency and also at a higher frequency.* (B) *A linear resonator arrangement showing additional capacitors for three-frequency operation.*

The paper then discusses the use of beam antennas for multiband DX operation. Beam antennas for amateur DX communications are normally required to cover bands about 3% in width centred near 14, 21 and 28MHz. To achieve this, beam antennas used by amateurs have traps to effectively shorten the elements at the higher frequencies. This, says Mr Moxon, is a wasteful process because the half-wave element for 14MHz can be used as two half-waves in phase at 28MHz to obtain 2dB of extra gain by the additive process.

The traps, which are liable to deteriorate, also add losses, restrict bandwidth and increase top weight. Alternatives include resonant feeders and tuning and matching networks located in the centre of the elements. However, the author of the paper recently adapted a linear resonator, as shown in Fig. 2 (a), to provide operation with full aperture at the higher frequencies, without significant effect on operation at the lowest frequency. The inductance L of the conductor AB is tuned by C to act as an insulator at 28MHz. For 21MHz the capacitor is increased to achieve resonance with the inductance of the outer portions of the dipole. (Further analysis is given in Ref. 4).

The capacitance may be switched, or resonance may be achieved simultaneously at 21 and 28MHz by providing two capacitors as shown in Fig. 2 (b). This works on the principle that higher frequency resonances have little effect on the lower frequencies, while the high value of *k* (*k* being the coupling factor between the current paths and X_L/X_C) brings the parallel and series resonances so close together that the 21MHz path via C_1 is inductive at 28MHz. The main effect of the extra capacitances in Fig. 2 (b) is that the effective value of L is modified. The two capacitors, C_3, are added to increase the shunt inductance of 28MHz (having little effect at 21MHz) to avoid narrowing of the bandwidth.

Mr Moxon points out that this type of resonator may also be used to tune a conductor to or away from any specific resonant frequency, or, for example, to allow masts or rigging to be used as antennas at a small number of discrete frequencies. It may also be used to overcome nulls in the polar diagram of an antenna caused by the near presence of resonant metal structures.

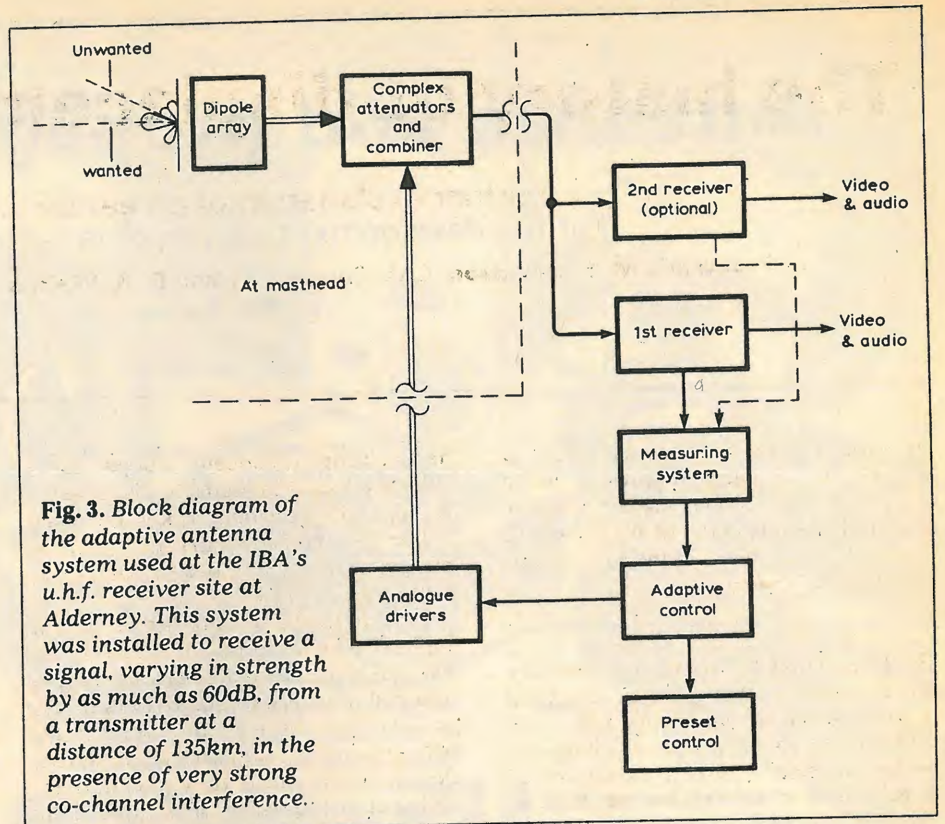

Fig. 3. *Block diagram of the adaptive antenna system used at the IBA's u.h.f. receiver site at Alderney. This system was installed to receive a signal, varying in strength by as much as 60dB, from a transmitter at a distance of 135km, in the presence of very strong co-channel interference.*

Broadcasting

The Independent Broadcasting Authority (IBA) expect that by completion of the u.h.f. transmitter network they will be operating about 650 transmitters in Bands IV and V. This means that when the fourth channel comes into operation, the total number of transmitters will be about 2600 within the 44 channels of the u.h.f. band. While careful planning avoids serious interferences arising within the appropriate service areas, broadcasters who need to receive signals outside these areas, for rebroadcast, find that irregular propagation can cause them considerable interference problems. Consider for example the u.h.f. link across the English Channel from Stockland Hill to Alderney, part of the colour-tv feed to the Channel Islands. This is an over-the-horizon sea path of 135km length and, characteristically, the received signal is very variable in strength with a range of about 60dB and generally very weak. For this reason, the signal is very susceptable to co-channel interference (c.c.i.) from several sources both within and outside the UK. Crystal Palace in London, Wrekin in Shropshire and Kippure in Ireland (the latter being at an angle of only 7° off the wanted signal) are particularly powerful sources of c.c.i. at the receiving end of this link.

To obtain a broadcast quality signal the reception pattern of an antenna needs on occasions to have null depths of the order of 45dB in the directions of interfering sources. Since this was not possible with conventional arrays, the IBA decided to investigate the properties of adaptive arrays. Details of this investigation are given in a paper[5] by M. D. Windram from the Authority's Winchester establishment.

The paper lists the main advantages of the adaptive array. When operating the adaptive array automatically adjusts the antenna pattern to give minimum interference, and it will handle these interferences whether they are from single or multiple sources. The antenna can also track the changing apparent direction of interference resulting from propagation effects, and because of its adaptability does not present a severe mounting and tolerance problem, as does a fixed array.

After considerable theoretical study and investigations into the behaviour of a simple four-element adaptive array, the IBA built a prototype half-size (eight element) array. The results of tests on this array confirmed the theory and an operational antenna was installed at Alderney in March 1977. The final operational antenna system used at Alderney is shown in Fig. 3. This is a 16×4 dipole array constructed as a 2×2 array of 8×2 dipoles.

A similar system, having a linear array of 16 elements, is described in the IEE paper. The output of each element is connected to a network which effectively controls the amplitude and phase of that output. These output signals are then combined to create a voltage-controlled antenna, the pattern of which is a function of the control voltages. This combined output is fed to the system's receiver or receivers which provide the video and audio outputs and also the signals required for the system's measuring circuitry. Up to four receivers may be used within the control loop. The output from the measuring system is then passed to the adaptor control unit which provides the control logic required to alter the antenna control voltages to modify the antenna pattern. The control logic is converted into analogue form to drive the element combiner, so completing the feedback loop.

Initial analysis showed that the ideal element spacing was approximately 2/3λ since this combined reasonable directivity with easy null control. Cartesian (X+jY) type control of the antenna outputs was chosen as this provided the continuous control needed in the adaptive process, where for small changes in control, discontinuities could cause instability. Pure phase shifters have finite phase ranges and would therefore present serious problems.

For u.h.f. arrays of a size similar to that used at Alderney, it is necessary because of the expense, stability and maintainability to use control algorithms which take measurements by making step changes in the control voltages to the array, thus stepping the antenna pattern and measuring the result in terms of c.c.i. on the output signal. The use of correlation methods or similar techniques are too expensive, although in principle capable of giving more accurate measurements of error. The theory of the adaptive array and the theoretical conclusions made by the IBA are described in much greater detail in Mr Windram's paper.

The operational system used at Alderney has helped the IBA to maintain a virtually continuous colour service without drop-out due to excessive co-channel interference. Based on results so far Mr Windram says, "we can now state with confidence that propagatic mechanisms such as sea scatter and tropospheric scatter do not degrade the performance of the adaptive aerial, and in fact the adaptive aerial has considerable advantages over a fixed array in that it can track the changes in apparent c.c.i. direction caused by scattering processes".

The IBA is now investigating the design of a simpler four-element system for use on links having perhaps two or at the most three sources of interference requiring rejection of about 45 to 50dB. This system will use the same principles but the amount of equipment will be considerably reduced, and this combined with rapidly improving technology makes possible the use of a microprocessor to control the array. In conclusion Mr Windram says that it has been shown from theory and confirmed in practice that an adaptive array pre-

continued on page 76

The history of displacement current

Further explanation of an earlier article

by **I. Catt** and **M. F. Davidson** (CAM Consultants) and **D. S. Walton** (Icthus Instruments Ltd)

As a result of correspondence following their article "Displacement current" in the December 1978 issue, the authors feel that further explanation of their views is required. They offer it in the form of this brief historical survey.

IN THE EARLY nineteenth century electromagnetic theory made advances, a cornerstone of the theory being the doctrine of conservation of charge q, which developed into the doctrine of continuity of electric current flow, $dq/dt = i$.

In the middle of that century Maxwell struggled with the paradox of the capacitor, where charge entered one plate and then flowed out of the other plate apparently without traversing the space between the plates (Fig. 1). It seemed that electric charge was being destroyed on the upper plate and being re-created when it reappeared on the lower plate. Maxwell "cut the Gordian knot" as Heaviside put it (Heaviside 1893) by postulating a new type of current, called "displacement current", as flowing across the gap BC in Fig. 1 so as to save the principle of continuity of electric current.

"Displacement current" was a result of his postulation of "electric displacement". Maxwell said that the total outward displacement across any closed surface is equal to the total charge inside the closed surface (Maxwell 1873).

It is not surprising that objections were raised. Notice, in Fig. 2, that if in any circuit there should be a break, BC, in the current path, we are bound by the principle of conservation of charge to say that the current i, that is the flow of charge, entering B from A accumulates as charge $\int i dt$ at B, and the current reappearing at C "accumulates" as equal negative charge $-\int i dt$. By definition, electric displacement outward from B equals the total charge trapped at B; $D = \int i dt$ and $i = dD/dt$. It is not a coincidence that "displacement current" saves the idea of continuity of electric current; *it does so by definition.* With the postulation of displacement current, it would never in future be possible to devise an experiment which might refute the principle of continuity of electric current. Popper would therefore say that "displacement current" is an unscientific concept (Popper 1963). Whenever charge seems to disappear at a point, displacement takes its place. Whenever electric current seems to disappear at a point, displacement current takes its place.

It is important that Maxwell and Heaviside believed that the current entering a capacitor plate became trapped and had nowhere to go. Writers on the subject must be glad that some route between B and C for real current did not declare itself, since they say that the brilliant postulation of displacement current led to the postulation by Maxwell of waves in space.

Meanwhile, even as Maxwell was contemplating the ethereal displacement current, practical electricians were inventing and building wired telegraph systems. The distortion of signals travelling long distances was bad, and was thought to be due to the fact that the capacitance of the telegraph wires had to be charged up through the resistance of the wires, resulting in an RC time constant which attenuated different frequencies differently. As late as 1910 virtually all electricians (including Lord Kelvin) did not accept Oliver Heaviside's claim that a telegraph wire had distributed inductance as well as capacitance, and that if only this inductance were increased by the addition of periodic loading coils, distortion-free transmission over long distances could be achieved (Heaviside 1893).

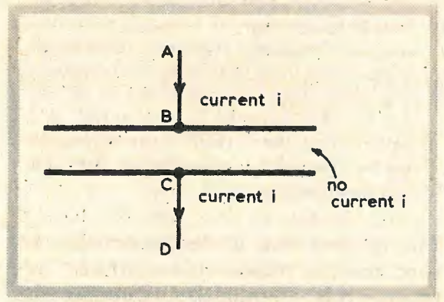

Fig. 1. *Charge flowing into one plate of a capacitor, as current i, and flowing out of the other plate.*

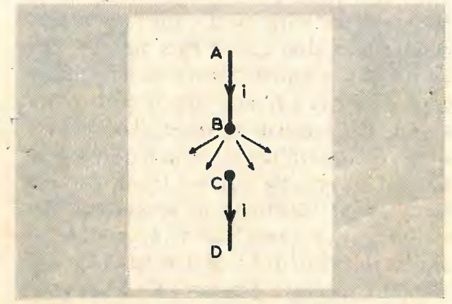

Fig. 2. *Electrical circuit AD with a break in the current path at BC. Charges accumulate at B and C.*

It was important for Heaviside to encourage a sensible approach to the characteristic impedance of telegraph lines, because the practical pay-off in telegraphy and telephony would be immense. (This misunderstanding delayed the introduction of telephones for twenty years.) This practical pay-off would be best achieved by arguing that signals travelling down (between) telegraph lines were undistorted TEM and similar to the waves in space discovered by Hertz in 1887, twenty years before, and previously postulated by Maxwell as one implication of his proposed displacement current.

It was important for Heaviside not to criticise the theory he was trying to argue from, Maxwell's electromagnetic theory. So it would have been injudicious for Heaviside to question the concept of displacement current, and he never did.

The essence of the concept of a transverse electromagnetic wave, TEM, is that nothing – field, flux, or current – flows laterally across the surface of the wave front. The analogy is the Severn Bore, where we see a single step of water rushing up the River Severn. Everything ahead of the step is steady, and everything behind the step is steady. There is no lateral, sideways flow. In the electromagnetic case (Fig. 3), the idea of a lateral flow of current across the face of a TEM step is absurd, and would result in a longitudinal magnetic field; the step would "get ahead of itself". Further, since the step travels forward at the speed of light, $1/\sqrt{\mu\epsilon}$, any lateral flow would cause embarrassment by travelling even faster, in the same way that when you walk across inside a moving train by Pythagoras' Theorem you are travelling faster than the train.

Now although in the case of a capacitor, displacement current needed to be regarded as just like a real current, for instance causing a magnetic field; in the case of the D flux at the front of a step of TEM ($E \times H$) energy current travelling down a telegraph line, the displacement clearly must not behave like a real current – for instance by creating a magnetic field which would reach out ahead of the wave front and ruin its TEM nature.

Maxwell and later Heaviside did not notice the discrepancy in the requirements of displacement current; that in a capacitor it must act like a real current but in a transmission line it must not; because neither of them knew that a capacitor is no more nor less than a transmission line (*Wireless World*, Dec. 1978, p. 51). This is even today known by very few scientists. Maxwell, along with today's text-book writers (e.g. Fewkes 1956, Bleaney 1957), believed that the displacement current dD/dt travelling across between the plates of a capacitor BC was uniformly distributed, and it is only very recently that it has been pointed out that the flow of current and field in a capacitor is identical with that in a transmission line; that the field moves out from the capacitor's leads as if they were links to one end of a transmission line. So the discrepancy could not become apparent.

A serious difficulty for displacement current arises when we realize that the two plates, BB′, CC′ in Fig. 4, *are* a transmission line. We know that the current i travelling down to B from A then flows out sideways from B along the capacitor plate BB′. This route, along the capacitor plates, failed to declare itself to Maxwell, and everyone has followed his lead.

In a transmission line (Fig. 4), everyone agrees that the current i entering the line at B leaves B by flowing along the line BB′. No displacement current dD/dt between the lines is needed for us to retain the doctrine of conservation of charge and conservation of current. In fact, if this dD/dt *were* regarded as a current, far from saving the doctrine, it would destroy it, because now more current (i+dD/dt) would be leaving the first section of the plate BB′ than was entering it. The last sentence is difficult to grasp; no matter, because it is easy to see, and sufficient to see, that if i enters B from A and i leaves B along BB′, continuity of current is preserved without our having to postulate displacement current.

"But surely we cannot just drop displacement current when for a century every expert (e.g. Solymar 1976, Winch 1963) has been protesting that it is the foundation of our craft; that 'Maxwell's leap of genius' in proposing displacement current was what got the subject going – leading to Hertz's discovery of waves in space, for instance?"

The answer lies hidden in Heaviside's magnificent, regal statement, "We reverse this." In his "Electrical Papers", Vol. 1, 1892, page 438, Heaviside wrote;

Now, in Maxwell's theory there is the potential energy of the displacement produced in the dielectric parts by the electric force, and there is the kinetic or magnetic energy of the magnetic induction due to the magnetic force in all parts of the field, including the conducting parts. They are supposed to be set up by the current in the wire. We reverse this; the current in the wire is set up by the energy transmitted through the medium around it . . .

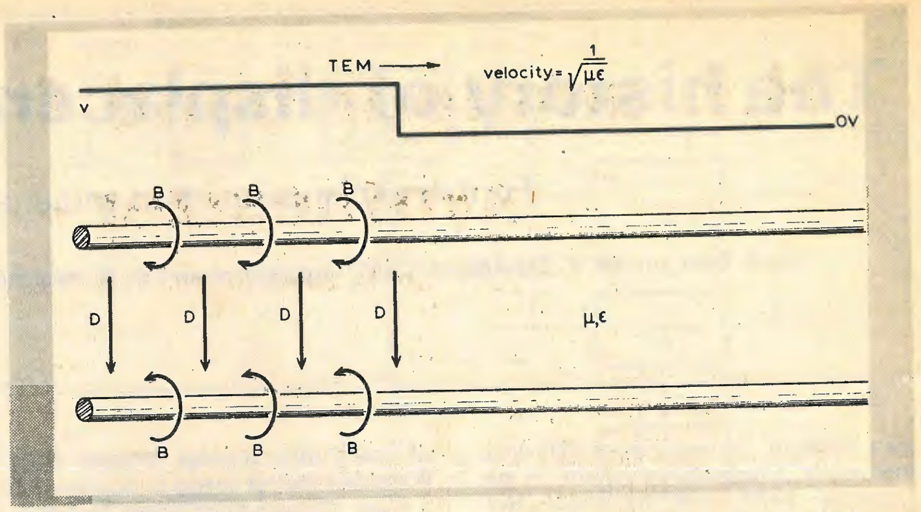

Fig. 3. *A TEM step (top) travelling at the speed of light and guided by two wires (below). The B arrows represent magnetic flux lines and the D arrows electric strain between the wires.*

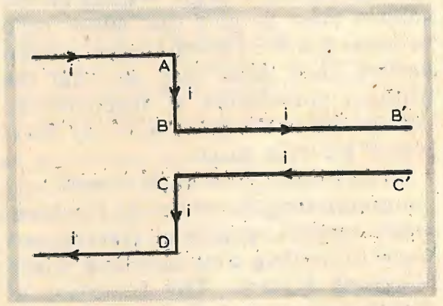

Fig. 4. *Current flowing into and out of capacitor plates BB′ and CC′. These two plates together constitute a transmission line.*

The discrediting of displacement current merely makes Heaviside's "We reverse this" mandatory. It means that the field must be the cause and electric current an effect, rather than (as Maxwell thought) the other way round.

If we keep to "Theory H", the theory that the field $E \times H$, travelling along between the wires at the speed of light – what Heaviside called the "energy current", is the cause, then electric charge and electric current are merely what define the *edge* of an energy current. If electric current is that which defines the side of an energy current, then we may with equal justification postulate "displacement current" as that which defines the front face of a step of energy current. Under "Theory H", Maxwell's 'leap of genius' (in postulating displacement current and thence waves in space) becomes tautological; "Because a wave in space if it existed would have to have a front face (displacement current), then I propose such a front face and therefore I propose waves in space."

Maxwell would have saved us a century of confusion if he had had enough insight to say, "Since circuits containing capacitors, that is, open circuits, work, it follows that the essence of electromagnetics cannot be electric current in closed circuits of conductors; it must be something else. What about waves in space?" Heaviside, seventy years ago, missed the key point by a whisker. He failed, but he failed gloriously. He never discovered the flaw in the structure, displacement current.

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The next seminar by the authors on digital electronics design will be held at St Albans on May 3-4. For information, contact C.A.M. Publishing, 17 King Harry Lane, St Albans, Herts.

H.f. amateur band frequency synthesizer — 1

by **M. Small,** B.Tech. (G4DVI)

This article describes a frequency synthesizer which is capable of covering most of the h.f. band, and which has been used as the local oscillator of an h.f. amateur-band transceiver by the author for five months. The synthesizer contains three basic components: a digital phase-locked loop, a variable frequency interpolation oscillator and a heterodyne mixer.

WISHING to build a transceiver to cover the amateur bands from 10-160m, and to avoid the expense of buying a large number of crystals, the author was prompted to investigate synthesizers using phase-locked loops. A costing showed that, with the availability of cheap t.t.l. m.s.i., a phase-lock loop which would provide the equivalent of 32 crystals could be built for the component cost of between 5 and 8 crystals.

There are many different ways of making frequency synthesizers. (a survey of synthesizers appeared in the Sept., Oct. and Nov., 1978 issues and on p.83 of this issue — *Ed.)*

The system sketched in Fig. 1 comprises a phase-locked loop which provides frequencies, in 500kHz steps, between 7 and 23MHz. The output of this is combined with a variable frequency from 5 to 5.5MHz, the products of mixing covering a band from 1.5 to 28.5MHz.

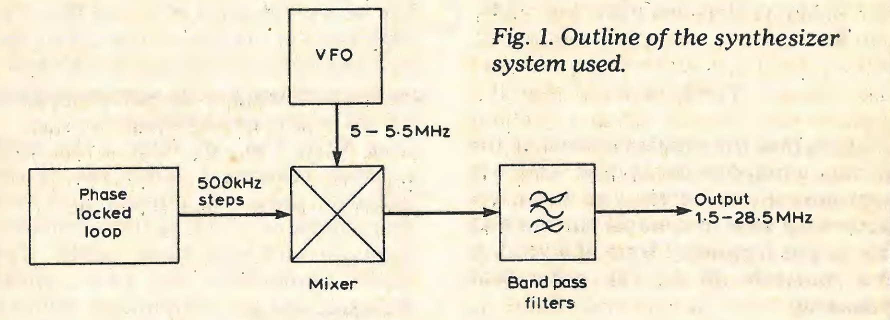


Fig. 1. Outline of the synthesizer system used.

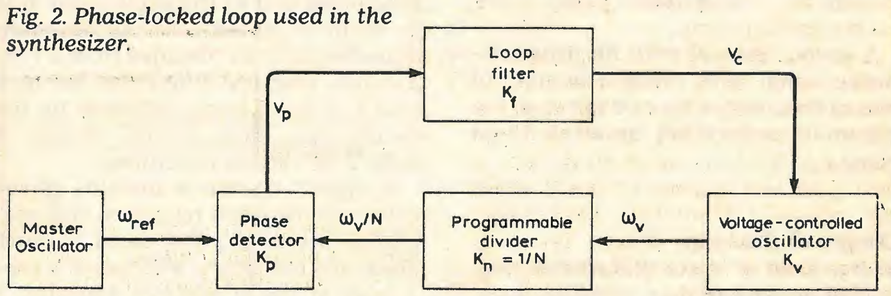


Fig. 2. Phase-locked loop used in the synthesizer.

Table 1 showing local oscillator and p.l.l. frequencies.

Amateur band	Coverage provided MHz	Required local oscillator frequency MHz	Phase locked loop frequency MHz
160	1.5-2.0	10.5-11.0	16.0
80	3.5-4.0	12.5-13.0	7.5
40	7.0-7.5	16.0-16.5	11.0
20	14.0-14.5	23.0-23.5	18.0
15	21.0-21.5	12.0-12.5	7.0
10	28.0-28.5	19.0-19.5	14.0
	28.5-29.0	19.5-20.0	14.5
	29.0-29.5	20.0-20.5	15.0
	29.5-30.0	20.5-21.0	15.5

Performance

range	1.5 to 28.5MHz, in 500kHz bands.
output	70mV r.m.s. into 500 ohms.
stability	Digital phase-locked loop: 10 ppm/degree Centigrade Interpolation oscillator: 50Hz per 15 minutes after 10 minute warm up.
purity of output	In-band spurious outputs typically 90dB below carrier. Out-of-band products from mixer more than 30dB below carrier.
lock up time of phase-locked loop	Small signal: 5ms to within 10% of change. Large change: approx. 8ms per MHz change.

Two sets of local oscillator frequencies would give coverage of the amateur bands for a given intermediate frequency. For a given v.f.o. frequency, there are also two sets of frequencies from the phase-locked loop which could be used to obtain the required local-oscillator frequencies. Tables of all these possibilities were drawn up but only the final one used, Table 1, is shown. This was chosen because direct coverage of the normal h.f. band is also obtained, extending the potential use of the device.

Principle of phase-locked loop

The operation of a phase-locked loop system can be seen from Fig. 2. The loop contains a voltage-controlled oscillator whose output frequency (ω_v) is a function (K_V) of the control voltage V_c.

$$\omega_v = K_v \, . \, V_c \text{ rads/sec}$$

The output from this oscillator is buffered and fed into the programmable divider which divides the input frequency by some integer N, so that its output has a frequency equal ω_v/N and its transfer function $K_n = 1/N$.

The output from the divider is taken to a phase detector where it is compared with a reference frequency ω_{ref}, derived from a master oscillator. The phase detector produces an error voltage V_p, whose magnitude is a function K_p of the phase error between the two signals.

$$V_p = K_p . \phi_e$$

This error voltage is smoothed by the loop filter, to remove residual traces of the reference frequency and to tailor the response of the system. It is then fed back to the voltage-controlled oscillator. The loop filter has a transfer function K_f

$$V_c = K_f . V_e$$

Given that the characteristics of the various components in the loop are appropriately matched, the loop will settle with time to a stable state where the output frequency from the v.c.o. is the multiple N of the reference frequency.

$$\omega_v = N\omega_{ref}$$

Clearly, since N may be programmable within some range, a number of output frequencies may be selected, the minimum separation between them being ω_{ref}.

Design of the loop

Design aims of a p.l.l. will specify such factors as settling time, stability, spectral purity and drift. More detailed analysis is required to enable the designer to predict how these aims can be achieved, and the primary approach to this problem is through the use of servo mechanism theory and Laplace transform analysis.

The Laplace transform allows the analysis of both the transient and steady state conditions in feedback control systems. It is valid for positive real time, linear parameters. An introduction to its use for p.l.l.s can be found in reference 1.

In this method the feedforward and feedback transfer functions of the control loop are defined in terms of the complex variable s. The resulting equations may be tested using largely algebraic techniques to determine the stability of the system. In addition, their type and order can be used to indicate the transient response characteristics to be expected under various conditions of input.

In the p.l.l. system of Fig. 1, the feedforward transfer characteristic of the loop,

$$G(s) = K_p . K_f . K_v \quad \ldots\ldots\ldots\ldots\ldots (1)$$

and the feedback transfer function,

$$H(s) = K_n = 1/N. \quad \ldots\ldots\ldots\ldots\ldots (2)$$

The characteristic equation of the loop CE is defined to be

$$1 + G(s) . H(s) = \phi$$

which, in the case of this loop, is

$$1 + K_p . K_f . K_v . K_n = \phi.$$

When the loop is closed its transfer function is

$$\frac{1}{1 + G(s) . H)s)}.$$

Substituting from (1) and (2), this becomes for our system

$$\frac{1}{1 + K_p . K_f . K_v/N} \quad \ldots\ldots\ldots\ldots (3)$$

Now some of the functions K_p, K_v, K_f have a complex nature; that is they are functions of s. Equation (3) will therefore be a polynomial of s, and the characteristics of the polynomial define the type and order of the system. The practical consequence of its type in particular will be discussed shortly.

Loop filter. The loop filter is the main variable component which can be designed to tailor the fundamental loop characteristics – lock up time, transient response and loop band width. The other components, the v.c.o., phase detector and programmable divider, usually have characteristics which are fixed or defined by the application. It is generally accepted that the optimum characteristics are obtained from a type 2 system, practical differences between type 1, 2 and 3 being indicated by the steady-state phase errors, shown in Table 2 for various conditions.

A type 2 system maintains phase coherence between reference and controlled oscillators for steps in both phase and frequency, whereas in a type 1 system there always remains a residual phase error which varies with frequency. The extra advantage of a type 3 system being able to follow a changing frequency with phase coherence is not usually worth the extra design complexity. A loop filter of the form shown in Fig. 3(a) will produce a type 2 system.[2]

The transfer function of such a filter is (if A is large)

$$K_f = \frac{1 + T_2}{T_1}$$

where $T_1 = R_1 . C_1$ and $T_2 = R_2 . C_1$

These time constants can further be expressed in terms of the loop natural frequency (ω_n) and damping factors (ζ)

$$T_1 = \frac{K_p . K_v}{N\omega_n^2} \qquad T_2 = \frac{2\zeta}{\omega_n}.$$

hence

$$R_1 = \frac{K_p . K_v}{N\omega_n^2 C_1} \qquad R_2 = \frac{2\zeta}{\omega_n C_1}$$

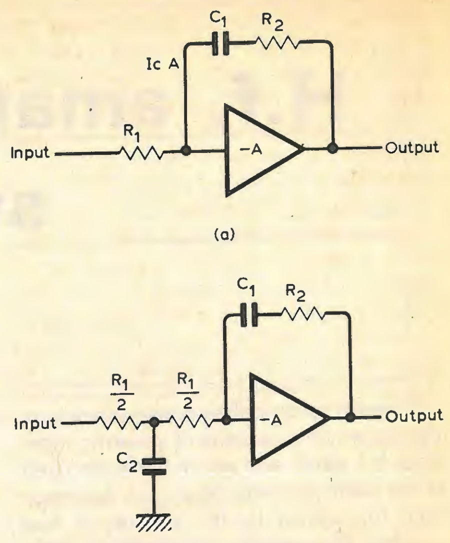


Fig. 3. Loop filter to obtain a Type 2 form of phase characteristic is at (a), modified as at (b) to contain additional filter R_1C_2 for the reduction of error pulses.

The values required for ω_n and ζ must be chosen by the designer to obtain the required settling characteristics (transient response) or frequency response (peaking and roll off). The values for ω_n and ζ can be chosen using the normalized transient response curves shown in Fig. 4, which plot the response to a step in frequency. The effect of varying the damping factor is shown and the normalized time axis is a function of ω_n. From these it can be seen that for reasonable values of damping factor $2 > \zeta > 0.5$ a system will lock to within 10% of the step within the time, $t = 5/\omega_n$. Thus, the required settling time can be used to determine ω_n and the shape of the response.

Limiting conditions

For the phase-lock loop system to possess the characteristics predicted by the solution of these equations, it is necessary that none of the components are driven beyond the range over which their transfer functions are as described, that is to say, into limiting. This is normally avoided by allowing sufficient tolerance between the boundary design conditions and the known physical limits on the components.

The limits on components to be considered are

– maximum and minimum output voltages obtainable from the operational amplifier.
– limit of the linear voltage/frequency characteristic of the varicap diode.
– maximum output from the phase detector.

STEADY STATE PHASE ERROR

Type	step phase	step frequency	step rate of change of frequency
1	zero	constant	continuously increasing
2	zero	zero	constant
3	zero	zero	zero

These limits must be allowed for under the worst case design value of overshoot as found from the normalized time-domain response curves. This is the case most likely to drive the operational amplifier or the varicap diode out of the linear region. The combined effect of maximum overshoot at the edge of the band covered together with error pulses from the phase detector should also be catered for. The problem of error pulses is most readily reduced by inserting a simple, low-pass filter between the phase detector and the integrator. This can be obtained by dividing the resistor R_1 in the integrator circuit into two parts and inserting a capacitor C_2, as in Fig. 3(b).

The turnover frequency of this filter should be chosen to be 10 times the natural frequency of the loop, ω_n, so as not to reduce the phase margin of the system. The filter has the additional advantage that it reduces the feed through of the reference frequency and so contributes to the spectral purity, which may be expected from the output of the voltage-controlled oscillator.

The turnover frequency can be shown to be

$$f_c = \frac{4}{2\pi . R_1 . C_2}$$

Response to large changes in N

The response of the system to a large change in the division ratio N can be much slower than that predicted by the Laplace method. This occurs when the maximum cumulative phase error that the phase detector can handle is exceeded during lock up. However, it is possible to estimate the maximum frequency step which will remain within this limit and the response time when it is exceeded.

The maximum phase error that the phase detector used here can handle is $\pm 2\pi$ radians. If this is exceeded, the output remains of the correct polarity, because the device contains a frequency detector, but its magnitude is a sawtooth function of increasing phase error, as in Fig. 5. This sawtooth has a repetition frequency equal to the instantaneous difference between the two input frequencies. The sawtooth modulates the control voltage, causing the system to settle in what appears to be an oscillatory manner. Since the loop contains what is effectively a low-pass filter, the oscillations appear to increase in amplitude as the v.c.o. approaches its target frequency.

It is possible to predict the maximum frequency step which can be achieved with a phase error of less than $\pm 2\pi$ radians. If the loop is initially in a locked condition, both the reference frequency and the output from the programmable divider have the same frequency and phase, illustrated in Fig. 6 by the portion of the graph A-B. At point B, the modulus of the divider is instantaneously changed by some step. The

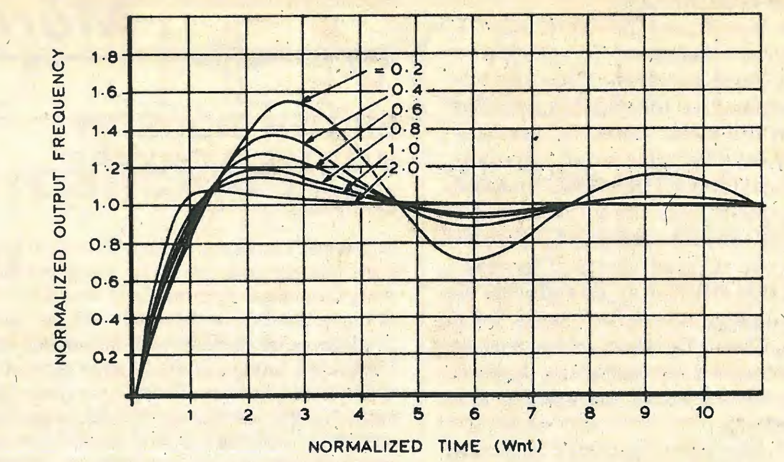


Fig. 4. Normalized response curves in the time domain of Type 2 system to a step in frequency.

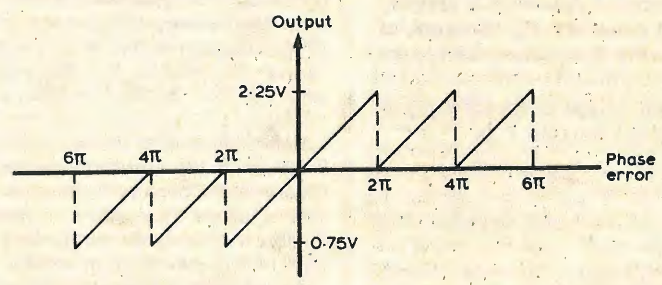


Fig. 5. Sawtooth output of phase detector for wide capture band.

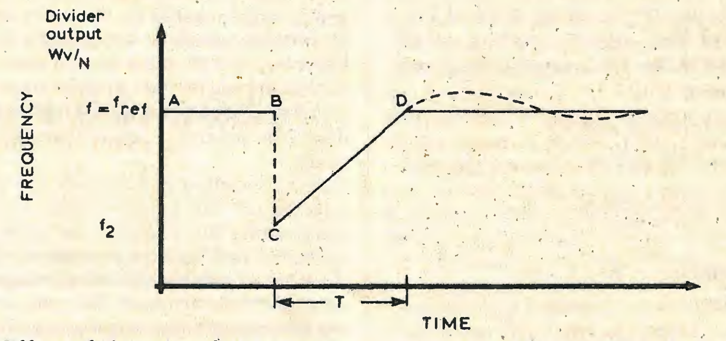


Fig. 6. Effect of changing division ratio of programmable divider.

v.c.o. frequency is initially unchanged and the result is that the output from the divider changes to a new frequency f_2, shown by B C in Fig. 6. The loop now starts to respond to correct the increasing phase and frequency coherence will again be achieved after time T.

The magnitude of the phase error is

$$\phi_{CD} = \pi\ (f_{ref} \pm f_2)T \text{ rads.}$$

If the original division ratio was N_1 and the new ratio is N_2 then

$$f_2 = \frac{N_1}{N_2} . f_{ref}.$$

So the original equation can be rewritten

$$\phi_{CD} = \pi . f_{ref} . \left(1 \pm \frac{N_1}{N_2}\right) . T.$$

Given that the maximum phase error is

$$-2\pi < \phi_{max} < 2\pi,$$

$$-2\pi < \pi . f_{ref} . \left(1 \pm \frac{N_1}{N_2}\right) . T < +2\pi$$

$$= \left(1 - \frac{2}{f_{ref} . T}\right) < \pm\frac{N_1}{N_2} < \left(1 + \frac{2}{f_{ref} . T}\right)$$

For example, if the term $f_{ref} . T$ has a value of 50, which is reasonable to ensure minimum feed through of f_{ref}, then N_1/N_2 must be within the range.

$$\frac{48}{50} < \frac{N_1}{N_2} < \frac{52}{50}$$

So the maximum step in N corresponds to about –4%, if phase coherence is to be maintained.

Reference feedthrough

The most significant problem with a digital phase detector is reference frequency feed through. This occurs when the loop is locked because of leakage in the phase detector, integrator or any other similar small unbalancing conditions. The feedthrough frequency modulates the v.c.o. and this modulation can be detected as sidebands on the wanted signal. The magnitude of this effect may be reduced by the loop integrator which acts as a low-pass filter. Further suppression may be obtained by including further low-pass filters or by balancing the leakage effects.

The MC4044 phase detector contains a charge pump with a small reverse leakage current, which may, at extremes of temperature, be 5μA, but is typically less than 0.1μA. If it is assumed that the reference frequency is greater than the time constant T_2, the gain of the filter at this frequency tends to R_2/R_1.

The apparent phase detector output due to the leakage current I_L is

$$V_{p\,(leakage)} = R_1 I_L.$$

Thus the error voltage due to this leakage is

$$V_{E\,(leakage)} = \frac{R_1 . I_L . R_2}{R_1} = R_2 . I_L$$

It is possible to compute the magnitude of the sidebands produced for small leakage effects using normal f.m. theory. For f.m. signals with a small modulation index the magnitude of the first sideband is

$J_1 = ½$ (modulation index).

In the case here this is

$$J_{1\,(leakage)} = ½ . \frac{V_{e\,\cdot\,(leakage)} . K_v}{\omega_{ref}} .$$

$$\text{i.e.} \quad \frac{\text{sidebands}}{\text{carrier}} = ½ \frac{R_2 . I_L . K_v}{\omega_{ref}}$$

$$= 20 \log_{10} ½ . \left(\frac{R_2 . I_L . K_v}{\omega_{ref}} \right) \text{dB}$$

To be continued □

References

1. Garth Nash. Phase-locked loop design fundamentals. Motorola application note AN535.
2. P. Atkinson and A. J. Allen. Design of Type 2 digital phase-locked loops. *Radio and Electronic Engineer*, Nov. 1975, p.657.

More letters

BRITISH INDUSTRY WASTES WORKERS' SKILLS

Mr Pepper's advice (January letters) to those with engineering skills to emigrate to a seller's market is economically sound and his example testifies to the reality of our social freedom, i.e. to the existence of international free-trade. Intra-nationally of course, constraints other than those of commodity market-value are recognised by executives and other workers, e.g. *Der Spiegel* recently reported that British workers are "treated like dirt" (classwise) and of course they too sometimes find their skills better paid elsewhere.

The recovery of "British" industry has long been sought in the same direction. Most large firms find it more profitable not to export but to manufacture within their market region, i.e. not the produce but the production is exported. The "British" problem is therefore twofold:

1. Dependence upon supra-national firms.
2. The working structure chosen by most firms wherein personnel placement in "division of labour" categories is made a class attribute with rigidly controlled contributions to and rewards from society.

As a socially constructive approach to the problem I recently suggested to my employer (a major international industry) via the suggestions box that an "innovators' workshop" be incorporated as a subsidiary of the group, administered by the innovators with spare time access to the group's employed expertise, and to some capital plant during normal unused periods, in order to develop to prototype stage potentially commercial products for separate exploitation with joint equity.

Being socially revolutionary the idea was rejected (cf. the Lucas Combine plan). To demonstrate the scope of the project I described in outline to the management a novel 3D system enabling transmission and recording of "look around" 3D motion colour images, with "zoom" and projection facilities.

It is not, therefore, the technocrat's current differentials alone, but the hierarchy's increasing failure to employ creatively skills of all kinds which defines our socio-economic problem.

C. H. Dierks
Nether Stowey
Somerset

3D TELEVISION

Being away at the time your November issue was published I only recently saw the article "What future for television?" with its discussion on three-dimensional viewing. It certainly revived memories of a quarter of a century ago for we could have had such then, compatible and in colour.

My father, the late Granville Bradshaw, whose inventions spanned many fields but who was better known for his advanced designs of automobile, motorcycle and aero engines, some of which are to be found in the Science and other museums worldwide, developed in the 1930s a system for the three-dimensional display of pictures where an object in the foreground, say, was angularly displaced in relation to the background as the viewer moved across the screen of the display, thus giving a very realistic 3-D impression. In fact it was as if one could 'look around the back' of the object as in real life.

With this in mind when, in the early 1950s television concerns were becoming somewhat apprehensive of losing their new-found audiences which flocked back to the cinemas with their wide screen and sterescopic systems now all the rage, he conceived the idea that the principle of his 3-D picture display, which was wholly mechanical, could be adapted for television viewing and asked me to design an appropriate electronic 3-D system based on this, which I did.

Both the BBC and the then ITA were approached and were greatly interested but had to admit they had no mandate to move into this field, let alone any finance with which to carry out experiments, so, as it has so often been said, yet another British invention being too far ahead of its time was stifled at birth.

Readers of that eminent journal of the day *Picture Post* may remember the publication of an article headed "We *can* have 3-D Television" on this very project. The date, July 1953.

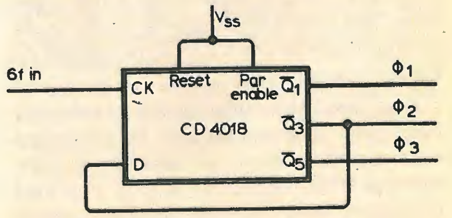
Geoffrey Bradshaw
Leatherhead
Surrey

May I correct Professor Bell for a minor inaccuracy in his article "What future for television" (November issue)? I remember as a boy seeing in London the feature/musical film "Kiss Me Kate" at the Empire Leicester Square and "House of Wax" at the Warner Leicester Square in 3D using 45°/45° polarised glasses. I also refer him to the *British Kinematograph Society Journal* for reports on 3D films, especially in the USSR. His comment ". . . . but does not appear to have produced any normal film in 3D, neither feature or documentary" is consequently in serious error.

H. L. Yentis
Edgware
Middlesex

GENERATING THREE PHASES

Three phases may be generated more simply than the method suggested in "Circuit Ideas" in the August 1978 issue p.60, by substituting



a CD4018 variable divider for the CD4017, since this gives square wave outputs, displaced in phase from one another (see the accompanying diagram).

D. Austin
Birmingham

NEWS OF THE MONTH

White paper on broadcasting strongly criticized

The Government's White Paper on broadcasting was likened to a haystack stuffed with weapons in the November 78 issue of *Independent Broadcasting*, the IBA's quarterly journal. This was a personal reaction by the IBA's director of television, Mr Colin Shaw, a former chief secretary to the BBC.

In the article, Mr Shaw said that the White Paper proposed Government intervention on a scale previously unknown in Britain. This, he said, far exceeded anything that would be considered tolerable if it were applied to the press or book publishing. He recalled that the broadcasters had always acknowledged that the Government's responsibility for the allocation of frequencies secured by international agreement gave politicians a greater right and opportunity to intervene in the conduct of broadcasting, and that, until now, they had exercised this right with caution. Very early in the history of broadcasting in Britain, ministers had evolved the formula, in dealing with parliamentary questions, that the day-to-day responsibility for the broadcasting services rested with the broadcasting authorities. By these means, British broadcasting had enjoyed a degree of independence in editorial control as great as any to be found in the world and out of them had grown a reputation for the range and quality of programming which was widely envied. However, according to Mr Shaw, there were indications that both of these might be in danger. "Well intentioned as it may be, and innocent-seeming, in some of the proposals it contains, the White Paper stands like a haystack stuffed with weapons against some future need," he said.

Mr Shaw also discussed the threats posed to the independence of broadcasting by some of the proposals for ministerial appointments to the IBA and BBC advisory bodies and to service management boards in the BBC. He asked whether the members of the OBA would have the trustee role traditionally given to the Governors of the BBC and members of the IBA, who act both as trustees of the national interest and as a buffer between the Government and programme makers. "In a television interview not long ago after the White Paper appeared, the Home Secretary seemed to be saying that they would not", he said, " . . . The OBA would be highly vulnerable to Government pressure in the absence of such a buffer".

GEC and Hitachi join forces to make tv sets

Following the example set by Rank and Toshiba, who in August last year said that they were to operate jointly, two more companies, GEC and the Japanese company Hitachi, have announced that they are to work together in the manufacture of television sets at Hirwaun in South Wales. This union has been welcomed by Alan Williams, Minister of State for Industry, whose own policy is to encourage co-operative ventures between Japanese and British companies.

Mr Williams said when the announcement was made that this venture, like the one taken by Rank and Toshiba, would make it clear in Japan that we (the British) really do want Japanese companies in our country. He welcomed the project for a number of reasons. Apart from saving a large number of jobs which were very seriously threatened in an area of high unemployment, it would enable Japanese technology to be applied to British industry. It would also increase efficiency and exports and save time on imports, and it would show that yet another major country had chosen the UK as a base for its manufacture for the whole of Western Europe. GEC already sourced over half of their non-tube components and materials from within the UK, and the new joint venture would make the maximum use of UK tubes, components and materials, subject to commercial considerations. There would also be extra investments to improve the quality of the components and this in turn would add to the capability of the British component industry and help to improve the quality and reliability of British-made consumer electronics.

Mr Williams suggested that the venture would be a great encouragement to Japanese and other foreign investors. Repeatedly these investors had shown that small and medium-sized, well-managed enterprises in this country could operate well, could be highly efficient and have high productivity, resulting in the country having the best-profitability in Europe.

Discussions between Hitachi and the Department of Industry, about Hitachi's proposal to establish a colour-tv manufacturing facility in the UK, initially took place during 1977 and early 1978, but as a result of opposition from certain sections of the British tv industry the company eventually withdrew its proposals. However, during his visit to Japan in April 1978, Mr Williams stressed his, and the British Government's, disappointment at Hitachi's decision, and he indicated that it was in sensitive sections such as tv manufacture that co-operation between Japanese and British companies would bring mutual benefits, and might prove the best way forward.

RCA to enter videodisc market

Following the lead of Philips and MCA (see News, p.39, Feb. 79 issue) RCA has decided to launch its "Selecta Vision" videodisc system in the United States of America. RCA's president, E. H. Griffiths, said that they would proceed with "maximum speed" to get the product ready for introduction in the US, and a schedule for the product's introduction, and marketing concept aimed ultimately at full national distribution, would be announced later this year.

The company is giving the videodisc system top priority because their market research indicates that it will become a multi-million-dollar business in the 1980's. Before RCA would consider going ahead with the project two years ago the company's chief executive set certain goals which had to be met. They planned to develop a videodisc player that could be sold at a retail price of $400 (about £200) or less, and an uncoated disc that would contain one hour of programming per side, or a total of two hours per disc. There also had to be available adequate software, or programming, to support the introduction of the system and to sustain it in the market. RCA say that they have now met these goals.

The RCA system is very different to the Philips/MCA system in that it uses a grooved disc that is played with a diamond stylus (the latter uses an optical system so that no stylus or needle ever touches the disc). RCA's disc revolves at 450 rev/min, contains one hour of programming on each side, and is expected to sell for about $10 to $17 (about £5 to £8.50).

The disc comes in a plastic sleeve, similar to a record album cover, which, when inserted into a slot on the front of the videodisc player, deposits the disc on the turntable. To remove the disc, the empty sleeve is simply re-inserted into the slot.

RCA's initial catalogue of programmes will contain 250 titles including feature motion pictures, musical sports, cultural, education and children's programmes.

New electronics teaching programmes available in UK

A series of electronic training systems for subjects ranging from elementary principles to modern communications and computers, is now available in the UK. These systems, which are supplied by Dagem Systems Ltd, are modular programmes containing all the equipment and manuals needed to perform a series of laboratory experiments in the subjects they cover. The elementary, basic and intermediate laboratory systems, for example, consist of a set of experimental circuit boards and plug-in components. Each circuit is permanently wired underneath its board and the plug-in components, which complete the circuit, are used only for the parameters which are changed during the experiment. Each electronic training system is supplied with its appropriate theoretical and experimental manuals.

First transatlantic video link using optical fibres

On December 12 a two-way sound and video system, originated and terminated with optical fibre equipment, linked the Post Office's Contravision studio in London with a Bell Canada studio in Toronto, Canada. This was the first ever transatlantic link of its kind and also the first time that colour television had been used for Contravision, which is the Post Office's conference-by-tv system. The two-way link enabled the participants to hold 'across the table' discussions with their colleagues on the other side of the Atlantic.

The transatlantic discussions demonstrated the capabilities of optical fibre transmission systems in sending sound and vision signals over long distances and also marked the start of a two-year household trial of an optical fibre system — initially serving 35 residential telephone customers in Yorkville, Toronto — which Bell Canada is carrying out.

The main link in the communications chain was the Intelsat satellite positioned 22,300 miles above the Atlantic Ocean. This carried the signals between Britain and Canada. Underground optical fibre cable systems in London and Toronto were used to carry the signals to and from the two studios. In London, outgoing signals were transmitted over a 1.7km optical fibre link, supplied by British Insulated Callenders Cables Ltd (BICC) and Plessey Telecommunications Ltd, to the Post Office Tower. This system has been in public service for the past two years as part of the Post Office's public Contravision network.

According to the Post Office, together with British industry they have developed optical fibre systems to the extent that they could be installed and working in the UK telephone network by 1980. Their aim initially is to introduce optical fibres into key inter-city networks and between telephone exchanges within main city centres. Already telephone calls are being carried by two experimental optical fibre links in the UK — a 13km link in Suffolk and a 9km link in Hertfordshire. Two further trial links are nearing completion. These are between Maidenhead and Slough, supplied by Plessey and BICC, and between Uxbridge and Ruislip, supplied by GEC and TCL. On the Suffolk link, at Martlesham, Post Office researchers are studying more advanced systems for inter-city and undersea operations, as well as cost-reduced systems.

The optical fibre cables at the Canadian end of the transatlantic link were made by Northern Telecom Ltd and were linked to a laboratory where research for the two-year trial is being carried out. Bell Canada's research company, Bell Northern Research Ltd, started work on practical fibre-optic transmission systems in 1972. Then, in 1977, following work for the Department of National Defence, they installed a 1.42km optical fibre link between two switching centres in Montreal to test optical fibres under field conditions. Each pair of fibres in this trial are used to transmit and receive 96 simultaneous telephone conversations.

News in brief

Post Office trials on an **inductive coupler to help people using hearing aids** fitted with pick-up coils to make better use of the telephone have been completed. The coupler replaces the standard telephone inset. Eighty per cent of the trial 'guinea pigs' reported a substantial improvement in reception when using the new device. Some minor modifications were made as a result of this trial, and a first contract for 100,000 units has now been placed. First deliveries of these devices are expected early this year.

The University of Essex will be holding its annual **electronics summer school for teachers** during the week July 9-13, 1979. This year, as well as courses in linear circuit design and digital circuit design, a third **course in electronic systems** is available which is closely related to the A.E.B. electronics systems A-level course. The **linear design course** covers the use of transistors and operational amplifiers in analogue applications, particular emphasis being placed upon design philosophy related to the basic circuits in a hi-fi amplifier. The **digital design course** concentrates on the use of the transistor as a switch and develops design using integrated logic circuits. A programme of laboratory experiments is included on each course so that the lecture material is fully supported. Further information on the summer school may be obtained from Dr M. J. Hawksford or Mrs J. L. Mead at the Department of Electrical Engineering Science, University of Essex, Wivenhoe Park, Colchester CO4 3SQ (Tel. 0206 862286, ext. 2262/2299).

Third Marisat shore station commissioned

Japan's maritime-communications shore station, for use with the Marisat (Maritime satellite Communications) satellite above the Indian Ocean, was officially commissioned on November 18. The station, which is located at Yamaguchi in the western-most part of the main island, was completed in September by the Nippon Electric Co. Ltd (NEC) for Kokusai Denshin Denwa Co. Ltd (KDD), Japan's international communications company. KDD's Intelsat standard A earth station is also located on the same site.

The new station can provide, via the Marisat satellite, 22 high-grade telegraph lines and two telephone lines between land subscribers and ships in the Indian Ocean and the water off Japan and Southeast Asian countries. It is the third station of its kind in the world and the first to be capable of accessing the Marisat satellite over the Indian Ocean. The other two stations, which have access to Marisat above the Pacific and the Atlantic oceans, are located in the USA, one at Santa Paula in California, and the other at Southbury in Connecticut. Since the Marisat system can now cover almost all the waters of the world it not only ensures a high standard of world-wide maritime communications services and efficient operation of ships, but also provides better safety and distress services.

The Marisat station has a duplex configuration and a 13m-diameter Cassegrain antenna, which is commonly used for the C and L bands. A network control processor assigns the channel and controls the line connection between ships (both at sea and in ports) and land subscribers or shore stations, performs telegraph and telephone signal conversion, and supervises the status of lines.

In addition, the Marisat system, which is jointly owned and operated by several US communications companies, also provides services for facsimile and data transmission. All of these services are, of course, only available to ships equipped with a Marisat ship terminal. A typical ship terminal consists of an r.f. and antenna assembly mounted in a water-proof radome above deck and a communications console installed below deck. NEC, together with Anritsu Electric Co. Ltd of Tokyo also manufacture such a terminal.

Picture shows a Jetstream T. Mk 2 aircraft, the first of sixteen being delivered to the Royal Navy. On-board equipment includes a static invertor, Model 060-05, made by Brandenburg Ltd. The Model 060-05 is a three-phase unit delivering 115V at 400Hz for the aircraft's electronic equipment. It operates from 28V d.c. and can provide a total output power of 1500VA. Output frequency and voltage are maintained constant over a wide range of input voltages and load variations.

The sixteen aircraft, which will replace Sea Princes currently in service in an observer training role, are manufactured by the Scottish Division of British Aerospace's Aircraft Group.

Post Office meets Government's financial targets

According to a statement by Sir William Barlow, the Chairman of the Post Office, continued stable prices and a vigorous drive for increased business has enabled the Post Office to achieve results which show that the Corporation is still meeting the financial targets set by the Government.

Interim unaudited results show that in Telecommunications, the Post Office had an income of £1549.1 million and a profit after interest of £144.7 million over the half year to September 29, 1978. Figures for the full year to March 31, 1978, show a £2924 million income and £326.6 million profit. In Posts, results for the full year showed an income of £1325.1 million and profit of £40.4 million and for Girobank and Remittance Services, £77.9 million and £0.7 million respectively. Corporation figures, again for the full year, give an income of £4183.2 million with a profit before dividend and taxation of £367.7 million.

The financial results for the current half year, for each of the three main businesses, are consistent with their full year targets set by the Government. For Telecommunications this represents 6% return on mean net assets at replacement costs. Mr Barlow suggested that the half year results reflected the increased use which was being made of the Post Office services. This, he said, was partly due to the fact that telephone rentals and call charges had not increased for more than three years and postal charges had been frozen for 18 months. Telephone traffic had continued to increase and determined efforts were being made to improve the quality of the international telephone operator service, which Mr Barlow considered had fallen short of the standard required.

Product liability conference

A special one-day conference on product liability is to be held at the Europa Hotel, London, on Friday, March 2. It is hoped that the conference will enable delegates to study in-depth not only the UK's liability law today, and its likely changes tomorrow, but also its practical effects through insurance and through hazard reduction.

Greville Janner, Q.C., Member of Parliament for Leicester West, said when the conference was announced that every executive and manager concerned with the manufacture or marketing of products should have been following developments in our law with grave concern and in preparation for change. He referred to the Law Commissions, the Royal Commission on Civil Liability (the Pearson Commission) and to the EEC Draft Directive, as well as to changes which have already been made in the USA and in many of the EEC countries (see News, p.47, Jan 79 issue).

Speakers at the conference will present the practical aspects of product liability law, as it affects all those concerned with the manufacture, distribution, purchase or sale of industrial products. Mr Janner will also explain how to use documentation in order to cope with produce liability problems — actual and likely — with special regard to the new anxieties created by "The Supply of Goods (Implied Terms) Act" and "The Unfair Contract Terms Act". The other speakers will be: Lord Pearson, who was chairman of the Royal Commission on Civil Liability and Compensation for Personal Injuries (the Pearson Committee Report, 1978); Professor Anthony Jolowicz of Trinity College, Cambridge, an expert in EEC and USA product liability law; Oliver Prior, a product liability insurance specialist and Brian Mair, who is the MD of Plessey Assessment Services Ltd, a product liability consultancy.

The conference is to be held by Industrial & Commercial Technical Ltd (In Com Tec), Park House, Park Street, Camberley, Surrey.

Government enters mobile radio business

The British Government has now gone into mobile radio after its acquisitions a few years ago with Ferranti and the more recent investment in Inmos Ltd. The National Enterprise Board (NEB) and Berec Group Ltd (formerly Ever Ready Company (Holdings) Ltd) have reached agreement in principle to form a joint company to acquire the business of Burndept Electronics (ER) Ltd, a wholly-owned subsidiary of the Berec Group. It is planned that the NEB will invest £510,000 in Burndept in exchange for 51% of the equity, with Berec retaining a 49% holding. This investment will enable the company to expand in existing markets and also to develop additional products.

Burndept Electronics, who manufacture a wide range of two-way radio communications equipment, employ about 400 people and are located in Erith, Kent, and Biggleswade, Bedfordshire. They supply personal radios to the majority of UK police forces and also to a variety of industries. The company also manufactures a full range of vehicle-mounted radio equipment, base stations, complex radio control schemes and emergency rescue systems.

In the last six years Burndept has made about a £1 million loss, mainly due to the cutbacks in police spending and to inflation eating away the profit on their fixed price contracts. Berec, who were unable to give the financial and technical support needed, plan to concentrate on their portable power business.

News in brief

The Post Office is anxious to do the right thing in relation to **microwave radiation exposure** and are, within their own powers, seeking to allay the fears currently being expressed by the media. They are providing attenuators for new inland microwave radio contracts to reduce the power fed to antennas by an order of 20dB, when necessary, thus reducing the radiation from the antenna. Instructions are also being given to people working in front of antennas to ensure that the power inputs to the antennas are either removed, reduced sufficiently or measured to confirm that the radiation level is permissible.

Audience response to wavelength changes

A document issued by BBC Radio says that, on balance, reception for all four BBC radio channels on their new wavelengths, is better than it was before the introduction on the 23rd November, 1978. The majority of listeners questioned four days after the changes said that reception had improved or remained the same and only a small proportion reported that their reception had deteriorated. The BBC is examining those areas where it is known that people are experiencing poor reception.

Figures from the normal BBC Daily Audience Research Survey were as follows: percentage of listeners reporting that reception was now better on Radios 1, 2, 3 and 4 was 45%, 35%, 24% and 35% respectively; those reporting that reception had deteriorated were 6%, 10%, 14% and 12% respectively. Listeners reporting that reception was about the same on Radios 1, 2, 3 and 4 were 49%, 55%, 62% and 53% respectively.

A preliminary examination of listening figures for the first three days on the new wavelengths show a slight increase in audiences for Radios 1 and 2 and no change in the size of audiences for Radios 2 and 4.

Maritime radar to be fitted to Nimrod

Searchwater, perhaps the world's most advanced maritime radar, will soon be fitted in the RAF's Nimrod aircraft. The radar and equipment division of EMI Electronics at Hayes, Middlesex, delivered the first production model of Searchwater to the Ministry of Defence on November 7 last year.

Searchwater is the result of more than six years of research and development work by the staff of EMI Electronics and engineers from the Royal Signals and Radar Establishment at Malvern, Worcestershire. The radar uses its own computer to detect, measure, track and classify its targets and its power and versatility have already been demonstrated during extensive flight trials. At very long ranges Searchwater can even detect targets as small as the periscope of a submerged submarine, say EMI. During the six years of its development, designers continually modified Searchwater to accommodate the latest electronic technology despite the rapid changes taking place.

Tandberg ends Norwegian operations

At a special meeting in Oslo, the Norwegian Government recommended to the management of Tandberg Radiofabrikk A/S that the company close down their trading operations with effect from the next day (Dec. 14). Despite this, the government has pledged to continue to support the company with a view to restructuring the special product divisions of the Group that have a continuing commercial future. In addition, a sum of 50 million NKr which had been offered to the company two days before would still stand and would be employed for an orderly wind-down of the operations in Norway and to investigate the remaining operations.

Tandberg have eleven overseas subsidiary companies and other representatives worldwide, including the Leeds company Tandberg (UK) Ltd, the most successful of the daughter companies with a turnover of over £6½ million.

V.d.u. health hazards warning

TASS, The Technical, Administrative and Supervisory Section of the Amalgamated Union of Engineering Workers, is warning its committees of representatives of the potential health hazards associated with the use of visual display units. This warning comes in a document, from the general secretary of TASS, Ken Gill, which says a sizeable body of evidence shows that unless a v.d.u. or terminal is used correctly there can be potential health hazards to the operator. The document is concerned specifically with the introduction of these units in areas of clerical work and gives, as a guidance to the representatives, the conditions in which v.d.u.s should be used.

According to the document, clerical work ideally requires brightly lit work areas, preferably near daylight, whereas v.d.u.s are best used in shady conditions. This contradiction means that the v.d.u.s are seldom used under the correct lighting and, in some cases, reflections on the screen can be brighter than the projected image. The document suggests that offices in which v.d.us are used should be kept gloomy and local lighting provided where necessary for work areas.

The health hazards associated with v.d.us include visual fatigue, stress, posture ailments and radiation exposure. TASS attempts to give the causes of these afflictions and describes in quite considerable detail the symptoms experienced by the sufferers. Visual fatigue they say is caused by glare, reflections and lack of contrast on the screen. Stress results among other things from slow computer response times, poor environmental conditions and 'the information load'. Posture ailments such as backache, headache and aching muscles are blamed on the bad standard v.d.u. layout, the fact that the screen is usually above the keyboard. This, says TASS, imposes an immobility which leads to the aches/pains described.

Radiation exposure is the cause of major concern to TASS because they say that the health hazard has not yet been determined. However, to minimise risk they suggest that v.d.u.s should be frequently serviced by qualified engineers and the front of the tube covered by a glass panel. They also suggest that the set be enclosed in a metal case to give maximum protection in case of explosion.

As a guide to office committees who may negotiate agreements on the introduction of v.d.u.s, TASS gives a total of 14 recommendations. In addition to regular maintenance of the units, they suggest that the screens be tested for glare and reflections and that ambient lighting be reduced to below 300 lux, with additional local lights being fitted where necessary for ordinary clerical work. One recommendation suggests that each piece of v.d.u. equipment should have a plaque attached stating how it should be operated and specifying the health hazards which can occur if the safeguards are not followed.

News in brief

Strathearn Audio Limited, the Belfast high-fidelity equipment manufacturer, established by the Government five years ago, **is to close.** The reason for the closure is that the Treasury is unwilling to consider providing additional funding until the autumn of 1979, by which time their proposed association with Aiwa would have been in effect and the company's viability would have been assured, because of heavy debts. Despite the company chairman's faith in the company — those on the inside claim to be able to see the light at the end of the tunnel and a very real future ahead — the Treasury feels unable to provide them with the necessary funds to pay for the development of new products and to pay off the debtors.

continued from page 66

sents a successful solution to the problems of c.c.i in the u.h.f. band. With advancing technology, he says, costs may be expected to fall to the point at which adaptive antennas will be used increasingly by the broadcasters, especially when the fourth channel is brought into use.

Antenna work in ESA

Three years ago at the last IEE antenna conference, the European Space Agency's activities, mainly concerning their then new payload antennas, were described. Since then, several of these activities have been completed and new developments have started. A paper[6] by J. Aasted from ESA reviews the present antenna and propagation activities at ESA.

A major part of ESA's work in payload antennas has been in the development of dual-polarized reflector antennas. This has led to a better understanding of the depolarization mechanism and has also resulted in the development of new antenna types having much improved cross-polarization performance. One example is the off-set reflector antenna which, though previously rejected for dual polarized systems due to its assymetry, is now a prime contender because of improved feed designs.

In the lower-frequency S and L bands, reflector antennas become impractical for small beamwidths and array antennas may be preferred. These also allow the use of multiple simultaneous beams. ESA have developed and are now testing an L-band 19-beam antenna system which is to be used for earth coverage from a geostationary satellite. As one moves to the higher frequency bands (11/14 and 20/30GHz) and narrow beam widths (½° to ¾°) the need arises for improved test ranges because the standard ranges are likely to be increasingly affected by multipath effects. ESA is therefore investigating the near-field measurement technique. Of the three scanning methods the Agency has chosen to develop the spherical technique and an experimental facility is now being set up at the Technical University of Denmark.

ESA is presently developing a standard cardioid type radiator for S-band and are anticipating moving all telemetry and telecommand into this band, or even higher. The antenna is designed to be boom-mounted on top of a payload. They are also planning to develop reflector-type, multiple beam antennas with contoured coverage for the higher 20 and 30GHz bands. The realisation of these antennas will require tight tolerance reflectors and a new class of feed systems. Work on this has already been started and that will be intensified in the next two years.

So far, ESA's work in propagation has concentrated on the 11/14GHz bands. Data from ten radiometers stationed across Europe have been analysed and have formed the basis for the European propagation model which will be verified with direct measurements from OTS. The Agency is also developing radiometers for the 20 and 30GHz bands. At the higher frequencies, however, says the ESA paper, deep fades may occur which radiometers are unable to record. Because of this a propagation experiment is planned using H-SAT, which will carry a beacon for the purpose. In addition, ESA will be carrying out diversity experiments to try to solve the fading problem.

To be continued

References

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5. Windram, M. D., Independent Broadcasting Authority, Crawley Court, Winchester, Adaptive antennas for u.h.f. broadcast reception, pp 30-35, Part 1.
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All IEE Conference Publication Number 169, Antennas and Propagation, from International Conference on 28-30th November, 1978.

Radio communication in tunnels

A note on the "split-path" paradox.

by K. F. Treen

From time to time, suggestions are made that radio propagation, (particularly with reference to the private mobile radio-frequency spectrum) throughout the length of tunnels in which bends introduce excessive losses, could be achieved by receiving the signal with a suitable antenna at the end of a straight portion and then connecting this antenna to a second antenna which would re-radiate the signal in the required direction. In terms of propagation losses, conventional available powers and antenna gains, this is not a very practicable arrangement.

PASSIVE COMMUNICATION in tunnels is not comparable to the passive reflector systems used in some microwave links, either as the main reflectors in a line of sight link, where they are used as means of avoiding feeder losses, or en route to avoid obstacles present in the shortest path. In these cases the wavelengths are small and reflector sizes are very large in terms of wavelength.

For the purposes of this note, propagation loss is calculated as a free-space attenuation which, between isotropic antennas, is $(4\pi r)^2/\lambda$ where r is the range and λ the wavelength in the same units.

This expression is optimistic for most tunnel conditions and available wavelengths; in practice, signal strengths would be much less than calculated.

Consider a tunnel of length r with a transmitter at one end and a receiver at the other. If the transmitter effective radiated power (e.r.p.) into the tunnel is W_t watts and the receiver antenna gain is G_r, the tunnel end to end attenuation considered as free space, is given by $(4\pi r)^2/\lambda$. With a transmitter e.r.p. of W_t watts and a receiver antenna gain of G_r, the r.f. power fed to the receiver is given by

$$W_t \times \left(\frac{\lambda}{4\pi r}\right)^2 \times G_r \text{ watts} \quad \ldots \quad (1)$$

Assume a bend in the tunnel at a point distant l from the source and around which significant propagation will not take place. At this point insert two auxiliary antennas, one directed normally to the transmitter and the other to the receiver. Let the two antennas be connected together with a lossless feeder cable and let their respective gains by G_1 and G_2

The r.f. power at the output of the auxiliary receiving antenna is

$$W_t \times \left(\frac{\lambda}{4\pi l}\right)^2 \times G_1 \text{ watts.}$$

This power is fed without loss to the auxiliary re-transmitting antenna, giving an effective re-radiated power of

$$W_t \times \left(\frac{\lambda}{4\pi l}\right)^2 \times G_1 \,.\, G_2 \text{ watts.}$$

The distance to the final receiver is $(r-l)$, and the power fed to the input of the receiver is given by:

$$W_t \times \left(\frac{\lambda}{4\pi l}\right)^2 \times G_1 \,.\, G_2 \times \left(\frac{\lambda}{4\pi(r-l)}\right)^2 \times G_r \text{ watts} \quad \ldots\ldots\ldots \quad (2)$$

Equations (1) and (2) represent the 'direct' (i.e. directly through a straight tunnel) and the 'indirect' signal strengths respectively. It is clear that equation (1) represents a power greater than equation (2). Dividing (1) by (2) we get:

$$\frac{16\pi^2 l^2 (r-l)^2}{G_1 G_2 \lambda^2 r^2} \quad \ldots\ldots\ldots\ldots \quad (3)$$

Applying practical values to a system in which the receiver is mobile and is situated at the end of the tunnel distant r from the transmitter.

Let frequency = 450 MHz; hence wavelength (λ) = 0.67m.
Let length of tunnel (r) = 2000m.
Let bend be at 1000m ($l = r/2$).
Let transmitter e.r.p. = 7dBW. (5W)
Let receiver antenna gain (G_r) = 3dB. (2:1)
Let back to back antenna gains each equal 8dB. (6.31:1)

Then from equation (1), for the direct case, the r.f. power input to the receiver is equal to:

$$5 \times \left(\frac{0.67}{4\pi \times 2000}\right)^2 \times 2 \text{ watts.}$$

$= 7.1 \times 10^{-9}$ watts, or -81.5dBW, a very adequate signal strength.

Equation (2) gives the result for the indirect case as:

$$5 + \left(\frac{0.67}{4\pi \times 1000}\right)^2 \times 6.31 \times 6.31 \times \left(\frac{0.67}{4\pi \times 1000}\right)^2 \times 2 \text{ watts.}$$

$= 3.21 \times 10^{-15}$ watts or -145dBW, too weak for reliable operation.

The difference of 63.5 dB is given directly by equation (3). It is also apparent, by inspection of that equation that the difference value is maximum when $l = r/2$. As the point at which the intermediate antennas move from the centre ($l = r/2$) point in either direction, the r.f. input power to the receiver increases, at first fairly slowly but as either end is approached the increase is asymptotic to 6dB as the distance to the ends is halved. In order to restore the 'direct' condition it would be necessary to interpose an amplifier with a gain given by equation (3) between the pick-up and re-radiating antennas (and of course, effectively decouple them from each other), or alternatively increase the gain of these antennas such that the total sum gain is:

$$2 \times \left(\frac{G_1 G_2}{2} \times \frac{16\pi^2 l^2 (r-l)^2}{G_1 G_2 \lambda^2 r^2}\right),$$

which reduces to:

$$\frac{16\pi^2 l^2 (r-l)^2}{\lambda^2 r^2} \quad \ldots\ldots\ldots\ldots \quad (4)$$

Applying the values for r, l and λ given above, we get the sum again as

$$\frac{16\pi^2 \times 1000^2 \times 1000^2}{0.67^2 \times 2000^2}$$
$$= 8.79 \times 10^7$$
$$= 79.4\text{dB}.$$

Thus each antenna would need to have a gain of approximately 40 dB, generally an impracticably difficult task in most tunnels. As the frequency is raised (hence generally falling outside the band allocated for private mobile radio purposes) the production of high gain antennas becomes easier; on the other hand, the free space attenuation increases. In some rare cases losses may be decreased by the generation of waveguide modes of propagation but these could not normally be relied upon.

If we consider raising the frequency by ten times to 4500 MHz. ($\lambda = 0.067$m) and maintaining the same received power as in the direct case, (7.1×10^{-9} watts or −81.5 dBW) with the same transmitter e.r.p. of 5W (7dBW) we would need a receiver antenna gain of 23dB instead of 3dB, an almost impossible value to achieve for an omnidirectional mobile antenna. Alternatively, the e.r.p. of the transmitter could be increased by 20 dB to 27dBW (500W) by using say, a 1 watt transmitter and a parabolic antenna of 0.67 metres diameter which, at 50% efficiency, would provide a gain of 27 dB. For the indirect case at 4500 MHz, we can again apply equation (4) to ascertain the sum gain of the intermediate antennas. Substituting the values as before we get

$$\frac{16\pi^2 \times 1000^2 \times 1000^2}{0.067^2 \times 2000^2}$$
$$= 8.79 \times 10^9$$
$$= 99.4\text{dB}.$$

Thus each of the two antennas would need a gain of about 50dB which at 50% efficiency would entail a paraboloid of 9.54 metres diameter, a somewhat impracticable value.

In conclusion, what is shown above is not that radio communication through tunnels is impossible, (adequate systems either as separate entities or in association with external mobile radio schemes have been achieved) but that sufficient illumination by the radio wave cannot be provided simply by passive means. In many cases, radiating cables would provide the most satisfactory solution with a minimum of design problems and, when used with repeaters, would cater for almost any configuration.

A short curriculum vitae of Mr Treen appeared in the issue for August, 1978, in which he was the author of an article on a proposed radiating cable system.

Wireless World — a decade of growth

More and more people are reading *Wireless World*. This is clear from our latest circulation figure, which has just topped the 70,000 mark. According to the Audit Bureau of Circulations the average number of copies distributed in the twelve months ending 31st December, 1978 was 70,125 per issue. This was an increase of 1,608 copies per month on the corresponding 1977 circulation of 68,517.

And here we are not merely noting an isolated increase for one particular year. If you look back over the past decade, this increase proves to be in fact one more step in a continuing process of growth. In 1968 we had a circulation of 48,401 copies per month. The graph then shows a steady overall climb with fluctuations of only about a thousand from the ideal smooth curve — giving an average increase over the whole decade of 2,172 copies per month each year. And remember the journal is paid for by its readers, it's not a "give-away" as many are. People who buy it really need it.

These figures can only mean that *Wireless World*, now in its 68th year of publication but unwithered by age, is still doing its job. It is not only keeping its long-standing professional and general readers, some of whom have taken the journal for thirty years or more, but continuously attracting new readers in the highly competitive and increasingly specialized field of electronics publishing. On average more than one person reads each copy, and the total readership now amounts to 215,000.

An important aspect of this growth is the continuing increase in *Wireless World's* overseas circulation, which is now over 23,000 per month — a figure greater than the total circulation of some of our contemporaries in professional electronics publishing. Apart from the major groups of readers — in all countries of Western and Eastern Europe, all states of the USA, in the USSR and China, in most countries of the African and South American continents, not forgetting Australasia, Scandinavia, the Indian sub-continent and South-East Asia — you will find them in unexpected places from Afghanistan to Haiti, from Ethiopia to Iceland, from Alaska to Sri Lanka and on small islands like the Faroes, the Azores and those in the Pacific and Indian Oceans. The "World" in our title really does mean what it says!

BOOKS RECEIVED

BSO Directory '79, edited by Linda Holland, is compiled by the people who produce the journal *Broadcasting Systems and Operation*, and is a comprehensive guide to broadcasters, equipment and services. The book is in four parts; the first being a list of the world's radio and television authorities and stations, with addresses. Part 2 contains the names, company executives, agents and activities of companies supplying equipment and services. The third part is a listing of equipment and services, classified by type, with the names of relevant companies in each field, and the final section contains brief descriptions of the equipment produced by the world's manufacturers. Each section is indexed.

The 208-page book is extremely comprehensive, being the first such compilation to appear, according to the publisher, whe expresses the intention to expand the listings in forthcoming editions. The publishers are B.S.O. Publications Ltd, P.O. Box 1, 41 High Street, Wivenhoe, Colchester CO7 9EA, and the price is £25.

Elements of Computer Science, by Glyn Emery, with assistance from David Bale, is designed to accompany a first-year course in computer science. The treatment is such that no knowledge of computing is necessary to take full advantage of the text: the very basics of logic and a logical view of problem solving are treated in three chapters, as are the various number systems. Programming is built up from a discussion of the structure of data and its control, through programming and operating systems, to a section on the structure of languages. Although the main part ov the book is concerned with digital computing, a section on the analogue variety takes up the final chapter. Exercises are provided after each chapter. Glyn Emery is Professor of Computer Science at the University College of Wales, Aberystwyth. The book is published in paperback by Pitman Publishing Ltd, 39 Parker Street, London WC2B 5PB, at £2.95.

Man-made Radio Noise, by Edward N. Skomal, analyses and characterises virtually all the sources of man-made interference, found in industrial society. Each type of noise source is given a chapter (automotive, power lines, etc) and is then related to other sources in an analysis of composite noise in metropolitan areas, at the surface. This exercise is then repeated to give a picture of composite noise at specific altitudes over large cities. The book is extremely comprehensive in coverage and the treatment is thorough and mathematical. Copious references are provided. Costing £16.15 in hard back, this 342-page book is published by Van Nostrand Reinhold Company Ltd, Molly Millars Lane, Wokingham, Berks.

LETTERS TO THE EDITOR

MOBILE CB DANGERS

If Mr Riley is trying to argue a case against mobile c.b. based on danger to human life (January letters), he should produce more convincing evidence than the results of artificial tests conducted by a university research group. I have no statistics to prove it, but I doubt if radio-controlled mini-cabs, which have both inexperienced drivers as well as mobile radio operators, show an excessively high accident rate due to use of the radio in heavy traffic.

Surely only the silliest driver will attempt to operate a radio while negotiating a hazard, which requires both hands to be on the steering wheel? The tests referred to by Mr Riley, would, I am sure, produce even more alarming results if the drivers concerned were told to light a cigarette or change a tape cassette, while negotiating the obstacle course set for them by the university.

The point which should be made about mobile c.b. radio is how many lives could be saved by intelligent use of it on the roads. I am at present in correspondence with the Home Minister over this aspect of c.b. radio, in connection with the recent tragic pile-ups on the M1 and M5. I firmly believe that prior warning could have been given in time to those drivers involved if some had been equipped with mobile c.b. The time factor is vital in fog and, under these circumstances, any driver, especially truck drivers, would have the c.b. open all the time; therefore, they would be prepared for advance warning of an accident from any c.b. equipped vehicle a mile or so ahead. This would allow time to take evasive action and also warn other drivers in the vicinity, visually and on the radio, of the situation.

Mr Riley states that police "frown on" the use of mobile c.b. If this is the case, what then is their reaction to the carnage of a motorway pile-up, which often includes their own men and vehicles? Police patrol cars on the motorway are just as vulnerable as other vehicles in fog, and are equally helpless in either warning or being warned by other drivers, or of summoning assistance if their vehicles are immobilised in the accident area.

In my opinion, the time has now come for Chief Constables to stop frowning on c.b. and to start listening instead to the conclusions of their own motorway patrolmen; and then make public their views of the benefits that mobile c.b. radio could bring to motorway safety and the saving of human life.

Tanlaw
House of Lords
Westminster

Whilst Mr Riley makes some valid points with the help of the OU (January letters) he also makes some presumptions, e.g. that a driver using a "c.b." would continue to discuss the evening's menu with his wife, etc., and simultaneously attempt almost impossible trials of judgement on the road. Also Mr Riley feels that accident statistics would suddenly rise "if dozens of inexperienced c.b. users suddenly [took] to the road." This assumes that inexperienced c.b. users would also be inexperienced drivers. Tell that to new taxi drivers.

May I state that, notwithstanding my name, I am English, white and a road user, also I value my life and others. Furthermore, I have had several years' experience on US roads, notably, with about a "dozen" truck drivers who drive the road crew and p.a. equipment belonging to the rock-and-roll group that I work for between every major USA city (many, many thousands of miles). Invariably, if they *suspected* danger ahead (or behind) they immediately dropped the 'mic' in their laps and coped with the situation, if any, then recontacted. Most importantly the same reaction was seen by myself in the many 17-21-year-olds that I have as friends in Los Angeles and Miami. Incidentally my own (hired) car had everything but c.b. and I didn't miss it.

Mike Januszkiewicz
Ipswich
Suffolk

TELETEXT CHARACTER ROUNDING

My November 1978 article on the character rounding board IV for the *Wireless World* decoder mentioned that the power unit originally supplied with decoder kits could not provide the additional 530mA needed for the new board. (Current and very recent kits have an uprated power supply which can provide the extra, as long as the regulator heat sinking is sufficient.)

Since the board was originally designed, low power Schottky t.t.l has become available at prices only marginally higher than the standard type. With the same or only slightly lower speeds, and a fanout of five into standard t.t.l., the low power Schottky (L.S.) can in most cases replace it directly with an appreciable saving in current consumption.

Board IV built with L.S. i.cs apart from IC_{208} (74121), draws 230mA against 530mA for the standard (the r.o.m. accounting for 50mA in both cases), the only change necessary being an increase in C_{202} from 1n to 1n5.

On board III the current fell from 570 to 270mA with four i.cs having to stay as standard — IC_{104} (74150) not available as L.S., IC_{125} (7473) where the L.S. version has different logic, and IC_{105} (74157) and IC_{125} (7408) which drive the television set and video interface.

This means that the two L.S. boards together draw less than the standard board III, and can therefore be fed from the original power unit, saving the cost and inconvenience of renewing or adding to it, while with the new larger one 600mA at least is left available for possible future extensions, such as ultrasonic remote control. It is understood that the kit supplier intends to offer L.S. i.c. sets as an option for these two boards.

On board IV the timing component values for the odd/even field detector monostable IC_{208} were derived from T.I. data for the 74121 and it has been found that with other manufacturers' products the value of R_{202} may have to be changed if the character rounding jitters or does not work.

Owing to a typographical error the reference "Broadcast Teletext Specification — BBC, IBA, BREMA — September 1976" was omitted from the list of references at the end of the article, and some of the reference numbers in the text are therefore wrong. Also the source resistance of a t.t.l. output in the high state is printed as 190 ohms instead of 130, and the phrase "two r.a.ms in parallel" in the centre of p.49, should read "two r.o.ms . . . .".

J. H. Hinton
Cambridge

DISPLACEMENT CURRENT

I am slightly alarmed by some of the statements in the article "Displacement current — and how to get rid of it" (December 1978). I suggest that there would justifiably be an outcry if the authors were to have written paragraph 5 as follows . . .

Since the inductance has now become a transmission line, it is no more necessary to postulate 'magnetic flux' in an inductor than it is necessary to do so for a transmission line. The excision of 'magnetic flux' from electromagnetic theory has been based on arguments independent of the classical dispute . . . (an apparent negation of Faraday's law of Induction).

Displacement current (without the inverted commas) is as real and justifiable a concept as conduction, or convection, current in charge transport — it is directly analogous to the time differential of magnetic flux in magnetic theory ($\partial\bar{D}/\partial t$ instead of $\partial\bar{B}/\partial t$ if you want to be precise). Displacement current is neither a mathematical convenience nor an artefact of a faulty model for a capacitor, it is a fundamental part of Maxwell's equations.

To those who have designed high frequency networks, interchanging between a capacitor or inductor and a transmission line is common practice: the inductors and capacitors used actually look like short transmission lines. Such circuits can be analysed using either of two methods; the discrete approach in which case each line has an equivalent inductance and capacitance or the distributed approach in which case characteristic and terminating impedances are important. Paragraph 4 could be misleading because it confuses the lumped and distributed techniques: a transmission line used as a capacitor, or a capacitor appearing as a transmission line, must have some inductance which is inherent in the component construction. This will become clear in the next paragraph.

Consider an ideal transmission line. For analysis this has a few useful parameters; L – the series inductance per unit length, C – the shunt capacitance per unit length, Z_o – the characteristic impedance ($= \sqrt{L/C}$), and v – the characteristic velocity ($1/\sqrt{LC}$). (And where do we get these parameters from? Why, of course, from electromagnetic theory using $\bar{B},\bar{H},\bar{E},\bar{J}$, and naturally enough $\bar{D}$ the electric flux or displacement vector.) The impedance measured at the end of an open circuited transmission line of length d is simply $Z_{in} = Z_o/j \tan(\omega d/v)$. But if $(\omega d/v)$ is small, a condition of lumped circuit analysis, we can expand the tan term to obtain

$Z_{in} = Z_o/(j\omega d/v) + \frac{1}{3}Z_o(j\omega d/v)$.
Using the transmission line parameters this gives $Z_{in} = 1/j\omega(dC) + j\omega(dL/3)$ which can be interpreted quite easily as a capacitor and inductor in series. To me that would seem a very plausible mechanism for an internal series inductor in a capacitor.

At 'low frequencies' a capacitor may well be a good equivalent circuit for a particular form of transmission line, but at increased frequencies the series inductance must be considered: eventually we must switch to a distributed analysis, otherwise we are going to be barking up the wrong tree in the wrong ball park. For digital systems where harmonics extend into the GHz region very careful consideration must be given to distributed effects in what are nominally lumped components.

P. I. Day
Maidstone
Kent

The authors reply:
We would like to make three points which we hope will clear up any misunderstanding that Mr Day has over the statements we made.

1. He wrongly assumes that we say inductance does not exist. Series inductance does not exist as a separate entity, but distributed inductance does, linked to distributed capacitance as a measured property of a transmission line defined as characteristic impedance.
2. We are considering an ideal step response of a component and the inclusion of frequency in the discussion is making an unnecessary complication.[1].
3. If Mr Day believes that you can swap "magnetic flux" with the displacement vector (current) then where does this exist when a step is propagating down a transmission line?

I. Catt, M. F. Davidson and D. S. Walton

Reference

1. Interconnection of logic elements, *Wireless World* June 1978, p. 61.

FERRITE ROD AERIALS

In his article in the December 1978 issue Professor Sutcliffe refers to the ferrite rod as ". . . collecting and concentrating the radiated magnetic field and channelling it through a coil wound round the middle of the rod". He states that this approach is strangely unrewarding although it has provided a challenging exercise in field theory and mathematics.

I am still looking for a lucid explanation as to the manner in which ferrite rod receiving aerials and, for that matter, dielectric receiving aerials can achieve gain. It is easy to get a physical picture of say a parabolic dish several wavelengths in diameter and placed normal to the direction of the transmitter acting as a collector whose aperture is effectively that derived from its geometry and concentrating the field at the focus. Nothing utterly complicated is done to the electromagnetic wave except possibly some shadowing for a distance behind the dish. Even a half-wave dipole or a Yagi array have a physical aperture of which one can conceive reasonably easily but when one considers the ferrite rod aerial used in many receivers today it is difficult to grasp the means by which an oncoming wave becomes aware that it is to be intercepted by something that is physically small in relation to its alleged effective aperture.

Does the wave, once it finds itself in the presence of permeable or dielectric material, somehow signal back to those adjacent portions of the oncoming wave that they have to 'concentrate' and, should this take a finite time, could one consider that a signal comprising a series of very short pulses with complete gaps in between the pulses would be received by the ferrite rod aerial with no aerial gain being achieved?

Perhaps I have got it all wrong and the answer is associated with the ratio of wavelength to the comparatively small physical size of the ferrite rod aerials.

The concept of a ferrite rod or dielectric aerial as a transmitter conjures up a somewhat different picture; the 'concentration' is there at the beginning. Perhaps the reciprocity theorem is not quite right after all.

K. F. Treen
Totteridge
London N20

MILITARY ELECTRONICS

Your admirable editorial in the January issue glosses over the real dilemmas which face the practitioner of electronic engineering. The first is that military and civil developments are tightly enmeshed — or optimistically, there has been a good deal of beating of swords into plough-shares. An obvious example is radar: this was originally a military development but now forms the essence of air traffic control, maritime navigation and checking the speed of road traffic. The Loran navigation system grew out of devices to aid bombing missions and Omega has obvious military potential for the USA. There is little difference between a 'spy-in-the-sky satellite' and a 'weather satellite'. The initial war-time urge to develop powerful electronic computers was based on various military needs; but the EMI brain (or body) scanner would not be possible without computer technology. The progressive miniaturisation of computers has made it easier to put adequate navigational computers in aircraft, rockets and space vehicles, whether civil or military; and at the present time microprocessors are finding industrial use so that our government says that the future of British industry depends on its learning to use microprocessors.

So long as all the large electronics firms are substantially involved in military work, the ordinary citizen is expected to acquiesce in it. Society has always tolerated a very small minority of drop-outs, whether monks in the mediaeval past or hippies in the present day, but it cannot continue to function unless *most* of its members accept its norms. (Of course it may be argued that it should *not* continue to function.) A few can take refuge in university work, but even here one suspects that the funding of research may sometimes be influenced by anticipation of military advantage. Very few of those who have developed expertise in electronics will be prepared to scrap the lot because they regard some of the applications as evil. As the physicist Max Born wrote*: "Science has undoubtedly two aspects: it can be regarded from the social standpoint as a practical collective endeavour for the improvement of human conditions, but it can also be regarded from the individualistic standpoint, as a pursuit of mental desires, the hunger for knowledge and understanding, a sister of art, philosophy, and religion."

So should electronic engineers feel a special responsibility about armaments, in the same way that some eminent American physicists felt that the original development of the atom bomb had placed a special responsibility upon them, or should moral and political arguments be left to moral and political organisations? If the latter, is it reasonable for electronic engineers who are probably depending on the armaments trade for half their income (on average) to support organisations such as International Voluntary Service whose long-term aim is to eliminate the need for armaments? What about the short-term effect on employment of any significant reduction in the armaments business? There are no easy answers, but we all need to arrive at some sort of answer.

D. A. Bell (Professor)
Walkington, Beverley,
Yorks

Natural Philosophy of Cause and Chance, reprinted by Dover Publications, 1964

Your leader "The death delivery business" in the January issue is most timely. How can one pretend that the world expenditure on armaments is necessary for the defence of democracy when the records of the two super-powers are of expansionism, cruelty and corruption, and when armaments are used in so many countries not for defence but for internal suppression?

When hundreds of millions of people exist on such incomes as £50 per *annum* can one justify such squandering of the earth's resources?

The military-industrial complexes of the two super-powers have more in common with each other than they have with their respective populations, and one of today's greatest dangers is that if the populations object to these unnecessary expenditures, these complexes may be tempted to indulge in offensive acts in order to justify their own existence and continuation in being.

The left and right wings of society are equally to blame. It is unfortunate that many people delude themselves that they have no responsibilities in this matter because they do not see the results of their handiwork. Responsibility lies not only with those who pull triggers but also with those who drive lorries, type letters and clean offices. Can they not be made to realise that those who would live by the sword must expect to die by the sword? Unfortunately the rest of us also are likely to die by it.

Roy C. Whitehead
Sutton
Surrey

INTELLIGENT MACHINERY

Recently I have been likening a microprocessor to a paralysed person in a wheelchair, because it cannot itself perform any *actions*. I now realise that I should have said "a deaf and blind person in a wheel-chair" because a microprocessor cannot itself gather information: it can only manipulate information which is fed to it in machine-readable form. In other words, intelligent *machinery* (November 1978 editorial) requires sensors and actuators as well as the information processor. It is for this reason that the Electronic Engineering Department of the University of Hull, for example, offers a degree course in "Instrumentation and Control" as well as the course in Electronic Engineering (which includes a computer option). There is more to automation than silicon chips!

D. A. Bell (Professor)
Walkington, Beverley,
Yorks.

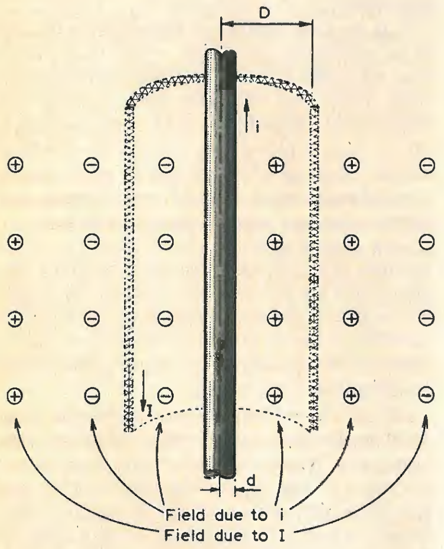
Until his retirement in 1978, Professor D. A. Bell was Professor of Electronic Engineering at the University of Hull. – *Ed.*

"DID YOU KNOW?"

Epsilon spoils his otherwise interesting article in the December 1978 issue by incorporating several errors.

The inductance formula used to derive his expression for X (p. 67) is the well known formula for a length of straight wire,
$L = 10.2\log_e(2l/r)\mu H$ from which
$X = 2\pi f 10.2\log_e(2l/r - 1)\ \Omega$
(f in MHz, all other dimensions in metres. I have used r here for radius – I think D for a radius is highly confusing!)

Fig. 5 contained several important errors. I think the diagram should look like this:



Because of the incorrect drawing, the sentence including ". . . (but note that this expression is not applicable when x is less than d) . . ." became misleading. It is true, however, for the drawing as shown above.

The reason is, of course, that for high frequency currents, skin effect keeps the current to the surface of the centre conductor and hence both i and H are zero within. Likewise, in the outer conductor, skin effect keeps the currents to the *inside* surface of it.

The author explains the zero ground plane current in terms of magnetic effect and mutual inductances. However, a valuable alternative approach is to regard it in terms of field boundaries. The outer conductor forms one boundary (and the inner conductor the other) for both the electric and magnetic fields as in a waveguide. Thus the current on both the conductors forms the field boundary and all of the current flows in these boundaries. Since skin effect keeps the current to a thin inside layer of the outer conductor there can be no field and no current elsewhere. Thus at very low frequencies where the skin depth is thick compared with the outer conductor wall thickness a resistive volt drop will occur along it and current will flow in parallel paths like the "infinite" ground plane.

In the high frequency case, perhaps Epsilon would like to comment on the current route if one end of the braid is open circuit?

One final point concerning ground planes. Even an infinite ground plane has resistance and inductance. The "spreading" resistance around the two connecting points gives it resistance and the flux produced by a current between connecting points gives it inductance.

Regarding the discussion on audibility of phase errors (Letters, December issue and earlier), a sine wave chopped into short bursts with varied start and stop times cannot be used for audibility tests. If we consider the two extreme cases of Figs. 1 and 2 where the sinewave is switched at zero or at peak,

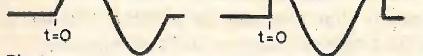


Fig 1 Fig 2

the spectra of these two pulses is *totally* different. Fig. 1 has a fall-off as $1/\omega^2$ at high frequencies, whereas Fig. 2 has a fall-off as $1/\omega$ at high frequencies. These are equivalent to 12dB/octave and 6dB/octave.

Any distinction the ear makes between them will probably be the result of the energy rich h.f. spectrum associated with the abrupt level change in Fig. 2 at $t = 0+$. I think this point is the same as Mr Coleman's.

B. J. C. Burrows
Ewelme
Oxford

Epsilon replies:
As expected from previous discussions with colleagues, my article "Did you know?" in the December 1978 issue aroused many comments. Some readers wrote to me concerning the capacitor problem (I shall deal with their comments at a later point in this reply) and others, while not disagreeing with my explanation concerning the screening of the coaxial cable, had clearly had many unfortunate experiences to the contrary.

Regrettably, one or two minor errors did appear as follows. In the second equation on page 67 the r.h.s. should be divided by two, and a 2π should appear in the third equation. d in Fig.3 refers to the inner conductor rather than the outer as originally shown, and on balance I find Mr Burrows's version of Fig.5 more satisfactory. It is hoped that the minor errors did not interfere with readers' enjoyment.

Mr Burrows's letter is concerned mainly with the explanation of coaxial cable screening in terms of field boundaries and skin effects. I have no objection to treating a cable as a TEM waveguide (except that this leaves the original question unanswered), but do raise a protest at the invoking of skin effect as the reason that screening exists. To begin with, skin effect does not cause *all* the current to flow in the inside of the cable, and for many of the frequency ranges of commercial interest appreciable currents flow on the outside of the braiding. Furthermore, even if currents were limited to the inside of the braiding, the problem as formulated in the article would remain unchanged.

If the outer braid of the cable is broken, the solution to the current flow is clearly geometry and frequency dependent. However, certain observations can be made. The cable is no longer screened, a forward current will flow in the braiding, which will have a potential above ground, and return currents will flow in the earth plane. Their path (or rather, that of the elementary current filaments) will follow a route which gives the lowest loop inductance, i.e. the current will be concentrated under the projection of the cable onto the ground plane.

Turning now to the capacitor problem, some readers expressed doubt about the given solution, preferring instead to seek comfort in their own explanations. These mainly relied on the presence of losses, caused by resistance or arcing (solutions which I excluded by the reasoning given in the article), or by radiation, which some claimed was always present. Other readers ignored the statement that inductance was intrinsic.

One reader raised the interesting problem of what happens when the capacitance is altered *slowly* by separation of the plates or by changing the dielectric constant. In such cases the same inconsistency between the answers obtained by the conservation of charge or of energy appears. The explanation lies in the mechanical strain between the plates, which is caused by electrostatic attraction and which changes to account for the energy difference.

Further insight into the original problem can be obtained by allowing the capacitors to have distributed constants and using a configuration which precludes the escape of radiative energy. Consider the circuit shown in Fig.1, which consists of two capacitors made in the form of coaxial cylinders. The cylinders are really coaxial lines, closed at one end but open circuited, and are a good substitution for the familiar tubular capacitors.

One capacitor is charged to a voltage V and is connected to the other to form a completely closed system from which energy cannot escape. The capacitors can operate at superconducting temperatures, so that there are no resistance losses. Sketch the voltage along the capacitors as a function of time.

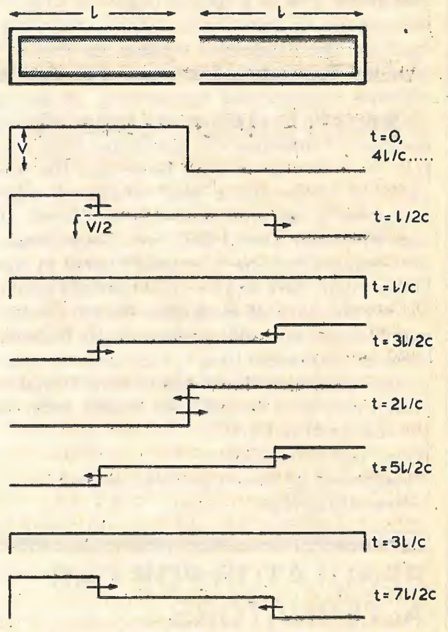


Fig. 1

The answer is given in Fig.1, and to forestall further questions, note that:
(a) Energy and charge are conserved.
(b) The current flow also has the form shown in the figure, with a peak amplitude given by V/Z_o, (Z_o is the characteristic impedance of the coaxial structure).
(c) Since current is finite, and in any case can

be made small by making V small, it can always be below the critical level at which superconductivity is suppressed.
(d) By a similar reasoning, arcing need not occur.
(e) There is no escape of radiation.
(f) There is no such thing as a perfect open circuit, and end effects will modify the square wave shown. However, this does not invalidate the above arguments.
(g) No matter how short the capacitor length, the oscillating nature of the discharge remains.

Point (g) is really the whole crux of the matter, since it guarantees an oscillation which can temporarily store the "missing" energy in inductive fields.

I hope that the more refined model will assist readers in their further understanding of the subject.

FOUR YEAR DEGREE COURSE

I have noted your article entitled "New four year degree course in electronics" which was published in the December issue of *Wireless World*. As you well know, there is considerable interest in the establishment of a variety of four year courses in this country prompted by the UGC's initiative in 'management enriched' courses. Many other universities in the United Kingdom are following a similar route on a free-lance basis and, as you correctly report, Southampton is one of these establishments.

It is, of course, appropriate that any initiative of this kind should be given its place in the technical and academic press but it should not escape the notice of editors of these journals that courses of four years duration have been operated for many years in the United Kingdom. I am not thinking of four year sandwich courses but of genuine four year academic courses such as the one which Hull has made available since the mid-1960s. This is a special degree course in electronic engineering which not only qualifies the successful student for the degree of Bachelor of Science but also a diploma in electronic engineering for those students who have achieved a high academic standard. Consequently, graduates from the four year course in Hull have had the experience of the extra year which we now recognise as an enhanced degree course. It was Professor David Bell, my predecessor, who established the four year course in the Department here and he must take the credit for his remarkable foresight. Relatively minor changes are taking place in the Department at the present time to incorporate in the course structure those component subjects which now find favour with bodies such as the IEE and the UGC.

Alan Pugh (Professor),
Department of Electronic Engineering,
University of Hull.

REGULATOR FOR CAR ALTERNATORS

We would like to draw your attention to the article "Regulator circuit for car alternators" in your August 1978 edition. As electronic design engineers we would like to express our dissatisfaction with the article, and feel very displeased that such a poor design should appear in *Wireless World*. An example of the design deficiencies involves Tr_3, whose maximum base drive is 140mA, assuming a 14.4V line. This device (MJE3055) has a specified minimum h_{FE} of 20 at I_c = 4A and V_{CE} = 4V, which would produce a collector current of 2.8A minimum. Assuming a nominal 3.5R rotor resistance the device would then try to dissipate 13W. If the machine has a nominal 30A output, the regulator may limit this to about 20A due to the lack of available field current. Neither of these are desirable features although the former will assist R_1 in driving out moisture from the unit!

The maximum collector current of Tr_1 will be 6.3mA, of which 2.7mA will flow in R_2, leaving a base current of 3.6mA in Tr_2 when it is desired to turn off Tr_3. The device specified for Tr_2 (2N3053) has a minimum gain of 25 with I_c = 150mA and V_{CE} = 2.5V so the collector current could be 90mA with 50mA still flowing as base current in Tr_3. This means that a minimum collector current of 1.0A could still flow, with Tr_3 dissipating 11W and the machine output being a minimum of 7A. Assuming a higher gain for Tr_3 to help saturation merely worsens the minimum output figure. This cannot be regarded as satisfactory.

It should be noted also that the worst case specified saturation voltage of a 2N3053 is 1.4V with I_c = 150mA, I_b = 15mA, so increasing the available base drive to Tr_2 could not guarantee to turn Tr_3 off even with its existing inadequate base drive.

The selection of a nominal zero temperature coefficient is not satisfactory in view of the negative temperature coefficient of the terminal voltage of a lead acid battery. If a part charged battery is being charged from a relatively high output machine, the battery temperature will rise, terminal voltage fall and charging current increase.

The battery temperature will then rise further and so on. This can rapidly damage a battery and possibly cause it to explode, yielding hot concentrated sulphuric acid. This tendency may be exacerbated by the high value of the recommended setting voltage.

Other perhaps more minor problems are also apparent. It is unlikely that the range of setting provided by R_9 will cope with reasonable variations in R_4, R_5, R_9, D_1, Tr_1 and Tr_2. The wiper of R_9 may possibly lift off due to vibration and put the machine on to nearly full field and maximum output. Sensing the machine voltage on the ignition switch is prone to trouble arising mainly from voltage drops across the switch, connections wiring and fuses if fitted. No useful indication of the method of selection of C_1 is given. A better design would include circuitry to induce switching. The circuitry to drive the warning light would be unnecessary if a nine-diode machine was used. The extra three diodes provide an additional isolated positive supply, and can be easily fitted to older machines.

We feel that a design which has so many major and minor faults in philosophy, design and component selection should not be published in any magazine, and particularly not in a semi-professional magazine such as *Wireless World*. We wonder how many other designs would prove to have similar shortcomings, if subjected to a similar analysis.

M. J. Newsome and S. A. White,
London, NW10.

Mr Watkinson replies:
The gain of transistors follows a distribution curve where the peak is at the typical gain. The percentage of units having worst case gain is very small, as these units are at the tail of the distribution. When dealing with the alleged inability of Tr_2 to turn off Tr_3 statistics tells us that the chances of having two devices which are simultaneously worst case are negligible, being the product of the two probabilities.

On my own unit Tr_3 saturates at 0.3volts. I have not wasted my time measuring the minimum collector current.

I am aware of the temperature coefficient of accumulator voltage, but I cannot see why it is valid to assume that the temperature of the regulator tracks the temperature of the battery as the two are usually found in different places on the vehicle. In my own vehicle the battery is not in the engine compartment, but the regulator is. Having accepted that the two components differ in temperature, adopting a zero coefficient is simple good design practice.

No figures accompany the allegation about the range of adjustment of the pot, but the fail-safe mode is deliberate. The inductive current limiting of the alternator prevents damage on full field. This is better than having no generator at all, particularly at night. A friend drove his van around with full field current for several weeks until he tired of topping up the battery and replaced the regulator.

It is no easy matter to install extra diodes in an alternator. Not only would this render the unit a one-off; impossible to replace away from home, but the extra parts, wiring and connections required would consume more effort than making the trivial but effective circuit I have offered. I had nine-diode machines in mind when I wrote about the tortuous means used to drive a light bulb.

The article clearly shows how to avoid trouble with voltage drops and if the instructions are followed no trouble will result.

The prototype unit was constructed in 1973 and has given no trouble. The battery dates from before this and only requires occasional topping up.

Whilst heralding *Wireless World* as a semi-professional publication Messrs Newsome and White descend to the sensational verbiage of the crusading tabloid in their attack, which does nothing to support their shaky technical criticisms. In closing I should point out that the acid in batteries is dilute only; perhaps this will save me when mine explodes!

J. R. Watkinson.

MICROCOMPUTER BUSES

I would like to take up Mr Aylward's points about the amateur bus standard E-78 (December letters).

I am endeavouring, with the support of the microprocessor manufacturers and a great many professional microprocessor users, to define a microprocessor bus standard for use with the new generation of 16-bit microprocessors. I do not believe that E78 is suitable as a professional standard, for it suffers too many deficiencies to support the devices Mr Aylward mentions. I would like to invite anyone who is interested in this topic to write to me for further information.

Paul L. Borrill
Mullard Space Science Laboratory
University College London
Holmbury St Mary
Dorking
Surrey

Frequency synthesizer — 4

Examples of design using techniques already described

by **R. Thompson,** M.I.E.E.

Single frequency

Having looked generally at types of synthesizing circuit, three applications have been chosen to illustrate specific designs. The first example is a synthesizer for an atomic standard. The problem is simplified here by approximating the hydrogen maser frequency to 1420.405 MHz, ignoring the last five significant digits. The requirement is to produce a reference frequency at 5 MHz, locked to the accuracy of the maser. This represents the type of synthesizer required for special purpose, single-frequency use, Figure 21 shows a possible arrangement.

Because of the high frequency of the maser the synthesis is organised in two loops. One loop generates 1400 MHz and subtracts this from the maser signal; the other loop synthesizes the residue, or intermediate frequency. An i.f. of 20.405 MHz is suitable to provide the high gain necessary to amplify the maser signal. The 1400 MHz is generated by a 140 × p.l.l. multiplier, followed by a 2 × harmonic multiplier. A single-stage p.l.l. multiplication by 240 is not used because the output frequency would be too high for the divider. The synthesis of 20.405 MHz can be carried out with a simple divider and p.l.l. multiplier.

Variable frequency

The next example has a very different requirement, the provision of a frequency which can be easily varied over a range of many decades, while retaining reference frequency stability. This requirement cannot be met simply by putting several decades of variable dividers in a p.l.l. Apart from the problem of designing a v.c.o. capable of overating over several decades of frequency, there could be severe tuning time problems. The reference frequency would equal the lowest frequency increment, which may be required to be a fraction of one Hertz. The loop bandwidth would have to be at least an order narrower than this so that the tuning time could be very long. There would be wide changes in loop gain as the frequency was changed which would have to be compensated for if a reasonably constant damping factor is to be maintained.

Because of these difficulties the normal design approach to this type of synthesizer is to cascade synthesizing stages, each stage providing one decade of frequency control. Figure 22(a) shows the basic arrangement.

Selector switch D selects a harmonic of Δf between 0 and $9\Delta f$. This is divided by 10 and added to the harmonic selected by switch C. This combined frequency is divided by 10 and added to the Δf harmonic selected by B; and so on. The final output frequency is therefore a decimal number of times Δf, the digits being readily and independently variable.

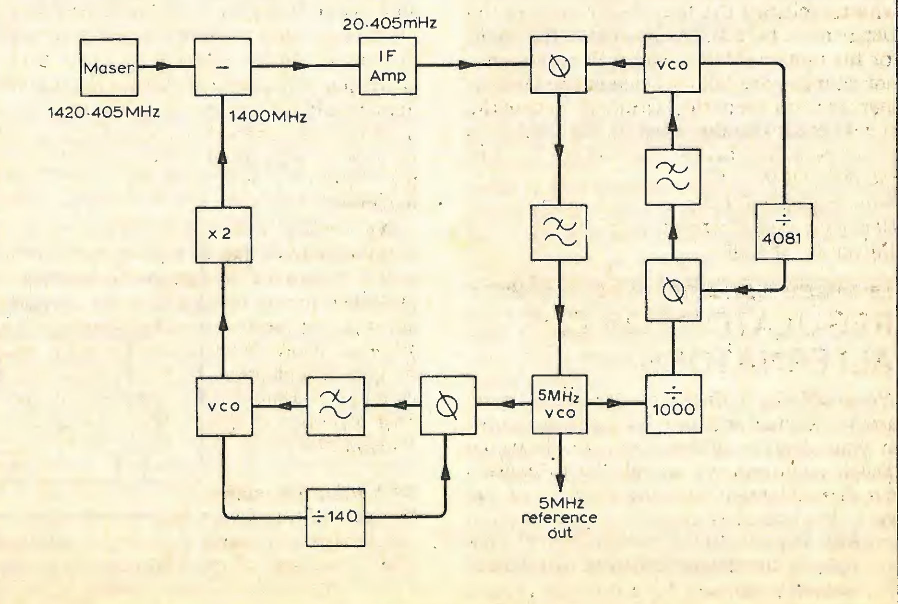
The disadvantage of this simple scheme is that the interface between stages is at widely varying frequency. This can be avoided by the arrangement shown in Fig. 22(b). The cascading of stages incorporating 10 times dividers and mixers is similar to the previous scheme. However the frequency added in each stage is the sum of the selected harmonic plus 0.9 f_1. This means that the output of each stage consists of the variable frequency plus a fixed offset. This offset can be removed at the output of the final stage.

Figure 23 illustrates a typical decade module suitable for cascading in a manner similar to that shown in Fig. 22(b). The harmonic multiplier and 0.9f_1 mixer/generator are combined in the one p.l.l. The fixed portion of the divider ensures that f_1 is generated by the v.c.o. when the selected value of C and D are zero. With the example frequencies shown N_0 is 180. Stepping switch C by one increases the p.l.l. multiplication by one, therefore adding 10 kHz to the output frequency. The output frequency never varies by more than ½% and modules can be cascaded at will allowing smaller increments of frequency. An advantage of the divide and cascade system is that loops can all be operated at high comparison frequencies giving low noise and fast tuning time, but the tuning time increment can be made arbitrarily small by cascading more stages and/or increasing the division ratio.

V.h.f. variable

As a final example; a typical v.h.f. communications synthesizer has been chosen. The requirement is for a carrier frequency selectable in 25kHz channels over the range 150-170 MHz. Here the frequency range to be covered is comparatively restricted, allowing the use of a single p.l.l. with a variable divider. Figure 24 (a) illustrates a suitable arrangement

Fig. 21. *Arrangement of synthesis to obtain a 5MHz signal locked to an atomic standard of 1420-405 MHz.*



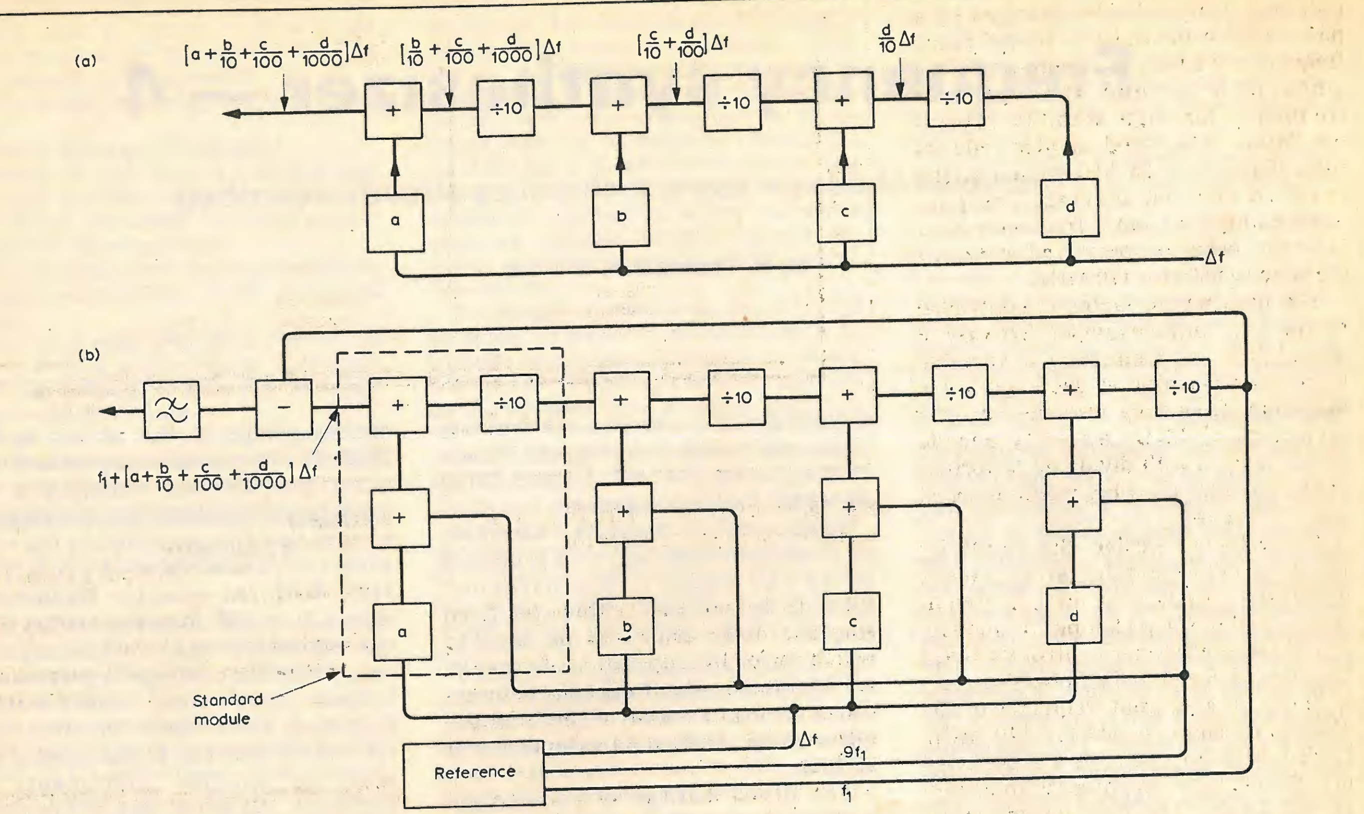


Fig. 22. *Cascade of synthesizers to provide a variable-frequency output at (a). Circuit at (b) avoids wide frequency difference between stages.*

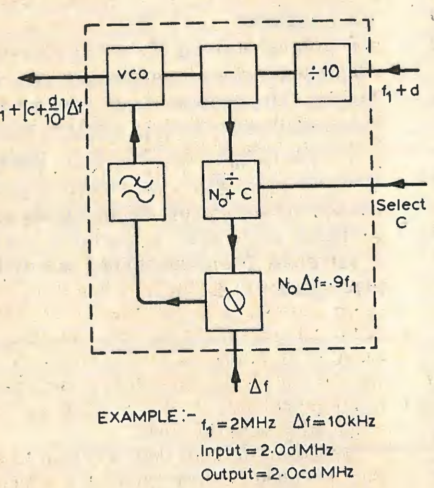


Fig. 23. *Divider used in Fig. 22.*

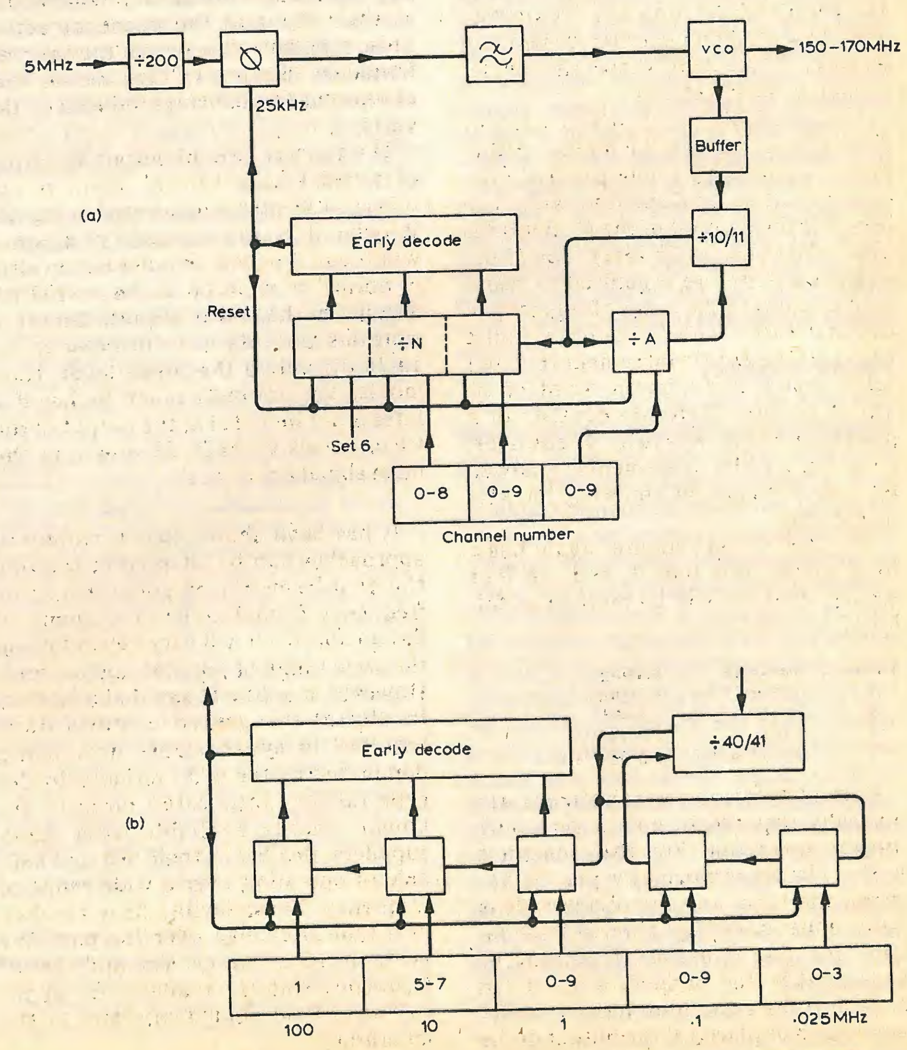


Fig. 24. *Variable-frequency synthesizer for v.h.f. communications. Divider is shown at (b).*

This is a two-stage synthesizer consisting of a fixed divider followed by a p.l.l. variable multiplier. The reference frequency of 5 MHz is a common choice since it is around the optimum frequency for high stability crystal oscillators. The fixed divider reduces the reference to 25 kHz which is the required channel spacing. The p.l.l. must multiply its input frequency by a factor of 6000 to obtain 150 MHz, increasing to 6800 for 170 MHz.

The multiplying factor is controlled by the p.l.l. variable divider. Because of the high v.c.o. frequency a variable modulus prescaler is used, giving a maximum frequency into the variable divider of 17 MHz. An early decode circuit is used with divide by *N* portion of the counter, allowing medium-speed logic to be used.

As explained earlier, the divide by 10/11 variable-modulus arrangement allows the output to be incremented in steps equal to the p.l.l. input frequency. The three synthesizer control switches are marked in channel numbers starting with 000 for an output frequency of 150 MHz and rising to 800 for 170 MHz. Each switch programmes a presettable decade divider to the number indicated on the switch, the final decade stage having a fixed programming of 6. All zeros on the switches therefore gives the required division of 6000 for 150 MHz, while 800 will give a division of 6800 for 170 MHz. If the setting switches are required to indicate frequency directly a modified counter design can be used. Figure 24(b) shows the divider portion of such a circuit.

The variable modulus prescaler divides by 40/41 and the higher scaling ratio may possibly allow the early decode circuit to be dispensed with. The least significant digit of the *N* counter is now 1 MHz (40 × 25 kHz). The *N* decades are therefore organised to relate their settings to the output frequency in decimal form. The 'A' counter must count off the 25 kHz increments below 1 MHz; that is a maximum count of 40. The A counter therefore consists of a programmable modulo 4 counter, counting 25 kHz increments, followed by a decade counter counting 100 kHz increments.

The final decade counter again has a fixed preset, this time 1, and the four setting switches will be marked as follows:

switch	markings	scaling
1	5, 6 or 7	x 10 MHz
2	0 to 9	x 1 MHz
3	0 to 9	x 0.1 MHz
4	25, 50 or 75	x 0.001 MHz

Communications synthesizers are normally required to give a very pure output spectrum. For this reason a buffer circuit is normally placed between the v.c.o. and the dividers. This buffer must have high reverse attenuation so that spurious frequencies generated in the dividers are not fed back into the v.c.o. In practice a buffer would also be placed at the output of the v.c.o. to isolate the synthesizer from spurious noise generated in the load which could effect operation of the loop. Another factor which will help maintain a clean output signal is the comparatively high 'comparison' frequency of 25 kHz. This allows a fairly fast loop which means that the loop will cancel much of the low frequency phase noise generated in the v.c.o.

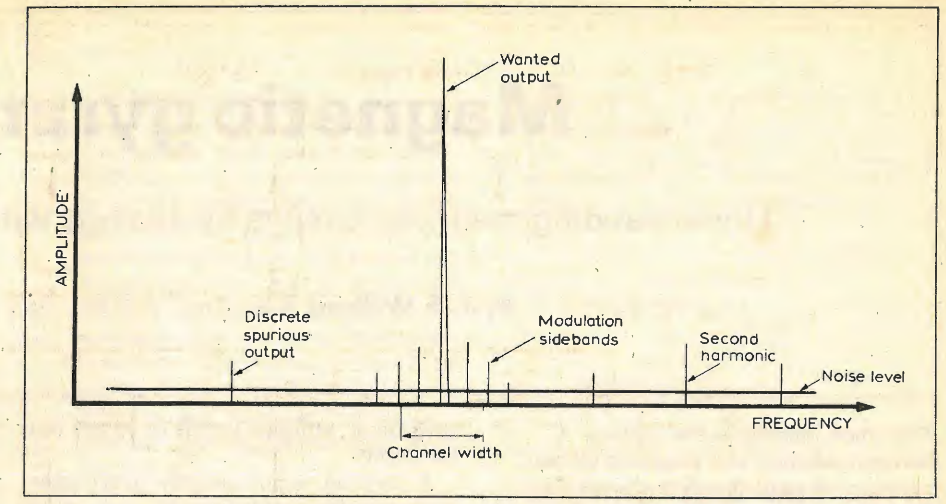


Fig. 25. *Synthesizer in Fig. 24 provides this general type of spectrum.*

The loop design will probably be a high-gain, second-order type with a lead lag filter. The high gain will minimise the comparison frequency component at the output of the phase detector. This, supplemented by additional high frequency filtering, will reduce the level of spurious frequencies produced by the v.c.o.

The general form of output spectrum obtained with a typical communications synthesiser is illustrated in Fig. 25. Wideband noise measured in a bandwidth equal to the channel bandwidth, is normally required to be 80-100 dB down on the main signal. Discrete spurious outputs are normally to be 10-20 dB above the noise level. Harmonics are normally much higher if a filter is not included at the output of the v.c.o. Levels of 20-30 dB down on the main signal are typical.

It has been shown that a variety of approaches can be adopted in meeting the requirements of generating one frequency from another. The choice of design approach will vary depending on the wide range of possible applications. However, it is true to say that advances in digital integrated circuits have resulted in synthesizers now being dominated by the p.l.l./variable divider type design. Integrated circuits are cheap, readily available from many suppliers, flexible in their use und capable of operating over a wide range of frequency. These factors have resulted in a radical change over the past five years in the accuracy, size and cast of frequency sources available for application in field equipments and in the laboratory.

References

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2. Phaselock Techniques — F. M. Gardner (Wiley 1966)
3. Phase-locked Loop Systems — Data Book. Motorola Semiconductor Products Inc.

SIXTY YEARS AGO

The March 1919 issue was much concerned with getting the amateurs back on the air after their enforced silence during the 1914-18 war. We feared that the government, having taken complete control of wireless communication, would "relinquish their hold very reluctantly, and in their future activities may totally prohibit the erection and the maintenance of a wireless installation by the amateur." A campaigning article in support of the amateurs contained backing up statements by Guglielmo Marconi himself, Professor J. A. ("diode") Fleming and Professor W. H. Eccles, and ended with a call for readers' views. Obviously the amateurs did get back.

But apart from the immediate and the practical, the magazine still had time for the more esoteric and speculative aspects of radio science. Marconi, for example, was asked in an interview for his views on what we now call SETI (search for extra-terrestrial intelligence) but then described as "communication with the stars".

"Senatore Marconi then went on to state that he hoped for communication with intelligence on other stars. Dealing with the question of the language difficulty, he said that although it was an obstacle he did not think it was insurmountable. 'You see, one might get through some such message as 2 plus 2 equals 4, and go on repeating it until an answer came back signifying yes — which would be one word. Mathematics must be the same throughout the physical universe. By sticking to mathematics over a number of years, one might come to speech; it's certainly possible.'

"Certainly communication with the stars, if at all possible, must be effected by wireless telegraphy; and the more recent discovery of a means of magnifying signals to almost any degree places within our hands an instrument of almost infinite delicacy. When so great a scientist as Senatore Marconi talks seriously of these possibilities it behoves the sceptic to consider his position."

Magnetic gyration

Understanding magnetic circuits by analogy with electrical circuits

by J. B. Williams B.Sc.(Eng), A.C.G.I., M.I.E.E.

This article introduces the analogy between electrical and magnetic circuits, covering the basic theory and workings. The analogy is a consistent one and does not fail the modern test of energy which has changed many concepts in recent years. The difference can perhaps best be imagined as if we had for years been treating all our electric circuits in terms of charge, not current, and often electric field strength and charge densities. We abandoned these concepts for circuit work many years ago.

A LARGE PROPORTION of practising electrical and electronic engineers have only a hazy understanding of magnetic circuit theory while being quite familiar with electric circuit theory. So widespread is this among many with very different backgrounds that one is forced to ask whether the fault lies in the presentation of the subject rather than in the people concerned.

Many engineers are used to tackling problems outside their own field, such as those in heat transfer, by analogy with electrical circuits. The subject of magnetism, closely related to the familiar electrical area, has however not been very satisfactorily treated by this method. A confusing system of units has for many years disguised the fact that electrical and magnetic quantities are dimensionally amenable to manipulation by the same mathematics. As explained by "Cathode Ray" in the January 1973 issue, the introduction of SI has removed this first barrier by making the electrical and magnetic quantities relate directly without the use of strange conversion factors.

Most electrical circuit theory is based on the concept of impedances, both resistive and reactive, i.e. those capable of energy dissipation and energy storage. An attempt was made to overcome the lack of a suitable magnetic "impedance" by using the concept of reluctance, which was supposed to be analogous to resistance in an electrical circuit. However resistance is a dissipative component and reluctance, which is related to inductance, is a storage component. This makes for a very poor analogy.

Perhaps the biggest blockage to understanding was the link between the electrical and magnetic circuits. The electrical current links directly into the magnetic circuit but the more useful parameter, voltage, seems to be left out on a limb.

A method which largely overcomes these problems and opens the way to an easier understanding is due to work by Buntenbach* and others in the U.S.A. but does not appear to have had a wide circulation in this country. It is the aim of this article to introduce this system to a wider readership.

It is necessary to go back to the basic formulae of electromagnetism to see the dimensional similarities.

The first relationship is between magnetomotive force F, the magnetic "voltage", and electrical current

$$F = NI \qquad (1)$$

where N is the number of times I that is producing F, or more normally the number of turns. The second relationship is between voltage and rate of cutting of flux ϕ. This is the rate of flux change ϕ multiplied by the number of times it is linked, i.e.

$$V = N\dot{\phi} \qquad (2)$$

The important magnetic property permeability μ is linked to inductance that the magnetic circuit produces

$$L = N^2\mu A/l \qquad (3)$$

The term $\mu A/l$ could be called the specific permeability as it is the modified value for that particular shape of magnetic circuit, it is known as permance, P i.e.

$$L = N^2P. \qquad (4)$$

As N is a dimensionless number F has the dimension of amps, ϕ the dimension volts, and P the dimension inductance. The previous reluctance-resistance analogy was based on the similarity of the equations

$$V = IR$$

$$\text{and } F = \phi S = \frac{\phi}{P} \qquad (5)$$

where S is reluctance. However there is another electrical equation of similar form

$$V = \frac{Q}{C} \qquad (6)$$

*Analogs between magnetic and electrical circuits, by Rudolph Buntenbach. *Electronic Products*, October 1969.

Inductance is a storage not a dissipative parameter and hence so is permanence (equation 4). Thus attempting to use resistance as the analogous property for reluctance, S (the reciprocal of permanence) is not a happy state of affairs. There is a much better analogy in equations 5 & 6, capacitance also being a storage parameter.

Thus the "current" in the magnetic circuit is not ϕ but rate of change of flux $\dot{\phi}$. This means that we now have a looking-glass circuit in which the "voltage" has the dimension amps and the "current" the dimension volts. The main component in this circuit P behaves like a capacitor but has the dimension of inductance. Flux ϕ is seen to be analogous to charge Q.

Another way of checking this is to consider the energy stored in a magnetic circuit.

$$E = \tfrac{1}{2}LI^2 = \tfrac{1}{2}PN^2I^2$$

$$E = \tfrac{1}{2}PF^2 \qquad (7)$$

This can be seen to be analogous to the capacitive energy equation

$$E = \tfrac{1}{2}CV^2$$

Magnetic-electric circuit link

Having explored the magnetic circuit and found it to behave in an analogous fashion to the electric circuit, although it is a looking-glass similarity, now look at the link or mirror itself. The basic equations 1 & 2 link the "voltages" and "currents" on the two circuits. In addition, the magnetic circuit should have a magnetic impedance Z_m $(=F/\dot{\phi})$ and this should be related to the electrical impedance Z

$$Z = V/I = \frac{N\dot{\phi}}{F/N} = \frac{N^2\dot{\phi}}{F}$$

$$Z = \frac{N^2}{Z_m}$$

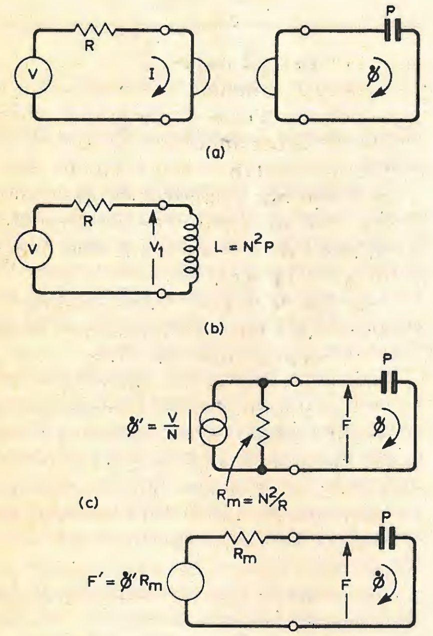
Equations 1 & 2 can be seen to be the defining relations of a Tellegen gyrator with a gyration constant N. This gyrator gyrates a voltage to a current times N, which is the required relationship. An impedance in one circuit gyrates to admittance times N^2 in the other circuit as in equation 8. The gyrator thus fulfils the requirements of the electrical-magnetic circuit link.

It is worth investigating the simplest magnetic arrangement to gain some understanding of the working of the analogy.

Air-cored inductor

In Fig. 1 if V is a step function, the classic result is obtained in the electrical circuit:

$$V_1 = V\exp{-tR/L} \qquad (8)$$



In the magnetic circuit ϕ is also a step function, from equation 2, and hence a similar equation can be derived. This can be calculated directedly but a short cut can be used by using the current-to-voltage source transformation in Fig. 1 (c) and (d). The voltage source and its resistor have the same properties as the current source and its resistor. This can be checked by considering the opena dn short-circuit conditions for the two sources.

The circuit in Fig. 1 (d) is now familiar and we can write down the expression for when F is a step function:

$$F = F'(1 - \exp{-t/PR_m})$$

by analogy to the standard capacitor charging equation. Hence

$$\dot{\phi} = \frac{F' - F}{R_m}$$

$$\dot{\phi} = F'\exp{-t/PR_m}$$

$$\dot{\phi} = \dot{\phi}'\exp{-t/PR_m}$$

Converting each term in this equation to its electrical counterpart yields equation 8.

It can also be seen that if a fixed voltage is applied to the inductor (i.e. R is small and R_m large) $\dot{\phi}$ is constant and hence the F across P increases linearly.

If V is an alternating source the electrical impedance is $j\omega L$ and hence the magnetic impedance is $1/j\omega P$. F and $\dot{\phi}$ are seen to be at 90° to each other as are V and I in the electrical circuit.

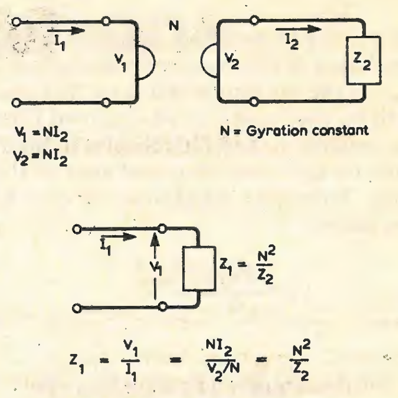
Nowhere in this discussion of the inductor have we mentioned the flux ϕ. This is the integral of $\dot{\phi}$ and is given by

$$\phi = PF$$

which is analogous to equation 5. In the a.c. case this becomes sinusoidal like the other quantities and is apparently in phase, thus leading to much traditional confusion.

Tellegen gyrator

The gyrator is a theoretical circuit component like a resistor, capacitor or perfect transformer, but unlike these others a simple practical realisation does not exist. It is similar to a transformer in that it links two circuits, but the link is between the voltage in one circuit and the current in the other. For this reason it is useful as the theoretical link between the electrical and magnetic circuits. It is denoted with two semicircles facing each other.



Rules of gyrator behaviour in either direction:
- Voltages gyrate to current sources multiplied by N
- Resistances gyrate to conductances multiplied by N^2
- Inductances gyrate to capacitances multipled by N^2
- Short circuits gyrate to open circuits
- Components in series gyrate to components in parallel

Magnetic cores

At first sight substituting a core of a magnetic material merely gives a much larger value to P (large μ hence large P from equation 3) but iron and ferrite cores are also conductive. Much ingenuity has gone into minimizing the conductive paths, but they still exist, producing as it were small single-turn secondaries distributed a round the core. These can be approximated by one limped component as in Fig. 2.

The conductive path, being an electric circuit, is linked into the magnetic circuit via another gyrator where $N_2 = 1$. This reflects into the magnetic circuit as a series resistance and hence into the electrical circuit as a resistance in parallel with the inductance.

Transformers

A transformer has another electrical circuit gyrated into the magnetic circuit with constant N_2 as in Fig. 2. More secondaries can easily be added by putting in more gyrators in series in the magnetic circuit. The primary voltage V_1 causes $N_1\dot{\phi}$ in the magnetic circuit which in turn causes V_2.

$$V_2 = \dot{\phi}/N_2$$

$$\therefore V_2 = V_1N_1/N_2$$

which is the normal transformer voltage equation.

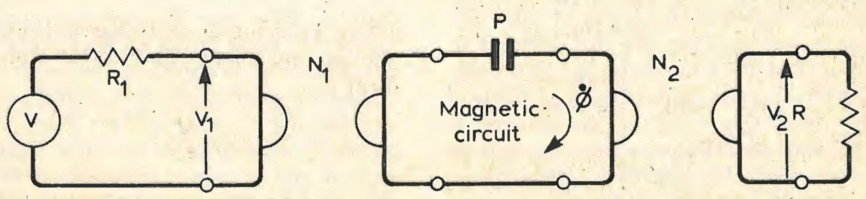
If V_1 is a fixed alternating voltage then ϕ is a fixed sinusoid and there will be a drop of F_p i.e. $V_1 = N\dot{\phi}$. But at this frequency P has an impedance $Z = 1/2\pi fP$ i.e.

$$\text{i.e. } \dot{\phi} = 2\pi fPF_p$$

$$\therefore V_1 = N2\pi fPF_p \qquad (10)$$

$$\text{But } \phi = PF$$

$$\therefore V_1 = N2\pi f\phi$$



$$\text{i.e. } V_1 = \frac{2\pi Nf\phi_{max}}{\sqrt{2}} = 4.44Nf\phi_{max} \qquad (11)$$

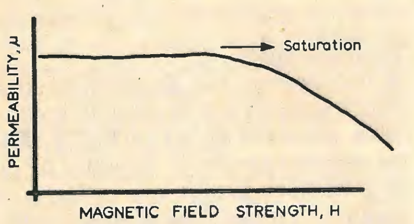
This is the transformer equation and is important in the design of transformers. ϕ_{max} is the maximum working flux that is to be used and can be obtained form the usually-quoted flux density B, multi plied by the cross-sectional area of the core. However equation 10 can be rewritten

$$V_1 = \frac{2\pi NfPF_{pmax}}{\sqrt{2}}$$

$$V_1 = 4.44Nf\mu A\hat{H}l = \frac{4.44Nf\mu A\hat{H}}{l}$$

$\hat{H}$ being mmf per unit length. This would be the useful form if the basic magnetic information on the material was presented as a graph of μ against H, or a value of μ was given up to a certain value of H where it starts to fall as saturation begins. This is more in line with standard capacitor practice where the maximum voltage, not charge, is stated.

Presenting the information in this form means that P can be calculated directly



and hence so can the open-circuit primary current, as $F_p = NI_1$.

Consider now the effect of a load on the secondary.

The load on the secondary can be reflected back into the magnetic circuit, a heavy load being a small resistor. This becomes a large "resistor" in the magnetic circuit. As $\dot\phi$ is fixed the "drop" F_L must become large and hence F_{total}. The current in the primary must rise in the same way as F_{total}. Thus F is the variable in the magnetic circuit.

Energy

The amount of energy stored in a core is an important factor in d.c. to d.c. converters and in some forms of filter design. It is also important to understand the effect of air gaps introduced into the core.

When a voltage is connected to the terminals of an inductor $\dot\phi$ flows in the magnetic core. The mmf F developed across P can be determined from

$$\dot\phi\, t = PF$$

where t is time, which is a restatement of equation 9 for a fixed $\dot\phi$. In other words, F (and hence I) rises linearly with time. The energy stored is $\frac{1}{2}PF^2$ from equation 7. If the primary is suddenly open circuited, the energy is left stored in the form of mmf F on a "capacitance" P. An open circuit of the primary converts to a short circuit on the other side of the gyrator. A very large $\dot\phi$ will thus flow causing a very large primary voltage. This can be coupled to some arrangement that only removes the energy at a high voltage, such as a breakdown device, and a voltage converter such as the ignition coil of a car has been produced. A high $\dot\phi$, corresponding to the high voltage, will flow until the energy stored in the core has been dissipated.

If an air gap is added in the magnetic path it would appear that another component should be added in series in a magnetic circuit is normally shown as total reluctance

$$= \frac{l_1}{u_1a_1} + \frac{l_2}{u_2a_2}$$

$$\text{i.e } \frac{1}{P_{total}} = \frac{1}{P_1} + \frac{1}{P_2}$$

which is two "capacitors" P_1 and P_2 in series.

As magnetic materials have a very much larger μ than air it can be seen from equation 3 that only a very short length of air gap is required to make P_1 and P_2 equal. For example a gap of around 0.025mm (1 thou) is required in small commercial ferrite cores.

If we now have two "capacitors" of value P with $\dot\phi$ flowing through them, twice the energy can be stored in them in the same time. In practice a piece of magnetic material can only be worked to a certain value of F before saturating and hence more energy can be stored in the system.

The value of F across each P will be the same and hence the total F will be twice as large. The current ramp will thus be twice as fast. The two "capacitors" can be gyrated out into the electrical circuit as two inductors in parallel. □

continued from page 51

The central feature of the approach is partitioning: the material is partitioned into topics that fit within a page-pair with successive pairs grouped together into themes as appropriate; each page is partitioned into smaller units based on the diagram or graph. This feature has been found to be particularly helpful when the work has to be edited or up-dated. It also allows particular pages or sections to be included in other courses, e.g. an appropriate section of one course can be simply transferred to another as revision material.

There remain objections to this new format: it is artificial and constrains the material to fit a particular pattern; it is inappropriate to some topics; the balance between the types of information is wrong. They are not difficult to rebut. The work has to be put into some pattern and the tighter the organisation the more the mind of the author is concentrated. Where a topic cannot be comfortably fitted into a single page-pair it can be extended to two or more. The structure is formalized, as an aid to clarity in writing and understanding, not as a rigid set of rules. These can be bent as required, to make more room for analysis at the expense of examples or vice versa. After such changes it is important to return to the original structure as the starting point for the next section, so that the benefits of a formal and systematic approach are retained.

Finally, no matter how enticing ideas may be, they must be shown to be practical. The subject area chosen is that of oscillation in the broadest sense, encompassing ramp sawtooth, and triangular wave generators; astables, monostables and diode-pump circuits; RC and LC sinusoidal oscillators; the techniques of frequency and amplitude control. Wherever possible the opportunity has been taken to find unifying concepts, simple equations to cover the largest range of applications and novel and useful applications of the ideas. The merits or otherwise of the new format and of the material presented in it should perhaps be considered separately. There are cases where consciously and unconsciously the writing has been shaped by the format, but on re-reading this series of articles in their draft form I have no doubt that the format is much more widely applicable. Conversely, the particular viewpoint embodied in these articles could have been expressed in a conventional layout with little change in the detailed material.

No new format is going to replace the standard text book, nor is this one intended to. What it does is to present the reader with an alternative. In writing this series the organization of the work has been a considerable stimulus to new ideas and to the re-arrangement of the old. I hope you will find the results as helpful.

I would like to record my thanks to many colleagues who have helped through discussion and argument to evolve this approach; to those students who have patiently suffered earlier experimental versions of this format; to the editor and staff of Wireless World for their willingness to consider new ideas and their skill in making them work in print. □

Antenna aiming calculations

Method using a pocket programmable calculator

by Andrew M. Stephenson

TERRESTRIALLY BASED antennas may be aimed by reference to any of several co-ordinate systems, but the one chosen will have to accommodate local operational constraints. If we forget for the moment those fixed and special-purpose antennas such as in permanent microwave relays and large satellite ground stations, which can be established in a relatively leisurely fashion or have the advantage of convenient reference points, the only co-ordinate system that is of real use is that known as the horizon system, whose two coordinates are azimuth (a) and altitude (h).

Azimuth, often colloquially referred to as "compass bearing", is taken here as the eastward angle from due north, to the target antenna (0^0 to 360^0, or 0^0 to ± 180°.). Altitude is the angle between the horizontal and the target (0° to ±90°). See Figs 1 and 2, in which station A is aiming for station B.

The purpose of this article is to describe a set of mathematical formulae with which it is possible to derive a and h, given the latitude (L) and longitude (λ) of stations A and B. The prevalence of excellent scientific calculators now makes their evaluation straightforward. Indeed, the advent of the pocket programmable machine has almost rendered this task trivial, and has permitted additional calculations to be made which formerly were best performed graphically or by means of approximations. An appendix includes a pair of programmes for the Hewlett-Packard HP-25. Owners of the HP-65 and other calculators may also find them useful as inspiration.

The shortest path between two points on a sphere lies along a "great circle", as shown in Fig. 1. The azimuth of B from A is the angle between their great circle and the one that passes through A and the poles.

To avoid wrestling with the generalised mathematics of solid elliptical geometry, it is usual to regard the Earth as a sphere. This is a good enough approximation since the practical discrepancies will usually be swamped by other (e.g., atmospheric) effects. Even so, the derivation of useful formulae for the azimuth is not to be undertaken lightly. There are many versions, all descending by one tortuous route or another from standard spherical geometry formulae, and the ones given here therefore should not be regarded as definitive. It may be that the reader's calculator possesses a special function that renders them obsolescent; he is encouraged to discover refinements of his own.

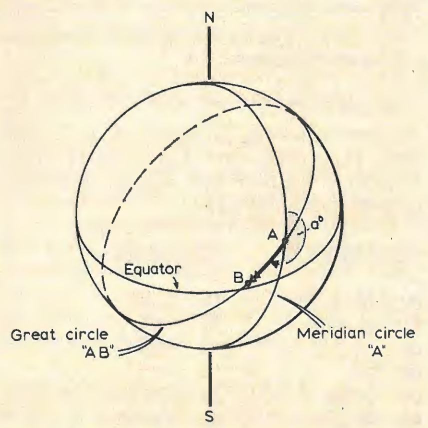


Fig. 1. *Illustrating the azimuth part of the horizon system of co-ordinates. The azimuth of point B from point A is the angle a° between their great circle and the great circle that passes through A and the poles.*

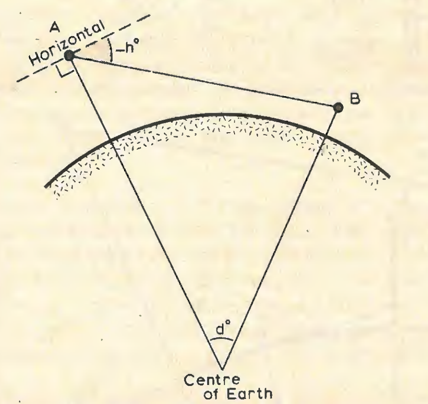


Fig. 2. *Illustrating altitude, h (actually angle h°), and the angular distance, d°, between points A and B.*

The usual approach is first to determine the angular distance between A and B, which is shown as angle d° at the centre of the Earth in Fig. 2, then use it to find a, while saving it for the evaluation of h.

Thus:

$$d = \cos^{-1}\{\sin(L_A)\,.\,\sin(L_B) + \cos(L_A)\,.\,\cos(L_B)\,.\,\cos(\lambda_B - \lambda_A)\}$$

From this, without further ado or preliminary explanations:

a = Argument (X,Y) where

$Y = \sin(\lambda_B - \lambda_A)\,.\,\cos(L_A)\,.\,\cos(L_B)$

$X = \sin(L_B) - \cos(d)\,.\,\sin(L_A)$

Stop a moment. Many calculators now have polar/rectangular co-ordinate conversion keys. These can save many programming headaches, such as when X becomes very small compared with Y. Use the function if it is there; otherwise, take care.

One should also beware of two special cases that can arise. The commoner of them is when A is at either of the poles. As a general rule it is safer not to attempt the derivation of meaningless figures, so if this condition arises, reconsider what the "compass bearing" would be. Likewise, if A and B are directly opposite each other on the Earth, one great circle is as good as another, and d can only be 180°. Of these two cases, it is only worth testing for $L_A = \pm 90°$ (or cos $(L_A) = 0$), when d will probably still be needed and will still mean something.

Having set the azimuth, we still have the altitude to find. This much simpler problem masks a whole set of dependent ones. B may be below the horizon for one reason or another, either because the sea is in the way, or because some mountain happens to be taller than was thought before arrival at the station site. Such details can be checked as follows.

Fig. 3 summarises the situation. Each station has its antenna situated at some height (H_A and H_B) above the nominal surface of the Earth, taken as sea level here. The Earth's radius is R. The altitude of B may easily be shown to be:

$$-h = \tan^{-1}\frac{Y}{X} \text{ where}$$

$$Y = \frac{(H_A + R)}{(H_B + R)} - \cos(d)$$

$$X = \sin(d)$$

Again, use should be made of the rectangular-to-polar function if it is available, lest the calculator be confronted with the awkward problem of one antenna directly above the other (which can happen).

Next, it may be useful to know if B lies below the horizon. As shown earlier, "horizon" can mean two things, either of which can be acutely embarrassing to those users who had not intended to rely on atmospheric refraction to complete the signal path for them.

In the case of the sea level horizon:

$$-h_H = \cos^{-1}\left[\frac{R}{(H_A+R)}\right]$$

(Note that the angular surface distance of the horizon is also h_H.)

In the case of spurious obstructions, we are (or should be) more interested in what clearance (ΔH) exists between them and the line-of-sight signal path. Since these obstructions are usually close enough to appear on the same medium-scale map as A (and possibly B, too), the input values are conveniently expressed as plane measures: surface distance (D_S) and height (H_S).

$$\Delta H = \left[\frac{(H_A+R)}{\tan(h)\,.\,\sin(\sigma)+\cos(\sigma)} - (H_S+R)\right]$$

$$\text{where } \sigma = \frac{180\,.\,D_S}{\pi R}$$

If stations A and B are close enough, it may be better to use as d in the altitude formula a value derived from the map surface distance, D_S:

$$d = \frac{180\,.\,D_S}{\pi R}$$

This reduces the effects of errors arising from the original measurement of λ and L, and may obviate the need for azimuth calculations if the bearing can be taken from the map too. The course adopted will depend on local circumstances, naturally.

Appendix A contains two HP-25 programmes: Azimuth, which generates a and d; and Altitude, which covers the calculations relating to h, h_H, and ΔH. Appendix B gives some examples of the use of these programmes, and suggests a use for the formulae that may not at first be obvious.

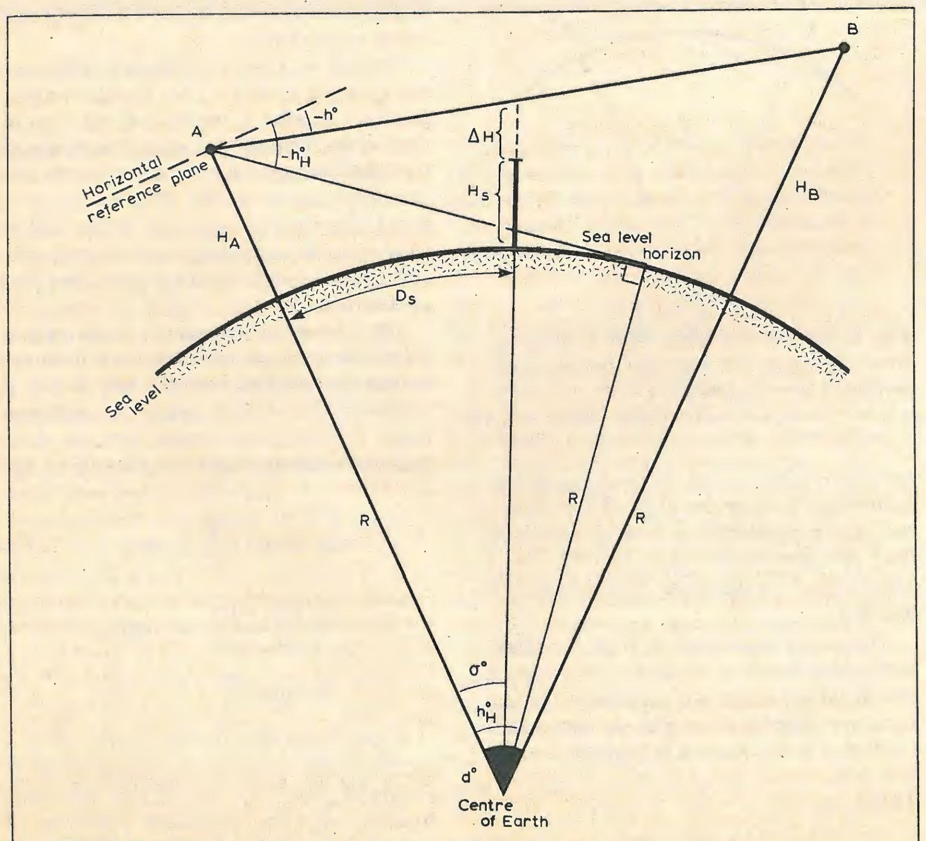


Fig. 3. *Factors in altitude and height formulae.*

Appendix A: HP-25 antenna aiming programmes

All angles are in decimal degrees unless otherwise shown (D.MS). "(w)" means "write as a value"; other symbols have their keyboard meanings.

Azimuth

Accepts: own long. (λ_A); own lat. (L_A); other long. (λ_B); other lat. (L_B) – all in D.MS. Computes: azimuth (a); angular separation of stations A and B (d).

STEP	KEYS	STEP	KEYS
00	(R/S)	16	f SIN
01	g→H	17	RCL 1
02	STO 3	18	f SIN
03	R/↓	19	×
04	g→H	20	+
05	RCL 0	21	g COS⁻¹
06	–	22	STO 7
07	STO 2	23	RCL 2
08	f COS	24	f SIN
09	RCL 3	25	RCL 3
10	f COS	26	f COS
11	×	27	×
12	RCL 1	28	RCL 1
13	f COS	29	f COS
14	×	30	g x=0
15	RCL 3	31	f FIX 0
32	×	41	g→P
33	RCL 3	42	x↔y
34	f SIN	43	g x⩾0
35	RCL 7	44	GTO 47
36	f COS	45	RCL 4
37	RCL 1	46	+
38	f SIN	47	RCL 7
39	×	48	x↔y
40	–	49	GTO 00

USE OF PROGRAMME

♯1 (w) 360
STO 4
♯2 (w)λ_A
g→H
STO 0
(w)L_A
g→H
STO 1
f PRGM
♯3 (w)λ_B
ENTER ↑
(w)L_B
R/S
display shows a; y-register and R_7 contain d. If $L_A = \pm 90°$, display switches to integer format.
♯4 For new 'other station', repeat from ♯3.
♯5 For new 'own station', repeat from ♯2.

Notes: 1. If $L_A = 90°$, a is returned as 0°. 2. If A and B diametrically opposite each other, an error condition may arise owing to calculator imprecision. 3. Stores R_5 and R_6 are unused.

Altitude

Accepts: angular separation of A and B (d); radius of Earth (R); height of own antenna (H_A); height of other antenna (H_B); obstruction height (H_S) and surface distance (D_S). Computes: altitude of other antenna ($-h$) and of the sea level horizon ($-h_H$); clearance between obstruction and signal line-of-sight path (ΔH).

STEP	KEYS	STEP	KEYS
00	(R/S)	25	R/S
01	RCL 4	26	STO 1
02	STO 2	27	R/↓
03	+	28	RCL 4
04	STO ÷ 2	29	STO + 1
05	STO 0	30	÷
06	x↔y	31	gπ
07	RCL 4	32	÷
08	+	33	1
09	÷	34	8
10	RCL 7	35	0
11	f COS	36	×
12	–	37	f COS
13	RCL 7	38	f LASTx
14	f SIN	39	f SIN
15	g→P	40	RCL 3
16	x↔y	41	f TAN
17	STO 3	42	×
18	RCL 2	43	+
19	g COS⁻¹	44	RCL 0
20	x↔y	45	x↔y
21	f x<y	46	÷
22	GTO 25	47	RCL 1
23	f PAUSE	48	–
24	GTO 23	49	GTO 25

USE OF PROGRAMME

♯1 (w) radius of Earth
STO 4
♯2 (w) angular sep., d
STO 7
♯3 f PRGM
(w)H_B
ENTER ↑
(w)H_A
R/S
displays altitude of other antenna, $-h$. If this is below the sea level horizon it will blink; this may be halted by pressing any key. In any case, the "horizon value, $-h_H$, will be in the y-register.
♯4 If $-h$ displayed is acceptable, GTO 26 (if not blinking, ignore this GTO operation); if not, then restart at ♯3 with new heights.
♯5 For clearances, continue:
(w)D_S
ENTER ↑
(w)H_S
R/S
displays clearance, ΔH, in same units as H and R.
♯6 To repeat for other obstructions, go to ♯5.
♯7 For new station heights, go to ♯3.
♯8 For new d, go to ♯2.

Notes: 1. R, H_A, H_B, H_S (and ΔH) must all be in the same linear units. 2. Altitudes computed are negative if *above* the horizontal. 3. Heights are all a.s.l. if positive; negative are below sea level. 4. Radius of Earth used may be local value. 5. Stores R_5 and R_6 are unused.

Appendix B: Examples

An ambitious radio amateur plans to establish a station (at $\lambda_A = -4°18'30''$; $L_A = 50°31'05''$; and 333.5m above sea level) from which he hopes to contact three other stations as follows:

1. By h.f. to a friend in Melbourne, Australia (λ_B = approx 145°; L_B = approx −37°50′). 2. By u.h.f. to another friend on a nearby hill ($\lambda_B = -3°59'08''$; $L_B = 50°31'13.7''$; and H_B = 12m mast + 445m a.s.l.).

3. By S-band microwave link to a geostationary satellite over the Atlantic Ocean ($\lambda_B = -30°$; $L_B = 0°$; and H_B = 35796660.91m a.s.l.).

The radius of the Earth he takes as 6367467.5m, this being the arithmetic mean of the equatorial and polar values. Note that H_B for the satellite is its orbital radius minus this value.

Procedure

(a) He determines the various bearings and d values using the Azimuth programme.

$a_1 = 71.588°$true	$d_1 = 154.8570868°$
$a_2 = 89.201°$	$d_2 = 0.2052409307°$
$a_3 = 211.936°$	$d_3 = 55.04195678°$

(b) Retaining the d values for those applications in which obstructions could be a hazard or where he will want an altitude figure, he uses the Altitude programme to determine $-h$, assuming the extra height provided by his masts as 5m (i.e., $H_A = 5 + 333.5 = 338.5$m a.s.l.).

$-h_1 = 77.429°$ blinking. (i.e.: approx 77° below the horizontal.)
$-h_2 = -0.195°$. (i.e.: approx 0.2° above the horizontal.)
$-h_3 = -27.241°$.

(c) He estimates that only the u.h.f. link is liable to be obstructed, so he checks the map and sees two possibly troublesome hills. Re-use of Altitude programme checks the clearances:

$D_{S1} = 3442$m $H_{S1} = 250$m $\Delta H_1 = 101.15$m
$D_{S2} = 18741$m $H_{S2} = 381$m $\Delta H_2 = 48.88$m

Theoretically, therefore, he has a clear view of Station 2, and knows this before reaching the site. Unhappily, no amount of programming will ensure that the owners will allow him to camp there (at Kit Hill, Cornwall, west of Dartmoor).

LITERATURE RECEIVED

Advantages of **automatic testing** equipment are set out in a booklet from Teradyne, who feel that fables and cartoons are a help in disseminating their message. Teradyne Ltd, Clive House, 12 Queens Road, Weybridge, Surrey .... WW 401

Replacement guide for semiconductors of all types, using Philips devices, is now available. Salient performance data is provided for transistors, thyristors and triacs, but replacements only for other devices. Mullard Ltd, Mullard House, Torrington Place, London W.C.I.

To provide a basic insight into the preparation and production of **printed circuits,** Isola of Duren have published a 32-page booklet, in which the Isola material is described and manufacturing methods illustrated. Information is offered on recommended ways of preparing artwork. Isola Werke A.G., D-5160 Duren, Postfach 236, West Germany WW 402

Analytical instruments for chemists is briefly described in a short catalogue from Hewlett-Packard. Instruments listed include gas chromatographs and accessories, liquid chromatographs, mass spectrometer systems and ancillary equipment. Hewlett-Packard, Winnersh, Wokingham, Berks RG11 5AR WW 403

Assistance with the design of radar circuitry is provided by Plessey's Radar Applications Handbook. Design details, with p.c. layouts, are given for preamplifiers, a 120MHz log. strip and swept-gain i.f. strip and detector. Analogue-to-digital converters are also covered. Copies can be had from Plessey Distributors.

120W, 300W and 600W **amplifiers** are the subject of a leaflet from Derritron. The units are intended as drivers for vibrators or p.a. amplifiers, giving 1% t.h.d., from 5Hz to 20kHz, at rated output. Derritron Electronics Ltd, Sedlescombe Road North, Hastings, East Sussex TN34 1XB .... WW 404

Electronic timer Series E is described by Tempatron in a new leaflet. This is a c.m.o.s. timer offering a variety of operational modes. Timing ranges between 0-100ms and 0-30h are available. Tempatron Ltd, 6 Portman Road, Reading, Berks .... WW 405

Components catalogue from Rank lists a variety of general electronic parts and spares for Rank Radio equipment. There is also a section on servicing instruments, tools and materials. Rank Radio International Ltd, RSVP Service, Walton Road, Ware, Herts SG12 0DY WW406

Development, design and use of KEF Calinda and Cantata loudspeakers is subject of Kef-topics, Vol.3, No.2. Eight-page paper, covering background and performance details of speakers. Accompanying note points out that lower curve in Fig.8 (b) should be reactance, not resistance. KEF Electronics Ltd, Tovil, Maidstone, ME15 6QP. WW407

Linear circuit applications is a 20 page booklet containing over 40 applications of RCA i.c.s. Obtainable from Distronic Ltd, 50-51 Burnt Mill, Elizabeth Way, Harlow, Essex .... WW 408

Phase Angle Voltmeters is title of note from North Atlantic, Techn. Bulletin 120, describing theory of these instruments. It can be obtained from Bill Cullum, Applications Engineer, North Atlantic Industries Inc., 60 Plant Avenue, Hauppage, N.Y. 11787, USA WW 409

Magnetic Perception Heads: Principles and Practice, describes heads used for detection of moving objects. Application note is produced by Orbit Controls Ltd, Lansdown Industrial Estate, Gloucester Road, Cheltenham, Glos GL51 8PL .... WW 410

Dry reed relays fully described in 32 page catalogue from Associated Automation. General background information followed by specific data on devices made by AA. Catalogue is available from 70 Dudden Hill Lane, London NW10 1DJ .... WW 411

GaAs power oscillators, described in Application Note TE-213 from Microwave Semiconductor Corporation. Devices used cover frequency range 3-18GHz. Useful list of references. Can be had from Pascall Electronics Ltd, Hawke House, Green Street, Sunbury-on-Thames, Middx TW16 6RA WW 412

Voltage regulators for microprocessors listed and characterized in 15 page booklet from Lambda Electronics Co., Abbey Barn Road, High Wycombe, Bucks .... WW 413

Multiplying d-a converters in c.m.o.s. is subject of 40 page guide published by Analog Devices. Section on theory is followed by 25 applications, including gain adjustment, panners, function generator, phase shifter and power series generator. Analog Devices, Central Avenue, East Molesey, Surrey WW 414

Optoelectronic devices from Monsanto described in new short-form catalogue, available from Swift Hardman, P.O. Box 23, Baillie Street, Rochdale, OL16 1JE ...... WW 415

Portable Data terminal and v.d.u., Tele-ZIP, allowing communication between telephone and computer, using television set as v.d.u., and ZIP-64 low-cost v.d.u. both described in leaflets from Data Dynamics, Data House, Springfield Road, Hayes, Middx . WW 416

High-voltage and r.f. connectors from Suhner described in two catalogues, available from Suhner Electronics Ltd, Telford Road, Bicester, Oxfordshire OX6 OLA WW 417

NEW PRODUCTS

Professional readers are invited to enter codes on the reply-paid card bound in at pages 112/3

Measuring systems

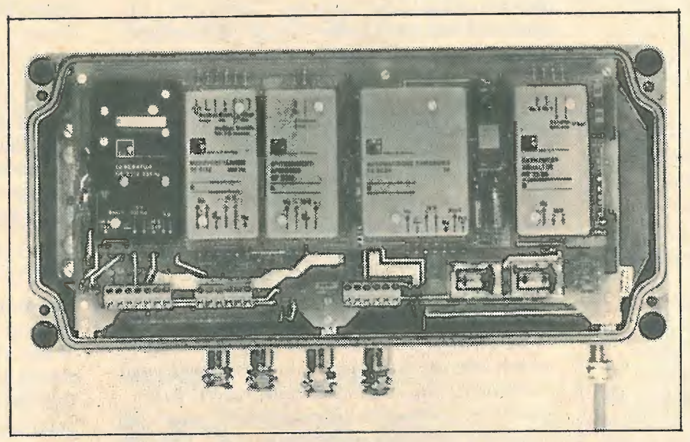
A range of modules (amplifiers, signal conditioners, etc.) enable a complete industrial measuring system to be assembled to individual requirements. A typical system for a weighing application is shown in the photograph and is built up using a power supply, amplifier, peak value store, auto-tare and limit switch, all contained in a cast metal housing which is secure against dirt and the direct jet from a hose. Reference-signal generators are included, providing 225Hz, 5kHz or direct-voltage outputs. The equipment is made by Hottinger Baldwin Messtechnik and is marketed here by Carl Schenck (UK) Ltd, Stonefield Way, Ruislip, Middx HA4 0JT.
WW301

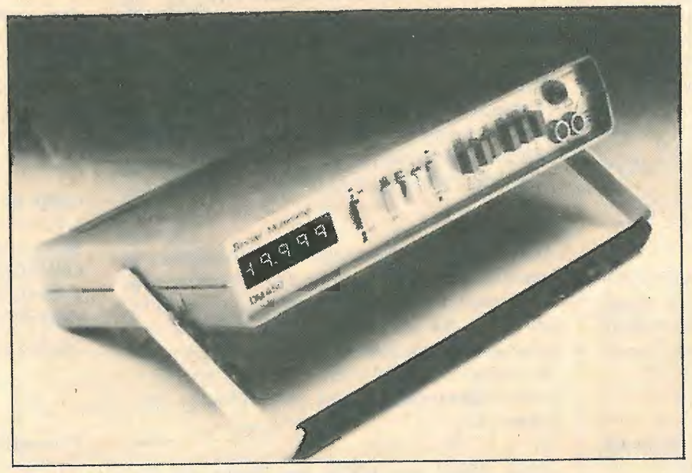
Digital multimeters

Two new meters by Sinclair, the DM350 and DM450, are 3½ and 4½-digit instruments respectively, offering a similar set of ranges and facilities, the DM450 at greater accuracy and resolution. Basic accuracy is 0.1%±1 digit and 0.05% ±1 digit and each type will measure from 100μV d.c. and a.c., 1nA d.c., 1μA a.c. and from 100mΩ to 20MΩ. Each has a diode test facility. The instruments are in very slim plastic cases with tilt stands, similar in form to that of the older DM235, and can be provided with a carrying case and neck strap for 'hands-off' use. Four C cells provide the power, or an a.c. adaptor can be used. Rechargeable batteries and a high-voltage probe are accessories. Sinclair Radionics, London Road, St. Ives, Huntingdon, Cambs PE17 4HJ.
WW302

Temperature probe

Effectively a temperature-to-voltage transducer, the Model TP-28 from B and K Precision enables temperature in the range −50° to +150°Celsius to be measured by means of an ordinary analogue or digital voltmeter. Liquids, gases or solids can be examined and in the case of a liquid the short settling time after a 100° change of 10s is achieved. A suggested way of using the probe is to examine small electronic components for overheating.


WW301


WW302

The meter used with the probe must have an impedance of over 10kΩ on the 0-3V range. Maximum error of the combination is quoted as ±1.7°C ± the error of the meter. Power to the probe unit is 9V, a small radio battery lasting around 120 hours of continuous use, and the end of battery life is indicated. B and K Precision, 6460 W. Cartland Street, Chicago, Illinois 60635, U.S.A.
WW303

Power resistors

The Erg range of miniature, wirewound power resistors, with new closer tolerance, are said to fill the gap left by metal oxide power resistors in the lower values of resistance. The range is from 30 milliohms up to 18kΩ in the higher voltage applications, at an initial tolerance of 1% to 5% – any value in the range. Instability is claimed to be reduced by the use of crimped leadouts, and temperature variations are normally specified as +60 p.p.m./°C. Alternative specifications for specialized work are available. Erg Components, Luton Road, Dunstable, Beds LU5 4LJ.
WW304

Television sound i.c.

The TDA2190 integrated circuit contains an i.f. limiter amplifier with output low pass filter, f.m. detector, d.c. volume control, audio input/output point for tone controls and v.c.r. audio preamplifier and power amplifier. The power amplifier can operate in either a class B or a constant current consumption mode. The power output at V_s = 24V is up to 4.5W into 16 ohms (class B) or 3.5 W into 16 ohms (c.c.c. mode). The device is mounted in a power d.i.l. package incorporating a copper slug for up to 15W power dissipation. SGS-ATES (UK) Ltd, Planar House, Walton Street, Aylesbury, Bucks.
WW305

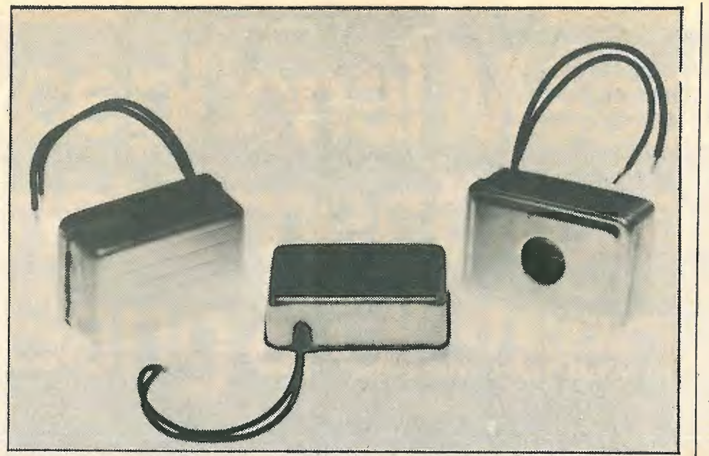
Remote controlled transmitters

A range of 1.0kW frequency synthesized h.f. solid-state transmitters, designated the T1005 series, offers full remote control over any distance. Up to 10 transmitters can be controlled from a single unit. The makers say a country's complete h.f. transmitting network could be controlled from one point in this way. Frequency, type of service and other operational facilities, including optional antenna selection, are all under the control of the remote operator. Frequency and service information can be stored on up to 15 channels for recall purposes. Commands are made on a 20-button keyboard, and a digital readout is provided of transmitter, channel and frequency selected. The series of transmitters covers a frequency range of 1 to 29.9999 MHz, with 290,000 channels in 100Hz steps. Transmission modes are s.s.b., c.w., m.c.w., d.s.b. and optional i.s.b. A control system gives protection from mismatch of an antenna circuit ranging from short-circuit to open-circuit output. Redifon Telecommunication Ltd, Broomhill Road, Wandsworth, London SW18 4JQ.
WW306

Buzzers

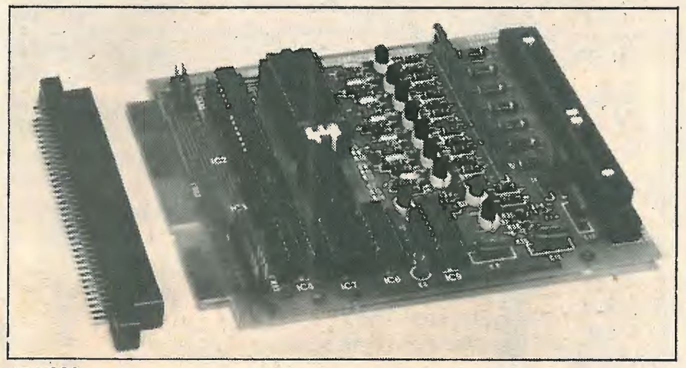
Small buzzers, for use in portable, battery-operated equipment, are now available in a new range, Type GA100/K, from Highland. The 400Hz tone is produced electronically, at between 70 and 83dBA at 22cm. Supplies of 2.5, 6,

12 or 24V d.c. are needed, depending on the version ordered, each type being contained in 22 x 15 x 10mm plastic case, which is colour coded to indicate voltage. The units can be mounted by a clip, by double-sided adhesive strip or by adhesive. Weight is 7g. Highland Electronics Ltd, Highland House, 8 Old Steine, Brighton, East Sussex BN1 1EJ.
WW307


WW307

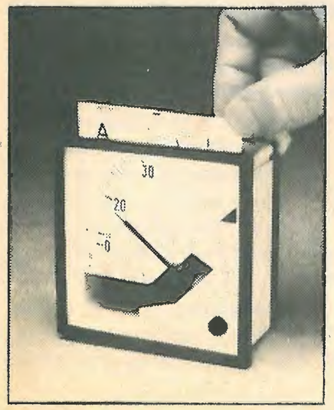
Printer interface

A driver for the Roxburgh SF-30 print mechanism accepts ASCII, bit-parallel character-serial inputs from c.m.o.s. voltage levels. The type 3001 operates the seven-electrode head of the SF-30 to print 64 alphanumeric characters on a 7 x 5 matrix of dots, accommodating 18 characters per line at two lines per second. Voltage supplies needed by the driver board are 12V, −12V, 24V and 35V, provided by a separate power supply, also obtainable from Roxburgh, who are at 22 Winchelsea Road, Rye, East Sussex TN31 7BR.
WW308


WW308

Interchangeable-scale meters

A range of analogue panel meters, comprising ammeters, voltmeters (both moving-coil and moving-iron), varmeters and frequency meters, have removable, interchangeable scale plates. These can be put in or taken out without opening or tampering with the rest of the instrument, so the user can add his own markings. Available in three DIN sizes, 72, 96 and 144 mm square with quadratic scales, all the meters are to specifications CEI 13.6, IEC Publication 51, BS89, VDE 0410, DIN 43700, 43701 and 43802. The total range of scales available goes from mA to MV. The meters have 90° sweep, compressed scales for overload and employ damped, jewelled movements. Long scale instruments (240°) are also available. IMO Precision Controls Ltd, 349 Edgware Road, London W2 1BS.
WW309

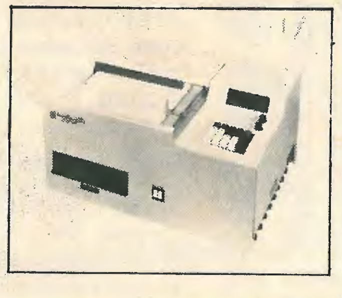


Taut-band VU meters

Sifam's new volume level meter has a performance "virtually indistinguishable from that of a true VU meter under most conditions" according to their marketing director. The new meters meet the requirements of the American Standard C16.5 1954, the company say, except the clause relating to dynamics. They are more heavily damped and have a rise time of about 0.1 second greater than traditional VU meters. They quote time from 0 to −3VU as 0.21 to 0.26 seconds, which compares with 0.13 to 0.15 for their conventional meters. Makers say the price is less than £5. Sifam Ltd, Woodland Road, Torquay TQ2 7AY.
WW310

Signal-processing xy recorder

Sounding more like a new British Standard, BS8000 is a microprocessor-based xy plotter than can digitize, record and process up to eight channels of analogue information. Either raw or processed data are plotted in real time or stored on a flexible disc, equivalent to about 100 metres of chart paper. You can record on pre-set triggering or on event triggering modes at up to 20,000 points per second, or at regular intervals with as few as 86 points per day. Information can be processed before plotting, of course, in a variety of ways that includes averaging, smoothing, differentiation, integration.



Last year the same company introduced the first chart recorder with built-in memory enabling the Transcribe 10 to perform as a transient recorder. Bryans Southern Instruments Ltd, Willow Lane, Mitcham, Surrey CR4 4UL.
WW311

Large-numeral multimeter

We first saw the Metrix digital multimeter at the recent opening of Precision Instrument Laboratories new showroom. It is notable in that two PP3 batteries will give 1000 hours operation. And the number of hours service left in the battery can be displayed once the expected life drops below 200 hours. What's more, manganese alkaline batteries double this time to give three years "autonomy" at eight hours a day. This long battery life for a digital multimeter, and its 18mm numerals, single-function switch and price of £109 make it unique among such meters. The c.m.o.s. microprocessor and liquid crystal display consume 250μA. Accuracy on most range is ±1% reading ±0.25% f.s.d. (better on direct voltage) and best resolution 1mV, 10A and 1Ω. Many other performance details of the instrument, made by Metrix of Chemin de la Croix Rouge, Annecy are available from their U.K. agents Precision Instrument Laboratories Ltd, 727 Old Kent Road, London SE15.
WW312

Power regulator

The Domino power regulator has a group of parallel slave units controlled by a voltage or current master amplifier. By connecting an appropriate number of 20A slaves in parallel, any required current can be regulated. The units are encapsulated circuits enclosed in a metal case, which has an electrically isolated flat aluminium surface for mounting on convection or force-cooled heat sinks. Each slave can dissipate up to 250W at 20A, and the voltage master provides voltages between 0 and 55V. The constant current system can provide accuracies and linearities claimed to be better than 0.01%. A redundancy system enables full output to be maintained if one of the slaves becomes faulty. Roband Electronics Ltd, Charlwood Works, Charlwood, Surrey RH6 0BU.
WW313

Router for p.c.bs

A router has been designed specifically for development of prototype p.c. boards. The removable guide pin, adjustable fence and end/depth stop, fitted as standard, allow a variety of work to be done. Profiles can be cut from a master using the guide pin; cut-outs for edge connector keys, relays and other components can be made using the fence and end stop, and unwanted tracks removed using the cutter heights adjustment. Also, boards can also be chamfered to remove rough edges. Construction is of steel and aluminium and the key type chuck has a 4mm maximum capacity. The work area is lit by a lamp and the 100-watt motor drives the cutter at 16000 to 18000 r.p.m. A vacuum cleaner adaptor is available for removing swarf. Price is £245 plus v.a.t. Circuitape Ltd, 33 New Street, Aylesbury, Bucks.
WW314

SIDEBANDS by Mixer

Silicone geraniums

In the interval between the fall of the despotic valve and the beginning of integration, the majority of semiconductor devices were carved out of germanium. It wasn't a name commonly used by non-technical people and, as often as not when they did come across it, it came out as *geranium*. It even crept into *Wireless World* on one or two occasions, but we kept quiet about it and everyone was too kind to refer to the mistake. The BBC, of course, maintained such a high standard that they never, ever committed such a gaffe.

It's all changed now, though. We don't have much geranium now, but we do seem to have much the same trouble with silicone. I recently had a letter from F. L. Devereux who, as most readers will know, was Editor of *W.W.* for many years. He writes a very entertaining letter, does Dev., and although he appears cheerful on the surface, one can sense the raw, naked aggression under the surface. His bête noire is the now widespread use of the word silicone, when silicon is meant, as in silicon chip. And the surprising thing is that the BBC are as much to blame as anyone, this time. He has this fantasy, he says, of microprocessors being made of a kind of elastomer and moulded into the form required by the designer.

It's a bit sad about the Beeb, I feel. The Pronunciation Unit used to be concerned mainly with words like Brno, Szechwan and axolotl, but must now be kept fairly busy explaining how to speak plain English. Since the gabblers, mutterers and mid-Atlantic snarlers took over, one can't depend on broadcasters for a lead any more. It's as though the Coldstream Guards had started to slop around like a bunch of old lags in the exercise yard.

Production wine

It's been a good year for apples. We have two trees, both a bit peculiar but laden down to the ground with the rummest-looking fruit I've ever come across. One is a crab-apple, which is fair enough, I suppose, although a bit limited in application, and the other produces gigantic red apples. Not just red skins, you understand, but red all the way through. The first year we moved into the house, I kept waiting for them to turn into ordinary apples, but they never did.

Well, anyway, in our family, we draw the line at red apple pie and after a while we got fed up with apple jelly, so I thought I'd get into wine making. Two years ago, I made a tentative gallon of wine in a most unscientific way and it was beautiful. It went through the malo-lactic fermentation (pure luck, nothing to do with intent) and it tasted like nectar. So, this last October, I went gently mad and made seven gallons, only this time I got hold of all the technical-looking glassware and yeast, and tablets and stuff and did the job properly and it's awful. Actually, it's only just now clearing, but I've been having a furtive taste every now and then and the effect is grotesque. It feels as though it's making hair grow on the inside of your head.

As I've mentioned before, electronics is into practically everything now, so there has to be a way of testing the brew before it goes beyond recall. You can't tell by looking at it that it's going to be either poisonous or liquid gold, and there is definitely a need for some kind of gizmo or dip into it, with a meter scaled from, say, 'Uk' to 'Wow', or 'sink' to 'cellar'. Warned in time, my seven gallons could possibly have been upgraded from Uk to So-So, but now there are going to be lots of very drunk sewer-rats stumbling around. Maybe a pH meter would help, if I knew what to look for, but I haven't come across anything, so far, which will warn me to take remedial action. It could be I've identified a hole in the market here.

Freudian chip

I always seem to be going on about computers. It isn't that I have anything against them — not much, anyway — but I do become noticeably agitated when someone suggests that computers could take over from the Almighty in their spare time and spend the rest of the week playing each other at three-dimensional chess. In a recent communication from a firm of program (see? I haven't forgotten!) suppliers for a home computer, the spectacular suggestion is made that if one is experiencing a pain in the brain, all one has to do is post a floppy disc into the machine, which promptly turns into a psychiatrist. Honestly! Cross my heart, that's what it says. The sample of operator/computer conversation in the handout seems to be concerned with this chap who can't stand the sight of his mother and I would dearly like to know how it finishes. Also, what effect a fault in programming would have. The first case of matricide committed on advice from a computer would definitely be in the 'man bites dog' class of news item, and could conceivably cause a good deal of head scratching in the legal profession. The program is actually very relevant since anyone who thinks a computer is going to help in circumstances of that kind is almost certainly in need of a psychiatrist.

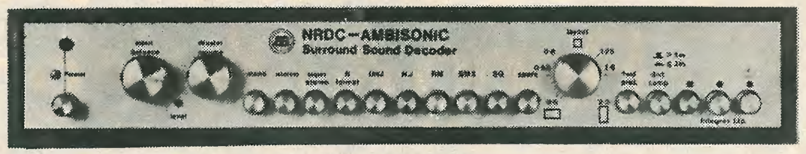
Sight and sound

A letter from John Corner, of Whiteley Electrical Radio, informs me that the public address system at London Bridge was not, when I wrote the piece in the October issue, new. It was the old equipment I heard, the new one still being in their factory. So much for British Rail's accuracy in replying to a request for information. I've heard the new system now, and the concourse coverage is much improved, but there does seem to be a certain amount of trouble in the station itself. I'm now convinced that the problem lies more in the way it is used than in the system — some announcements are clear as a bell, others convey no information at all. Not to me, at any rate. The ones I can make out are spoken slowly, with expression; the others are read in a flat monotone, at a speed which allows the main echo to coincide with the next syllable, rendering both useless.

The recommended drill now adopted by experienced commuters is to hang about unconcernedly in the concourse until the train one wants is signalled on the big new visual-display board and then to race like a stag to get to the train before all the fierce ladies with their enormous bags beat you to it. The p.a. is of great help here, because as soon as you see the destination come up, you can start running and listen for the platform number on the wing, so to speak. I've gained nearly five seconds, several times, in this way. If you stop to pick up the people you've knocked down there is, of course, a danger of losing the advantage.

I still think v.d.us on the platforms would be a good idea, since those whose business it is to make life difficult sometimes change the destination of a train when everyone is comfortably settled with the crossword, and if you can't hear the platform p.a. you are left wandering about asking complete strangers what in the world is happening. I am usually reduced to chasing after the mob, and I am certain I shall finish up in Eastbourne one of these days. Not that I have anything against Eastbourne, but I happen to live near Croydon.

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 **£49.50** + VAT
or ready built and tested **£67.50** + VAT

NEW S5050A STEREO AMP

50 watts rms-channel. 0.015% THD. S/N 90 dB, Mags/n 80 dB.

Tone cancel switch. 2 tape monitor switches.

Complete kit only **£63.90 + VAT.**

Wireless World Dolby™ noise reducer

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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: £43.90** + VAT

Also available ready built and tested .... **Price £59.40** + VAT

Calibration tapes are available for open-reel use and for cassette (specify which) .... **Price £2.40** VAT*

Single channel plug-in Dolby™ PROCESSOR BOARDS (92 x 87mm) with gold plated contacts are available with all components .... **Price £9.00** + VAT

Single channel board with selected fet .... **Price £2.75** + VAT*

Gold Plated edge connector .... **Price £1.75**+VAT*

Selected FETs **65p** each + VAT, **110p** + VAT for two, **£2.10** + 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?

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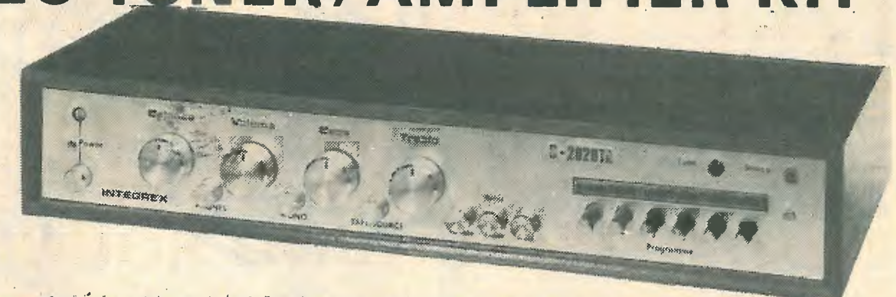
INTEGREX

S-2020TA STEREO TUNER/AMPLIFIER KIT

SOLID MAHOGANY CABINET

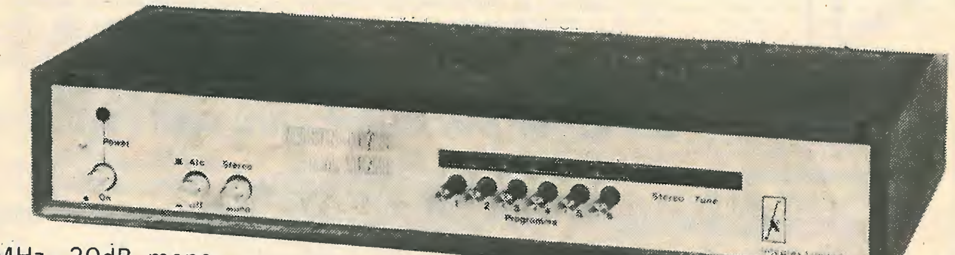


A high-quality push-button FM Varicap Stereo Tuner combined with a 24W r.m.s. per channel Stereo Amplifier.

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: £59.95** + VAT
Nelson-Jones Mk. 2 Stereo FM Tuner Kit. Price: **£69.95** + VAT.

NELSON-JONES MK. I 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 £36.40 + VAT
With ICPL Decoder £40.67 + VAT
With Portus-Haywood Decoder £44.20 + 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 £33.95 + 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: £35.95 + VAT

BASIC NELSON-JONES TUNER KIT £15.70 + VAT
BASIC MODULE TUNER KIT (stereo) £18.50 + VAT
PHASE-LOCKED IC DECODER KIT ... **£4.47**+VAT
PUSH-BUTTON UNIT .... **£6.00** + VAT
PORTUS-HAYWOOD PHASE-LOCKED STEREO DECODER KIT .... **£8.80** + VAT

It's W-W-WINTER S-SALE T-T-TIME again!

74 SERIES TTL ICs

Type	Price	Type	Price	Type	Price	Type	Price	Type	Price
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7401	£0.09	7428	£0.25	7473	£0.22	74107	£0.22	74164	£0.65
7402	£0.09	7430	£0.08	7474	£0.22	74110	£0.35	74165	£0.65
7403	£0.09	7432	£0.20	7475	£0.27	74111	£0.55	74166	£0.75
7404	£0.09	7433	£0.28	7476	£0.22	74118	£0.75	74167	£2.00
7405	£0.09	7437	£0.20	7480	£0.40	74119	£1.10	74174	£0.60
7406	£0.22	7438	£0.20	7481	£0.80	74121	£0.22	74175	£0.60
7407	£0.22	7440	£0.10	7482	£0.65	74122	£0.35	74176	£0.55
7408	£0.12	7441	£0.45	7483	£0.55	74123	£0.38	74177	£0.55
7409	£0.12	7442	£0.38	7484	£0.82	74136	£0.50	74180	£0.80
7410	£0.09	7443	£0.88	7485	£0.65	74141	£0.50	74181	£1.25
7411	£0.15	7444	£0.88	7486	£0.22	74145	£0.54	74182	£0.55
7412	£0.14	7445	£0.64	7489	£1.60	74150	£0.65	74184	£1.00
7413	£0.22	7446	£0.60	7490	£0.30	74151	£0.45	74190	£0.68
7414	£0.45	7447	£0.45	7491	£0.60	74153	£0.45	74191	£0.68
7416	£0.22	7448	£0.52	7492	£0.32	74154	£0.80	74192	£0.65
7417	£0.22	7450	£0.09	7493	£0.28	74155	£0.48	74193	£0.60
7420	£0.09	7451	£0.09	7494	£0.70	74156	£0.48	74194	£0.55
7421	£0.19	7452	£0.09	7495	£0.45	74157	£0.48	74195	£0.55
7422	£0.15	7453	£0.09	7496	£0.48	74160	£0.55	74196	£0.60
7423	£0.20	7454	£0.09	74100	£0.80	74161	£0.60	74197	£0.58
7425	£0.18	7460	£0.09	74104	£0.35	74162	£0.60	74198	£1.00
7426	£0.21	7470	£0.24					74199	£1.00
								74279	£1.00

CMOS ICs

Type	Price	Type	Price	Type	Price	Type	Price
CD4000	£0.12	CD4017	£0.65	CD4031	£1.60	CD4055	£1.00
CD4001	£0.13	CD4018	£0.70	CD4035	£0.90	CD4056	£1.15
CD4002	£0.13	CD4019	£0.35	CD4037	£0.78	CD4069	£0.15
CD4006	£0.80	CD4020	£0.80	CD4040	£0.78	CD4070	£0.15
CD4007	£0.14	CD4021	£0.75	CD4041	£0.68	CD4071	£0.15
CD4008	£0.80	CD4022	£0.75	CD4042	£0.68	CD4072	£0.15
CD4009	£0.40	CD4023	£0.13	CD4043	£0.78	CD4081	£0.15
CD4010	£0.42	CD4024	£0.55	CD4044	£0.78	CD4082	£0.16
CD4011	£0.13	CD4025	£0.13	CD4045	£1.15	CD4510	£0.80
CD4012	£0.14	CD4026	£1.00	CD4046	£0.95	CD4511	£0.80
CD4013	£0.35	CD4027	£0.45	CD4047	£0.75	CD4516	£0.85
CD4014	£0.70	CD4028	£0.60	CD4049	£0.35	CD4518	£0.85
CD4015	£0.70	CD4029	£0.75	CD4050	£0.35	CD4520	£0.85
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BP24	52 Projects Using IC741 for equivalents	0.75	£0.68
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Regulated Current 0-2A
AC Input Maximum 25v

Eliminates the use of batteries and thus saves £'s — can be used time and time again. **ONLY £7.60+V.A.T.**

BRAND NEW
ITT 923 Silicon.
Diodes 200mA 200v.

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1,000 off	£15.00
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Single-sided. Fibre-glass. Board 12" × 3½" approx 2 pcs **S143 £0.60**

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No. THY1A/50	1 Amp.	50 volt	TO5	18p
No. THY1A/400	1 Amp.	400 volt	TO5	32p
No. THY3A/50	3 amp.	50 volt	TO64	25p
No. THY3A/200	3 Amp.	200 volt	TO64	32p
No. THY3A/400	3 Amp.	400 volt	TO64	40p
No. THY5A/50	5 Amp.	50 volt	TO66	25p
No. THY5A/400	5 amp.	400 volt	TO66	40p
No. THY5A/600	5 Amp.	600 volt	TO66	50p
No. C106/4	6 Amp.	400 volt	TO220	42p

TRIAC

S84 8 Amp. 400 volt TO220 **80p**

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ITT	V413 equt	12p
BR100	D32 each	12p

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16201	18 Electrolytics	4.7μF — 10μF	
16202	18 Electrolytics	10μF — 100μF	
16203	18 Electrolytics	100μF — 680μF	

All 3 at SPECIAL PRICE of £1.20*

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16161	24 Ceramic Caps	100pF — 390pF
16162	24 Ceramic Caps	470pF — 3300
16168	21 Ceramic Caps	4700pF — 0.047μF

All 4 at SPECIAL PRICE of £1.60

RESISTOR PAKS

Order No.

16213	60¼W.	100 ohm — 820 ohm
16214	60¼W.	1K — 8.2K
16215	60¼W.	10K — 82K
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16218	40½W.	1W — 8.2K
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16220	40½W.	100K — 820K

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No. MVR7805	μA7805	TO220	55p
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No. MVR7824	μA7824	TO220	55p

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μA723C TO99 **38p** 72723 14 pin Dil **38p**
LM309K TO3 **£1.20**

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S5	5 x 5 Pin 180 DIN Plugs	50p*
S6	8 x 2 Pin Loudspeaker Plugs	50p*
S7	6 x Phono Plugs Plastic	50p*
S8	5 x 3.5 mm Chassis Sockets (Switched)	25p*
S9	5 x 2.5 mm Chassis Sockets (Switched)	25p*
S11	2 x Stereo Jack Sockets with instruction leaflet for H/Phone connection	50p*
S12	5 x 5 Pin 180 DIN Chassis Sockets	40p*
S13	8 x 2 Pin DIN Chassis Sockets	50p*
S14	6 x Single Phono Sockets	40p*

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S110 Mixed Bundle P.C.B. Fibre-glass, paper single and double-sided Fantastic value **75p**

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No. 16134	50 750mA Sil. top hat Rects.	40
No. 16135	20 3 amp Sil. stud Rect.	40
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No. 16137	30 NPN Plastic trans. like BC107/8	40
No. 16138	30 PNP Plastic trans. like BC177/8	40
No. 16139	25 NPN trans. like 2N697/2N1711 TO39	40
No. 16140	25 PNP trans. like 2N2905 TO39	40
No. 16141	30 NPN trans. like 2N706 TO18	40
No. 16143	30 NPN Plastic trans. like 2N390[illegible]	40
No. 16144	30 PNP plastic trans. like 2N390[illegible]	40
No. 16145	30 PNP Germ. trans. like OC71	40
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2 amp 750mW

	VCE	VCB	HFE	
NKT301	40	60	30-100	**35p** per
NKT302	40	60	50-100	**35p** per
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From U.S.A. *by* DINDY
SCREW CASED
LOW NOISE CASSETTES
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FETs

2N3819 **15p** 2N5458

2 AMP. BRIDGE RECTIFIERS

Metal Stud Mounting

No. S45	50V	(KBS 005)
No. S46	100V	(KBS 01)
No. S47	200V	(KBS 02)

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S99 Mixed Pak 2 — 5 Amp. 50-600v. All coded. 4 for £1

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08	High-quality electrolytics 10mF-500mF voltage range 15 50V Our mix 40 for	£1.00*
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Order No.			
191	6 x 470 Ohm	LIN Single	40p*
	6 x 1K	LIN Single	40p*
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193	6 x 22 K	LIN Single	40p*
195	6 x 47 K	LOG Single	40p*
194	6 x 47 K	LIN Single	40p*
	6 x 100 K	LIN Single	40p*
	6 x 100 K	LOG Single	40p*
	6 x 500 K	LOG Single	40p*
	6 x 50 K	LIN Single	40p*

Slider 60mm TRAVEL

	6 x 2 5 K	LOG Single	40p*
	4 x 100 K	LOG Dual	40p*
	4 x 1 3 MEG	LOG Dual	40p*
	6 x 220 K	LIN Single	40p*
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Mixed slider pots—various values and sizes: our mix only **£1.00***
5 x Chrome slider knobs **40p***

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Wirewound Pots Linear 1 Watt Rating Mixed—useful values: 5 for **£1.00***

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Car Radio type Dual Switched Pot P.C. mounting
K Lin switched
2 5 K Lin each **60p***

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mm Shaft

	4 x 100 K Lin	£1.00*
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173	15 Rotary Pot Assorted	40p*
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20 mixed values 400mW Zener diodes 3-10V	£1.00
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SILICON POWER TRANS. N.P.N.

BD371 2 Amp 1 2w 60Vceo Hfe 40-400 Case TO92 with heat tab — 5 for **60p***
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S127 GP91 1SC Special Offer **£1.00***

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Super Save Pak
S124 6 × 741P **£1.00**
S125 5 × 555 **£1.00**

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S137 20 Assorted Slider Knobs — Chrome Black **£1.00***

S131	2 × 12v Relays plastic case	£0.70*
S132	2 × 24v Relays plastic case	£0.60*
S133	1 Switch bank 5-way incl silver knob	£0.75*
S134	2 × Magnets suitable for reed switches	£0.10
S135	1 Veroboard pak 2 pcs 45sq ins approx	£0.80
S136	15 Veroboard pak 2 pcs 60sq ins approx	£1.10
16199	1 Veroboard pak pcs 30sq ins approx	£0.50
16200	15 Veroboard pak pcs 30sq ins approx	£0.50

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SUPER DUPER COMPONENT BOX

Min 3lbs in weight consisting of a fantastic assortment of Electronic Components — Pots, Resistors, Condensers, Switches, Relays, Board-Semiconductors, wire, hardware, etc etc etc
★ This is a large box and is sent separate to your order ★
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COMPLETE AUDIO AMPLIFIER KITS

STA15. 15 watts per channel amplifier kit. CONSISTS: 2 × AL60 — 1 × PA100 — 1 × SPM80 — 1 × 2034 transformer — 2 × coupling capacitors. **£37.70 inc. V.A.T. + 86p p&p.**

STA25. 25 watts per channel amplifier kit. CONSISTS: 2 × AL60 — 1 × PA100 — 1 × SPM120/45 — 1 × 2040 transformer — 1 × reservoir capacitor — 2 × coupling capacitors. **£41.45 inc. V.A.T. + £1.16 p&p.**

STA35. 35 watts per channel amplifier kit. CONSISTS: 2 × AL80 — 1 × PA100 — 1 × SPM120 — 1 × 2041 transformer — 1 reservoir capacitor — 2 × coupling capacitors. **£48.45 inc. V.A.T. + £1.16 p&p.**

STA50. 50 watts per channel amplifier kit. CONSISTS: 2 × AL120 — 1 × PA200 — 1 × SPM120/65 — 1 × 2041 transformer — 1 reservoir capacitor — 2 × coupling capacitors. **£58.20 inc. V.A.T. + £1.10 p&p.**

STA125. 125 watts per channel amplifier kit. CONSISTS: 2 × AL250 — 1 × PA200 — 2 × SPM120/65 — 2 × 2041 transformers — 1 × reservoir capacitors — 2 × coupling capacitors. **£72.85 inc. V.A.T. + £1.25 p&p.**

TRANSISTORS

BRAND NEW — FULLY GUARANTEED

Type	Price	Type	Price	Type	Price	Type	Price	Type	Price
AC107	25p	BC177	12p	BF194	*9p	TIP32A	34p	2N1613	15p
AC126	14p	BC178	12p	BF195	*9p	TIP32B	35p	2N1711	15p
AC127	16p	BC179	12p	BF196	*12p	TIP32C	36p	2N1893	28p
AC128	16p	BC182	*9p	BF197	*12p	TIP41A	34p	2N2218	15p
AC128K	24p	BC182L	*9p	BF200	25p	TIP41B	35p	2N2218A	18p
AC176	16p	BC183	*9p	BFX29	22p	TIP41C	36p	2N2219	15p
AC176K	24p	BC183L	*9p	BFX84	18p	TIP42A	36p	2N2219A	18p
AC187	16p	BC184	*9p	BFY50	12p	TIP42B	37p	2N2221	15p
AC187K	26p	BC184L	*9p	BFY51	12p	TIP42C	38p	2N2221A	16p
AC188	16p	BC212	*10p	BFY52	12p	TIP2955	65p	2N2222	15p
AC188K	26p	BC212L	*10p			TIP3055	42p	2N2222A	16p
AD161/		BC213	*10p	MPSA05	*22p	ZTX107	*6p	2N2369	10p
162 MP	80p	BC213L	*10p	MPSA06	*22p	ZTX108	*6p	2N2904	14p
AF139	30p	BC214	*10p	MPSA55	*22p	ZTX109	*7p	2N2904A	15p
AF239	30p	BC214L	*10p	MPSA56	*22p	ZTX300	*7p	2N2905	14p
BC107	6p	BC251	*10p			ZTX301	*7p	2N2905A	15p
BC108	6p	BCY70	12p	OC44	12p	ZTX302	*9p	2N2906	12p
BC109	6p	BCY71	12p	OC45	12p	ZTX500	*8p	2N2906A	14p
BC118	*10p	BCY72	12p	OC71	9p	ZTX501	*10p	2N2907	12p
BC147	*8p	BD115	*40p	OC72	12p	ZTX502	*12p	2N2907A	13p
BC148	*8p	BD131	*35p	OC75	10p	2N696	10p	2N2926G	*8p
BC149	*8p	BD132	*37p	OC81	14p	2N697	10p	2N2926Y	*7p
BC154	*16p	BF115	17p			2N706	7p	2N3053	12p
BC157	*9p	BF167	19p	TIP29A	35p	2N706A	8p	2N3055	35p
BC158	*9p	BF173	20p	TIP29B	36p	2N708	8p	2N3702	*7p
BC159	*9p	BF180	25p	TIP29C	38p	2N1302	12p	2N3703	*7p
BC169	*10p	BF181	25p	TIP30A	36p	2N1303	15p	2N3704	*6p
BC170	*6p	BF182	25p	TIP30B	37p	2N1304	15p	2N3903	*11p
BC171	*6p	BF183	25p	TIP30C	38p	2N1307	18p	2N3904	*11p
BC172	*6p	BF184	25p	TIP31A	32p	2N1308	22p	2N3905	*11p
BC173	*7p	BF185	25p	TIP31B	33p	2N1309	22p	2N3906	*11p
				TIP31C	34p				

RESISTORS

40 MIXED VALUES. 1 watt & 2 watt RESISTORS. No. S143 ***£0.60**

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DIODES

Type	Price	Type	Price	Type	Price	Type	Price	Type	Price
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BA100	6p			BYZ18	28p	OA91	7p	IN5400	10p
BA115	5p	BY100	15p	BYZ19	28p	OA95	7p	IN5401	11p
BA144	5p	BY127	*10p	OA47	5p			IN5402	12p
BA148	10p	BYZ10	32p	OA70	5p	IN34	5p	IN5404	13p
BA173	10p	BYZ11	32p	OA79	7p	IN60	6p	IN5406	16p
BAX13/		BYZ12	32p	OA81	7p	IN914	4p	IN5407	17p
OA200	5p	BYZ13	30p			IN148	4p	IN5408	19p

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ZN414 RADIO CHIP 75*

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to take 6 x HP7s
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EX-G.P.O. MICROSWITCHES

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S65—50 2.5mm round single pin fixing **30p**

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No. 1514	NORP 12	**45p** each
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POWER SUPPLY STABILIZER BOARD

Unused ex-equipment stabilizer board. Input 30V. D.C. Output 20V. Complete with circuit diagram
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O/N 2015
30p each

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DEPT. W.W.3, P.O. Box 6, Ware, Herts.
COMPONENTS SHOP: 18 BALDOCK STREET WARE, HERTS.

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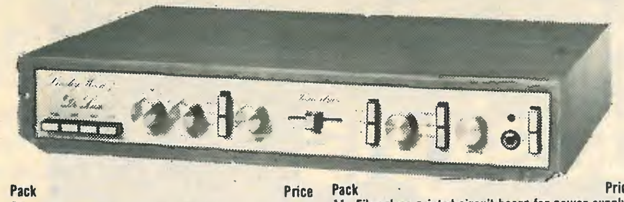
ELECTRONIC KITS OF DISTINCTION FROM POWERTRAN

DE LUXE EASY TO BUILD LINSLEY-HOOD 75W AMPLIFIER



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. High Quality Teak Veneer 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

PACK PRICES FOR STANDARD KIT

AVAILABLE AS SEPARATE PACKS
PRICES IN OUR FREE CATALOGUE

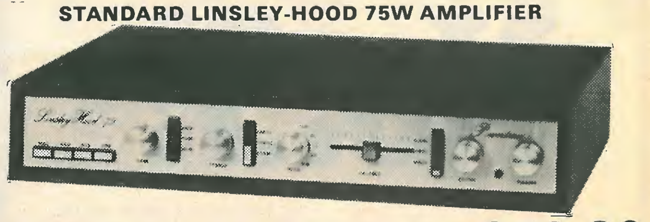
SPECIAL PRICE FOR COMPLETE KIT £99.30

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.

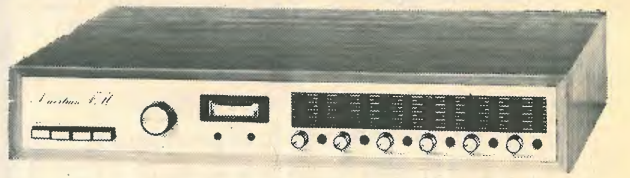
Our new De Luxe model uses 14 boards which interconnect with gold plated contacts and are designed to have the potentiometers and switches mounted upon them. This system almost eliminates internal wiring, making installation, after their assembly, delightfully straightforward, and as each board can be 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.

STANDARD LINSLEY-HOOD 75W AMPLIFIER



SPECIAL PRICE FOR COMPLETE KIT £79.80

WIRELESS WORLD FM TUNER

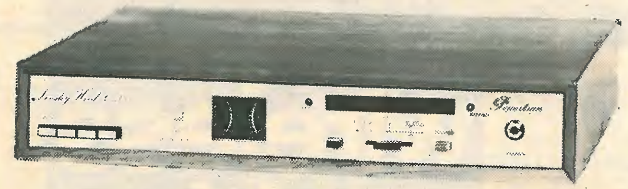


Designed in response to demand for a tuner to complement the world-wide acclaimed Linsley-Hood 75W Amplifier, this kit provides the perfect match. The Wireless World (Skingley and Thompson) published original circuit has been developed further for inclusion into this outstanding slimline unit and features a pre-aligned front end module, excellent a.m. rejection and temperature compensated varicap tuning, which may be controlled either continuously or by push-button pre-selection. Frequencies are indicated by a frequency meter and sliding LED indicators, attached to each channel selector pre-set. The PLL stereo decoder incorporates active filters for "birdy" suppression and power is supplied via a toroidal transformer and integrated regulator. For long term stability metal oxide resistors are used throughout.

AVAILABLE AS SEPARATE PACKS — PRICES IN OUR FREE CATALOGUE

SPECIAL PRICE FOR COMPLETE KIT £70.20

LINSLEY-HOOD CASSETTE DECK



SPECIAL PRICE FOR COMPLETE KIT £79.60

Pack	Price
1. Stereo PCB (accommodates 2 rep. amps, 2 meter, amps, bias/erase osc. relay)	£3.35
2. Stereo set of capacitors, M.O. resistors, potentiometers for above	£7.95
3. Stereo set of semiconductors for above	£8.50
4. Miniature relay with socket	£2.90
5. PCB, all components for solenoid, speed control circuits	£3.80
6. Goldring-Lenco mechanism as specified	£18.50
7. Function switch, knobs	£1.90
8. Dual VU meter with illuminating lamp	£6.95
9. Toroidal transformer with E.S. screen prim. 0-117V, 234V. Sec. 15V	£4.90
10. Set of capacitors, rectifiers, I.C. voltage regulator P.C.B. for power supply (Powertran design)	£2.80
11. Set of miscellaneous parts, including sockets, fuse holder, fuses, interconnecting wire, etc.	£3.40
12. Set of metalwork including silk screened fascia panel, internal screen, fixing parts, etc	£7.10
13. Construction notes	£0.25
14. High Quality Teak Veneer cabinet 18.3" x 12.7" x 3.1"	£10.70

One each of packs 1-14 inclusive are required for complete stereo cassette deck. Total cost of individually purchased packs £83.00

Matsushita WY 436 AZ head (optional extra) . £4.50 (free with compete kit)

Published in Wireless World (May, June, August 1976) by Mr. Linsley-Hood, this design, although straightforward and relatively low cost, nevertheless provides a very high standard of performance. To permit circuit optimization separate record and replay amplifiers are used, the latter using a discrete component front-end designed such that the noise level is below that of the tape background. Pushbutton switches are used to provide a choice of equalization time constants, a choice of bias levels and also an option of using an additional pre-amplifier for microphone use. The mechanism used is the Goldring-Lenco CRV, a unit distinguished in its robustness and ease of operation. Speed control and automatic cassette ejection are both implemented by electronic circuitry. This unit which is powered by a toroidal transformer and uses metal oxide resistors throughout offers an excellent match for the Wireless World Tuner and the Linsley-Hood 75 Watt Amplifier. Circuit changes as published in February, 1978, follow-up article are included in the kit AT NO EXTRA COST! A higher performance head (Matsushita WY 436 AZ head as recommended in the follow-up article) is offered as an optional extra but this will be automatically supplied FREE OF CHARGE with all orders for complete kits!

T20+20 AND T30+30 20W, 30W AMPLIFIERS

Designed by Texas engineers and described in Practical Wireless, the Texan was an immediate success. Now developed further in our laboratories to include a Toroidal transformer and additional improvements, the slimline T20+20 delivers 20W rms per channel of true Hi-Fiet exceptionally low cost. The **easy to build** design is based on a single F/Glass PCB and features all the normal facilities found on quality amplifiers including scratch and rumble filters, adaptable input selector and headphones socket. In a follow-up article in Practical Wireless further modifications were suggested and these have been incorporated into the T30+30. These include RF interference filters and a tape monitor facility. Power output of this model is 30W rms per channel.

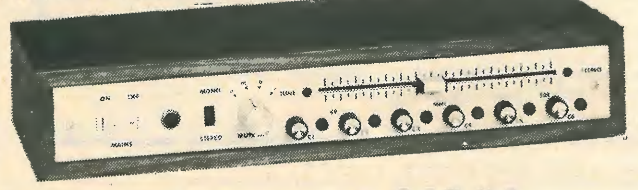
SPECIAL PRICES FOR COMPLETE KITS

T20+20 KIT PRICE £33.10

T30+30 KIT PRICE £38.40

AVAILABLE AS SEPARATE PACKS — PRICES IN OUR FREE CATALOGUE

WWII TUNER

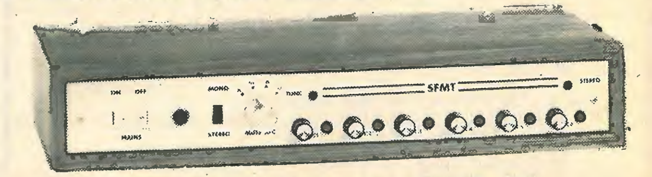


SPECIAL PRICE FOR COMPLETE KIT £47.70

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.

POWERTRAN SFMT TUNER



PRICE FOR COMPLETE KIT £35.90

AVAILABLE AS COMPLETE KIT ONLY

This is a simple, low cost design which can be constructed easily without special alignment equipment but which still gives a first-class output suitable for feeding any of our very popular amplifiers or any other high quality audio equipment. A phase-locked-loop is used for stereo decoding and controls include switchable afc, switchable muting and push-button channel selection (adjustable by controls on the front panel). This unit matches well with the **T20+20** and **T30+30** amplifiers.

EIRE GRENADA SAUDI ARABIA NEW ZEALAND NORWAY SINGAPORE ICELAND SWEDEN MALAYA INDONESIA BRAZIL SWITZERLAND ZAMBIA GIBRALTAR CHILE SPAIN

MUSCAT & OMAN FRANCE DENMARK GAMBIA AUSTRALIA HONG KONG NAURU GERMANY TUNISIA LUXEMBOURG NIGERIA FINLAND SOUTH AFRICA CZECHOSLOVAKIA AUSTRIA

200+200 watt AMPLIFIER

As featured in Electronics Today International

400W rms continuous —— 800W peak!
0.03% THD at FULL power!
PLUS all the following features too!

- ★ Each channel totally independent with its own stabilised power supply driven by custom designed TOROIDAL transformers!
- ★ Inherent reliability — monster heat sinks for cool running at the hottest venues — electronic open and short circuit protection!
- ★ Ultra low feedback (an incredible low 14dB overall!), super high slewing rate (20V/μs), 200W rms continuous to 4 ohm from EACH channel, input sensitivity 0.775V (0dB).
- ★ Professional quality components, sturdy 19 rack mounting chassis 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 instruction suitable for both experienced constructors and newcomers to electronics.
- ★ Value for money — quality and performance comparable with ready-built amplifiers costing over £600!

PSI 4002 STUDIO MODEL

Cabinet size 17.2" x 6.7"

COMPLETE KIT ONLY £196.90+VAT

READ THE REVIEW IN SOUND INTERNATIONAL DEC 78!

TRANSCENDENT 2000 SINGLE BOARD SYNTHESIZER

As featured in Electronics Today International

The kit includes fully finished metalwork, fully assembled solid teak cabinet, filter sweep pedal, professional quality components (all resistors either 2% metal oxide or ½% metal film!) and it really is complete — right down to the last nut and bolt and last piece of wire! There is even a 13A plug in the kit — you need buy absolutely no more parts before plugging in and making great music! Virtually all the components are on the one professional quality fibre glass PCB printed with component locations. All the controls mount directly on the main board, all connections to the board are made with connector plugs and construction is so simple it can be built easily in a few evenings by almost anyone capable of neat soldering! When finished you will possess a synthesizer comparable in performance and quality with ready built units selling for between £500 and £700!

COMPLETE KIT ONLY £172.00 + VAT!

Comprehensive handbook supplied with all complete kits! This fully describes construction and tells you how to set up your synthesizer with nothing more than a multi-meter and a pair of ears!

CHROMATHEQUE 5000 5-CHANNEL LIGHTING EFFECTS SYSTEM

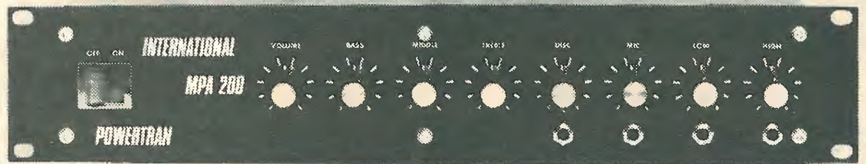
This versatile system featured as a constructional article in ELECTRONICS TODAY INTERNATIONAL has 5 frequency channels with individual level controls on each channel. Control of the lights is comprehensive to say the least. You can run the unit as a straightforward sound-to-light or have it strobe all the lights at a speed dependent upon music level or front panel control setting or use the internal digital circuitry which produces some superb random and sequencing effects. Each channel handles up to 500W and as the kit is a single board design wiring is minimal and construction very straightforward.

Kit includes fully finished metalwork, fibreglass PCB, controls, wire, etc. — Complete right down to the last nut and bolt!

COMPLETE KIT ONLY £49.50 + VAT

MPA200 100W MIXER/ AMPLIFIER

COMPLETE KIT £49.90 + VAT



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

Linsley-Hood Low Distortion Oscillator.

LDO Pk. 1	Fibreglass PCB	£1.65
LDO Pk. 2	MO Resistors, capacitors	£2.60
LDO Pk. 3	Semiconductors	£3.90

E. F. Taylor Pre-Amplifier

EFTP Pk. 1	Fibreglass PCB (stereo)	£1.45
EFTP Pk. 2	MO Res, caps. (stereo)	£3.20
EFTP Pk. 3	Semiconductors (stereo)	£4.20

Details of Stuart Tape Recorder and SQ Quadraphonic Decorders are in FREE CATALOGUE

All kits also available as separate packs (eg PCB component sets, hardware sets, etc). Prices in our FREE CATALOGUE.

EXPORT A SPECIALITY!

Our Export Department can readily despatch orders of any size to any country in the world. Some of the countries to which we sent kits last year are shown in this advertisement. To assist in estimating postal costs our catalogue gives the weights of all packs and kits. This will be sent free on request, by airmail, together with our "Export Postal Guide" which gives current postage prices. There is no minimum order charge. Prices same as for U.K. customers but no Value Added Tax charged. Postage charged at actual cost plus 50p documentaton and handling. Please send payment with order by Bank Draft, Postal Order, International Money Order or cheque drawn on an account in the U.K. Alternatively for orders over £500 we will accept Irrevocable Letter of Credit payable at sight in London.

Value Added Tax not included in prices UK Carriage FREE

PRICE STABILITY. Order with confidence! Irrespective of any price changes we will honour all prices in this advertisement until March 31st, 1979, if this month's advertisement is mentioned with your order. Errors and VAT rate changes excluded.

U.K. ORDERS: Subject to 12½%* surcharge for VAT (i.e. add ⅛ to the price). No charge is made for carriage. *Or current rate if charged.

SECURICOR DELIVERY: For this optional service (U.K mainland only) add £2.50 (VAT inclusive) per kit.

SALES COUNTER: If you prefer to collect your kit from the factory, call at Sales Counter (at rear of factory). Open 9 a.m.-4.30 p.m. Monday-Thursday.

QUALITY: All components are brand new first grade full specification guaranteed devices. All resistors (except where stated as metal oxide) are low noise carbon film types. All printed circuit boards are fibreglass, drilled roller tinned and supplied with circuit diagrams and construction layouts.

FOR FURTHER INFORMATION PLEASE WRITE OR TELEPHONE FOR OUR FREE CATALOGUE

POWERTRAN ELECTRONICS

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WW — 027 FOR FURTHER DETAILS

WW — 062 FOR FURTHER DETAILS

WW — 073 FOR FURTHER DETAILS

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Please Use Capital Letters

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WIRELESS WORLD Wireless World, March 1979 WW 963

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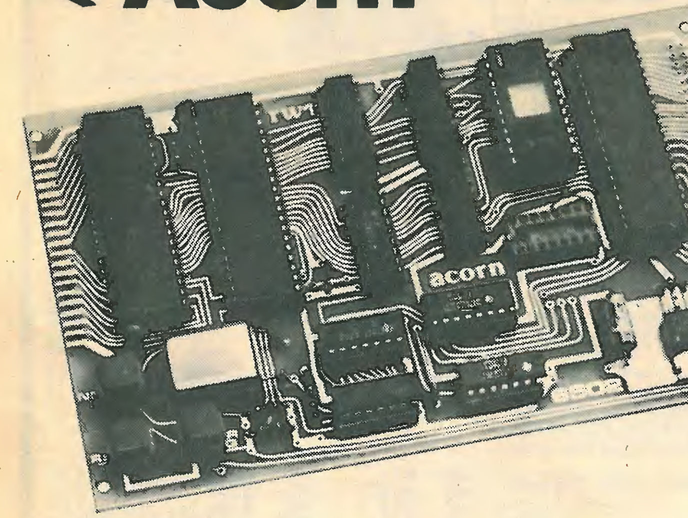

C. T. ELECTRONICS (ACTON) LTD.

267 & 270 ACTON LANE, LONDON W4 5DG. Telephone: 01-994 6275

Registered in England 1179820

CMOS

4000UB	0.17	4027B	0.44	4075B	0.20
4001UB/B	0.17	4028B	0.77	4076B	1.17
4002UB/B	0.17	4029B	1.03	4077B	0.39
4006B	1.04	4032B	0.89	4078B	0.20
4007UB	0.18	4034B	1.71	4081B	0.20
4008B	0.87	4040B	0.97	4082B	0.20
4011UB/B	0.18	4043B	0.88	4093B	0.80
4012UB/B	0.20	4044B	0.84	40160B	1.19
4013B	0.43	4049UB	0.50	40161B	1.19
4014B	0.83	4050B	0.43	40162B	1.19
4015B	0.83	4051B	0.82	40163B	1.19
4016B	0.48	4052B	0.82	40174B	0.85
4017B	0.79	4053B	0.82	40175B	0.86
4018B	0.83	4066B	0.55	40194B	1.19
4020B	1.11	4068B	0.20	4510B	1.01
4021B	0.90	4069UB	0.20	4511B	1.25
4022B	0.82	4070B	0.46	4512B	0.91
4023UB/B	0.18	4071B	0.20	4516B	1.01
4024B	0.70	4072B	0.20	4518B	0.97
4025UB/B	0.20	4073B	0.20	4528B	0.80

6' IMHOFF 19" Racks. Brand new. **£25.00 each** +8% VAT.

We have at time of press over 2 million Electrosil & Welwyn Metal Oxide Resistors well below manufacturer's price. Phone for details.

This advertisement is a fraction of stock held by us. Phone for details:

No mail order accepted unless over £5.00.
Hours of business 9.30am-6pm, Mon-Sat continuous. Carriage & packing charge extra. Government, colleges and export welcome.

We have considerable stock of PT10 & PT15 Presets. Special price for PT15 of the following value: 100Ω, 1k5, 2k2, 4k7, 10k, 22k, 47k, 100k. All the above values @£25/1,000. @12½ VAT. Retail prices all values 10p either PT10 size or PT15. Open or enclosed.

2200μF 100V computer grade electrolytic Mullard **£1.00** +VAT. 12½.

PL259 Plugs with Reducers **50p each** retail. SO239 to suit Plug (259) Bulkhead Socket **45p each** +8% VAT.
BNC Plugs. Brand new. **30p** +8% VAT. Either 50Ω or 75Ω.
N Connectors available at a fraction of list price. Phone for details.

Sealectro Plugs (miniature) Conhex for VHF & UHF applications
75p straight entry type 51-130-3187-91, **90p** right-angled gold plated type 055-014-3196.
All the above RF Connectors are held in depth and are brand new.
Cassette Monotape Heads ¼" **£1.00 each.** Brand new.
Cassette Erase Tape Heads ¼" **£1.00 each.** Brand new. +12½% VAT.
Potentiometers W. Wound 1Ω-100v by A. B. or Colvern Ltd, 1½ watt **40p**, 3 watt **60p**, 5 watt **80p**.

ROTARY SWITCHES available in 30 different types, prices range from **45p-£1.20** +8%.
PREH Television Push-button Tuner Units. 4 and 6 button, brand new in original boxes. **75p each** +12½% VAT. Large quantity available.
★SPECIAL OFFER★ 100k LIN Mono Slider Potentiometer by Noble (metal body). 63mm length, **price 20p each** +12½ VAT. All boxed as original. **Discount on quantity.**

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Open Cermet Presets. Most values in stock. **15p each** +8% VAT.
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(+8% VAT)

PAPST Motor HSZ 20-25-2-425 EEM. 42V 50C/S 10μf cap across size: < 6cm Diam 3.4cm. Shaft: < 1.7cm Diam 4mm. **£1.00 each.**
Smiths Motor 240V 50 C/S 3-hole fixing. Spaced 4.75cm 3rpm. Shaft 1.5cm 3mm diam. **£1.50 each.**
Cassette-deck Motor by Fujiya. 6V DC. <3.25cm. Diam. 3.5cm. Shaft diam 2mm <.9mm. 3-hole fixing 4cm to centres. **£1.25 each.**
General Time Motors with clutch. 240V 1/5rpm. 2-hole fixing. 4.75cm, 3cm depth. Body diam. 4.85cm. Shaft length 1cm, diam. 3mm. **£1.50 each.**
Crouzet Motors. Speeds 6rpm and 10rpm. 2-hole fixing. 4.75cm, 3.9cm depth. Body diam. 4.5cm. Shaft <0.9cm. Diam. 4mm. **£1.50 each.**
Miniature DC Motor 4-15V operation. High torque. <3.5cm. Body diam. 2cm, 2-hole front fixing, shaft diam. 1.75mm. **£1.00 each.**
Plus large stocks General Time Motors in the following speeds: 1/180, ½ rph 12V DC; 1/5rpm 240V; 1rpm 240V.
Miniature Motor Clutches by General Time (USA) 24V operation. Body diam. 2.2cm, 6mm shaft centre. **£1.30 each.**

PUSHBUTTON SWITCH UNITS

4-way 2P/CO. **50p each.** 7-way 5,2P/CO 2,4P/CO. **80p each.** By A. B. Electronics. 8% VAT.

Mullard Pot Core FX2241 **30p each** 8% VAT.
Mullard Ex-computer Electrolytic 20,000μF/45V. **40p each.**

Toko FM, AM, IF Coils etc. Stockholding now in excess of ½ million PCS. Any style available to callers only. **10p each** or 50 PCS for **£1.00** +VAT 12½%.

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(8% VAT)

Single-sided 0.1 pitch.
40-way fixing holes 118mm — RS type **£1.20.**
24-way fixing holes 73mm — UCL **70p.**
Single-sided 0.15 pitch.
15-way fixing holes 75mm — gold plated — EB **60p.**
18-way fixing holes 85mm including locating pin. **75p.** 32-way fixing holes 136mm — gold plated — EB. **£1.50.** 27-way fixing-holes 122mm **£1.30.**
Double-sided 0.1 pitch.
2 x 40-way fixing-centres 117mm gold-plated — Viking **£2.00.**
Double-sided 0.15 pitch.
2 x 40-way fixing-centres 165mm gold-plated **£2.00.**

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(+12½% VAT)

6-0-6 500mA (240V Pri) (63×35×43)	£1.40
0-11 2A 0-22 1A (240V Pri) (76×64×60)	£2.40
12V 130mA (240V Pri) (36×45×40)	£0.75
18V 140mA (240V Pri) (38×31×32)	£0.80
18V 2A (240V Pri) (80×55×70)	£2.80
18V 2½A (240V Pri) (115×65×62)	£2.50
28V 2A (240 Pri) (53×45×37)	£1.00
32V 250mA (240V Pri) (46×37×31)	£1.20
Auto 110, 115, 120, 220, 230, 240, 250V 150VA	£1.50
0-2-4-6-8-10-12V 0-1-2V 5A (RMS) 240V Pri (98×67×80)	£6.00

TTL

7400	0.14	7449	1.00	74125	0.50
7401	0.14	7450	0.20	74132	0.70
7402	0.14	7451	0.20	74141	0.75
7403	0.14	7453	0.20	74145	1.00
7404	0.14	7454	0.20	74150	1.00
7405	0.18	7460	0.20	74151	0.70
7406	0.32	7470	0.35	74153	0.70
7407	0.32	7472	0.30	74154	1.00
7408	0.20	7473	0.30	74155	0.70
7409	0.20	7474	0.30	74156	0.85
7410	0.18	7475	0.45	74157	0.70
7411	0.20	7476	0.35	74160	0.95
7412	0.20	7480	0.60	74161	0.50
7413	0.30	7481	1.00	74162	1.00
7414	0.70	7482	0.90	74163	1.00
7416	0.30	7483	0.80	74164	1.00
7417	0.30	7484	1.10	74165	1.00
7419	0.50	7485	0.90	74166	1.00
7420	0.18	7486	0.30	74167	2.50
7421	0.20	7489	1.60	74170	2.00
7422	0.35	7490	0.35	74174	0.95
7423	0.32	7491	0.50	74175	0.80
7425	0.30	7492	0.45	74176	0.80
7426	0.30	7493	0.40	74177	0.80
7427	0.30	7494	0.90	74180	0.80
7428	0.40	7495	0.65	74181	1.85
7430	0.18	7496	0.65	74182	0.95
7432	0.26	7497	1.90	74184	1.50
7433	0.50	74100	1.40	74185	1.50
7437	0.30	74104	0.70	74188	2.50
7438	0.30	74105	0.70	74190	1.00
7440	0.18	74107	0.30	74191	1.00
7441	0.70	74109	0.55	74192	1.00
7442	0.50	74110	0.55	74193	1.00
7443	1.30	74118	0.95	74194	1.00
7445	1.00	74119	1.30	74195	0.95
7446	1.00	74121	0.28	74196	0.95
7447	0.75	74122	0.55	74197	0.80
7448	0.75	74123	0.55	74198	1.60
				74199	1.60
				74283	1.60

VEROBOARDS

0.1" Pitch Copper Clad		0.15" Pitch Copper Clad	
2.5"×5"	0.59	2.5"×5"	0.53
2.5"×3.75"	0.50	2.5"×3.75"	0.44
2.5"×17"	1.77	3.75"×17"	1.98
3.75"×5"	0.66	3.75"×5"	0.74
3.75"×3.75"	0.59		
3.75"×17"	2.28		
4.7"×17.9"	2.99	0.15" Pitch Plain Board	
2.5"×1" (Sold in 5s)	0.70	5"×3.75"	0.47
		2.5"×5"	0.30
0.1" Pitch Plain Board			
3.75"×17.9"	1.49	New V-Q DIP Board	1.11
3.75"×2.5"	0.36		
3.75"×5"	0.56		

ALUMINIUM BOXES. PLAIN

Type	L	W	H	Retail Price
AB 7	5¼	2½	1	0.70
AB 8	4	4	1½	0.70
AB 9	4	2½	1½	0.70
AB 10	4	5¼	1½	0.70
AB 11	4	2½	2	0.85
AB 12	3	2	1	0.70
AB 13	6	4	2	1.00
AB 14	7	5	2½	1.20
AB 15	8	6	3	1.55
AB 16	10	7	3	1.75
AB 17	10	4½	3	1.45
AB 18	12	5	3	1.75
AB 19	12	8	3	2.40

ALUMINIUM BOXES. BLACK REXINE COVERED

Type	L	W	H	Retail Price
RB 1	6	4½	1¾	1.30
RB 2	8	5	2	1.55
RB 3	9	5	3	1.85
RB 4	11	6	3	2.10
RB 5	11	7½	3½	2.55

ALUMINIUM BOXES. BLUE REXINE COVERED

Type	L	W	H	Retail Price
RB 1	6	4½	2½	1.45
RB 2	8	5	2	1.70
RB 3	9	5	3	1.80
RB 4	11	6	4	2.30
RB 5	11	7½	4½	2.70

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BSR DE LUXE AUTOCHANGER £17.50 Post £1

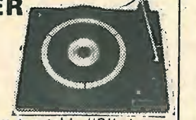
Plays 12", 10" or 7" records, Auto or Manual. A high quality unit backed by BSR reliability. Stereo Ceramic Cartridge. AC 200/250V. Size 13½-11¼in. 3 speeds. Above motor board 3¾in. Below motor board 2½in. with Ceramic Stereo/Mono cartridge.

BSR Budget Autochanger with stereo cartridge, plays all size records **£14.95** Post £1

HEAVY METAL PLINTHS ONLY

Cut out for most BSR or Garrard decks. Silver grey finish. Post £1.00
Model "A" Size 14½ x 12½ x 3in. **£3.50**
Model "B" Size 16 x 13¾ x 3in. **£4.50**
TINTED PLASTIC COVERS ONLY
Sizes: 14½ x 12½ x 4¼in. **£3.** 17½ x 14 x 4in. **£4.50.** 15¼ x 13½ x 4in. **£3.75.**
15 x 13½ x 3in. **£3.50.** 17¼ x 9½ x 3½in. **£3.** Post £1. 14½ x 14¾ x 2½in. Rosewood sides **£4.**
Ideal for record decks, tape decks, etc.

BSR SINGLE PLAYER



Ideal replacement or disco deck with cueing device and stereo ceramic cartridge. 3 speeds. Large turntable, modern design
£19.50 Post £1
BSR P182 3 speeds flared aluminium turntable "S" shape arm, cueing device, ceramic cartridge **£22.50.**
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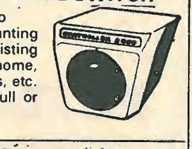
GARRAD HI-FI AUTO CHANGER Model 5-300

3-speed stereo cartridge. **£14.95**
Cueing devices Post £1

SMITH'S CLOCKWORK 15A 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.

ELAC HI-FI SPEAKER 8in. TWIN CONE

Large ceramic magnet. 50-16,000 c/s. Bass resonance 40 c/s. 8 ohm impedance. 10 watts RMS. **£5.95** Post 35p
20 watt model **£8.95** Post 45p

LOW VOLTAGE POWER PACK for MODELS

Ready made. Famous make. Will supply 10 volts D.C. at 400mA. With terminals and mains lead. **£2.50** Post 50p

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.**

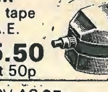
80 Ohm Coax

FRINGE LOW LOSS **15p** yd.
PLUGS **10p.** SOCKETS **10p.**
LINE SOCKETS **25p**
OUTLET BOXES **80p**
300 ohm FEEDER **5p** yd.

EMI 13½ x 8in. LOUDSPEAKERS

With tweeter and crossover. 10 watt. 3 or 8 ohm. **£8.95** Post 45p
With tweeter and crossover. 15 watts. 8 ohm. **£10.50** Post 65p
With tweeter and crossover. 20 watt. 8 or 15 ohm. 20 to 20,000 c.p.s. Post 75p **£11.50**
Suitable Bookshelf Cabinet
Teak finish. For EMI 13 x 8 speakers. Size 16 x 11 x 8 inches approximately. **£8.50** Post £1.00

THE "INSTANT" BULK TAPE ERASER



Suitable for cassettes, and all sizes of tape reels. A.C. mains 200/250V. Leaflet S.A.E. Will also demagnetise small tools
Head Demagnetiser only £4.75. **£5.50** Post 50p

RELAYS. 12V DC **95p.** 6V DC **85p.** 240V AC **95p.**
BLANK ALUMINIUM CHASSIS. 6 x 4—**95p;** 8 x 6—**£1.40;** 10 x 7—**£1.55;** 12 x 8—**£1.70;** 14 x 9—**£1.90;** 16 x 6—**£1.85;** 16 x 10—**£2.20. ANGLE ALI.** 6 x ¾ x ¾in—**15p.**
ALUMINIUM PANELS. 6 x 4—**24p;** 8 x 6—**38p;** 14 x 3—**40p;** 10 x 7—**54p;** 12 x 8—**70p;** 12 x 5—**44p;** 16 x 6—**70p;** 14 x 9—**94p;** 12 x 12—**£1;** 16 x 10—**£1.16.**
PLASTIC AND ALI BOXES IN STOCK. MANY SIZES
VARICAP FM TUNER HEAD with circuit & connections. Some technical knowledge required **£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 SP 30p. DPST **40p.** DPDT **50p.**
MANY OTHER TOGGLES IN STOCK. Please enquire.
PICK-UP CARTRIDGES ACOS. GP91 **£2.00.** GP94 **£2.50.**
SONOTONE stereo **£2.00.**
WIRE-WOUND RESISTORS 5 watt, 10 watt, 15 watt **15p.**
CASSETTE MOTOR. 6 volt **£1.00.**

RCS 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. Suitable for home use. Easy to build. Full instructions supplied. Cabinet **£4** extra. Will operate from 200MV to 100 watt signal.

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

All parts and instructions with Zener diode, printed circuit rectifiers and double wound mains transformer. Input 200/240V a.c. Output voltages available, 6 or 7.5 or 9 or 12V d.c. up to 100mA or less. Size 3 x 2½ x 1½in. Please state voltage required. **£2.95** Post 45p

R.C.S. POWER PACK KIT

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

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

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

R.C.S. DRILL SPEED CONTROLLER/LIGHT DIMMER KIT.
Easy to build kit. Printed circuit **£3.25**
Will control up to 480 watts AC mains 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 **£2.95**
Can be ganged to make multi-way stereo mixers Post 35p

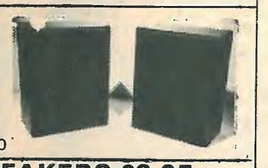
MAINS TRANSFORMERS ALL POST 75p.

250-0-250V 70mA, 6.5V, 2A	£3.45
250-0-250V 80mA, 6.3V 3.5A, 6.3V 1A	£4.60
350-0-350V 80mA, 6.3V 3.5A, 6.3V 1A	£5.80
300-0-300V 120mA, 2×6.3V 2A C.T., 5V 2A	£8.50
220V 45mA, 6.3V 2A	£1.75
HEATER TRANSFORMER. 6.3V ½ amp £1.50 3 amp	£1.75
GENERAL PURPOSE LOW VOLTAGE. Tapped outputs	
2 amp. 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 25 and 30V	£5.30
1 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60	£5.30
2 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60	£8.50
3 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60	£11.00
5 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60	£14.50

12V, 100mA	£1.00	20V, 40V, 60V, 1 amp	£3.50
12V, 750mA	£1.30	12V, 3 amp	£2.95
10-0-10V 2amp	£2.45	10V, 30V, 40V, 2 amp	£2.75
30V, 5 amp and 17V-0-17V 2 amp	£3.45	40V, 2 amp	£2.95
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
25-0-25V 2 amp	£3.50	30V-0-30V, 2 amp	£7.00
30V, 2 amp	£3.00	2 of 18V, 6 amp, each	£9.00
30V, 1½ amp	£2.75	12-0-12V, 2 amp	£2.95
		9V, ¼ amp	£1.30

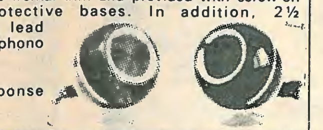
AUTO TRANSFORMERS. 115V to 230V or 230V to 115V 150W ... **£5.00**
250W ... **£6.00** 400W ... **£7.00** 500W ... **£8.00**
FULL WAVE BRIDGE CHARGER RECTIFIERS:
6 or 12V outputs, 2 amp ... **75p.** 4 amp ... **£1.25**
CHARGER TRANSFORMERS. 1½ amp ... **£3.50.** 4 amp ... **£6.50.**
12V, 1½ amp Half Wave Selenium Rectifier ... **25p**

COMPACT SPEAKERS



Teak or White 13 x 10 x 6in. approx. 50 to 14,000 cps. 10 watts. 4 or 8 ohms.
£16 pair Post £1.30

EXTENSION SPEAKERS £3.95 ea.



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 Quality
Frequency Response
Impedance: 8 ohms
Power Peak: 5 watts

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

HIGH VOLTAGE ELECTROLYTICS

8/350V	22p	8+8/450V	50p	50+50/300V	50p
16/350V	30p	8+16/450V	50p	32+32/450V	75p
32/500V	75p	16+16/450V	50p	100+100/275V	65p
50/350V	50p	32+32/350V	50p	150+200/275V	70p

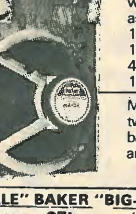
MANY OTHER ELECTROLYTICS IN STOCK

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.**
PAPER 350V-0.1 **7p;** 0.5 **13p;** 1mF 150V **20p;** 2mF 150V **20p;** 500V-0.001 to 0.05 **12p;** 0.1 **15p;** 0.25 **25p;** 0.47 **35p.**
MICRO SWITCH SINGLE POLE CHANGEOVER 20p.
SUB-MIN MICRO SWITCH, 25p. Single pole change over.
TWIN GANG, 385 + 385pF **50p;** 500pF standard **75p.**
365 + 365 + 25 + 25pF. Slow motion drive **65p.**
120pF **TWIN GANG, 50p;** 365pF **TWIN GANG, 50p.**
NEON PANEL INDICATORS 250V. Amber or red **30p.**
RESISTORS. 10Ω to 10M, ¼W, ½W, 1W, 20% **2p;** 2W, **10p.**
HIGH STABILITY. ½W 2% 10 ohms to 1 meg., **12p.**
Ditto 5%. Preferred values 10 ohms to 10 meg., **5p.**

ELECTRO MAGNETIC PENDULUM MECHANISM 95p Post 30p

1.5V DC operation over 300 hours continuous on SP2 battery, fully adjustable swing and speed. Ideal for displays, teaching electro magnetism or metronome, strobe, etc.

BAKER MAJOR 12" £15



Post £1.00
30-14,500 c/s, 12in. double cone, woofer and tweeter cone together with a BAKER ceramic magnet assembly having a flux density of 14,000 gauss and a total flux of 145,000 Maxwells. Bass resonance 40 c/s. Rated 25W. NOTE: 4 or 8 or 16 ohms must be stated.

Module kit, 30-17,000 c/s with tweeter, crossover, baffle and instructions. **£20** Post £1.60 each
Please state 4 or 8 or 16 ohms.

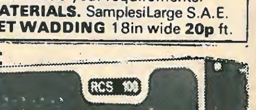
"SALE" BAKER "BIG-SOUND" SPEAKERS. Post £1

'Group 25'	'Group 35'	'Group 50/15'
12 inch 30 watt **£12** 4 or 8 or 16 ohm	12 inch 40 watt **£14** 4 or 8 or 16 ohm	15 inch 75 watt **£33** 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 **£21**
MASSIVE CERAMIC MAGNET Post £1.60
WITH ALUMINIUM PRESENCE CENTRE DOME.

TEAK VENEERED HI-FI SPEAKER CABINETS
For 13x8in. or 8in. speaker **£8.50** Post £1
For 6½in. speaker and tweeter **£5.95** Post 75p
Many other cabinets in stock. Phone your requirements.
SPEAKER COVERING MATERIALS. SamplesiLarge S.A.E.
LOUDSPEAKER CABINET WADDING 18in wide **20p** ft.

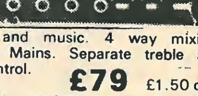
R.C.S. 100 watt VALVE AMPLIFIER CHASSIS



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 £10 extra. Send for leaflet.
Suitable carrying cab **£16.50** Price **£99** carr. £6.00

Horn tweeters 2-16kc/s. 10W 8 ohm or 16 ohm **£3.60.**
Audax Tweeters 3-18kc/s. 50W 8 ohm **£7.50.**
CROSSOVERS. TWO-WAY 3000 c/s 3 or 8 or 15 ohm **£1.90.** 3-way 950 cps/3000 cps, **£2.20.**
LOUDSPEAKERS P.M. 3 OHM 7x4in. **£1.50;** 6½in., **£1.95;** 8x5in., **£1.90;** 8in., **£2.50.**
SPECIAL OFFER: 80 ohm. 2¼in., 2¾in., 35 ohm, 3in., 25 ohm, 2½in., 3in., 5x3in., 7x4in., 8 ohm, 2½in., 3in., 3½in., 5in., 15 ohm, 3½in. dia, 6x4in., 7x4in., 5x3in., 3 ohm., 2½in., 2⅝in., 3½in., 5in. dia. **£1.50 each.**
PHILIPS LOUDSPEAKER, 8in., 4 ohms, 4 watts, **£1.95**
RICHARD ALLAN TWIN CONE LOUDSPEAKERS
8in. diameter 4W **£2.50.** 10in. diameter 5W **£2.95;** 12in. diameter 6W **£3.50.** 3/8/15 ohms, please state.
MOTOROLA PIEZO ELECTRIC HORN TWEETER. **£7.95**
Handles up to 100 watts. No crossover required.
BLACK PLASTIC CONSTRUCTION BOX with brushed aluminium facia. Sturdy job. Size 6¼ x 4¾ x 2in. **£1.50**

BAKER 150 WATT PROFESSIONAL MIXER AMPLIFIER



All purpose transistorised.
Ideal for Groups, Disco and P.A. 4 inputs speech and music. 4 way mixing. Output 4 8/16 ohms. A.C. Mains. Separate treble and bass controls. Master volume control.
100 volt line model **£99** **£79** £1.50 carr.

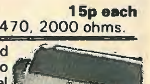
BAKER 50 WATT AMPLIFIER £59 Post £1

Superior quality ideal for Halls, PA systems, Discos and Groups. Two inputs with Mixer Volume Controls, Master Bass, Treble and Gain Controls. 50 watts RMS. Three loudspeaker outlets 4, 8, 16 ohm. AC 240V (120V available). Blue wording on black cabinet

GOODMANS COMPACT 12-INCH BASS WOOFER

Standard 12in. diameter fixing with cut sides 12" x 10". 14.000 Gauss magnet. 20 watts R.M.S. 4 ohm imp. Bass resonance = 30 c.p.s. Frequency response 30-8000 c.p.s.
£9.95 each Post £1

ALUMINIUM HEAT SINKS. FINNED TYPE.
Sizes 5" × 4" × 1" **95p.** 6½" × 2" × 2¼" **65p.**
JACK PLUGS. Plastic 25p; Metal 30p.
JACK PLUGS Stereo Plastic 30p; Metal 35p.
JACK SOCKETS. Open 20p; Closed 25p.
JACK SOCKETS Stereo Open 25p; Closed 30p.
FREE SOCKETS — Cable end 30p.
2.5mm and 3.5mm JACK SOCKETS 15p.
2.5mm and 3.5mm JACK PLUGS 15p.
DIN TYPE CONNECTORS
Sockets 3-pin, 5-pin 10p. Free Sockets 3-pin, 5-pin 25p.
Plugs 3-pin 20p; 5-pin 25p.
PHONO PLUGS and SOCKETS ea. 10p.
Free Socket for cable end ea. 15p.
Screened Phono Plugs ea. 15p.
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. **£4.50** Post 50p

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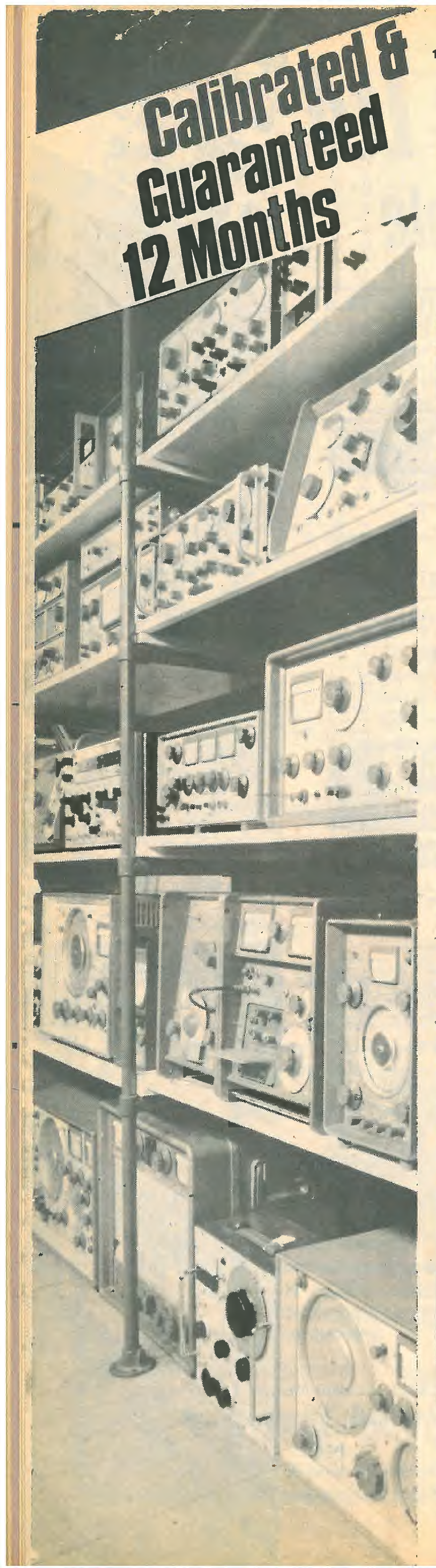

Electronic Brokers Ltd

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The Test Equipment People

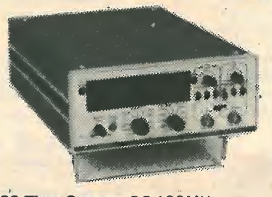
Digital Counters

ADVANCE

TC.15 + TC.15P1 Counter & Plug In DC-500MHz. 9 digit. 10mV sensitivity £495.00

TC.17 or TC.17A Time Counter Freq. period. Period Average. Pulse width count DC-80MHz £195.00

TC.21 Time Counter Freq. Time. Period. Count Pulse width 2Hz-10MHz £195.00



TC.22 Time Counter DC-100MHz £275.00

FLUKE

1900A opt. 01 5Hz-80MHz. 25mV Sensitivity with battery option £215.00

1900A Multifunction Counter. 6 digit LED display. Autoranging. 5Hz-80MHz. 25mV sensitivity £175.00

1910A-01 Multifunction Counter. 7 digit LED display, autoranging. 5Hz-125MHz. 15mV sensitivity. Battery/Mains operated £285.00

1910A as 01 model but no battery opt. £199.00

1911A-01 Multifunction Counter. 7 Digit LED Display. Auto ranging. 5Hz-250MHz. 15-30mV sensitivity. Battery/mains operated £380.00

1920A-06 Communications Counter 9 digit LED display. 5Hz-520MHz 15-25mV Sensitivity. Burst facility. A.F. resolution multiplier £490.00

1920A-13 Communications Counter As 1920A-06 but 5Hz-1GHz, and no A.F. resolution multiplier £525.00

1925A Multifunction Counter 9 digit LED display. 5Hz-125MHz. 15-25mV sensitivity. Adjustable trigger level. EMI Proof case £405.00

1953A-07 Universal Timer Counter 9 digit LED display DC-520MHz. 30mV sensitivity variable trigger level £675.00

1953A-15-16 Universal Timer Counter 9 digit LED display. DC-125MHz. 30mV sensitivity. Variable trigger level IEEE interface, rear inputs £850.00

1953A-15 as with opt. 16 but no rear input £825.00

PHILIPS

PM.6612 Timer Counter 10Hz-80MHz 9 digit display £405.00

PM.6615 Timer Counter 10Hz-1GHz. 10mV sensitivity £795.00

PM.6620 Timer Counter DC-45MHz. 50mV sensitivity £395.00

PM.6661 Frequency Counter 10Hz-80MHz. 20mV sensitivity. 8 digit £185.00

PM.6630A Timer Counter DC-160MHz 8 digit Display £600.00

PM.6645 Frequency Counter 30Hz-512MHz. 5mV sensitivity £710.00

Digital Voltmeters & Multimeters

ADVANCE

DRM6 True R.M.S. DVM 4½ digit, scale 1999. 10mV-1KV 10µV resolution. Frequency range DC-1MHz £295.00

FLUKE

8020A DMM. 3½ digit LED Display. DC volts and current. Resistance and diode test. Battery operated £99.00

8030A-01 DMM. 3½ digit LED Display. DC Voltage and current. True rms AC Voltage and current. Resistance and diode test. Rechargable battery supply £135.00

8600A-01 DMM 4½ digit LED display DC-AC voltage and current. Resistance. Mains or battery operated £335.00

8600A as 01 model but no battery opt. £290.00

HEWLETT PACKARD

3490A DM 5½ digit, scale length 120000. AC Volts 1V-1kV 10µV resolution. DC Volts 100mV-1kV, 1µV resolution. Resistance 100 Ohms-10M Ohms, 1M Ohms resolution. Full auto-ranging and variable sample rate. Self check facility £595.00

34702A DMM C/W 34740A Display 4½ digit. AC/DC & Ohms £295.00

PHILIPS

PM2424 DMM 4 digit £300.00

PM.2443 DC DVM 4½ digit, scale length 19999 £430.00

PM2513 D.M.M. 3½ digit £90.00

PM.2513A DMM 3½ digit, scale length 1999 £95.00

S.E. LABORATORIES

SM210 DC DVM 4 digit, scale length 9999. 100mV-1kV, 10µV resolution £250.00

SM214 AC-DC DVM 5½ digit, scale length 10999. SC-DC Volts 1.1V-1.1kV, 10µV resolution £300.00

SCHLUMBERGER

A243 Digital Voltmeter 5½ digit 1µV resolution Autoranging DC & AC (mean) & Ohms £675.00

WESTON

4449 3½ digit D.M.M. AC-DC volts and current. resistance £79.50

Miscellaneous

E.N.I.

500L R.F. Amplifier 2-500MHZ. 20Db gain. 300mW o/p £315.00

FLUKE

412B H.V. Power Supply 0-2100V. Resolution 5mV o/p current 5-40mA £365.00

BRUEL & KJAER

2607 Measuring Amplifier 2Hz-200kHz. 10µV-300V range. Average times 0.1S-300S. A, B, C and D weighting. Output signal 10V rms for F.S.D. on meter £1,200.00

Oscilloscopes

COSSOR

CDU 150 Dual Trace Oscilloscope DC-35MHz. 5mV20V/div. Full delayed sweep. Long persistence CRT £450.00

4000 Dual Trace Oscilloscope DC-50 MHz. 5mV-10V/div. Full delayed sweep. Unused £495.00

DYNAMCO

7100 Dual Trace Portable Oscilloscope with 1Y2 and 1X2 modules DC-30 MHz. 10mV-20V/div. Full delayed sweep £350.00

7500 Dual Trace Portable Oscilloscope DC-40MHz. 10mV-20V/div. Full delayed sweep. Unused £495.00

HEWLETT PACKARD

184B Storage Scope Rack style, variable persistance, c/w 1808A Dual Channel Vertical Amp, DC75MHz. 1825 Time base and Delay Generator, UNUSED CONDITION — BARGAIN £1,600.00

1707B Dual Trace Portable Oscilloscope DC-75MHz. 10mV-5V/div. Full delayed sweep £895.00

PHILIPS

PM.3240 Dual Trace Portable Oscilloscope DC-50MHz. 5mV-2V/div. Full delayed sweep. From £950.00

PM3010 Miniature Scope DC5MHz Dual Trace. Battery/Mains operation. Lightweight 1.8 Kg £325.00

SOLARTRON

CD 1400 Dual Trace Oscilloscope with 2 off CX 1441 and 1 off CX 1448 modules. DC-15MHz £155.00

TEKTRONIX

531A Bench Oscilloscope with Dial trace vertical Plug-In unit CA. DC-13.5MHz. Sensitivity 50mV-20V/div. £290.00

647A Bench Oscilloscope with Dual trade vertical Plug-in unit 10A2A and delayed time base plug-in unit 11B2A DC-100MHz Sensitivity 10mV-20V/div. £1,200.00

585A Bench Oscilloscope with Dual trace vertical Plug-in unit 82 DC-80MHz. Sensitivity 10mV-50V/div. £775.00

547 Bench Oscilloscope with dial trace vertical Plug-in unit 1A1 DC-50MHz. Sensitivity 5mV-20V/div. £775.00

545B Bench Oscilloscope with Dual trace vertical Plug-in unit CA DC-24MHz. Sensitivity 50mV to 20V/div. £425.00

432 Portable Scope Dual Trace DC 25MHz. 1mV/Div. SUPERB CONDITION. QUANTITIES AVAILABLE £495.00

661 Sampling Scope c/w 5T3 and 4S1. Dual Trace and accs. £585.00

CA Plug In for 530, 540 and 580 series £60.00

T932 Dual Trace Portable oscilloscope DC-35MHz. 2mV-10V/div. Sweep speeds 0.5S-10nS/div. With trigger hold off £550.00

7313 Split Screen Bistable Storage scope c/w 7A18 and 7B53A modules. DC-25MHz. 5mV-5V/div. Full delayed sweep C.R.T. readout. 4.9cm/µS writing speed. Auto erase can be converted to 4 trace unit with addition of another 7A18 module. EXCELLENTLY PRICED AT ONLY £2450.00

7A26 Dual Trace Plug In Unit. DC-200MHz. 5mV-5V/div £610.00

7D11 Digital Delay Plug In Unit. Delay by time or events. Digital delay readout to 7½ digits. 100nS-1S delay time. 1nS resolution. Delay internal CRT display £850.00

543B Bench Oscilloscopes with Dual trace vertical Plug-in unit CA £350.00

555 Dual Beam Scope (Mainframe) DC-33MHz wide choice of Plug-ins £300.00

422 Dual Trace Battery Portable Oscilloscope DC-15MHz. 10mV-20V/div £750.00

A copy of our trading conditions is available upon request

Oscilloscope Probes

PROBES

EB90 X1 Probe Kit DC-20MHz. 1.5 mtr cable 40pF I/P cap. 500V DC max. working. BRAND NEW £9.00

EB91 X10 Probe Kit. DC-80MHz. 1.2 mtr. cable I/P Z 10M Ohms paralleled by 10.8pF. Compensation 15-50pF. BRAND NEW £11.00

EB95 X1 and X10 Switched Probe Kit. DC-15MHz in X1. DC-80MHz in X10. I/P Z 10M Ohms paralleled by 10.8pF in X10. 1.2 mtr. cable. BRAND NEW £15.00

GREENPAR

GE81500/2 X1, X10 Probe Kit. DC-200MHz. 10M Ohms I/P resistance. Compensation 15-50pF. UNUSED £27.00

Power Meters

HEWLETT PACKARD

430C RF Power Meter with 477B Thermistor Mount 10MHz-10GHz. 100mW £225.00

MARCONI INSTRUMENTS

TF 893A AF Power Meter 20Hz-35KHz. 1mW-10W I/P Z 2.5 Ohms-20K Ohms £185.00

TF.1020A Series RF Power Meter DC-250MHz. 50-100W FS or 150-300W FS. I/P Z 75 Ohms on 50-100W model, 50 Ohms on 150-300W model. From £105.00

T.E.S.

MU964 AF Power Meter 20Hz-50KHz. 1mW-10W I/P Z 2.5 Ohms-20K Ohms £175.00

Pulse Generators

ADVANCE

PG.52B Modular Pulse Generator 0.1Hz-30MHz c/w 2 x P3, 3 x P2, P4, P5, P1 £700.00

PG59 Dual Output Pulse Generator (CT600) 1Hz-10MHz £595.00

PHILIPS

PM5715 Pulse Generator Similar spec. to PM5712 but with variable rise and fall times £575.00

PM5775 Pulse Generator 1Hz-100MHz Variable delay, width, rise and fall time. Single or double pulse, base line offset £800.00

PM5776 Pulse Generator Same spec. as PM5775 but dual O/P £900.00

Recorders

ADVANCF

Omniscribe 5000 Strip Chart Recorder 1 and 2 pen models available. Please contact us for full details on modules and main frames. From £200.00

PHILIPS

PM8110 Mini Single Channel Chart Recorder Sensitivity 10mV-10V full span. Chart width 12cm. Chartspeed 5 and 20mm/min £250.00

RECORD

3" Paper Width Recorder with 500 µA sensitivity FS. Left-hand zero. 1 and 6 per hour chart speed £75.00

Radio Receivers

EDDYSTONE

730/1A Communication Receiver 480KHz-30MHz in 5 ranges, BFO, noise limiting, AF filter, AVC, RF/gain, S Meter £175.00

730/4 Communications Receiver 480KH-30MHz, 5 Bands, BFO, noise limiting, AVC, RF gain, AF filter. UNUSED CONDITION £275.00

880 Communications Receiver 500kHz-30.5MHz in 1MHz wavebands. BFO, AGC, RF-IF gain, noise limiting, AF filter, S Meter £325.00

RACAL

RA117E Communications Receiver 1-30MHz MHz and KHz tuned separately. Selectivity 100Hz-13kHz in 6 ranges. BFO, AVC, Noise limiter, RF/IF gain, S meter £375.00

Signal Sources

ADVANCE

H1E LF Sine/Square Oscillator 15Hz-50kHz. Sine Square £75.00

J2E L.F. Oscillator 15Hz-50kHz £90.00

J4 L.F. Oscillator 10Hz-100kHz £135.00

SG67A Wide Range Oscillator 1Hz-1MHz sine or square wave £95.00

SG68A Low Distortion Oscillator 1.5Hz-150kHz. Battery operated. Distortion less than 0.01%. £150.00

FLUKE

6160A/DX Synthesised Signal Generator 4-30MHz. 1Hz resolution £675.00

HEWLETT PACKARD

202H AM/FM Signal Generator 54-216MHz. From £495.00

608D VHF Signal Generator 10-420MHz. From £495.00

612A U.H.F. Signal Generator 540-1230MHz. From £950.00

616A U.H.F. Signal Generator 1.8-4.2GHz £550.00

626A S.H.F. Signal Generator 10-15.5GHz £500.00

AM Generator 608E, 10-480MHz. AM 0-95% £675.00

MARCONI INSTRUMENTS

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TF.995A/5 AM/FM Signal Generator 1.5MHz-220MHz £380.00

TF995B/2 AM/FM Signal Generator 200KHz-220MHz £675.00

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PM5167 Function Generator 1MHz-10MHz. Sine, square, + pulse, ramp, triangle, single shot with variable phase £875

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TF.2343 Quantization Distortion Tester £400.00

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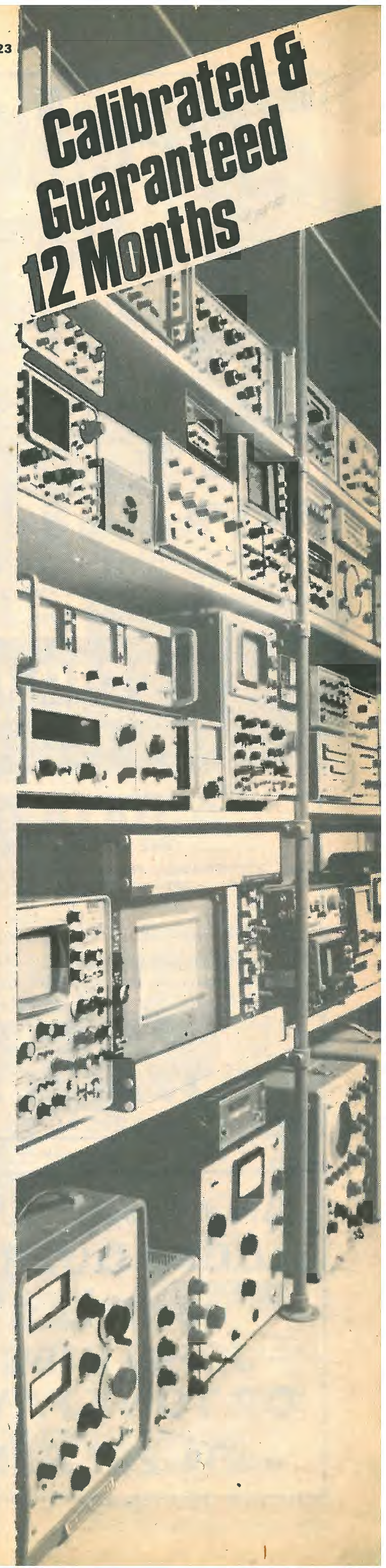
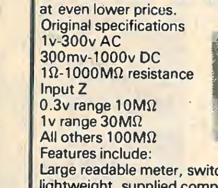


SOUTHEAST ENGLAND'S ELECTRONICS CENTRE

BARCLAYCARD VISA

PHILIPS GM 6001 20 HZ — 1000 MHZ VVM



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SUPER VALUE PCB Special

This superb P.C.B. consists of 59 digital I.C.'s including 7442, 7475, 7404 etc. etc. All I.C.'s are plugged in on 14 and 16 pin D.I.L. top quality gold plated sockets. The board also includes 77 long lead 2N3704 NPN transistors, 1 TIP 33, 77 IN4148 silicon diodes, res. caps. connectors etc. All components easily removable. Original cost well over £100.00.

59 digital I.C.'s
78 silicon transistors
59 D.I.L. I.C. sockets

Unbeatable value at **£4.75** + p.p. 75p.

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DISPLAY I.C. AND TRANSISTOR BARGAINS NEVER CHEAPER

All I.C.'s and Transistors by well known manufacturers and fully guaranteed. No fall outs. Comprehensive data on I.C.'s 12p per type.
2N4351 N channel MOS FET,
2N4352 P channel MOS FET, 95p each £1.50 per pair.
HIGH VOLTAGE NPN POWER SWITCHING transistors BVcbo 600v BVceo 500v BVebo 5v Ic 5 amps Pc 125 watts HFE 60 typ ft 2.5 mhz ideal invertors, etc. TO3 £1.50 each 4 for £5-00.
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M.P.U. CORNER

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Update your new or existing TRS 80 from 4K to 16K of RAM. Install your own chips and save £120.00. Kit includes full instructions and 8 x 16K full spec. devices. Simple plug-in and jumper change no soldering. **£108**

TRS 80 software now in stock. Programs include: Micro Chess, Space Fighter, Startrek 3, etc. Phone for details.

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5 VOLT 2.5 AMP T.T.L. P.S.U.
Made for T.T.L. this compact ex computer systems unit features a 10 amp transformer with D.C. outputs of 5 volts @ 2.5 amps and 7.5 volts @ 5 amps. The 5 volt output is fully regulated and smoothed and has electronic current limiting. May be easily moded for 5 volts @ 7.8 amps, believed working but untested. Complete with circuit **£7.25** p.p. £1-50

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Superb professional fully enclosed, made for the G.P.O. to the highest standard, offered at a fraction of their original cost they feature aluminium sides, hinged removable front panel, which can be secured by 2 screws to prevent prying fingers. All are finished in two tone G.P.O. grey and although brand new may have minor scuff marks/scratches due to bad storage. Dimensions:
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MEDIUM 16" D x 6½" H x 14¾" W £7.25 + P+P £1.15
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MUFFIN FANS

Ideal equipment cooling etc. tested, ex-equipment.
240v 50-60 HZ £5.75 + p.p. 40p
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Purchased from a major V.D.U. manufacturer, this end of line Motorola 3 chip R.O.M. set is pre-programmed to give a full 96 upper and lower case character font on a 10x7 mattrix for the upper case and a 14x5 mattrix for the lower descenders "g j p q y" thus resulting in a superb and extremely legible display. Full ASCII input, TTL compatible in and out. Supplied with 9 page data and instruction pack, brand new at only **£7.25** P+P 30p. This item cannot be repeated. Hurry while stocks last.

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7lb £ 4-75	14lb £ 7-50
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This fine example of modern miniature optical engineering consists of a 12 lamp and lens system constructed to project numerals between "0" and "9" and a "+" and " " sign onto an opaque screen to give extremely legible, rounded characters of up to 1" in height. Features easily replaceable 6 volt bulbs, changeable negative for different character fonts. Dimensions 1½" x 1" x 3½" supplied complete with bulbs and plug in carrier. Ex equipment **£1.75** p.p. 30p.

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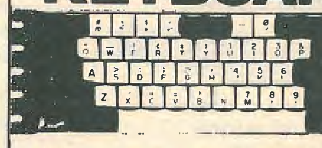

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This superb "little" blower, imagined as a cube measures only 3¼" x 3½" x 3¼" with a 1½" x 1½" air output aperture. Almost silent running, ideal for miniature projectors, computers, P.S.U.'s etc. Please state 110v or 240v operation. Brand new at only **£3.99** + p.p. 55p.

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AR8	0.60	EL81	1.05	PL802	2.80	3D6	0.40	6J7	0.75	20P1	0.40
ARP3	0.60	EL82	0.60	PLL80	1.80	3D21	20.00	6J7G	0.50	20P3	0.60
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DK96	0.80	EL802	1.50	PY500	1.35	5R4GY	1.10	6L18	0.60	30C18	
DH76	0.40	EL822	3.00	PY859	5.75	5U4G	0.95	6LD 20	0.50	see PCF805	
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DY802	0.55	EM81	0.60	QQV03-12	2.50	5Z3	1.00	6SG7	0.75	30FL12	1.20
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	1.30	EY51	0.45	QV03-12	2.50	6AB7	0.60	6SK7	0.60	30L17	1.00
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E180E	6.00	EY86/87	0.55	SC1/600	4.00	6AH6	0.70	6SN7GT	0.75	30PL1	1.00
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EA76	2.00	EX80	0.45	TT21	7.50	6AK8	0.40	6V6GT	0.80	30PL14	1.10
EABC80	0.50	EZ81	0.60	U25	1.00	6AL5	0.40	6X4	0.60	35L6GT	1.00
EB91	0.40	GY501	0.90	U26	0.85	6AL5W	0.65	6X5GT	0.55	35W4	0.60
EBC33	1.00	GZ32	0.65	U27	1.00	6AM5	1.60	6Y6G	0.95	35Z4GT	0.70
EBF80	0.50	GZ33	3.50	U191	0.75	6AM6	0.65	6Z4	0.65	50C5	0.70
EBF83	0.50	GZ34	2.00	U281	0.50	6AN8	0.85	6-30L2	0.90	50CD6G	1.20
EBF89	0.50	GZ37	2.50	U301	0.50	6AQ5	1.30	7B7	0.80	75	1.00
EC52	0.40	KT66	4.00	U801	0.80	6AQ5W	0.85	7V4	0.80	75C1	0.80
ECC81	0.55	KT88	5.75	UABC80	0.60	6AS6	0.80	9D2	0.60	76	0.80
ECC82	0.50	MH4	1.00	UAF42	0.75	6AT6	0.75	9D6	0.75	78	0.75
ECC83	1.15	ML6	1.00	UBF80	0.55	6AU6	0.40	10C2	0.60	80	0.75
ECC84	0.45	OA2	0.55	UBF89	0.50	6AV6	0.50	10F18	0.60	85A2	2.20
ECC85	0.50	OB2	0.60	UBL1	1.00	6AX4GT	0.80	10P13	0.60	723A/B	11.00
ECC86	1.25	PABC80	0.40	UBL21	0.75	6AX5GT	1.00	11E2	11.00	803	6.00
ECC88	0.60	PC85	0.50	UCC84	0.60	6B7	0.75	12A6	0.60	805	18.00
ECC189	0.80	PC86	0.85	UCC85	0.50	6BA6	0.40	12AT6	0.45	807	1.00
ECF80	0.50	PC88	0.75	UCF80	0.80	6BE6	0.50	12AT7	0.55	813	10.50
ECF82	0.45	PC900	1.25	UCH81	0.60	6BG6G	1.00	12AU7	0.50	829B	11.00
ECF801	0.75	PCC84	0.45	UCL82	0.75	6BJ6	1.10	12AV6	0.70	832A	4.50
ECH34	0.95	PCC89	0.55	UF41	0.80	6BQ7A	0.60	12AX7	0.50	866A	2.80
ECH35	1.50	PCC189	0.65	UF80	0.45	6BR7	2.30	12BA6	0.50	931A	6.00
ECH42	0.85	PCF80	0.80	UF85	0.50	6BW6	2.80	12BE6	0.60	954	0.50
ECH81	0.45	PCF82	0.40	UL41	0.75	6BW7	1.00	12BM7	0.60	955	0.55
ECH84	0.95	PCF84	0.65	UL84	0.75	6C4	0.40	12C8	0.55	956	0.50
ECL80	0.60	PCF86	0.65	UM80	0.60	6C6	0.55	12E1	4.25	957	0.90
ECL82	0.55	PCF200	0.90	UM84	0.40	6CH6	3.00	12J5GT	0.40	1625	1.00
ECL83	1.20	PCF201	0.90	UY82	0.55	6CL6	0.75	12K7GT	0.60	1629	0.70
ECL85	0.65	PCF801	0.90	UY85	0.50	6CY5	0.90	12K8GT	0.70	2051	1.00
ECL86	0.55	PCF802	0.65	VR105/30		6D6	0.50	12Q7GT	0.50	5763	2.50
EF37A	1.50	PCF805	1.80		1.80	6EA8	0.80	12SC7	0.55	5842	6.50
EF39	2.90	PCF806	0.85	VR150/30		6F6GB	0.90	12SH7	0.70	5933	3.00
EF40	0.70	PCF808	1.80		1.25	6F8G	0.75	12SJ7	0.55	6057	0.85
EF41	0.75	PCG200	0.80	Z66	0.90	6F12	0.65	12SQ7	0.55	6060	0.85
EF80	0.40	PCL81	0.60	X61M	1.50	6F14	0.80	12Y4	0.40	6064	0.85
EF83	1.50	PCL82	0.65	Z800U	3.00	6F15	0.60	13D6	0.60	6065	1.20
EF85	0.45	PCL84	0.70	Z801U	3.50	6F17	1.00	14S7	1.00	6067	1.00
EF86	0.55	PCL86	0.70	Z900T	1.50	6F24	0.90	19AQ5	0.75	6080	3.50
EF91	0.65	PCL805/85		1A3	0.60	6F33	4.20	19G3	10.00	6146	3.80
EF92	0.75		0.75	1L4	0.30	6H6	0.95	19G6	6.00	6146B	4.20
EF95	0.55	PD500	3.25	1R5	0.55	6J4WA	1.75	19H5	17.00	6360	2.00
EF183	0.65	PFL200	1.35	1S4	0.40	6J5	0.75	20D1	0.60	8020	5.50
EF184	1.60	PL36	0.80	1S5	0.40	6J5GT	0.55	20F2	0.60		
EF804	2.00	PL81	0.75	1T4	0.40						
EFL200	0.75	PL82	0.50	1U4	0.60						
EH90	0.60	PL83	0.50	1X2B	1.10						
EL32	0.90	PL84	0.65	2D21	0.55						
EL34	2.20	PL504	1.40	2K25	11.00						
EL37	3.00	PL508	1.30	2X2	0.80						

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.
MODULATION METER 210A. 2.5-300MHz. AM 0-100% FMD+100kHz in 4 rantes. **AIRMEC**
VHF WAVE ANALYSER 248 Freg 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 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 5 Mc/s.
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.

WHITE NOISE TEST SET. The instrument consists of two units: a Marconi Noise Generator Type TF 2091 and Noise Receiver Type TF 2092. Measures noise and intermodulation on wide band multichannel telephone systems. Suitable for 12 channel to 2,700 channel system.

MARCONI TF 867 SIGNAL GENERATOR
Range 15KHz to 30MHz. Output 0.4μ V to 4V to 13 or 75 ohms. Impedance with termination (supplied). Built in crystal check facility with handbook. CT 478; CT479; QT480 Signal Generators frequency from 1.3kMS up to 11kHz 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.

RHODE & SCHWARZ
Z-g DIAGRAPH TYPE 2DU 30-420MHz-50Ω. Model type ZDD, Frequency 300-2400MHz. 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.

LOW RESISTANCE HEADPHONES TYPE CLB £1.50. 40p postage. VAT 12½%.

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

VALVES AND TRANSISTORS
Telephone enquiries for valves, transistors, etc.; retail 749 3934; trade and export 743 0899.

OUR ANNUAL SALE OF TEST EQUIPMENT
STARTS FEBRUARY 1st

OSCILLOSCOPES (NEW PRODUCTION)
SCOPEX 4S-6, 6MHz. Single Beam, 10mV sensitivity. Display — 6 cm x 8 cm. Weight: 4.5kg.
SCOPEX 4D-10A, 10MHz. Dual Trace, 10mV sensitivity. Display — 6 cm x 8 cm. Weight: 6kg.
DARTON D12, 15MHz. Dual Trace. 1mV sensitivity. Display — 8 cm x 10 cm. Weight: 7.8kg.
SIGNAL GENERATOR H.P. MODEL 680C. High power, stable and high accuracy. Frequency 10 to 480MHz. Modulation level 0 to 95% at carrier levels 0.5V output level continuously from 0.1μV into a 50 ohm. Maximum output 1V.

FOR EXPORT ONLY
Mullard C11, High power installation, 1000W. Technical details and prices available on request.

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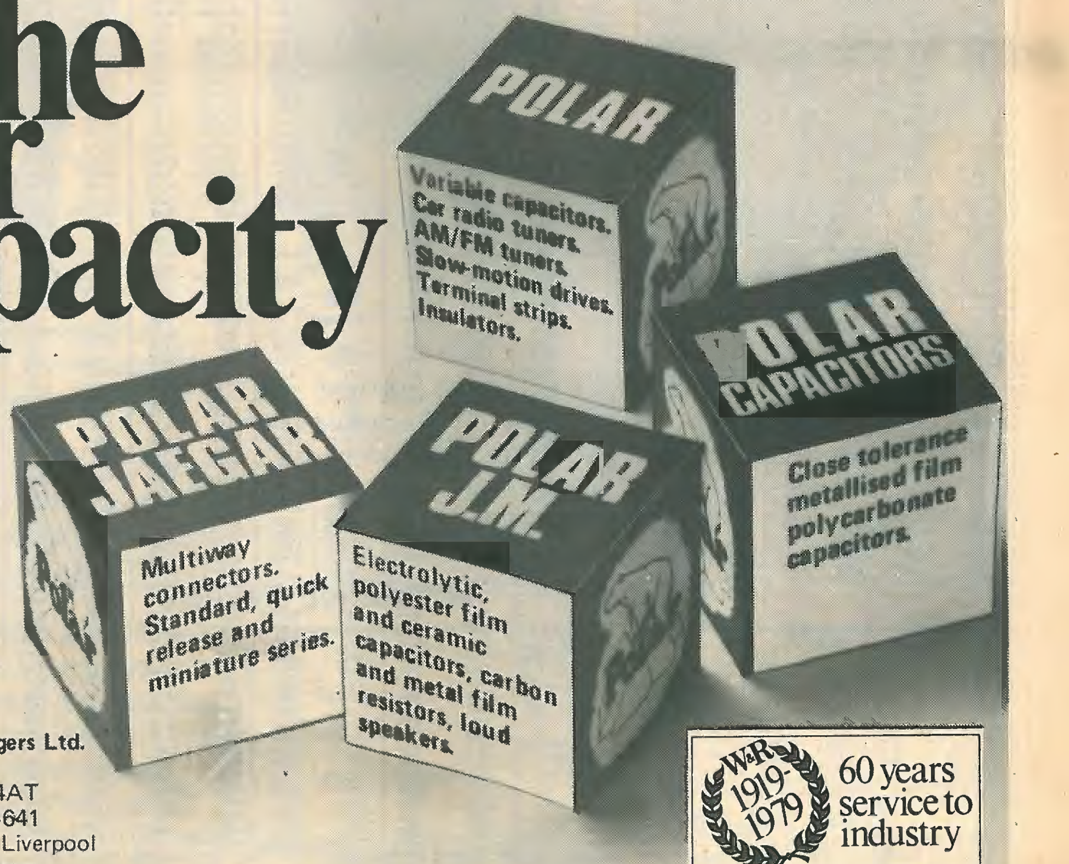

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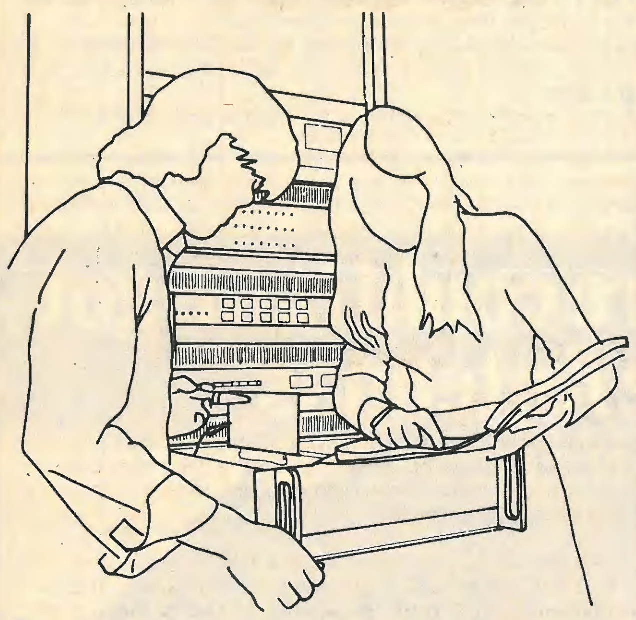

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If you are interested to hear more, please fill in the following details:-

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Years of experience: 0-1 ☐ 1-3 ☐ 3-6 ☐ Over 6 ☐

Present salary: £2,500-3,500 ☐ £3,500-4,500 ☐ £4,500-5,500 ☐ over £5,500 ☐

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(9002)

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COMMUNICATION ENGINEERS £8,500 + p.a.
Repair and Maintenance of VHF, UHF, Troposcatter and Multiplex equipment. HNC qualification or Forces experience (Foreman of Signals) preferred and experience essential. Engineers work 2 weeks on/offshore schedule.

COMMUNICATION TECHNICIANS £7,000 p.a.
ONC or City & Guilds Communications with 2 years practical experience.

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Experienced on following equipment: CCTV Systems, Process Instrumentation, Acoustic Equipment, Microprocessors. HNC or BSc qualification preferred.

ELECTRONIC TECHNICIANS c. £7,000 p.a. +
Technicians with some computer, digital and analogue instrumentation experience. Aberdeen based with periodic offshore work. Relocation assistance will be given.

COMPUTER ENGINEER/PROGRAMMER c. £8,000 p.a.
Qualified to BSc. or HNC level with indepth experience of computer and peripheral equipment. Reasonable knowledge of programming in Cobol/Fortran languages.

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To work offshore on 2 week on/off schedule. Petrochemical or heavy industrial experience required.

For further information and application forms please contact Margaret Duthie.

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Licence No. SC 144

MAINTENANCE TECHNICIAN

Experience in audio/visual electronic installation and a knowledge of light engineering/fabrication techniques would be an advantage.

You should have at least seven years' experience and be qualified to ONC level.

Salary within the scale £3,675-£4,212.

Application form from the Staffing Officer, Polytechnic of the South Bank, Borough Road, London SE1 0AA. (01-928 8989) quoting ref. ETS5.

Polytechnic of the South Bank

(8972)

Keeping in touch...

We are Europe's leading exporters of two way radio communications systems and as such can offer you the chance to work on exciting new development projects in some of the best equipped laboratories in the country.

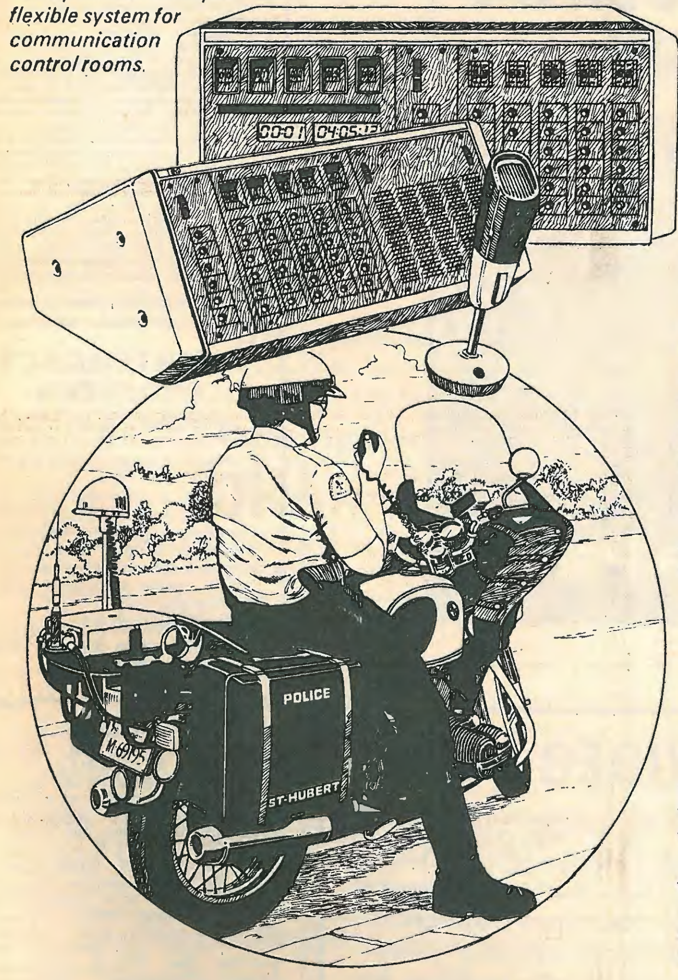
Join us in Cambridge and you will be benefiting from a plan of growth and development that has seen £7 million recently invested in a new laboratory, production and headquarters complex on the banks of the Cam.

Electronic Development Engineers (RF or Digital)

RF Engineers to join teams working on the development of fixed, portable and link products or sub-units. Must have radio communications development experience and be familiar with design of VHF/UHF communications equipment or low medium capacity multiplex radio links. We also require engineers with hand portable development experience.

Digital engineers to work on computer-based interactive systems including digital signalling, encoders/decoders, speech synthesis and data display. Must have experience of either machine code and assembler language programming or the design of digital and analogue circuits. We're looking for men and women qualified to B.Sc. or HND level, with at least 2 years' experience.

The most advanced control system in the world, the Pye MASCOT 1000 provides a unique flexible system for communication control rooms.



Systems Development Engineer

To evaluate technical feasibility of new enquiries and to propose cost-effective engineering solutions. This entails provision of technical documentation and liaison with production, installation and field service departments.

Applicants should be qualified to Degree, HND or HNC level and have experience of Systems Engineering, Commissioning, Design/Development or Field Work. Knowledge of two or more of the following is essential: HF/VHF/UHF equipment; data and line transmission; control; logic and processors; telegraphy, line printers or exchange practice.

Electronic Designers

To make a major contribution to a project team developing low capacity FDM/PCM radio links. Applicants should hold a degree/HND or equivalent qualification in Electronics and have had at least 10 years' relevant design experience.

Mechanical Designers

To participate in the total design of new products. You should have acquired experience of product design for medium to large quantity production runs, and have extensive knowledge of design in sheet-metal, plastics and diecast metal. An HNC or equivalent qualification is desirable.

PCB Draughtsmen

To join small teams of product engineers. You should have sound knowledge of the latest PCB design layout techniques and high quantity PCB production methods. Experience of computer aided design and precision plotting is a major asset. A relevant ONC or equivalent qualification is preferred.

We're offering good salaries to applicants of either sex with generous relocation expenses and good career prospects plus an extremely attractive working environment, including sports ground, pavilion and social facilities within the complex. Living in Cambridge has its own benefits too, not only is it an attractive city, but it offers excellent sporting, recreational and cultural facilities and a wide choice of reasonably priced housing. Added to which, London is quite close to hand, with the new M11 opening in Autumn and a rail journey soon to be brought down to under 1 hour. So, apply now quoting job title to Alan Depauw, Personnel Officer, Pye Telecommunications Ltd., St. Andrews Road, Cambridge, CB4 1DW. Telephone Cambridge 61222 Ext. 305.

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8990

If you've seen our distinctive product advertising in the national press, you'll be aware of our new range of Direct Entry computer controlled typesetting systems that are making such an impact on the printing and publishing industry worldwide. Isn't that the kind of field you should be working in — a new technology that is really going places?

Naturally we're looking for rather special field service engineers and to join us you have to be the type of man or woman who can think logically, look for the unexpected, and can diagnose and repair faults single handed — even when you're miles from base.

And because you'll have a lot of customer contact, often at high level, you'll have to be diplomatic and tactful. Technically, you should be qualified to ONC or HNC level and have had several years relevant field experience. A knowledge of optical physics and a general mechanical aptitude would also be useful. You can expect to travel widely initially about 2 days per week. We're offering up to £5000, a Cortina 1600 Estate, generous expenses and benefits. And with our policy of continual development bringing new equipment onto the market every year, your prospects could not be better.

So, don't you think it's time you responded to this challenge? If you do, contact David Hilton, Personnel Manager, Linotype-Paul Ltd., Kingsbury Road, London NW9 8UT.

ISN'T IT TIME YOUR SERVICE ENGINEERING SKILLS TOOK ON A NEW CHALLENGE?

THE ROYAL FREE HOSPITAL HAMPSTEAD

Medical Physics Technicians (Electronics) Grades III and IV

Two electronics technicians are required for the Electronics Workshop of this major teaching hospital to assist with the development and maintenance of electronic circuits and equipment.

Applicants (male or female) for the Grade III post should hold the City and Guilds Full Technological Certificate in appropriate subjects or an equivalant qualification and have good practical experience in the design of electronic circuits using state-of-the-art techniques.

Similar qualifications are required for the Grade IV post. A working knowledge of analogue and digital circuit techniques and an ability to service electronic equipment would be an advantage.

Salaries for these posts are on scales: £4,098-£5,142 p.a. (Grade III) and £3,432-£4,488 p.a. (Grade IV), including all allowances. The Grade and starting salary will depend on qualifications and experience.

Application forms (to be returned by 15th March, 1979) and Job Description available from the Personnel Department, The Royal Free Hospital, Pond Street, Hampstead, London NW3 2QG. Tel. 01-794 0500 Ext. 4286. Please quote ref. Grade III 0758 and Grade IV 0761.

Camden and Islington Area Health Authority. (T).

(8929)

UNIVERSITY OF WARWICK

ELECTRONICS TECHNICIAN

Applications are invited for the post of Electronics Technician Grade 7 in the Department of Chemistry and Molecular Sciences to take charge of a well-equipped electronics workshop. The duties include responsibility for maintenance of both electrical and electronic equipment in the Department. design and construction of specialised electronic equipment. modifications to existing equipment. and the supervision of a Grade 4 Technician employed primarily on repair and maintenance work. The Department is equipped with a wide range of scientific instrumentation including mass spectrometers. magnetic resonance instruments. spectrophotometers and chromatographic equipment. and the successful candidate (male/female) will probably hold an HNC or equivalent in the field of electronics and have wide experience in the design and maintenance of complex electronic equipment. The University is situated in pleasant rural surroundings within easy commuting distance of Coventry. Kenilworth and Leamington Spa. Starting salary is on an incremental scale £4,254-£4,782 P.a. (under review with effect from 1 October. 1978) and will depend on experience and qualifications. Applications giving full details including the names of two referees should be sent to the Personnel Office. University of Warwick. Coventry. CV4 7AL as soon as possible. Please quote reference number 22/2D/78.

(8935)

MAINTENANCE ENGINEER

A Maintenance Engineer is required for the repair and testing of a range of professional audio and lighting control equipment.

Applicants should have sound knowledge of modern analogue and digital techniques and, ideally, possess a current driving licence. Salary will be negotiable around £4,000 p.a.

Apply with full details of qualifications to Box No. 8956 (London area).

(8956)

QUEEN MARY COLLEGE (University of London)

TECHNICIAN (Grade 5)

required to join the Molecular Astronomy Group in the Physics Department at Queen Mary College. The post is tenable to the 31st December, 1981 and the successful applicant will be expected to assist in the development, construction and testing of Electronic/Optical systems and equipment, including Microwave Components. He will assist the group in preparing and carrying out observing campaigns at observatories in both Northern and Southern Hemispheres. HNC equivalent qualification is desirable, but more important is practical ability in Electronics and General Workshop practice. Salary scale £3,186 to £3,394 per annum (under review), plus £465 per annum London Weighting. 5 day week, 4 weeks' annual leave, plus a week at Christmas and Easter, which includes the public holidays. Further information may be obtained from Mr. D. A. Young, telephone 980 4811, ext. 349.

(8973)

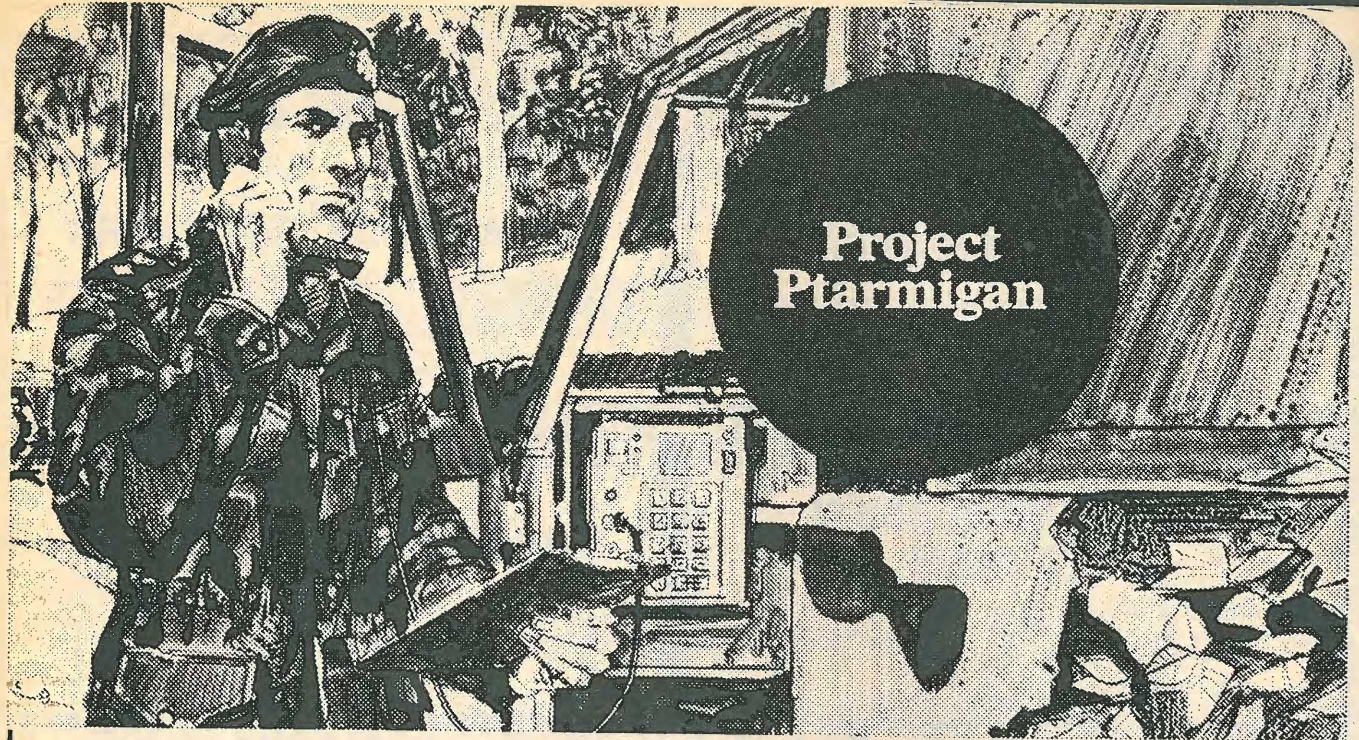
AUDIO + VIDEO LTD.

We are acknowledged as being the largest video tape duplicators in Europe with 5 Quad machines, 3 colour T/Cs, our own digital Standards Converter and countless duplication machines of all standards, providing unsurpassed quality. We are obviously looking for Engineers to match and will pay up to £7,000 for the right persons. If you have the desired experience contact Cliff Carroll on 01-580 7161.

(8993)

CHIEF TECHNICIAN (Grade 7) required in School of Education, University of Reading, to head team of 4 technicians providing service for teaching and research. Facilities include general labs., photographic lab., language lab., TV studio and A/V aids lab. and other specialised workrooms and labs. HNC or equivalent qualification desirable with substantial appropriate experience. Salary in scale £4254-4782 p.a. (under review). Apply for further details, quoting Ref. TW07A, to Assistant Bursar (Personnel), University of Reading, Whiteknights, Reading, Berks, RG6 2AH. (8940

RADIO TELEPHONE SERVICE ENGINEER required in Croydon. Proven ability to repair equipment more important than formal qualifications. Salary commiserate with ability. Contact LONDON CAR TELEPHONES on 01-680 1010. (8822



Technician Engineers

The Plessey Development Laboratory at Havant, Hampshire, is sub-contractor for the most advanced VHF communications system ever to be developed for the British Army. This system – known as "Single Channel Radio Access" – allows mobile subscribers to use the Ptarmigan trunk telephone network for both voice and data messages.

We are now proceeding with the second phase of development, creating new career opportunities for Technician Engineers who wish to advance their knowledge.

What jobs are on offer?

We are looking for Technician Engineers with experience in industry or H.M. Services to work in the following fields.

VHF Radio Equipment Development and Evaluation

Successful candidates will be involved in the development of transmitters and receivers and in the evaluation of their electrical and environmental performance under a variety of conditions.

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Candidates with a special interest in digital circuits and systems will find opportunities to work under the guidance of experienced senior engineers on the most up-to-date techniques, including microprocessors.

What qualifications?

The type of work we do needs people with practical experience of transistorised equipment, a common sense approach and a willingness to work with others towards a common goal. Ideally, you will possess a City & Guilds Full Tech. Cert., ONC or HNC.

Salaries and career prospects?

We operate a separate structure for Technician Engineers which offers scope for career development. You could become a Principal Technician Engineer in charge of a small section, while the exceptional younger person would be encouraged to qualify to transfer into the Professional Engineering grades. Because our plans for business expansion are soundly based on a full order book for a wide range of both government sponsored and private venture products, we can offer you both job stability and the up-to-date experience which is essential to our future growth.

Technician Engineers are recognised as important members of our teams and are rewarded accordingly. Situated in a semi-rural environment near Portsmouth, Chichester, the South Downs and several seaside resorts, we are well placed for housing, educational and recreational amenities. Generous relocation assistance will be given as appropriate and there is a comprehensive range of large company benefits.

Please write with brief career details or telephone for an application form. L. Wise, Recruitment Manager, The Plessey Company Limited, Martin Road, West Leigh, Havant, Hants. Tel: (0705) 486391. Applications are invited from either sex.

PLESSEY

(9007)

Electronics Engineers on the move

WALLINGTON, SURREY — **REF. WW95**

AUDIO TAPE ENGINEER

For design and development of magnetic tape copying machines, tape play-back machines. Experienced H.N.C. level.

Attractive salary offered

BERKSHIRE — **REF. WW96**

DIGITAL/LOGIC DESIGNERS

Self-motivating engineers experienced in MSI and LSI techniques required by R&D group of a major British defence contractor engaged in development of new equipment.

Salaries up to £7,000 p.a.

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Engineer experienced in design of static invertors and power supplies (in a range up to 1KVA) to lead a team developing equipment for military applications.

Salary negotiable up to £7,000 p.a.

ENFIELD — **REF. WW98**

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An electronics company seeks a young circuit design engineer to join the existing small dynamic development team. Good prospects. Formal qualifications preferred.

Salary c. £5,000 p.a. initially

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Salary c. £7,500 p.a.

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Are urgently required for client companies selling electronic components, computers and peripherals communications, industrial control equipment and scientific instruments.

Salaries to £10,000 p.a.

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REF. WW101

PERSONNEL MANAGERS COULD YOU USE THIS SPACE? TELEPHONE BRIAN CORNWELL FOR DETAILS

ILFORD — **REF. WW102**

TEST ENGINEERS

Technician engineers to test and trouble shoot mod transmitter, receivers. Minimum 4 years' experience. H.N.C. Electronic Engineering or C.&G. Full Tech. Cert. preferred.

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ENFIELD — **REF. WW103**

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We need your skills! A new department has been formed to design test gear and ATE for in house use. Several appointments will be made.

Salary £5,000-£7,000 p.a.

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Design and development of special purpose machines. Experience of AC and DC rotating machines and the associated electronic control equipment.

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Well-qualified engineer to represent major communications company throughout Middle East. Good knowledge of UHF/VHF equipment essential.

Salary negotiable

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SYSTEM DESIGN ENGINEER

To be responsible for the analysis and design of avionic systems including software design and customer acceptance.

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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.

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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.W. Engld.		E. Anglia	
N.E. London		N.W. Engld.		Wales	
N.W. London		Scotland		Overseas	
Home Counties: N.W.	N.E.	S.W.	S.E.		

Are you a houseowner?	Are you willing to relocate?
Are you prepared to travel — In U.K?	Overseas?
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.
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Computers/Periphs.	Test Gear/ATE.	Process Control	Power Supplies
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Signalling Systems	Security Eqpt.	Avionics	Simulators
Weapons	Scientific Eqpt.	Data Recorders	Photocopiers
Phototypesetting	Servo-mechs.	Components-Active	Components—Passive
Product Eng.	Electrical Eng.		

Others — Please state.

(8988)

Please indicate any Companies you do not wish us to contact.

Ref. Nos. of specific vacancies in which you are interested:

If you wish to detail further aspects of your experience or job requirements, please enclose on a separate sheet.

SENIOR RADIO TECHNICIANS

Starting Salary £8,500-£10,800 pa tax free

Saudia, flag carrier of the Kingdom of Saudi Arabia requires Senior Radio Technicians for its Communication Division based in Jeddah and Riyadh.

Duties will include general maintenance and repair of ground radio equipment as well as the upkeep of technical manuals, service records and spare part logs. Some travel will be involved visiting various locations served by the Airline within Saudi Arabia.

Applicants should have had at least 3 years recognised technical training and 5 years related experience. City and Guilds certificate or equivalent would be an advantage. Current driving licence is essential.

Commencing point on the salary scale related to qualifications and experience.

These posts which are open to men aged between 25-45, are offered on a two-year renewable contract together with free accommodation, free and reduced rate air tickets for you and your family, 40 calendar days vacation per annum plus relocation allowance.

Please write with full personal and career details quoting job title and department number to:–

Area Personnel Manager–Europe,
Saudi Arabian Airlines,
Department 153/1,
508/510 Chiswick High Road,
London W4 5SQ.

Closing Date: February 28th, 1979.

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8983

APPOINTMENTS IN ELECTRONICS

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ELECTRONICS TECHNICIAN (Grade 5) required in Department of Psychology, University of Reading, to take charge of the electronic workshop. The work involves both design and construction, and advice to staff and students on electronic problems, with considerable freedom of choice in methods used. The departmental programme already depends heavily on advanced analogue and digital techniques. Minimum qualifications would be a recognised membership; at least 7 years varied experience desirable. Salary in scale £3186-£3720 p.a. (under review). Apply with full details and names of 2 referees, quoting Ref. T06A, to Assistant Bursar (Personnel), University of Reading, Whiteknights, Reading, Berks, RG6 2AH. (8939

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We are looking for two young electronics engineers with degree or equivalent qualifications, to join our marine seismic acquisition company.

This is a field position, with the successful applicants joining the technical crew of our exploration vessel M/V GOEL EGEDE for on-board training in seismic technicques. They will start as Assistant Technicians with a salary of £6,000+ per annum, and one month's leave after each two months on the crew.

The seismic industry offers an interesting career with world-wide travel, and rapid promotion for the right person.

Geophysical Offshore Exploration is a member of the Sefel Group, which has seismic processing centres in Houston, Denver, Calgary and London.

Please write with full curriculum vitae to:

SEFEL

General Manager
Geophysical Offshore Exploration
Turriff Building
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Brentford
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(9008)

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Our Company specialises in both sales and servicing of Discotheque Sound and Lighting Equipment.

We are the UKs leading Company in this specialised field and due to continued expansion, we have vacancies in London, Bristol, Manchester and Glasgow.

Applications are invited from Electronic Service Engineers who have had at least 5 years' experience working with either Hi-Fi, Studio, PA or similar equipment.

We offer excellent salaries (depending on age and experience) generous staff discount scheme, a bonus paid 4 times per year, plus the opportunity to progress with a young, go-ahead company.

In the first instance, ring or write to: Mrs. L. Cooper, Personnel Officer for further details. (Reverse charges if you wish).

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Telephone: 01-441 1919

SERVICE SPECIALIST

Kontron Intertechnique
are looking for a

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for their range of computer based instruments. The position involves field service in Laboratories mainly in the South of England. Knowledge of state-of-the art digital systems is required.

This is a very demanding job but the company is prepared to reward a successful engineer with attractive remuneration and work satisfaction.

Apply to:

John Clapham
(Technical Director)
Kontron Intertechnique
P.O. Box 88
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Herts.
AL1 5JG

(9010)

MARINE ELECTRONICS

We need an engineer familiar with Radar, MF/HF synthesised SSB/VHF Autopilots, etc. to service and install anywhere, but must be based in London.

If you are able to be your own boss apply giving details of experience ,salary required.

We are also prepared to offer an engineering partnership arrangement, if you are the right man.

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(8959)

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Marconi Communication Systems Ltd., is amongst the world leaders in the design, development and manufacture of a wide range of advanced communication systems for industrial and commercial use.

Right now we are currently working on several exciting projects concerning communication and radar equipment for the Merchant Navy.

As a result we now need to recruit additional engineers (men/women) who will be immediately involved in the design and development phase with the extended responsibility of overseeing the designs through to production.

If you have a degree or equivalent coupled with practical experience of communications or radar displays and techniques, then we would like to talk to you about a position at our headquarters in Chelmsford.

The prospects for the future are bright and in addition to an attractive negotiable salary, we offer good conditions and benefits including removal expenses in appropriate cases.

Why not find out more by telephoning Gordon Short on Chelmsford (0245) 53221 or write to him at Marconi Communication Systems Ltd., New Street, Chelmsford, Essex, for an application form.

A GEC-Marconi Electronics Company

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(8946)

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If you think of all the different types of jobs offered by those 3,000 companies – and we've been doing this for seven years – you can see that we've helped thousands of people to better opportunities and higher earnings.

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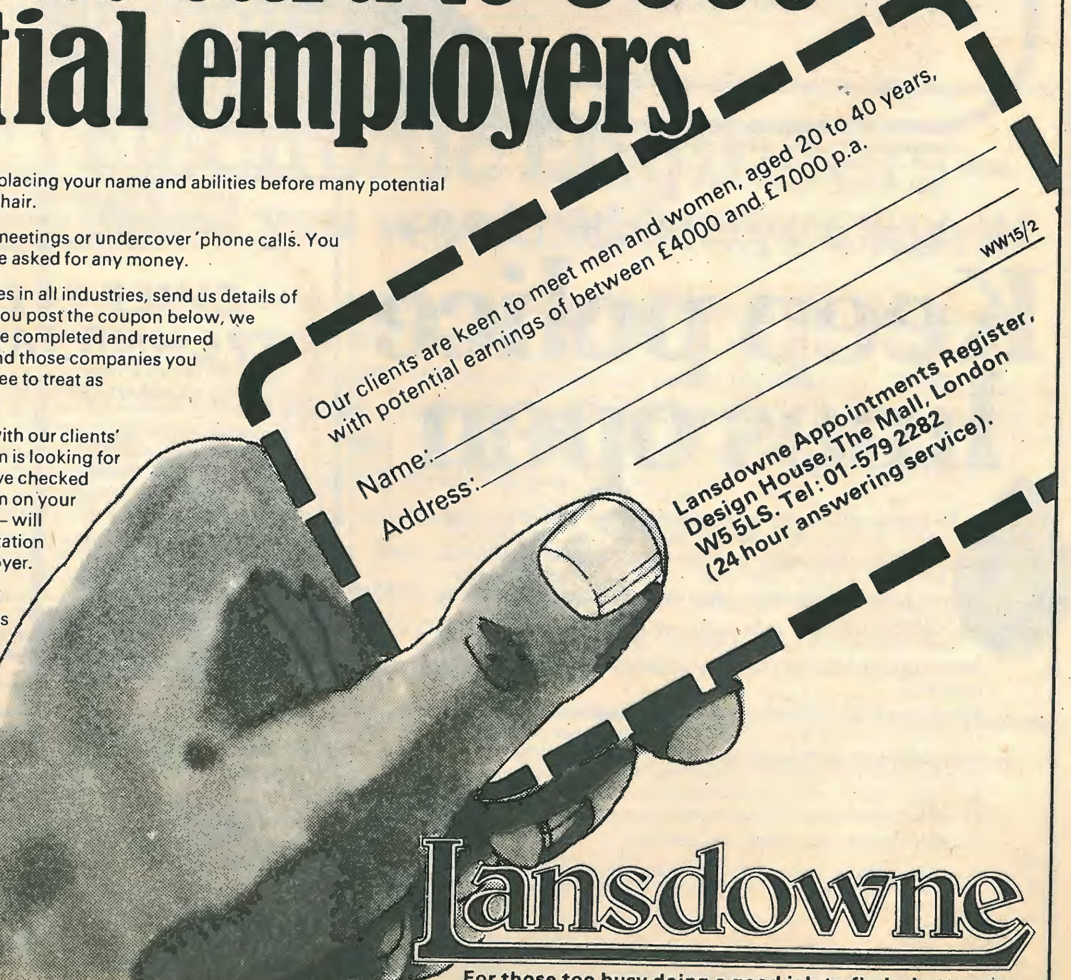
Lansdowne Appointments Register, Design House, The Mall, London W5 5LS. Tel: 01-579 2282 (24 hour answering service).



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For those too busy doing a good job to find a better one.

Development Engineer–

Electronics Measurements

The person selected for this position will be a member of a team which provides an electrical measurement service for Motor Car chassis and engine development.

Some of the more specific duties include:-

The application of strain-gauges and the installation of lead, pressure, displacement, noise and vibration transducers in motor car chassis and engines and the calibration and operation of these devices, together with the appropriate signal conditioning and recording apparatus.

Other areas of responsibility include the preparation of engineering reports, data analysis and the servicing and calibration of apparatus.

Candidates should possess Degrees or Higher National Certificates in electronic engineering and preferably have been employed for a number of years in the field of electronic measurements.

Our expansion in the field of modern technology offers good prospects for the successful applicant.

Persons selected from outside areas will be offered generous assistance with re-location costs.

Holidays commence at 28 days per annum, good social and welfare facilities and a subsidised employee canteen are available.

Male/female candidates should write, or better still phone, for further information to:

John Williams or Edward Owen,
Rolls-Royce Motors Limited,
Car Division,
Pym's Lane,
Crewe CW1 3PL.
0270 55155 Ext. 3339.

ROLLS-ROYCE MOTORS

(8971)

UNIVERSITY OF LEEDS
DEPARTMENT OF PHYSIOLOGY

Applications are invited for the post of:—

ELECTRONICS TECHNICIAN GRADE 5

The successful applicant will be responsible to the Chief Electronics Technician for the development, construction and maintenance of a wide variety of electronic equipment associated with research and teaching of biological studies.

Candidates should hold ONC or equivalent qualifications in relevant subjects and have at least 7 years' appropriate experience, including any training period. Salary on the scale £3186-£3720 a year.

Applications stating age, qualifications and full experience together with the names and addresses of two referees should be addressed to Mr. E. French, Departmental Superintendent, Department of Physiology, Medical and Dental Building, The University, Leeds LS2 9JT.

(8942)

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(8781)

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APPLIED MICROSYSTEMS LTD.

There are vacancies for a

LOGIC DESIGNER

with some 6800 microprocessor experience and also for a person to undertake printed circuit assembly in a small and growing company.

Ring or write to Steve Brown at 17 Baker Street, Weybridge, Surrey. Weybridge 48177.

(8943)

RADIO TECHNICIANS

Keep police lines open

Police depend on communications equipment every hour of the day — so if this equipment suddenly acts up, the police are seriously handicapped. That's where you can make a difference. As a Police Radio Technician in Central or South London, you'll help make sure our wide range of equipment is in top working condition.

Qualifications: two years' experience together with either C & G Telecommunications Technicians Intermediate Certificate; ONC or equivalent.

Salary: from £3092 - £4165 p.a. according to age at entry, rising to £4717 p.a. including Inner London Weighting Allowance. There are substantial extra allowances for those employed on shiftwork at New Scotland Yard. Benefits include day-time release to study for higher qualifications, assistance with course fees and 4 weeks' holiday a year. Good prospects of promotion.

For details and an application form, contact:

The Secretary, Room 213/WW/RT, 105 Regency Street, London SW1P 4AN. Telephone 01-230 3122 (24 hour answering service).

(8948)

NEWCASTLE AREA HEALTH AUTHORITY (TEACHING)
ELECTRONICS & MEDICAL ENGINEERING SECTION
NEWCASTLE GENERAL HOSPITAL

CHIEF ELECTRONICS TECHNICIAN (GRADE 2)

Applications are invited for the above position. The Chief Electronics Technician will assist the Senior Area Electronics Engineer in the maintenance of electronic and medical engineering equipment.

The position offers a unique opportunity to lead a specialist team of Technicians covering all applications of electronics in medicine, including brain scanning equipment and communications.

Salary Scale: £4,470 rising to £5,610 by 8 annual increments.

Candidates must have a broad experience of electronics, experience of medical electronics an advantage. Minimum academic qualifications — H.N.C. Electtronic Engineering or equivalent.

Job description and application forms available from Area Engineer's Office, Newcastle Area Health Authority (T), Area Headquarters, Scottish Life House, 2-10 Archbold Terrace, Newcastle-upon-Tyne NE2 1EF. Closing date for completed application forms: 7th March, 1979.

(8928)

ELECTRONICS TESTER

A vacancy exists in our Instrument Shop for an Electronics Tester, must have previous experience of testing electronic equipment including logic circuits.

Good working conditions, canteen facilities.

Apply: **Mr. M. Leigh, Manager Instrument Workshop, PO Box 290, Technico House, Christopher Street, London EC2P 2ER.**

(9004)

Radio Officers

Sea Sick?

If you've seen quite enough of the sea, and are thinking now of a shore-based job that suits your qualifications, the Post Office Maritime Service can offer you interesting work, job security, good pay, plus the pleasure of enjoying all the comforts of home where you appreciate them most – at home!

Vacancies exist at several coast stations for qualified Radio Officers to carry out a variety of duties that range from Morse and teleprinter operating to traffic circulation and radio telephone operating. And for those with ambition, the prospects of promotion to senior management are excellent.

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. Preferably you should have some sea-going experience.

The starting pay at 25 or over will be about £4450; after 3 years service this figure rises to around £5750. (If you are between 19 and 24 your pay on entry will vary between approximately £3500 and £4050). Overtime is additional, and there is a good pension scheme, sick-pay benefits and at least 4 weeks' holiday a year.

For further information, please telephone Andree Trionfi on Freefone 2281 or write to her at the following address: ETE Maritime Radio Services Division (WW), ETE17.1.1.2, Room 643, Union House, St. Martins-le-Grand, London EC1A 1AR.

(7141)

UNIVERSITY OF LIVERPOOL
DEPARTMENT OF PHYSICS

EXPERIMENTAL or SENIOR EXPERIMENTAL OFFICER

To collaborate with academic staff in the design and development of systems for collecting and processing experimental data. Work involves exploitation of microcomputers with links to PDP11's and large S.R.C. computers. Candidates must have some knowledge of digital circuits and computers and hold degree or equivalent qualification. Good opportunity for young graduate to gain experience. Salary according to age and experience, on the scale for Experimental Officers — up to £5604 p.a. — or Senior Experimental Officers — up to £6555 p.a. — (under review).

Applications forms may be obtained from The Registrar, The University, P.O. Box 147, Liverpool. L69 3BX.

Quote Ref: RV/474/WW

(8998)

SERVICE ENGINEER

Kontron Intertechnique have installation of Beta countries. We are seeking a Field Service Engineer to work in the area South of the Thames. The engineer would be responsible for field service within his own area.

This is a very demanding job but the company is prepared to award a successful engineer with attractive remuneration and work satisfaction.

Apply to:
John Clapham
(Technical Director)
Kontron Intertechnique
P.O. Box 88
St. Albans
Herts.
AL1 5JG

(9011)

Electronic Engineers–

What you want, where you want!

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If you wish to make the most of your qualifications and experience and move another rung or two up the ladder we will be pleased to help you. All applications are treated in strict confidence and there is no danger of your present employer (or other companies you specify) being made aware of your application.

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12 Mount Ephraim,
Tunbridge Wells,
Kent. TN4 8AS.

Tel: 0892 39388

TJB

Please send me a TJB Appointments Registration form:

Name ....

Address ....

....

(9005)

Instrumentation Engineer (Electronics)

The Development Instrumentation Department, at the Rolls-Royce East Kilbride Engine Test Facility, has a vacancy for a Section Leader to head a small group which is responsible for maintenance and manufacture of signal processing and recording equipment.

Work includes development and construction of specialised instruments as well as maintenance, fault diagnosis and repair of existing equipment.

Applicants should have appropriate experience and hold an H.N.C. or equivalent qualification. Salary will be in the range £4482 - £5082 and the usual excellent conditions of employment will apply.

Please apply in writing quoting experience to:
Personnel Manager, Rolls-Royce Limited,
Aero Division - Scotland, East Kilbride, Glasgow G74 4PY.

ROLLS ROYCE AERO DIVISION

8992

ROYAL POSTGRADUATE MEDICAL SCHOOL
Department of Medicine

TECHNICIAN

required to assist in electronic equipment development work in the Respiratory Division of the Department of Medicine.

Experience in analogue, digital and software techniques desirable, together with an interest in instrumentation development.

Salary on scale £3646 to £5086, initial placing dependent on qualifications and experience.

Application forms and further particulars may be obtained from the Personnel Office, Royal Postgraduate Medical School, 150 Du Cane Road, London W12 0HS, quoting reference number 2/120/WW.

(8934)

UNIVERSITY OF LIVERPOOL
DEPARTMENT OF PHYSICS

ELECTRONICS TECHNICIAN

To assist in developing and commissioning digital and analogue electronics equipment.

Applicants must possess recognised qualification and have previous experience. Salary on a scale up to £4365 p.a. according to qualifications and experience (under review).

Application forms may be obtained from The Registrar, The University, P.O. Box 147, Liverpool. L69 3BX.
Quote Ref: 473/WW

(8997)

ENGINEER TECHNICIAN

required to be responsible for expanding the electronic research and development laboratory for a small professional firm of consulting engineers. Salary by negotiation.

Please apply, quoting qualifications and experience, to Dr. Bruce Smith, Smith Associates Consulting System Engineers Limited, 20 Queens Road, Weybridge, Surrey.

(8944)

ELECTRONICS SERVICE ENGINEER

required for P.A. and Lighting hire company.

This position is for a qualified senior person of proven technical ability capable of managing a small busy workshop.

Apply in writing to:
John Denby
ENTEC
Shepperton Studio Centre,
Shepperton, Middlesex.

(8953)

AUDIO SERVICE ENGINEERS

We require additional staff to join our small team in our Service Department based in London NW1 (near Marylebone Station).

The work involves the maintaining, servicing and overhauling of top quality audio equipment for the film and T.V. industry.

Ideally, you should have previous experience in this field, although product training will be given. On some occasions you would also be required to visit other locations in the U.K.

In return, we are offering very attractive salaries plus non-contributory pension scheme and four weeks' annual holiday.

For further information, in strict confidence, please contact Maureen Sleight on Gerrards Cross (STD 02813) 88447 or write giving full C.V. to Mr. J. Rudling

HAYDEN LABORATORIES LIMITED
6 Bendall Mews, Bell Street, LONDON NW1

(8933)

HAYDEN

TELEVISION PROJECT ENGINEER

Pro-Bel Ltd manufactures custom built vision and audio switching systems for the professional broadcast industry, and markets the CapGen character generator and Elcon tape cleaner.

Due to expansion we require additional junior and intermediate engineers to be responsible for customer liaison, design and test of switching systems.

The position offers a chance to join a small expanding company and to be involved in all stages of contracts from initial planning to customer acceptance. A certain amount of U.K. and overseas travel will be involved.

In addition to a good salary we offer BUPA membership, a friendly environment and excellent career prospects.

For more details contact David Steel at:

pro-bel LIMITED

TERRACE ROAD, BINFIELD, BRACKNELL
BERKSHIRE RG12 5DN ENGLAND
Telephone BRACKNELL (0344) 56969/56960

(8930)

We've always looked for Test Engineers who weren't afraid of New Ideas

Pye Telecommunications have made many original contributions to the technology of mobile radio; for instance, we were the first manufacturer to use printed circuit boards. But whatever we have achieved, we have always backed it with the specialist skills and abilities of our test engineers – the men and women who put the final seal of approval onto all our equipment.

If you welcome the challenges offered by a wide variety of products, many incorporating up-to-the-minute technology, then you'll fit in at Pye. To join us you should have had sound experience of fault diagnosis, alignment, and testing at PCB level, preferably on communication equipment. Forces experience would be particularly suitable.

As the leading manufacturer of two-way UHF/VHF radio systems in Europe, we can offer you excellent working conditions, well-equipped workshops with a broad range of modern test gear, good career prospects and a stable company structure where you will find security and job satisfaction. Starting salaries are between £3800 and £4300 depending on technical ability.

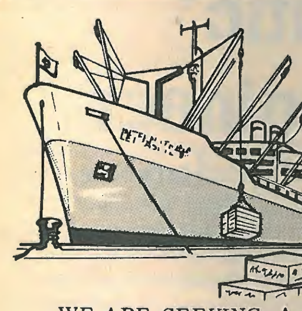
The positions are based at Haverhill in Suffolk, where key-worker housing may be available for those moving from other parts of the country.

For further details please write or phone, reversing the charges where necessary, to Mrs. Catherine Dawe, Senior Personnel Officer, Colne Valley Road, Haverhill, Suffolk. Tel: Haverhill 4422.

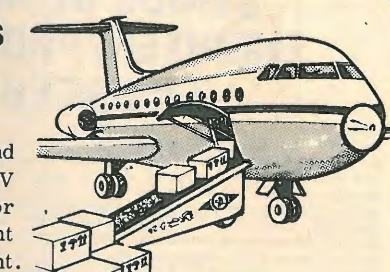
Pye Telecommunications Ltd
Colne Valley Road, Haverhill, Suffolk.
Tel: Haverhill 4422.

A member of the Pye of Cambridge Group

(8932)



Exporting Colour TV sets is never easy



Every market requires something different and whether it's a change to the circuitry for differing TV standards or systems, or an alternative styling or finish, it invariably requires engineering involvement in ensuring our customers get what they want.

WE ARE SEEKING A PROJECT LEADER TO LOOK AFTER THE TECHNICAL NEEDS OF OUR DORIC CUSTOMERS AT HOME AND ABROAD.

Ideally you will be a qualified, professional, self motivated TV engineer who can apply your skills to organizing a small but enthusiastic team to solve a wide variety of problems associated with the design, production and operation of a sophisticated range of colour TV receivers. You will be experienced in project management, development of colour TV and customer service, with particular emphasis on export markets. Some knowledge of safety performance of domestic electronics, test house approvals and quality assurance assessment in a modern factory environment will also be useful.

The team also checks out audio products from world-wide sources, prior to purchase, and hence some experience of the performance and constructional requirements of this type of equipment will be an asset.

You will be based at our engineering centre at Chessington, Surrey, but occasional visits to our factories in the North East and to our customers, both at home and overseas, will be required.

You will be paid an attractive salary and generous assistance with relocation expenses will be offered, where appropriate.

If this sort of challenge is of interest and you feel you can make a real contribution to the success of our operation, please write or telephone to:-

REDIFFUSION

Mr. H. Brearley,
Rediffusion Consumer Electronics Limited.
Fullers Way Sth., Chessington, Surrey. KT9 1HJ
Telephone: 01 397 5411

We've variety and interest to offer you as a service and test engineer in Stanmore

It's the variety that comes with working on a wide range of equipment. And the interest of knowing that your skills and experience are playing a vital role in maintaining the critical standards demanded by major airlines and Air Forces for their highly sophisticated avionics equipment.

Working either in aircraft or in our well equipped and pleasantly situated workshops in Stanmore, Middlesex, you will be involved in the repair, maintenance and overhaul of a variety of advanced airborne electronics equipment, both British and American.

It's work for which you'll need to have sound practical experience of radio and electronics theory, ranging from audio to microwave. You should also have experience of using advanced test equipment for fault diagnosis, although training can be given where necessary.

We can offer you an excellent salary and benefits together with really first-class working conditions and subsidised staff restaurant, so if it's variety and interest you're looking for write now with details of your experience to: Mrs. E. Wagg, Marconi Avionics Limited, 22-26 Dalston Gardens, Stanmore, Middlesex HA7 1BZ. Telephone: 01-204 3322.

MARCONI AVIONICS

A GEC-Marconi Electronics Company

(8763)

SOUND ENGINEER

The Royal Opera House requires an **Assistant Sound Engineer.** The position would suit someone with Studio or Broadcasting experience who is prepared to work long and unsocial hours. The work is very varied and requires an engineering background and some musical knowledge.

Apply to **Eric Pressley, Royal Opera House, Floral Street, London WC2E 7QA.**

(8978)

TOP JOBS IN ELECTRONICS

Posts in Computers, Medical, Comms, etc. ONC to Ph.D. Free service.

Phone or write: **BUREAUTECH AGY, 46 SELVAGE LANE, LONDON, NW7. 01-959 3517.**

(8994)

Engineers

- DESIGN / DEV
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High Salaries – Most Areas

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(8995)

Apex Personnel

EMI

SENIOR DESIGN ENGINEER/PROJECT ENGINEER

Pantak (EMI) Ltd., based in Windsor, Berkshire, are one of the world leaders in Industrial, Security and Medical X-ray equipment.

We require one Senior Design / Project Engineer in our Development / Design Dept. who will be principally concerned with the design of our new range of specialist electronic products which are based around inverter and switch mode circuits. The successful applicant will also be in control of a small team.

Minimum qualifications would be an HND with experience in the specified technologies, with approximately 10 years' previous experience. A B.Sc in Electronic Engineering would be a distinct advantage.

Benefits for the position are those you would expect from the EMI Group, and include:

★ An attractive salary around £7,000 p.a.
★ Career opportunities.
★ A 35-hour working week.
★ Four weeks' holiday.
★ First-class pension scheme with free life assurance.
★ Excellent subsidised canteen
★ Generous relocation expenses where applicable.

We also require

ONE ELECTRONIC TEST ENGINEER

who will be responsbile for testing and fault-finding analogue and digital control circuits.

For this position we offer a salary around £4,000 p.a. with all other benefits as above.

To find out more, telephone DAVID DRAKE, Personnel Officer, *now* on Windsor 55611, or write to him at:
PANTAK (EMI) LTD., VALE ROAD, WINDSOR, BERKS.

Pantak

A member of the EMI Group of companies
International leaders in music, electronics and leisure

(8962)

Automatic Test Engineer

North West London

Radiomobile, the leading manufacturer of in-car entertainment equipment is looking for a young Electronics Engineer who is willing to take a key role in a new and important development at their main production unit.

Your responsibilities will be:-

★ to take an active part in the implementation and running of Automatic Test Equipment.

★ To produce jigs and programmes for this equipment and to run self-check programmes when required.

★ To monitor the information from the A.T.E. and feedback details of component failures to the production area.

Applicants should be qualified to HNC (Electronics), C & G FTC (Electronic) or equivalent.

If you have a keen and demonstrable interest in radio and looking for an appointment with an attractive salary, plus bonus, plus benefit package.

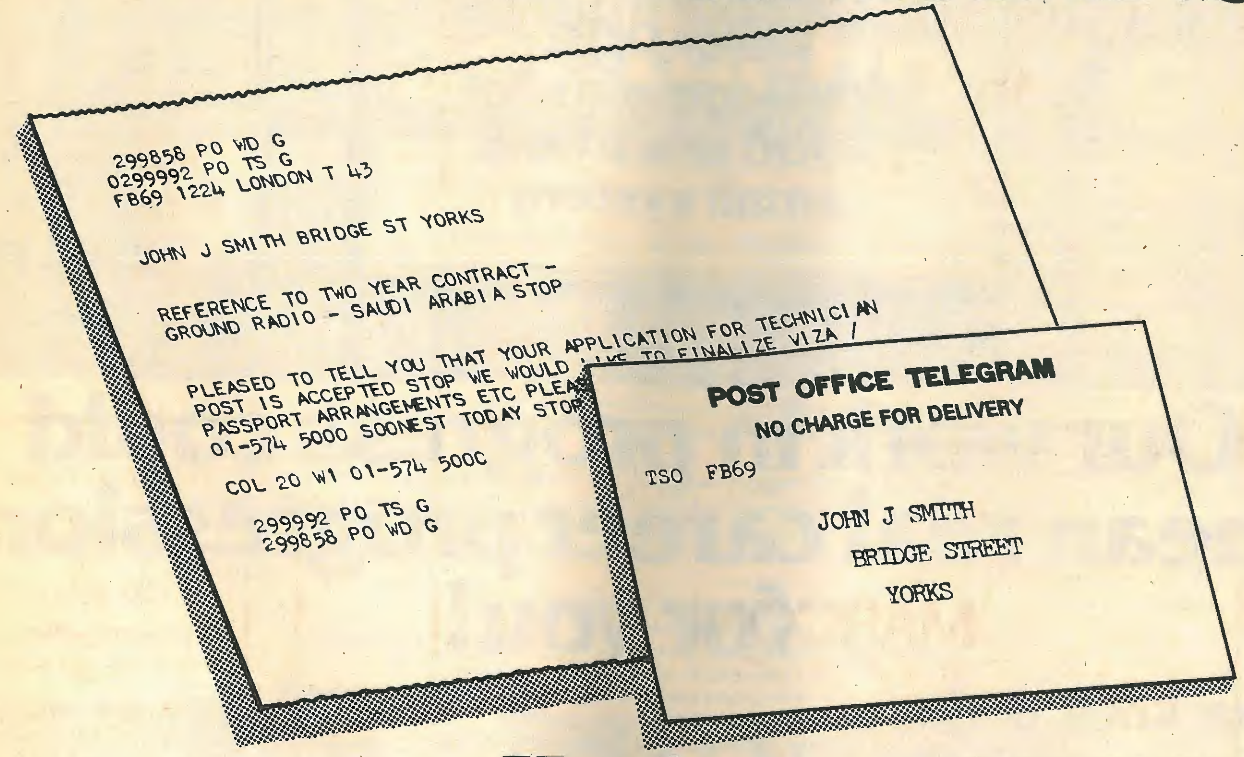
PER Professional & Executive Recruitment

Contact: Jane Brooks on (01) 235 7030 Ext. 246 (answering service out of hours (01) 235 6938)

Applications are welcome from both men and women

(8955)

RADIO TECHNICIANS



Here's a communication that's worth £16,350 tax free

Lockheed Aircraft International in Saudi Arabia are now offering two year contracts worth £16,350 tax free to Ground Radio Technicians who can install, maintain and repair SHF, UHF, VHF, and HF(SSB) radio equipment and systems and who preferably have knowledge of systems engineering and microwave systems. Lockheed's operations cover the installation, repair and maintenance of a wide range of highly complex electronic equipment in the fields of communications and aviation services.

So a two year contract with them will not only see a sizeable increase to your bank balance – it will also see you developing your specialist experience in an operational environment.

The minimum total earnings we have mentioned include bonus and cost of living allowance.

Then there's a substantial benefits package which includes:

* **Three paid leave periods annually with three free flights home to the UK**
* **Free food, laundry and bachelor accommodation**
* **Free medical care and life insurance**
* **Good recreational facilities**
* **Excellent prospects for employment beyond the contract period.**

If you are interested in hearing more about these excellent opportunities, write or phone, quoting ref: 017L, to Recruitment Officer, IAL, Aeradio House, Hayes Road, Southall, Middlesex. Tel: 01-574 5000.

IAL Lockheed International

HAMPSHIRE FARNBOROUGH COLLEGE OF TECHNOLOGY

Ref. 79/1/A22

LECTURER

Grade I in Electrical Engineering

Able to teach up to at least T.E.C. Certificate level. Appropriate qualifications required, with practical experience in Electronics. Further particulars from:

The Staffing Officer
Farnborough College of Technology
Boundary Road, Farnborough, Hants, GU14 6SB

S.A.E. please.

Closing date: 9th March, 1979.

(8975)

CANCER RESEARCH CAMPAIGN

4 MV Van de Graaff

ELECTRICAL ENGINEER/PHYSICIST

(Scientist or S.R.O.)

PHYSICS OR ELECTRONICS TECHNICIAN

for operation application and development of this unique multi-purpose machine for non-clinical research into biological and biochemical effects of radiation to improve cancer therapy. Neutron and pulsed and continuous beams of electrons produced.

Lecturer or S.R.O. to manage accelerator and its technical staff, should have degree (or equivalent) or high degree and experience of particle accelerators, Ionizing radiations, electronics, vacuum technology mechanical design starting salary to £6,530 (CMRC Grade 2) according to experience, qualifications and age.

TECHNICIAN Candidates, preferably with HNC or degree and some experience as above. Starting salary to £5,034 (MCR Tech) according to experience, qualifications and age.

Apply: Deputy Director CRC Gray Laboratory, Mount Vernon Hospital, Northwood, Middlesex HA6 2RN.

(9001)

Our work in progress could mean real career progression for you!

Bracknell, Berks; Kidsgrove, Staffs £4,000-£8,500

Join the company where exciting things are happening on brand new hardware! Right now we are working on major new Small System developments at Bracknell and Kidsgrove.

This could be your opportunity for real personal career progression. There will be considerable scope for your skills in one of our *integrated* development teams where both hardware and software people have the opportunity to work profitably together or you could find a rewarding future specialising in your chosen field.

Wherever you work you will find every opportunity for fast personal development and this, coupled with our unrivalled reputation for training, adds up to an offer not to be missed.

The successful application of your skills is vital to our total systems development.

That is why we need:

Programmers

with assembler, operating systems development or microcode experience.

Engineers

with a background in state-of-the-art technology.

In both cases we expect you will be in your 20's with at least 2 years experience behind you.

Naturally relocation expenses and full large company benefits are available.

Interested?

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International Computers

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ICL

(8958)

ELECTRONICS TECHNICIAN

c.£4,000 p.a. Southampton

STRUCTURAL DYNAMICS LIMITED

is a specialist, high technology company with a team of over 30 offering consultancy services in the vibration analysis of large steel structures and associated rotating machinery. The company's services include monitoring systems for machinery and structures and vibration/acoustic troubleshooting.

To support continued expansion an **ELECTRONICS TECHNICIAN** is required to assist on a number of electronic projects associated with analogue/digital instrumentation.

Candidates should preferably have an education to ONC standard, although a demonstration of practical ability in constructing and testing prototypes would be considered satusfactory. A knowledge of Linear I.Cs and CMOS devices would be advantageous.

Salary in accordance with experience, BUPA contributory pension scheme and four weeks' annual holiday.

Telephone J. G. Sindall on Southampton (0703) 35611 for an application form, or apply directly in writing to Structural Dynamics Limited, 18 Carlton Crescent, Southampton SO1 2ET.

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There will be opportunities to obtain higher qualifications.

Applicants should possess ONC/HNC (Electronics) or other appropriate qualifications and for Grade III, at least 3 years' relevant experience as a Grade IV technician or equivalent.

Salary Scale £3423-£5142 p.a. inclusive.

Application forms from Personnel Department, St. Bartholomew's Hospital, London, EC1A 7BE, in writing, or phone 01-600 9000, ext. 3186. Please quote ref. no. PTB/203.

Closing date 10 days to 2 weeks from date of appearance.

(8982)

Opportunities in Broadcast Technology

Pye TVT now have openings for Development Engineers. Based in Cambridge, you will be working in our studio and transmitter development laboratories on a wide variety of projects.

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You will be involved on a number of aspects of design in television f.m. sound and a.m. sound broadcast transmitters and transposers. Broadcast experience is an asset, but first essentials are interest and enthusiasm.

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For an application form, contact:
Alison Millar, Personnel Officer,
Pye TVT Limited, Coldhams Lane, Cambridge CB1 3JU.
Telephone Cambridge (0223) 45115

Pye TVT Limited
The Broadcast Company of Philips

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8991

RADIO TECHNICIANS

WORK IN COMMUNICATIONS R&D AND ADD TO YOUR SKILLS

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Your job as a Radio Technician will concern you in developing, constructing, installing, commissioning, testing, and maintaining our equipment. In performing these tasks you will become familiar with a wide range of processing equipment in the audio to microwave range, involving modern logic techniques, microprocessors, and computer systems. Such work will take you to the frontiers of technology on a broad front and widen your area of expertise — positive career assets whatever the future brings.

Training is comprehensive special courses, both in-house and with manufacturers, will develop particular aspects of your knowledge and you will be encouraged to take advantage of appropriate day release facilities.

You could travel — we are based in Cheltenham but we have other centres in the UK, most of which, like Cheltenham are situated in environmentally attractive locations. All our centres require resident Radio Technicians and can call for others to make working visits. There will also be some opportunities for short trips abroad, or for longer periods of service overseas.

You should be at least 19 years of age, hold, or expect to obtain shortly, the City and Guilds Telecommunications Technician Certificate Part 1 (Intermediate), or its equivalent, and have a sound knowledge of the principles of telecommunications and radio, together with experience of maintenance and the use of test equipment. If you are or have been in HM Forces your Service trade may allow us to dispense with the need for formal qualifications.

You start on £2927 at 19, up to £3700 if you are 25 or over, rising to £4252, and promotion will put you on the road to posts carrying substantially more. There are also opportunities for overtime and on-call work paying good rates.

Get full details from our **Recruitment Officer, Robby Robinson, on Cheltenham (0242) 21491, Ext. 2269, or write to him at GCHQ, Oakley, Priors Road, Cheltenham, Glos. GL52 5AJ.** If you seem suitable, we'll invite you to interview in Cheltenham — at our expense, of course.

(8508)

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You could become a Systems Engineer

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  - ☐ HNC in electronics
  - ☐ A completed electronics apprenticeship
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YES? Then we are interested in training you to join our skilled teams of Systems Engineers in maintaining our customers' computers. After a thorough initial training you will be based on one of our customer sites in the U.K. Within 18 months you should be a fully trained Systems Engineer with a career rich in opportunity ahead of you. You will have the satisfaction of using all your technical expertise, tact and personality as a representative of ICL.

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TO: David Reeves, CED Recruitment, ICL, Cavendish Road, Stevenage, Herts SG1 2DY.

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Address ____________________

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(9009)

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TELECOMMUNICATIONS OFFICER

The work includes the study of radio propagation matters over the whole of the radio spectrum (10kHz-275GHz); forward planning and regulation of frequency bands allocated to broadcasting, maritime and land mobile services; type-approval of equipment for mobile services; development of equipment for the location and suppression of radio interference.

Candidates (aged at least 23) must have ONC in Engineering (with a pass in Electrical Engineering 'A') or in Applied Physics, or an equivalent qualification. In addition, they should have had experience in the operation of radio receiving equipment and have a knowledge of current operational systems of radio communications.

Salary starting between £4080 and £4820 (according to age) and rising to £5170. Promotion prospects. Non-contributory pension scheme.

For further details and an application form (to be returned by March 14, 1979) write to Civil Service Commission, Alencon Link, Basingstoke, Hants, RG21 1JB, or telephone Basingstoke (0256) 68551 (answering service operates outside office hours). **Please quote T/5025.**

HOME OFFICE

(8984)

SITUATIONS VACANT

Telecommunications

We require staff, male or female, to prepare and maintain the latest in communications equipment used by the Police and Fire Brigade in England and Wales.

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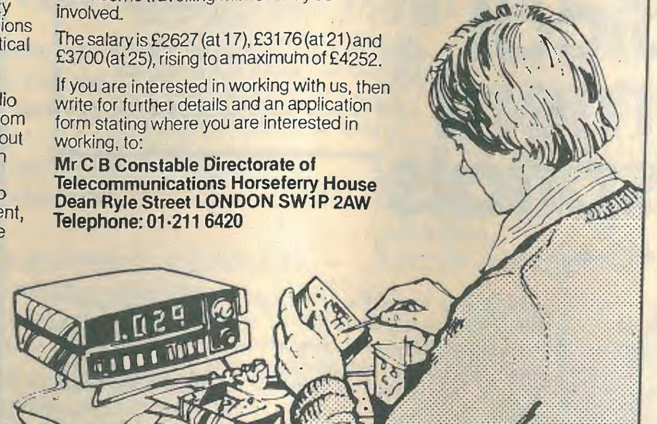
Possession of a driving licence is essential since some travelling will normally be involved.

The salary is £2627 (at 17), £3176 (at 21) and £3700 (at 25), rising to a maximum of £4252.

If you are interested in working with us, then write for further details and an application form stating where you are interested in working, to:

Mr C B Constable Directorate of Telecommunications Horseferry House Dean Ryle Street LONDON SW1P 2AW Telephone: 01-211 6420



HOME OFFICE

8894

Electronic Test Engineers

We manufacture and market audio noise reduction equipment which is used by major recording companies, recording studios and broadcasting authorities throughout the world and have enjoyed successful growth since incorporation in 1968.

The success of such films as "Star Wars" and "Close Encounters of the Third Kind" has led to an increased demand for our cinema equipment and contributed to our need for experienced test engineers for all our professional products.

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Salary + commission £7–8,000 p.a. Company car, pension and other attractive fringe benefits.

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Prices of above £70 to £500

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All our aerial equipment is professional MOD quality

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Candidates must have a degree or an equivalent qualification in electronics or electrical engineering and at least 2 years' experience in the design of electronic equipment covering analogue and digital circuits. Experience of medical electrical equipment advantageous.

Starting salary between £4,790 and £6,200 depending on qualifications and experience. Non-contributory pension scheme. Promotion prospects.

For further details and an application form (to be returned by 15 March, 1979) write to Civil Service Commission, Alencon Link, Basingstoke, Hants, RG21 1JB, or telephone Basingstoke (0256) 68551 (answering service operates outside office hours). **Please quote T(40)85/2.**

DHSS

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(9006)

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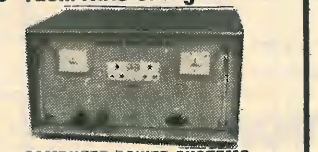

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(8363)

SITUATIONS VACANT

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Development Engineers are highly regarded at Ultra and enjoy considerable autonomy and opportunities for travel and customer liaison worldwide, and the chance to contribute and influence projects in a sophisticated technological environment.

To join us you should be qualified to degree level Electronics or Mechanical Engineering and have upwards of 4 years experience of development work in an electromechanical/ electronics environment.

Salaries will be negotiable and accompanied by a wide range of attractive large company benefits, including a very generous relocation package.

Men and women, for further information and an application form, please phone or write to **Mr. Gavin Rendall, Personnel Manager, Ultra Electronic Communications Limited, 419 Bridport Road, Greenford, Middlesex. UB6 8AU. Tel: 01-578 0081.**

UEL Electronic Communications Ltd

The Polytechnic of North London

TECHNICIAN (Grade IV)

Applications are invited for the appointment of a Grade IV Technician in the Department of Electronic and Communications Engineering.

This interesting post involves the operation and maintenance of high grade test equipment, together with the general responsibility for students' day-to-day requirements with experiments and projects in the laboratory. Participation in R and D work in the audio engineering field in liaison with the audio team is encouraged.

Educational level: ONC/OND, City and Guilds, approved apprenticeship or equivalent qualifications.

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