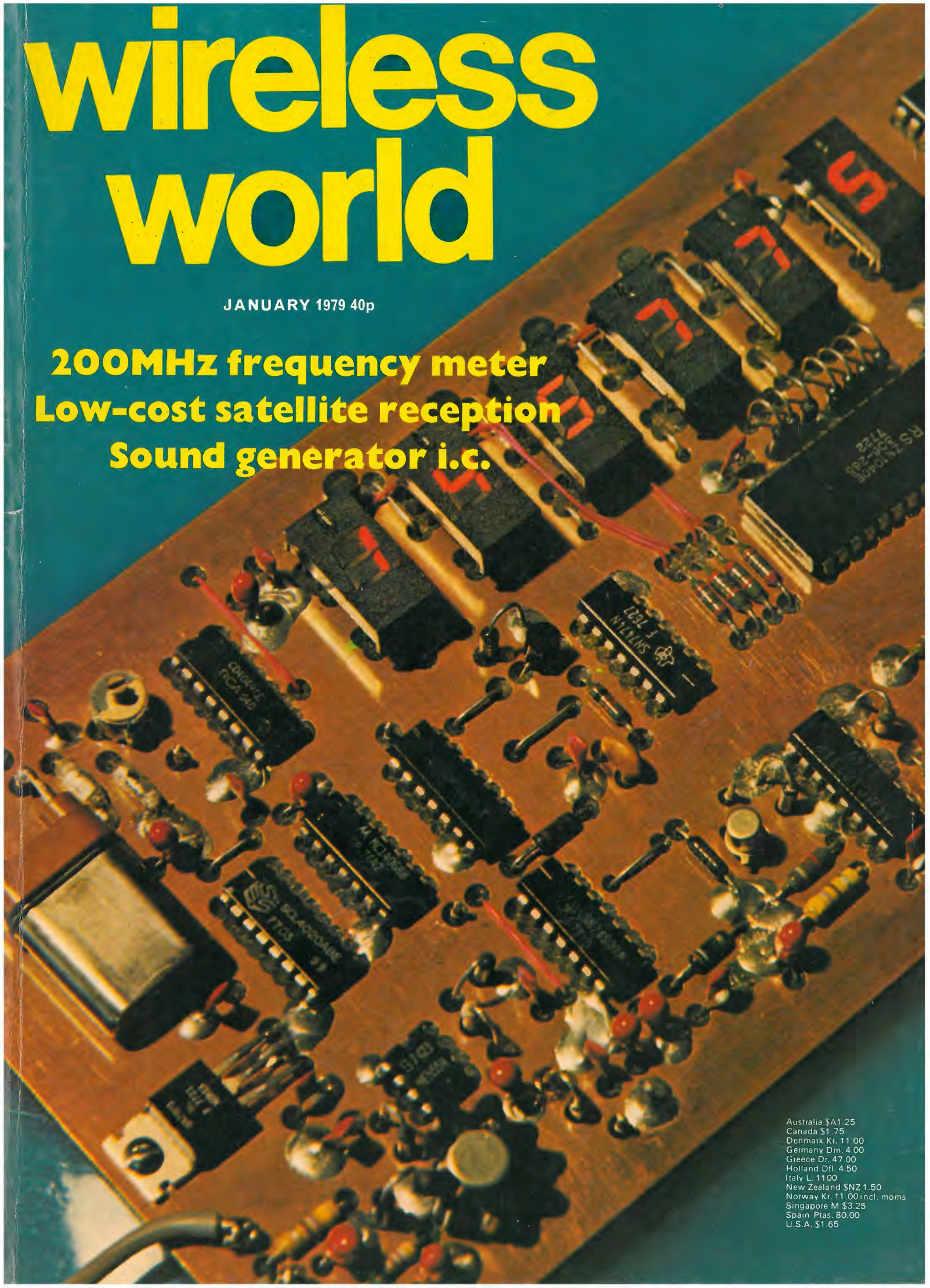
wireless world

JANUARY 1979 40p

200MHz frequency meter
Low-cost satellite reception
Sound generator i.c.



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The **mi** Signal Generator for vlf·lf·mf·hf·vhf bands

AM/FM Signal Generator TF 2016 is a general purpose instrument for receiver testing. Its facility for battery operation and its rugged construction make it ideal for field as well as factory use.

TF 2016 will deliver up to 4 V e.m.f. and yet has a leakage level that is so low that even receivers with a sensitivity of 0.1 μV can be tested without ambiguity. And the **total** output level accuracy of ± 1 dB ensures confidence every time.

Fundamental frequency generation is used over the entire frequency range thus ensuring the total absence of non-harmonics. The good tuning discrimination makes narrow band receiver testing quick and easy.

Amplitude modulation up to 100% modulation depth and frequency modulation up to 75 kHz deviation are available using the internal 400 Hz and 1 kHz oscillators. External modulation can be applied and, if required, internal a.m. and external f.m., or internal f.m. and external a.m., can be applied simultaneously.

A version of TF 2016 will shortly be available equipped with a 150 Hz preset pilot tone f.m. for use on Clansman receivers.

Pulse Modulator, TF 2169, may be fitted to the signal generator to provide pulsed r.f. for radar i.f. testing. IF probes can be supplied to help tuning to receivers fitted with battery economizer circuits. Alternative output level calibration plates, matching pads, attenuators and r.f. fuse units are included in the wide range of optional accessories.

Digital Synchronizer

The addition of this clip-on unit (as shown in our photograph) converts the TF 2016 into a synthesizer. It provides a stability of ± 1 part in 10^6 and allows the frequency to be set in 10 Hz steps.

Full information gladly supplied on request.

mi MARCONI INSTRUMENTS

Marconi Instruments Limited · Longacres · St. Albans · Hertfordshire · England AL4 0JN · Tel: (0727) 59292 · Telex: 23350
Marconi Electronics Inc · 100 Stonehurst Court · Northvale · New Jersey 07647 **USA** · Tel: (201) 767-7250 · Twx: 710-991-9752
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A GEC-Marconi Electronics Company

Front cover shows the 200MHz frequency meter which provides the main project for construction in this issue. See inside for Part 1.

IN OUR NEXT ISSUE

High quality audio pre-amplifier. **A development of Douglas Self's November 1976 design but with an active gain control and less expensive to build.**

Milestones in electronics, **an interview with Professor Bernard Tellegen, inventor of the pentode, discoverer of the Luxembourg Effect and pioneer of the gyrator.**

The lean years. **Sunspot activity is now increasing. Unusual coloured charts show this activity over the past few years in relation to critical propagation frequencies.**

Current issue price 40p, back issue (if available) 50p. at Retail and Trade Counter, Paris Garden, London SE1. Available on microfilm: please contact editor.

By post, current issue 55p, back issues (if available) 50p, order and payments to Room CP34, Dorset House, London SE1 9LU.

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wireless world

ELECTRONICS / TELEVISION / RADIO / AUDIO

JANUARY 1979 Vol 85 No 1517

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

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

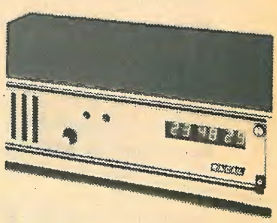
But it's fundamental to the very existence of communications recording to be able to replay a selected portion of tape to find out what was said by who, to whom . . . and when. And 'when' can be vital.

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

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

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

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



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

Racal-Thermionic the recording people

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

RACAL

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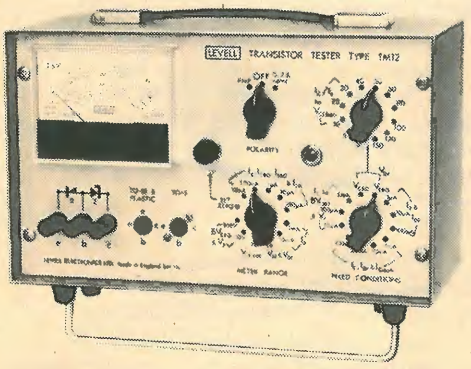
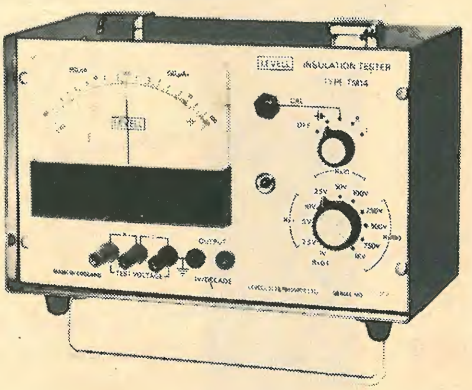
DON'T GAMBLE WITH PERFORMANCE BUY LEVELL TESTERS





Tests bipolar transistors, diodes and zener diodes. Measures leakage down to 0.5 nA at 2V to 150V. Current gains are checked from 1μA to 100mA. Breakdown voltages up to 100V are measured at 10μA, 100μA and 1mA. Collector to emitter saturation voltage is measured at 1mA, 10mA, 30mA and 100mA for I_C/I_B ratios of 10, 20, 30. The instrument is powered by a 9V battery.

TRANSISTOR RANGES (PNP OR NPN)

I_{CBO} & I_{EBO}: 10nA, 100nA, 1μA, 10μA and 100μA f.s.d. acc. ±2% f.s.d. ±1% at voltages of 2V, 5V, 10V, 20V, 30V, 40V, 50V, 60V, 80V, 100V, 120V, and 150V acc. ±3% ±100mV up to 10μA with fall at 100μA < 5%+250mV.

BV_{CBO}: 10V or 100V f.s.d. acc ±2% f.s.d. ±1% at currents of 10μA, 100μA and 1mA ±20%.

I_B: 10nA, 100nA, 1μA ... 10mA f.s.d. acc. ±2% f.s.d. ±1% at fixed I_E of 1μA, 10μA, 100μA, 1mA, 10mA, 30mA, and 100mA acc. ±1%.

h_{FE}: 3 inverse scales of 2000 to 100, 400 to 30 and 100 to 10 convert I_B into h_{FE} readings.

V_{BE}: 1V f.s.d. acc. ±20mV measured at conditions on h_{FE} test.

$V_{CE(sat)}$: 1V f.s.d. acc. ±20mV at collector currents of 1mA, 10mA, 30mA and 100mA with I_C/I_B selected at 10, 20 or 30 acc. ±20%.

DIODE & ZENER DIODE RANGES

I_{DR}: As I_{EBO} transistor ranges.

V_Z: Breakdown ranges as BV_{CBO} for transistors.

V_{DF}: 1V f.s.d. acc. ±20mV at I_{DF} of 1μA, 10μA, 100μA, 1mA, 10mA, 30mA and 100mA.

type TM12 **£120**

A logarithmic scale covering 6 decades is used to display either insulation resistance or leakage current at a fixed stabilised test voltage. The current available is limited to a maximum value of 3mA for safety and capacitors are automatically discharged when the instrument is switched off or to the CAL condition. The instrument operates from a 9V internal battery.

RESISTANCE RANGES

10MΩ to 10TΩ (10^{13}Ω) at 250V, 500V, 750V and 1kV.
1MΩ to 1TΩ at 25V, 50V and 100V.
100kΩ to 100GΩ at 2.5V, 5V and 10V.
10kΩ to 10GΩ at 1V.
Accuracy ±15% +800Ω on 6 decade logarithmic scale.
Accuracy of test voltages ±3% ±50mV at scale centre.
Fall of test voltages < 2% at 10μA and < 20% at 100μA.
Short circuit current between 500μA and 3mA.

CURRENT RANGE

100pA to 100μA on 6 decade logarithmic scale.
Accuracy of current measurement ±15% of indicated value.
Input voltage drop is approximately 20mV at 100pA, 200mV at 100nA and 400mV at 100μA.
Maximum safe continuous overload is 50mA.

MEASUREMENT TIME

< 3s for resistance on all ranges relative to CAL position.
< 10s for resistance of 10GΩ across 1μF on 50V to 500V.
Discharge time to 1% is 0.1s per μF on CAL position.

RECORDER OUTPUT

1V per decade ±2% with zero output at scale centre.
Maximum output ±3V. Output resistance 1kΩ.

type TM14 **£130**

Optional extras are leather cases and mains power units. Prices are ex works, V.A.T. extra in U.K.

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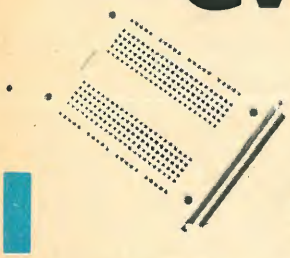
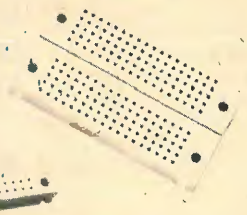
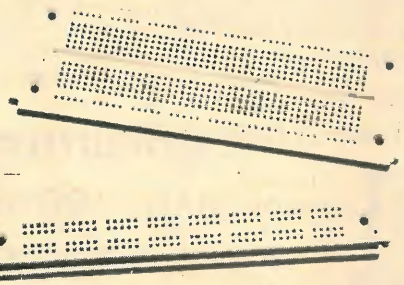
Now, from the breadboard specialists– even better boards!

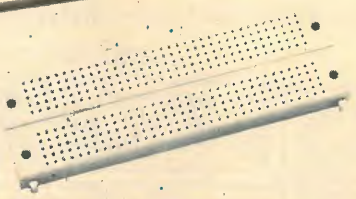


Since the appearance of the first breadboards back in the '40's, we've really been going places. (The U.K., for one.) So we now have an exceptional range of prototyping products which are outstanding in their simplicity, versatility and reliability. Just see. (And for prices and specs., eyes left!)



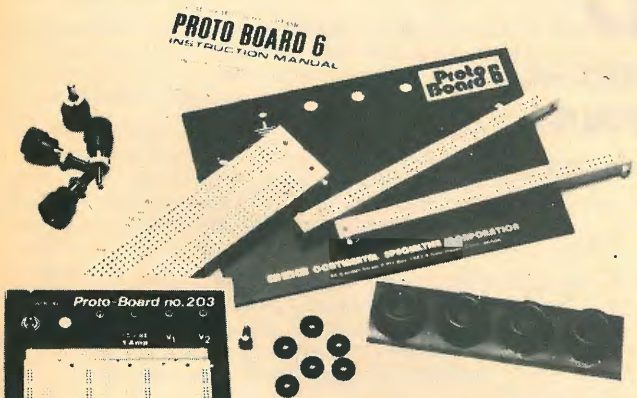
Experimentor Series.
Low-cost, interlocking, solderless breadboard – the world's first for 0.3in. and 0.6 in. pitch DIPs.

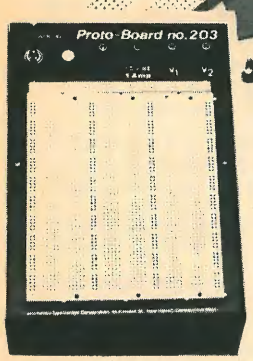




2 Quick Test Series.
Low-cost, snap-locking solderless circuit boards for fast design with discrete components.

3 The Protoboard Series.
Solderless breadboards with built-in 10% regulated 5Vd.c. 1A power supply; 2,250 solderless tie points; and capacity for DIPs of 14 to 40 pins.





4 Design Mate Test Instruments.
DM-1 power supply, 5V to 15Vd.c. at 600mA; DM-2 function generator for sine, square and triangle wave generation; DM-3 R/C bridge giving 10 ohm to 10 megohm, 10pF to 1.0µf; DM-4 pulse generator with 0.5 Hz to 5MHz frequency and 100ns to 1 sec pulse widths.

5 IC Test Clips.
Ultra-low cost IC clips in 14, 16, 24 and 40 pin versions.

Take a look at our low, low prices and quality specs., and get aboard! (Or if its data you're after, pick up the phone or drop us a line.) For the best, from the specialists in breadboards.

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Peace and quiet

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But the distortion contribution from a QUAD 405 amplifier in normal use (say 85dBa) moves the eardrum less than this amount.

Perhaps sitting in a very quiet room at –100°C and without the music we might nearly hear them ....but "'tis bitter cold."

For further details on the full range of QUAD products write to:

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Huntingdon, PE18 7DB. Tel: (0480) 52561.

*Sensitivity is never made more acute by the presence of other sounds.

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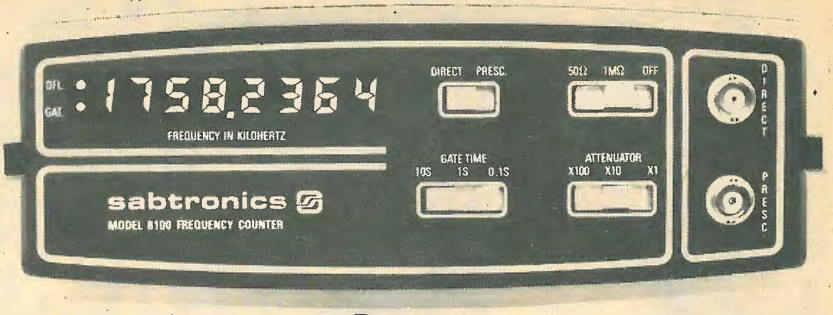
1978

We've made the impossible AGAIN. A superior frequency counter Kit for only £69.95



Now you can forget about price/performance trade-offs when you select a frequency counter. In Sabtronics' Model 8100 kit you get all the characteristics of a much higher-priced counter for only £ 69.95.
This frequency counter, employing LSI technology, has the performance and input characteristics you demand: guaranteed frequency range of 20 Hz to 100 MHz; selectable hi/lo impedance; superior sensitivity; selectable resolution and selectable attenuation. Plus an accurate time base with excellent stability. An 8-digit LED display features floating decimal point, leading zero suppression and overflow indicator. You would expect to find all these features only on high-priced instruments – or from Sabtronics' advanced digital technology.

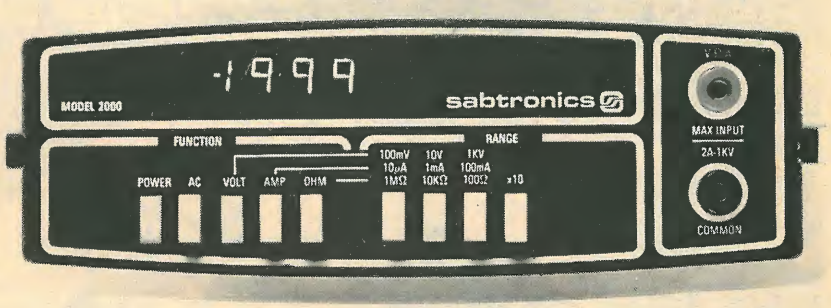
BRIEF SPECIFICATIONS:

Frequency Range: 20 Hz to 100 MHz guaranteed, (10Hz to 120 MHz typical) – Sensitivity: 25 mV RMS, 20 Hz to 70 MHz (20 mV typical); 45 mV RMS, 70 MHz to 120 MHz (30 mV typical) – Selectable Impedance: 1MΩ /25 pF or 50Ω – Attenuation: X1, X10 or X100 – Accuracy: ± 1 Hz plus time base accuracy – Aging Rate: ± 5 ppm/yr – Temperature Stability: ± 10 ppm, 0° to 50° C – Resolution: 0.1 Hz, 1 Hz, 10 Hz selectable – Display: 8-digit LED, floating DP, overflow indicator – Overload Protection – Power Requirement: 9-15 VDC.

Also available assembled at £ 84.95.

Optional prescaler will be available from around January 1979.

Uncompromising performance. Incredible price. A professional 3½ digit DMM Kit for less than £50.00



Incredible? True! Professionals and hobbyists alike are believers in this Sabtronics 2000, the only portable/bench DMM which offers such uncompromising performance at the astonishingly low price of £ 49.95.

Uncompromising performance you'd expect only from a specialist in digital technology such as Sabtronics: Basic DCV accuracy of 0.1% ± 1 digit; 5 functions giving 28 ranges; readings to ± 1999 with 100% overrange; over-range indication; input overload protection; automatic polarity.

The low price of £ 49.95? Simple: The Model 2000 is all solid-state, incorporating a single LSI circuit and high-quality components. You assemble it yourself, using our clear, easy-to-follow, step-by-step assembly manual. Kit is complete, including a high-impact case.

Now you too can have it! A professional-quality 3½ digit Sabtronics Model 2000 DMM kit for only £ 49.95. If you don't have one in your lab, use the coupon below to order NOW.

Easy to follow caliberation procedure provided in the assembly manual.

BRIEF SPECIFICATIONS:

DC volts in 5 ranges: 100 μV to 1 kV – AC volts in 5 ranges: 100 μV to 1 kV – DC current in 6 ranges: 100 nA to 2A – AC current in 6 ranges: 100 nA to 2A – Resistance: 0.1Ω to 20 MΩ in 6 ranges – AC frequency response: 40 Hz to 50 kHz – Display: 0.36" (9,1 mm) 7-segment LED – Input impedance: 10 MΩ – Size: 8" W × 6.5" D × 3" H (203 × 165 × 76 mm) – Power requirement: 4 "C" cells (not included).

Ordering information for overseas readers:

The price listed is for readers in U.K. only. Since export orders are exempt from VAT you may send your orders directly to

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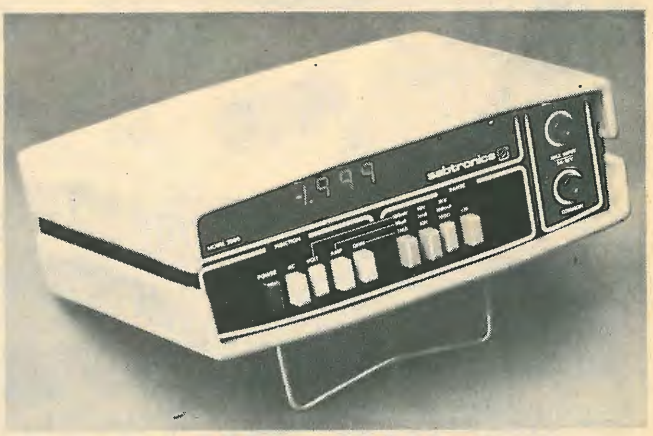
Winkelriedstrasse 35
CH-6003 Luzern/Switzerland

Price:
£ 69.95 + £ 6.50 for shipping and handling for Model 8100
£ 49.95 + £ 6.50 for shipping and handling for Model 2000



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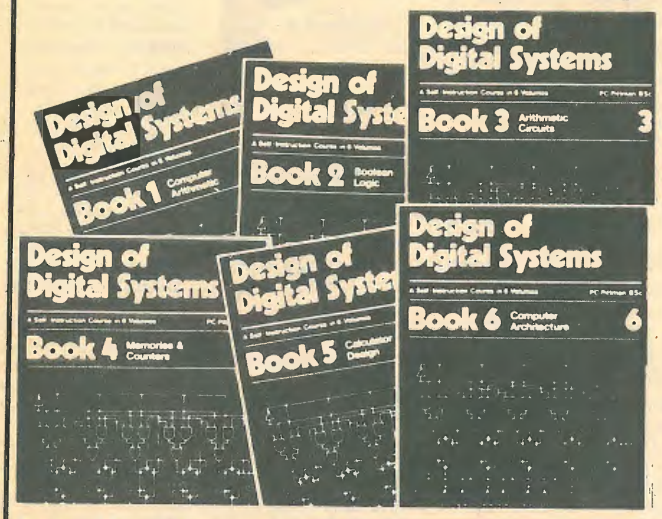
Understanding Digital Electronics

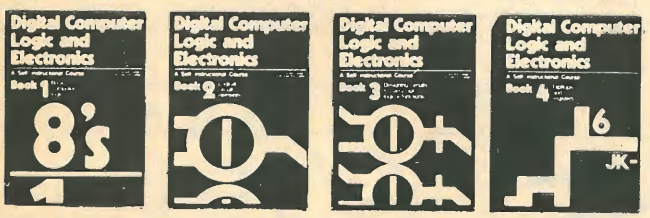
New teach-yourself courses



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.

Contents include: Binary, octal and decimal number systems; conversion between number systems; AND, OR, NOR and NAND gates and inverters; Boolean algebra and truth tables; De Morgans Laws; design of logic circuits using NOR gates; R-S and J-K flip flops; binary counters; shift registers and half adders.

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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.

After completing these courses you will have broadened your career prospects and increased your fundamental understanding of the rapidly changing technological world around you.

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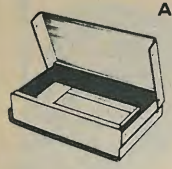
BIMENCLOSURES

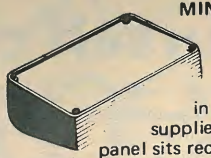
ALL METAL BIMCASES



Red, Grey or Orange 14swg Aluminium removable top and bottom covers. 18 swg black mild steel chassis with fixing support brackets.

BIM 3000
(250x167.5x68.5mm)
£14.58

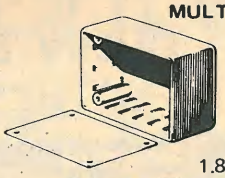
MINI DESK BIMCONSOLES



Orange, Blue, Black or Grey ABS body incorporates 1.8mm pcb guides, stand-off bosses in base with 4 BIMFEET supplied. 1mm Grey Aluminium panel sits recessed with fixing screws into integral brass bushes.

BIM 1005 (161 x 96 x 58mm) £2.18
BIM 1006 (215 x 130 x 75mm) £3.05

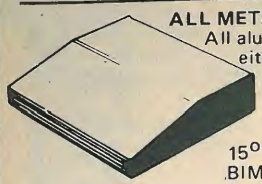
MULTI PURPOSE BIMBOXES



Orange, Blue, Black or Grey ABS with 1mm Grey Aluminium recessed front cover held by screws into integral brass bushes. 1.8mm pcb guides incorporated and 4 BIMFEET supplied.

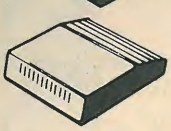
BIM 4003 (85x56x28.5mm) £1.18
BIM 4004 (111x71x41.5mm) £1.62
BIM 4005 (161x96x52.5mm) £2.19

ALL METAL BIMCONSOLES



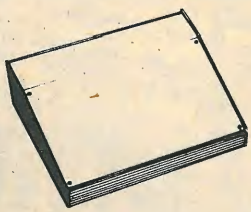
All aluminium, 2 piece desk consoles with either 15° or 30° sloping fronts, sit on 4 self-adhesive non-slip rubber feet. Ventilation slots in base and rear panel for excellent cooling.

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



15° Sloping Panel	30° Sloping Panel	
BIM7151 (102x140x51[28] mm)	BIM7301 (102x140x76[28] mm)	£10.67
BIM7152 (165x140x51[28] mm)	BIM7302 (165x140x76[28] mm)	£11.44
BIM7153 (165x216x51[28] mm)	BIM7303 (165x183x102[28] mm)	£12.61
BIM7154 (165x211x76[33] mm)	BIM7304 (254x140x76[28] mm)	£13.82
BIM7155 (254x211x76[33] mm)	BIM7305 (254x183x102[28] mm)	£15.36
BIM7156 (254x287x76[33] mm)	BIM7306 (254x259x102[28] mm)	£16.67
BIM7157 (356x211x76[33] mm)	BIM7307 (356x183x102[28] mm)	£17.58
BIM7158 (356x287x76[33] mm)	BIM7308 (356x259x102[28] mm)	£18.55

LOW PROFILE BIMCONSOLES



Orange, Blue, Black or Grey ABS body has ventilation slots as well as 1.8mm pcb guides and stand-off bosses in base. Double angle recessed front panel with 4 fixing screws into integral brass bushes. 4 BIMFEET supplied.

BIM 6005 (143 x 105 x 55.5 [31.5] mm) £2.37
BIM 6006 (143 x 170 x 55.5 [31.5] mm) £3.08
BIM 6007 (214 x 170 x 82.0 [31.5] mm) £4.12

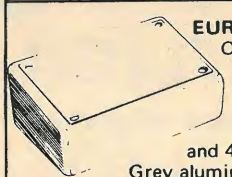
ABS & DIECAST BIMBOXES

6 sizes in ABS or Diecast Aluminium. ABS moulded in Orange, Blue, Black or Grey. Diecast Aluminium in Grey Hammertone or Natural. All boxes incorporate 1.8mm pcb guides, stand-off supports in base and have close fitting flanged lids held by screws into integral brass bushes (ABS) or tapped holes (Diecast).

	ABS		Diecast	Hammertone	Natural
(50x60x31mm)	N/A		BIM5001/11	TBA	TBA
(100x50x25mm)	BIM2002/12	£0.96	BIM5002/12	£1.46	£1.19
(112x62x31mm)	BIM2003/13	£1.13	BIM5003/13	£1.78	£1.46
(120x65x40mm)	BIM2004/14	£1.35	BIM5004/14	£2.24	£1.82
(150x80x50mm)	BIM2005/15	£1.52	BIM5005/15	£2.84	£2.28
(190x110x60mm)	BIM2006/16	£2.37	BIM5006/16	£3.94	£3.33

Also available in Grey Polystyrene with no slots and self-tapping screws
BIM 2007/17 (112x61x31mm) £1.00

EUROCARD BIMCONSOLES

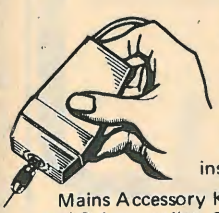


Orange, Blue, Black or Grey ABS body accepts full or ½ size Eurocards, with bosses in the base for direct fixing. 1.8mm wide pcb guides incorporated and 4 BIMFEET supplied. 1mm Grey aluminium lid sits flush with body top and held by 4 screws into integral brass bushes.

BIM 8005 (169x127x70[45] mm) £4.12
BIM 8007 (to be announced shortly)

BIMTOOLS

MAINS BIMDRILLS



Small, powerful 240V hand drill complete with 2 metres of cable and 2 pin DIN plug. Accepts all tools with 1mm, 2mm or .125" dia. shanks. Drills brass, steel, aluminium and pcb's. Under 250g, off load speed 7500 rpm. Orange ABS, high impact, fully insulated body with spring return on/off switch £10.53

Mains Accessory Kit 1 includes 1mm, 2mm, .125" twist drills, 5 burrs and 2.4mm collet £2.48

Mains Kit 2 includes Mains BIMDRILL as above, 20 assorted drills, mops, burrs, grinding wheels and mounted points, 1mm, 2mm, 2.4mm and .125" collets. Complete in transparent case measuring 230x130x58mm £22.14

12 VOLT BIMDRILLS

2 small, powerful drills easily hand held or used with lathe/stand adaptor. Integral on/off switch and 1 metre cable.

Mini BIMDRILL with 3 collets up to 2.4mm dia £ 8.10
Major BIMDRILL with 4 collets up to 3mm dia £13.60

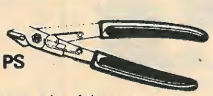
Accessory Kits 1 have appropriate drills and collets as above plus 20 assorted tools. Mini Kit 1 – £15.12, Major Kit 1 – £19.44.
Accessory Kits 2 have appropriate drills, collets plus 40 tools and mains 12V dc adaptor. Mini Kit 2 – £34.02, Major Kit 2 – £39.42.

Accessory Kits 3 as appropriate Kits 2 plus stand/lathe unit. Mini Kit 3 – £45.36, Major Kit 3 – £50.76.

BIMDIPS

Rapidly inserts and withdraws any 4-18 pin, .3" pitch DIL package without beding the legs. Adjustable metal jaws for MOS type devices grip the bottom of the leg for minimum strain. Will pick up IC's from a bench, a carrier or a pcb. £13.77.

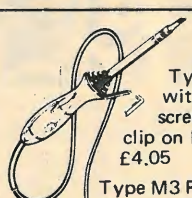
BIMSNIPS



Precision made side cutters, spring action, ground steel fine pointed blades for intricate work.

5¼" long £3.34

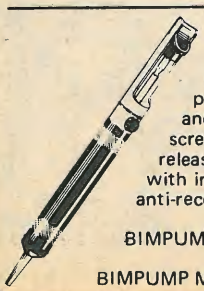
BIMIRONS



Type 30 General Purpose 27 watt iron with long life, rapid change element, screw on tip, stainless steel shaft and clip on hook. Styled handle with neon. £4.05

Type M3 Precision 17 watt iron, quick change tip, long life element, styled handle with clip on hook £4.43

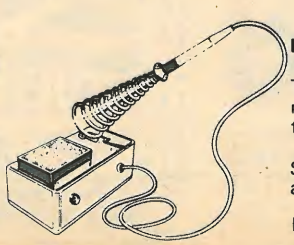
BIMPUMPS



2 all metal desoldering tools provide high suction power and have easily replaceable screw in Teflon tips. Primed and released by thumb operation with in-built safety guard and anti-recoil system.

BIMPUMP Major (180mm long) £7.99
BIMPUMP Minor (150mm long) £6.80

BIMSTATION



Type PSU6 Soldering Iron Station complete with 6V, 6 Watt miniature iron having stainless steel shaft, quick change slide on tip and long life element.

Station contains 240V/6V transformer, neon, coiled iron support and sponge iron tip cleaning pad.

New product available shortly

BIMENCLOSURES (Bimboxes, Bimconsoles and Bimcases) BIMTOOLS (Bimirons, Bimdrills, Bimsnips, Bimpumps, Bimdips) BIMACCESSORIES (Bimfeet, Bimdaptors) BIMDICATORS BIMBOARDS

BIMDICATORS

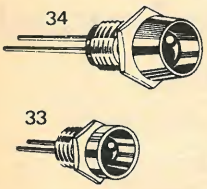
ECONOMY QUALITY LED's

.125" dia. lens .2" dia. lens

Mixed bags of .125" and .2" dia. lens in various colours
50 for £5.67, 100 for £10.00

FULL SPECIFICATION LED's

.125" or .2" with mounting clips and data
Red – £1.67/pack of 5, Green – £2.48/pack of 5, Yellow/Amber – £3.18/pack of 5



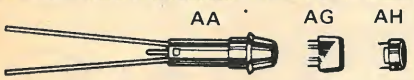
33 and 34 SERIES

Front viewing (30° angle) LED indicators

BIM 33 is nickel plated, uses 3.2mm dia LED and needs 6.5mm dia. fixing hole.

BIM 34 is chromium plated, uses 5mm dia. LED and needs 8mm dia. fixing hole.

Red – £2.80/pack of 5, Green/Yellow – £3.24/pack of 5



A SERIES

240V Neon with integral resistor. held in 8mm hole by plastic bezel.

Red, Amber, Clear or Opal lens £2/pack of 5, Green lens £3/pack of 5

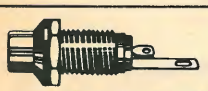
Low Voltage equivalent of above with Red, Amber, Clear, Opal or Green Lens.
6V £0.54 each, 14V £0.58 each, 28V £0.65 each

State Voltage, lens style, colour and whether tags or flying leads.

D SERIES

LES and Midget Flanged lampholder with 13mm dia. (A) and 18mm dia (B) lens. Solder tags. ½" dia. hole fixing (lamps not supplied) plus chrome bezel with A lens.

Red, Amber, Clear, Green, Opal £0.66 each



G SERIES

TI Midget Flanged lampholder. Lamps are available on request. 8mm fixing hole, solder tags. Front replaceable, 7.25mm dia. lens. Red, Amber, Clear, Green, Opal £0.43

05 SERIES

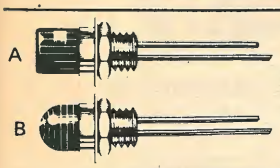
240V Neon with integral resistor. Self retaining in 13mm hole, Solder/.25" push on blades. 13mm dia. lens with 19mm dia. chrome bezel.

Red and Amber £0.61 each, Green £0.78 each.

M & MP SERIES

Low voltage nickel plated brass (M) and Polycarbonate (MP) indicators, 150mm leads, 6.4mm fixing hole Red, Amber, Clear, Green, Opal

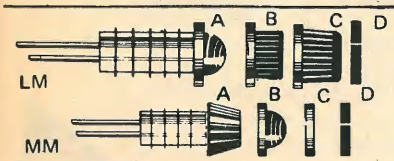
6.9mm dia. lens (M) 6V £0.65 each, 14V £0.68 each, 28V £0.79 each
7.5mm dia. lens (MP) 6V £0.55 each, 14V £0.59 each, 28V £0.68 each



BIM M LED SERIES

Nickel plated brass bodied LES indicator, 21mm wire wrappable leads, 6.5mm fixing hole, 2 styles, 6,8mm dia lens.

Red £0.67 each, Green £0.83 each, Amber £1.00 each



BIM LM & MM LED SERIES

Subminiature nylon bodied LED indicators with 12mm wire wrappable leads

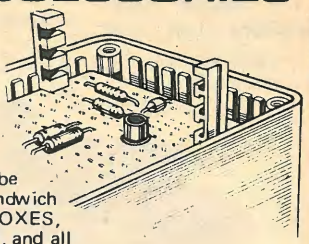
LM & MM push fit into 4.75mm & 4mm holes respectively. Each series has 4 lens styles in Red £0.67, Green £0.83, Yellow £1,00 each.

Both lenses 'D' are square

BIM 23, 26 & 56 LED SERIES

Black nylon bodied LED indicators. BIM 23 has 7mm flat face, BIM 26 & 56 utilise 4 & 5mm dia LED's. Push fit in 8mm hole. Red £0.46 each, Green £0.62 each, Yellow £0.77 each

BIMACCESSORIES



BIMDAPTORS

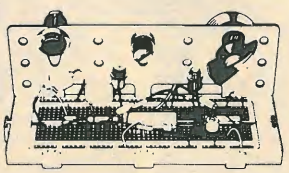
Allows pcb's to be flat mounted sandwich fashion in BIMBOXES, BIMCONSOLES, and all other enclosures having 1.5mm wide vertical guide slots. One plastic BIMDAPTOR on each corner of pcb(s) enables assembly to be simply slid into place. 54mm long, 10 slots on 5mm spacing and can be simply snipped off to length.

Packs of 25 £1.08 per pack

BIMFEET

11mm dia, 3mm high, grey rubber self adhesive enclosure feet.
Packs of 24 £0.77 per pack

BIMBOARDS



DIL COMPATIBLE BIMBOARDS

Accept all sizes (4-50 pin) of DIL IC packages as well as resistors, diodes, capacitors and LEDs. Integral Bus Strips up each side for power lines and Component Support Bracket for holding lamps, switches and fuses etc. Available as single or multiple units, the latter mounted on 1.5mm thick black aluminium back plate which stand on non slip rubber feet and have 4 screw terminals for incoming power.

BIMBOARD 1 has 550 sockets, multiple units utilising 2, 3 and 4 BIMBOARDS incorporate 1100, 1650 and 2200 sockets, all on 2.5mm (0.1") matrix.

BIMBOARD 1 £ 8.83
BIMBOARD 2 £21.01
BIMBOARD 3 £29.84
BIMBOARD 4 £38.79

DESIGNER PROTOTYPING SYSTEM

1, 2, or 3 BIMBOARDS mounted on BIM 6007 BIMCONSOLE with Integral Power Supply (±5 to ±15Vdc @ 100mA and fixed +5Vdc @ 1A) All O/P's fully isolated. Short circuit and fast fold back protection. Power rails brought out to cable clamps that accept stripped wire or 4mm plug.

DESIGNER 1 £55.62
DESIGNER 2 £61.02
DESIGNER 3 £66.42

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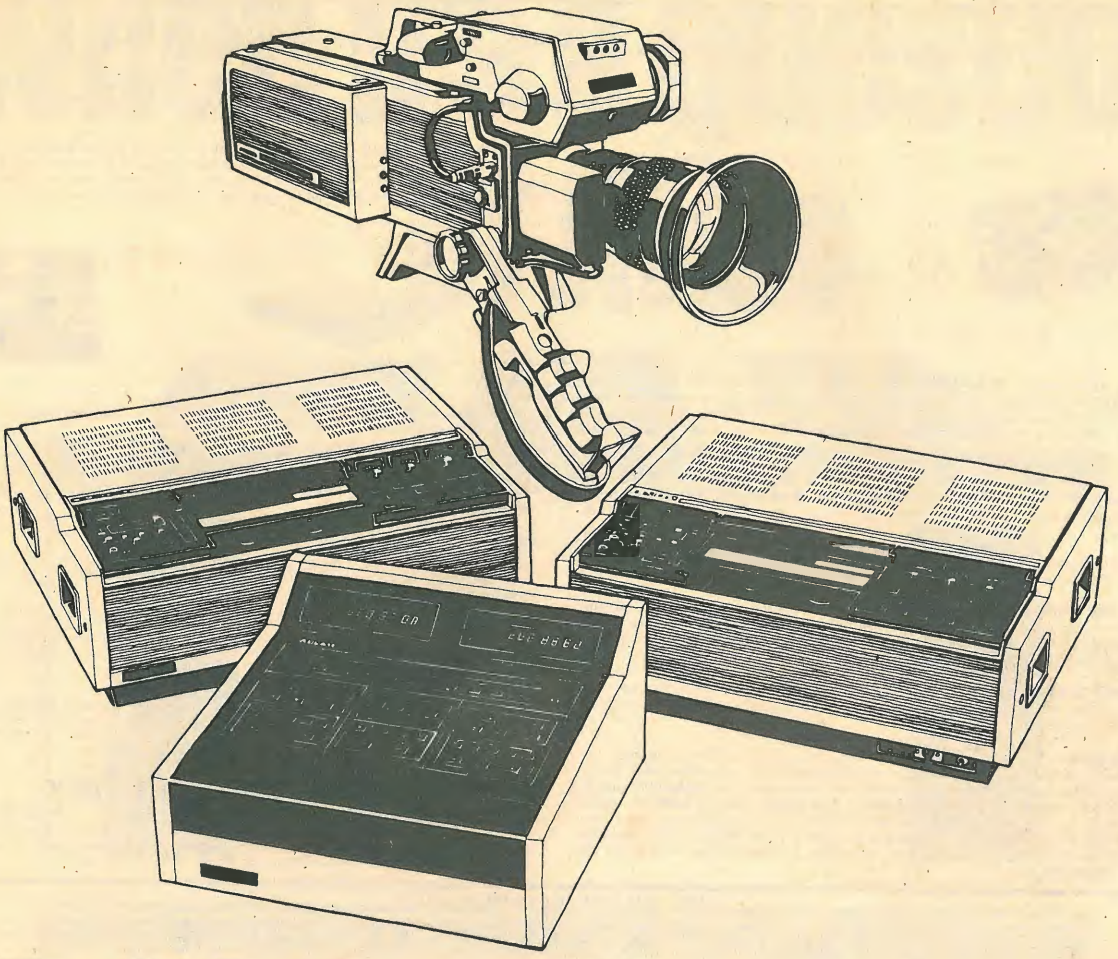
From Bell & Howell, exclusive distributors of JVC video products to the educational, industrial and institutional markets.



Bell & Howell introduce new ENG and off-line equipment from JVC

The new **CY8800E** 3-tube portable camera is designed to be hand held. With a choice of ⅔" Plumbicon or Saticon tubes, it is the latest product of JVC's 21-year involvement in video systems.

With a 49dB S/N ratio at f/4 and only 3000 lux illumination, the camera can also be used in light levels as low as 300 lux. Pictures through the 10:1 f/1.9 C-mount zoom lens, fitted as standard, look crisp and clean with better than 500 lines horizontal centre resolution. A wide range of facilities and compact packaging enable cameramen to provide shots of virtually any scene, indoors or on location. Standard features include a 1½" viewfinder with 3" magnifier, 3-way sensitivity switch (normal, +6dB, +12dB), auto white balance, bias lighting when fitted with Saticon tubes and built-in colour bar generator for fast alignment. Weight including lens and viewfinder is only 9.6kg.

For location work the well-respected JVC CR4400LE U-format portable recorder is an ideal companion, usable up to 12 metres away. The whole system operates from internal batteries or external power.

Used alone, the new **CR8500E** ¾" U-format video cassette recorder is designed to make editing simple and fast. Automatic variable speed playback in forward and reverse ensures accurate access to the exact edit point. Fully framed edits with an accuracy of ±2 frames and the proven JVC colour dub system ensure successful copies every time.

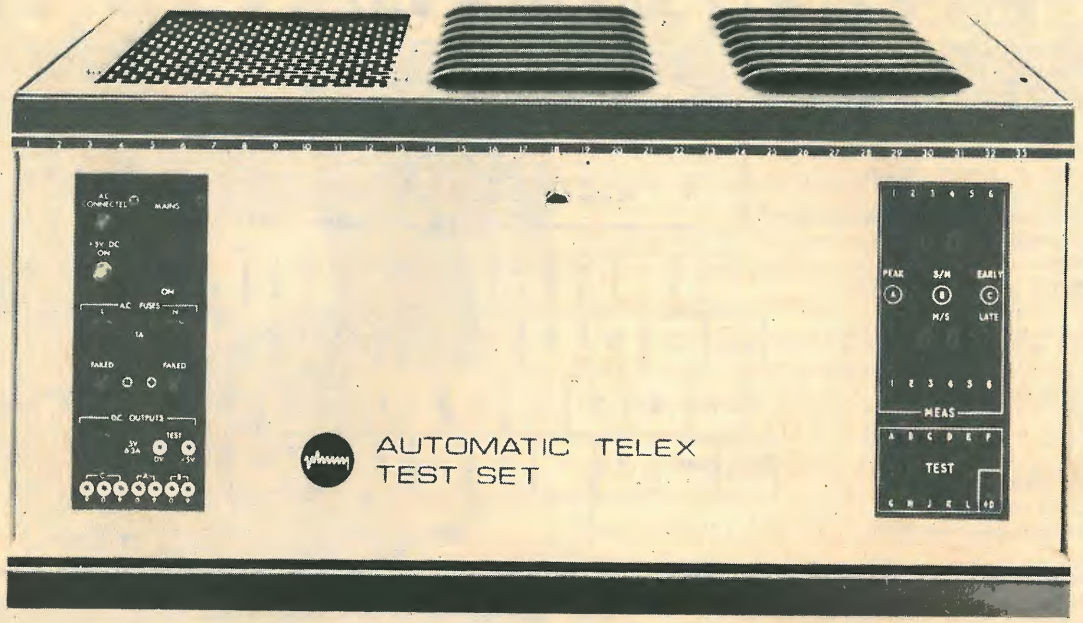
Together with the RM85E, two CR8500Es form a first-class edit suite for off-line or ¾" master editing. All transport and edit functions are remoted to the control console. From pressing the play button, video and audio head contact with the tape is maintained to enable any mode to be instantly selected. Location on the tape is constantly monitored by counting control track pulses, ensuring accurate tape position and time determination. Edit in and out times can be programmed and memorised for automatic assemble or insert editing and the precise position can be adjusted in single-frame steps in the preview mode before a commitment to record is made. The video and audio tracks may be separately or simultaneously edited in any combination.

The CR8500E brings a new degree of flexibility to the ¾" format; the CY8800E brings it to portable cameras. If you would like further information on JVC video equipment, use the reader inquiry service or write direct to Bell & Howell A-V Ltd., Freepost (no stamp required), Wembley Middlesex HA0 1BR.

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

WW — 070 FOR FURTHER DETAILS

When it's a question of ATE...



Plessey ATTS 10 is your built-in guarantee.

Plessey ATTS 10 is one of the latest developments in the Plessey range of telegraph margin and distortion testers. Combining signal generator and measuring set, ATTS 10 is designed for installation in a telex exchange or other communications centre.

Fully automatic, ATTS 10 is controlled from the keyboard of the teleprinter under test and provides test sequences to one of fourteen instructions. This enables the performance of the teleprinter to be rapidly assessed.

ATTS 10 operates to International Alphabet no. 2 at one pre-set link-selected speed in the range of 50, 75, 100, 110, 150, 200 and 300 bauds.

The level of distortion applied to test messages and the level at which distortion is measured are both accurate to within ± 1%.

ATTS 10 employs all solid-state circuitry, so it's rugged and reliable. It is designed for long periods of unattended operation.

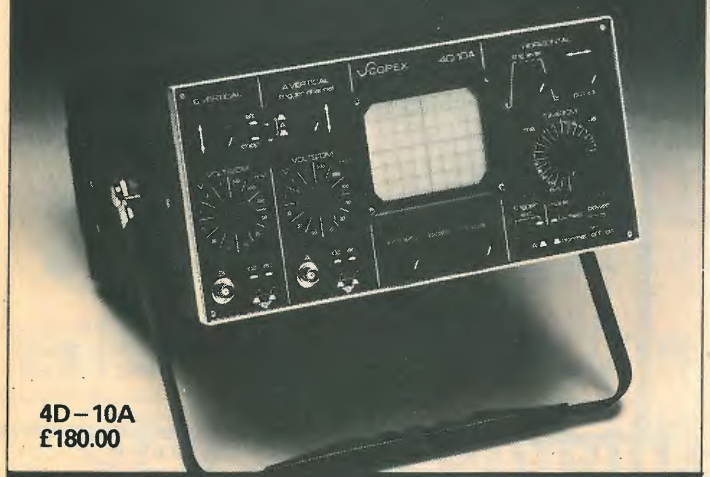
For full technical data on ATTS 10 and other Telegdata equipment contact Plessey.

PLESSEY CONTROLS

Plessey Controls Limited, Sopers Lane, Poole, Dorset, England, BH17 7ER
Telephone: (020 13) 5161 Telex: 41272

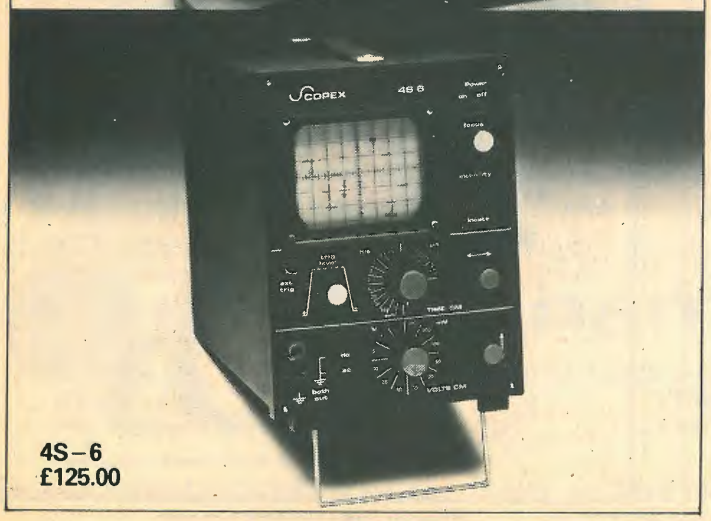
WW — 018 FOR FURTHER DETAILS

Scopex vital statistics: 2% more in accuracy, around 20% less in price.



4D–10A
£180.00

4D–25
£285.00



4S–6
£125.00

Greater accuracy, lower cost plus something more – a wide range covering dual trace, 10 and 25MHz, long persistance, rack mounted – single trace 6MHz, long persistance and battery portable models, plus a wide variety of accessories and probes.

The figure of 3% accuracy compares very favourably with the 5% claimed by our competitors. As does the Scopex reputation for producing reliable, easy to use oscilloscopes for just about every application.

Take the 4D – 10A dual trace model. Guaranteed 3% accuracy achieved by a stabilised power supply including the EHT. 10mV – 50V/cm sensitivity, TV field trigger and trace locate. £180.00*

Or the 4D – 25. Dual trace model with DC – 25MHz bandwidth and 10mV/cm sensitivity. Signal delay allows you to trigger from and see the leading edge of any signal. Trigger level and slope are selected on one dual function control. £285.00*

For more details of these and the full Scopex range simply return the coupon. Remember what you gain in accuracy, you lose in price.

*U.K. list price excluding VAT.

SCOPEX

WW1/79

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Please send me full details of the Scopex range of oscilloscopes.

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Company _____

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Tel.: _____

WW — 010 FOR FURTHER DETAILS

THINK OF A SHAPE

S 500D — dual channel up to 500W/RMS per channel DC-20 KHZ

Whatever it is, the H‖H 'S' range of power amplifiers will handle it

The H‖H 'S' range is designed to handle heavy industrial usage in the fields of vibrator driving, variable frequency power supplies and servo motor systems.

S 500D
Dual Channel
19" rack mount 3½" high
500w r.m.s. into 2.5 ohms per channel
900w r.m.s. in bridge mode
DC—20 KHZ at full power
0.005% harmonic distortion (typical) at 300w r.m.s. into 4 ohms at 1 KHZ
3KW dissipation from in-built force cooled dissipators

S 250D
Single Channel
19" rack mount 3½" high
500w r.m.s. into 2.5 ohms
Retro-convertible to dual channel
DC—20 KHZ at full power
Full short and open circuit protection
Drives totally reactive loads with no adverse effects

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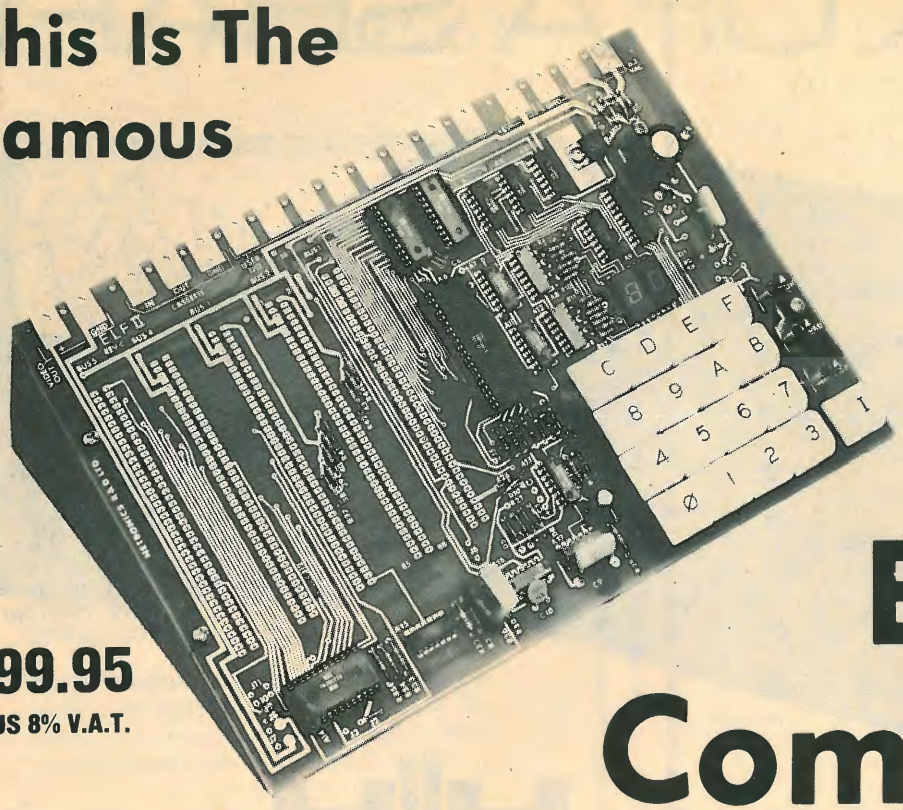

ELF II Computer

£99.95
PLUS 8% V.A.T.

SPECIFICATIONS

The £99.95 ELF II computer features an RCA COSMAC COS/MOS 1802 8-bit microprocessor addressable to 64K bytes with DMA, interrupt, 16 registers, ALU, 256 byte RAM expandable to 64K bytes, professional hex keyboard fully decoded so there's no need to waste memory with keyboard scanning circuits, built-in power regulator, 5 slot plug-in expansion bus (less connectors), stable crystal clock for timing purposes and a double-sided, plated-through pc board plus RCA 1861 video IC to display any segment of memory on a video monitor or TV screen along with all the logic and support circuitry you need to learn every one of the RCA 1802's capabilities

Stop reading about computers and get your hands on one! With ELF II and our new *Short Course* by Tom Pittman, you can master computers in no time at all ELF II demonstrates all 91 commands an RCA 1802 can execute and the *Short Course* quickly teaches you how to use each of the 1802's capabilities.

Elf II's video output lets you display an alphanumeric readout or graphics on any TV screen or video monitor and enjoy the latest video games.

But that's not all. Once you've mastered computer fundamentals, ELF II can give you POWER with add-ons that are among the most advanced found anywhere. American IEEE chapters plus hundreds of universities and major corporations have chosen the ELF II to introduce their students and personnel to microprocessor computing!

Learn The Skill That May Soon Be Far More Important Than Your College Degree!

The ability to use the computer may soon be more important to your earning power than a college degree. Without a knowledge of computers, you are always at the mercy of others when it comes to solving highly complex business, engineering, industrial and scientific problems. People who understand computers can command MONEY and to get in on the action, you must learn computers. Otherwise you'll be left behind.

ELF II Is The F-A-S-T Way to Learn Computer Fundamentals!

Regardless of how minimal your computer background is now, you can learn to programme a computer in almost no time at all. That's because Netronics has developed a special *Short Course on Microprocessor And Computer Programming* in non-technical language that leads you through every one of the RCA COSMAC 1802's capabilities so you'll understand *everything* ELF II can do . . . *and how to get ELF II to do it!*

All 91 commands that an 1802 can execute are explained to you step-by-step. The text, written for Netronics by Tom Pittman, is a tremendous advance over every other programming book in print.

Keyed specifically to the ELF II, it's loaded with "hands on" illustrations. When you're finished, ELF II and the 1802 will no longer hold any mystery for you.

In fact, not only will you be able to use a personal computer creatively, you'll also be able to *understand* computing articles in the technical press.

If you work with large computers, ELF II and our *Short Course* will help you to understand what makes them tick.

A Dynamite Package For Just £99.95 Plus 8% V.A.T.!

With ELF II, you learn to use machine language — the fundamental language of all computers. Higher level languages such as FORTRAN and BASIC must be translated into machine language before a computer can understand them. With ELF II you build a solid foundation in computers so you'll really know what you're doing, no matter how complicated things get.

Video output also makes ELF II unique among computers selling such a low price. Attached to your TV set, ELF II becomes a fabulous home entertainment centre. It's capable of providing endless hours of fun for both adults and children all all ages! ELF II can create graphics, alphanumeric displays and fantastic video games.

Only a low cost RF modulator is required to connect ELF II to your TV's aerial socket! (To order see below.)

ELF II's 5-card expansion bus (connectors not included) allows you to expand ELF II as your needs for power grows. It you're an engineer, or hobbyist, you can also use ELF II as a counter, alarm, lock, thermostat, timer, or for countless other applications.

ELF II Explodes into A Giant!

Thanks to ongoing work by RCA and Netronics, ELF II add-ons are among the most advanced anywhere. Plug in the **GIANT BOARD** and you can record and play back programmes, edit and debug programmes, communicate with remote devices and make things happen in the outside world. Add **Kluge Board** to get ELF II to solve special problems such as operating a more complex alarm system or controlling a printing press. Add **4k RAM** board and you can write longer programmes, store more information and solve more sophisticated problems.

Expanded, ELF II is perfect for engineering, business, industrial, scientific and personal finance and tax applications. No other small computer anywhere near ELF II's low price is backed by such an extensive research and development programme.

The **ELF-BUG Monitor** is an extremely recent breakthrough that lets you debug programmes with lightning speed because the key to debugging is to know what's inside the registers of the microprocessor and, instead of single stepping through your programme, the ELF-BUG Monitor, utilising break points, lets you display the entire contents of the registers on your TV screen at any point in your programme. You find out immediately what's going on and can make any necessary changes. Programming is further simplified by displaying 24 bytes of RAM with full address, blinking cursor and auto scrolling. A must for serious programmers!

Netronics will soon be introducing the ELF II **Colour Graphics & Music System** — more breakthroughs that ELF II owners will be the first to enjoy!

Now BASIC Makes Programming ELF II Even Easier!

Like all computers, ELF II understands only "machine language" — the language computers use to talk to each other. But, to make life easier for you, we've developed an **ELF II Tiny BASIC.** It talks to ELF II in machine language for you so that you can programme ELF II with simple words that can be typed out on a keyboard such as PRINT, RUN and LOAD.

"Ask Not What Your Computer Can Do . . . But *What Can It Do For YOU!*

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With ELF II, you learn to write and run your own programmes. You're never reduced to being a mere keypunch operator, working blindly with someone else's predeveloped software.

No matter what your speciality is, owning a computer which you really know how to use is sure to make you a leader. ELF II is the fastest way there is to get into computers. Order from the coupon below!

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NOW AVAILABLE FOR ELF II —

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☐ Deluxe metal **cabinet** with plexiglas dust cover for ELF II. **£29.95*** plus £1.50 p&p.

☐ **RF Modulator** for use with TV set. **£3.00*** post paid.

☐ **GIANT BOARD** kit with cassette I/O. RS 232-C/TTY I/O. 8-bit P. I/O decoders for 14 separate I/O instructions and a system monitor/editor. **£39.95*** plus £1.00 p&p.

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☐ Professional **ASCII Keyboard** kit with 128 ASCII upper/lower case set, 96 printable characters, on board regulator, parity, logic selection and choice of 4 handshaking signals to mate with almost any computer **£64.95*** post paid.

☐ Deluxe metal cabinet for ASCII Keyboard. **£19.95*** plus £1.50 p&p.

☐ ELF II **Tiny BASIC** on cassette tape. Commands include SAVE, LOAD, ÷, x, (), 26 variables A-Z, LET IF/THEN, INPUT PRINT, GO TO, GO SUB, RETURN, END, REM, CLEAR, LIST, RUN PLOT, PEEK, POLE, Comes fully documented and includes alphanumeric generator required to display alphanumeric characters directly on your TV screen without additional hardware. Also plays tick-tack-toe plus a drawing game that uses ELF II's hex keyboard as a joystick, 4k memory required. **£14.95*** post paid.

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Ultimate Rejection	>40dB
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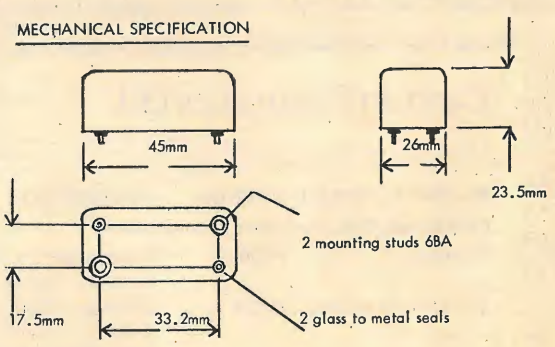

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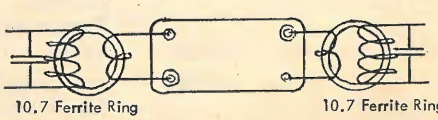

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BCX32	1043	8p	2S745A	690	4p
BCY70	1068	7p	2SB422	240	15p
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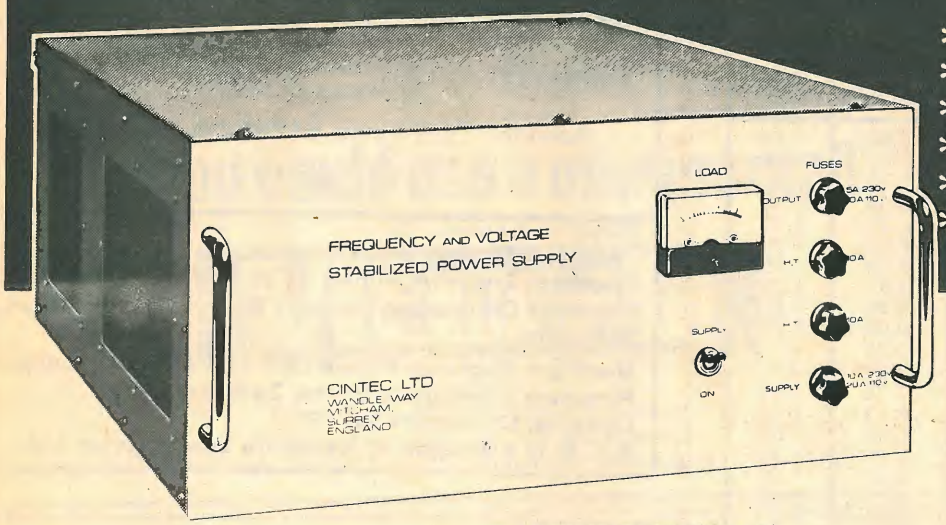

APPLICATIONS

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

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

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Reliable Frequency & Voltage Stabilization

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

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

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

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

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

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

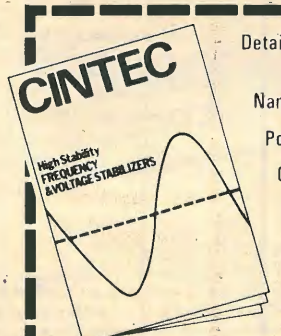
The Stabilizer may also be used as a frequency converter. For example, the supply to it can be any frequency between 45-65Hz and the output can be switched to either 50Hz or 60Hz.

SPECIFICATION

INPUT	100-125 volts or 200-250 volts at 45-65Hz.
OUTPUT RATING	115 volts or 230 volts
STABILITY Voltage	± 1% No load to full load—
Frequency	± 0.01% No load to full load
FREQUENCY	50Hz or 60Hz. Single or dual versions
WAVEFORM	SINUSOIDAL
DISTORTION	2%
AMB TEMP	−20 to + 40 C
DUTY	Continuous
DIMENSIONS	432 (W) x 196 (H) x 508mm (D) (17" x 7¾" x 20")
WEIGHT	45 or 30Kg unpacked
CONSTRUCTION	Cabinet or rack mounting
TERMINATION	Cannon Connectors at rear of case

24V DC Inverter

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



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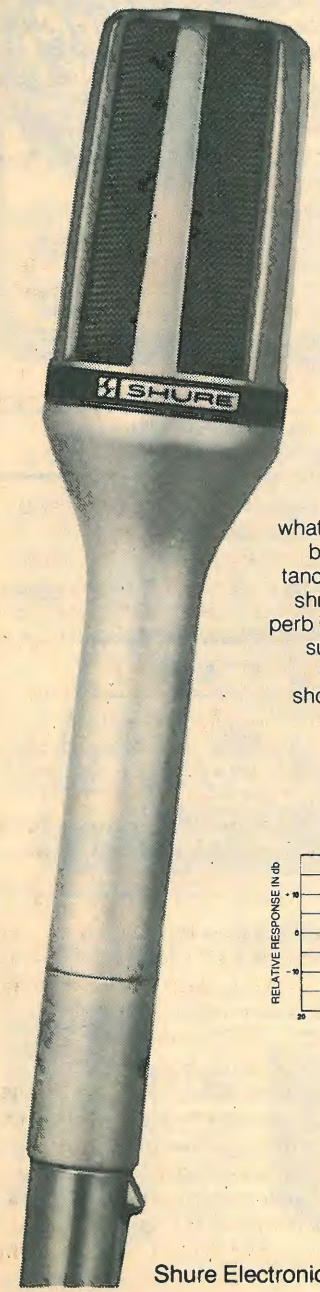
fact: you can choose your microphone to enhance your sound system.

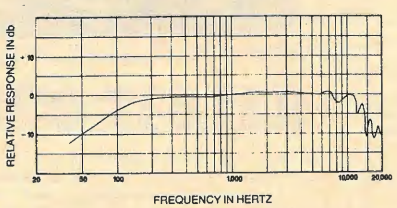
Shure makes microphones for every imaginable use.
Like musical instruments, each different type of Shure microphone has a distinctive "sound," or physical characteristic that optimizes it for particular applications, voices, or effects.
Take, for example, the Shure SM58 and SM59 microphones:



SM59

Mellow, smooth, silent...

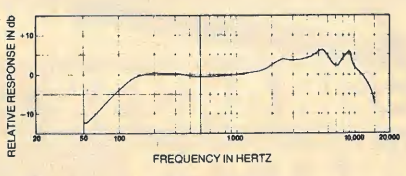
The SM59 is a relatively new, dynamic cardioid microphone. Yet it is already widely accepted for critical studio productions. In fact, you'll see it most often where accurate, natural sound quality is a major consideration. This revolutionary cardioid microphone has an exceptionally flat frequency response and neutral sound that reproduces exactly what it hears. It's designed to give good bass response when miking at a distance. Remarkably rugged—it's built to shrug off rough handling. And, it is superb in rejecting mechanical stand noise such as floor and desk vibrations because of a unique, patented built-in shock mount. It also features a special hum-bucking coil for superior noise reduction!

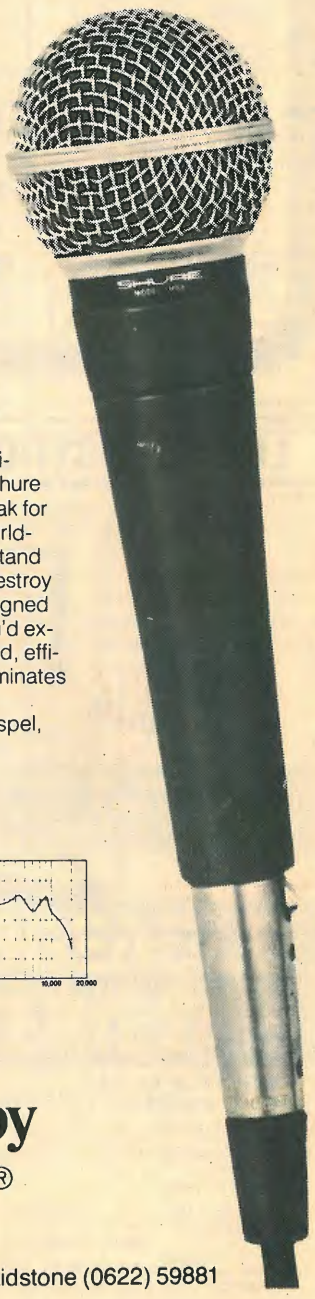


SM58

Crisp, bright "abuse proof"

Probably the most widely used on-stage, hand-held cardioid dynamic microphone. The SM58 dynamic microphone is preferred for its punch in live vocal applications... especially where close-up miking is important. It is THE world-standard professional stage microphone with the distinctive Shure upper mid-range presence peak for an intelligible, lively sound. World-renowned for its ability to withstand the kind of abuse that would destroy many other microphones. Designed to minimize the boominess you'd expect from close miking. Rugged, efficient spherical windscreen eliminates pops. The first choice among rock, pop, R & B, country, gospel, and jazz vocalists.





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wireless world

The death delivery business

WITH ADMIRABLE candour the editor of *Jane's Weapon Systems* reminds us what the real purpose of military equipment is. In the foreword to the latest edition of the book he says: "Since death is one of the design criteria of much of the hardware that is the subject matter of this book, it would be coy to the point of dishonesty to eschew the use of the word." If one did not know already, this thousand-page, four kilogram, £27.50 glossy catalogue of aberrant ingenuity would be a most effective demonstration of how this design criterion has come to depend more and more on electronics. We are in the business of the delivery of death. There is no need to elaborate on the communication and control systems used, for many of our readers know about them intimately. They design and make them. In Britain alone over half a million people get their living from military manufacturing and, of these, several tens of thousands are producing the electronic equipment. Over the past few years military electronics business has been growing at the rate of about 30 per cent per annum, and there have been great rejoicings in the halls of Decca, EMI, Ferranti, GEC-Marconi, Plessey, Racal and the many others dependent on them. Thanatos rules OK.

To judge from their public announcements, the managements of these companies are far from suffering any misgivings about this side of their activities – though they can sometimes be coy about revealing exactly who the customers are. They must be delighted by the latest "scenario" by the military analysts – *World War 3: A Military Projection Founded on Today's Facts* (Hamlyn). And the engineers, technicians and production people all seem happy in their work, for the death delivery business provides a good steady job for some and a permanent intellectual challenge for others. For the continuing obsolescence of the electronic systems is guaranteed by the arms race.

It must be that all these honest citizens are not really aware of what they are doing. Most of us, especially the younger ones, have not had the experience of seeing human beings torn into mutilated corpses by high explosives. Those of us who are not stupid or callous simply avert our eyes mentally. Or we employ the well established human trick of rationalizing and justifying what are basically irrational and unjustifiable motives – in this case fear and greed – by appeal to the abstractions and dogmas of politics, economics, patriotism or even religion. Or we are Captain Ahab: "All my means are sane: my motives and object mad."

But apart from the attitudes of individuals, ranging from indifference to fanaticism, what keeps this deadly trade going is an almost organic intercourse between the electronics firms and the military. A corruption case in 1978 gave point to it. The UK's Electronic Engineering Association, for example, might as well be a department of the War Office (now evasively called the Ministry of Defence). In his television series *The Age of Uncertainty* J. K. Galbraith described it in these words: "The military forces in each country exist in a symbiotic relationship with those who develop and manufacture the arms. Each lives off the other, each contributes to the other's growth, and the United States is then locked into a symbiotic relationship with the Soviet Union, and vice versa. In this relationship, each country, by the weapons it invents and acquires, provides the need for the other power to do likewise, and more. Each works with the other to ensure that the competition is self-perpetuating. No faith sustains this competition. It is a trap, and mankind is its victim."

And we in electronics are perfecting the trap.

Low-cost satellite receiving techniques

Direct television reception from satellites depends on low-cost reception equipment

by Pat Hawker

If direct television broadcasting from satellites if to be a reality, domestic receivers and aerials must be designed with reasonable cost and ease of installation in mind. The signal power at the aerial would be rather less than was originally envisaged, raising the question of noise and aerial gain. A design put forward by NHK in Japan is discussed.

FOR ANY NEW SYSTEM of broadcasting to succeed, it is a basic requirement that high-cost elements should be confined to the broadcaster rather than distributed among millions of receiving installations. For direct broadcasting from satellites to succeed, the picture in the home must be of good quality, and must relate to the costs of conventional terrestrial broadcasting reception, including receiver and aerial costs and installation and maintenance charges.

Set-makers have in the past coped effectively with the repeated demand by the frequency spectrum planners to use higher and even-higher frequencies. Radio broadcasting began around 1 MHz and soon involved 'Empire' services between 6-16MHz. Early high-definition television called for 40 MHz reception, the coming of Independent Television (ITV) in 1955 in Band III put television in the region of 200 MHz, and the 625-line UK colour services have raised the limit to 470-850 MHz. Yet never before has a single increase spanned so many octaves as would the introduction of 12GHz satellite television.

Furthermore, the World Agreement has placed an unexpectedly severe limit on permissible power flux. At −103 dBW/m^2 this is some 2dB lower than had been widely expected, and very much lower than the early visionaries had assumed.

Indeed, the 'down-link' (satellite-earth) is significantly more demanding in its requirements for good receiving installations than is the 'up-link' (earth-satellite) where cost is of far less importance.

The limiting factors in satellite reception are the aerial gain and thermal noise (noise temperature) of the receiver. Both the net gain of an aerial and the noise temperature of the system are usually referred to, or measured at, the input to the receiver. It must be appreciated that the aerial receives unwanted noise energy from the sky and that this increases rapidly at low angles of elevation. Ideally, the first stages of a receiver should have not only a low noise temperature (often defined in terms of noise factor) but also sufficient gain to reduce to an insignificant value the noise contributions of succeeding stages.

For the receiver designer, a significant advantage of space broadcasting would be the relative uniformity of signal strength; generally there would be much less variation than is common with terrestrial v.h.f./u.h.f. networks. If all broadcasts on Band VI were transmitted from space, the dynamic range of the receiver could be relatively small. There would also be fewer 'multipath' problems.

G/T requirements

The performance of a satellite receiving installation is often specified by the gain-to-noise temperature ratio (G/T) with both factors referred to the input of the receiver. Since T is a function of elevation angle of the aerial and G is a function of the frequency, both should be specified or clearly understood when considering a G/T figure-of-merit. The figure-of-merit may clearly be held to be a specific figure for a higher system noise temperature by increasing the gain of the aerial; or, for a lower gain aerial, by reducing the system noise temperature.

It may be noted that the original Intelsat specification for earth stations costing in the region of £1-million or more required the following performance:

$$G/T \geqslant 40.7 + 20\log_{10} f/4$$

and

$$G \geqslant 57 + 20\log_{10} f/4$$

In the 4GHz band this implied that, with an aerial net gain of 57.7dB (which could be achieved with a parabolic aerial of 85ft diameter) the earth station noise temperature of the receiver would not exceed 50°K. Of this 50°K, possibly 20°K might be contributed by a cooled parametric amplifier and up to 30°K by the aerial at the working elevation. It will be appreciated that such performance was close to the 'state-of-the-art' in the 1965–70 era, and parabolic aerials of about 100ft diameter were commonly used. For rebroadcast and distribution systems, a G/T ratio of the order of 15-20dB may be needed.

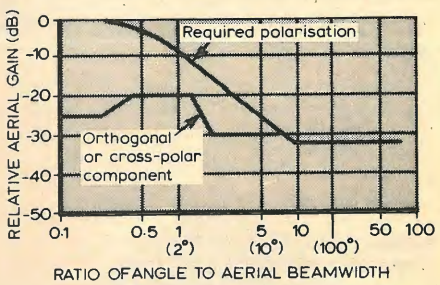


Fig. 1. *The CCIR template showing the reference patterns for minimum directivity characteristics of domestic community receiving aerials for satellite broadcasting. Maximum discrimination against the cross-polar component is required at the centre of the beam where an aerial gain of some 33dB is specified.*

12 GHz aerials

Such high G/T ratios are unnecessary for domestic and/or community reception. For the 11.7-12.5 GHz band with a power flux of −103dBW/m^2 a G/T of 6dB/K^{-1} will provide satisfactory colour television pictures at the outer edges of the service area.

This suggests that an aerial with a parabolic reflector of slightly less than 1m diameter would be required with a receiver noise factor of about 8dB. Within the United Kingdom arrival angles of a signal from a satellite positioned at 31°W would vary from about 27° in the south-west of England to about 17° in the Shetland Islands.

The effective gain of a parabolic aerial depends upon the profile accuracy of the paraboloid; in practice, it is usually accepted that there can be departures of up to one-tenth wavelength without significant deterioration of gain and directivity. However, at 12GHz a wavelength is only 0.025m; so, the profile tolerance is preferably of the order of ±0.0025m or better from true paraboloid — a figure demanding care in construction and installation, and protection of the surface skin against deformation and pitting during its useful life.

Based on a paper published in IBA Technical Review, No 11.

The receiving aerial also needs to be pointed towards the satellite with an accuracy better than 0.5°. When the figure is related to an average domestic u.h.f. aerial it will be appreciated that installations will require a high degree of care. Fortunately, however, provided that a means of adjustment is provided, it should prove possible to line-up an aerial by observing the picture, rather than by dead reckoning. The waveguide feed for a small parabolic aerial is complicated by the decision to use circular polarisation. However it will not be necessary to seek 'height-gain' for satellite receiving aerials; typically, an installation could be wall-mounted, and with a fairly simple provision for fine adjustment.

With an elevation of 24° in the London area, it should not be difficult to achieve a clear 'line-of-sight' towards the distant satellite; though lower apartments in any heavily built-up area might in a few cases present problems. The surface of a metallised parabolic aerial in an urban or coastal environment will almost certainly require protection, but it has been suggested that, for example, the paraboloid might be enclosed in polythene sheeting which could be renewed when necessary.

No matter how effectively the receiving aerial may have been designed, or how carefully it may have been packed and transported, the long-term performance will depend on the care with which it is installed. The construction and mounting must be capable of withstanding the effects of wind and weather, including any possible warping or structural changes throughout the estimated operational life.

The 'view' of the satellite must be unobstructed; while there will be few places in the UK where the natural topography is likely to cause screening, this may be a serious problem among large buildings or tall trees. Even where the power flux density is sufficient to permit the use of individual aerials, there will clearly be advantages in providing community systems, each with one master aerial and with associated front-end serving a number of installations. Distribution could be at the video baseband, h.f./a.m., v.h.f./a.m., or u.h.f./a.m. or 1.2GHz/f.m., etc. A possible source of interference is harmonic radiation from domestic microwave ovens.

The economics of the mass-market make it essential that the manufacture of any consumer aerial should be easy and straightforward. Aerials should be designed for easy packing and carriage, and reasonably priced. They should be suitable for assembly, erection and alignment by a rigger to a time-scale of the order of 30-60 minutes, offer low resistance to winds and perform without excessive degradation in the presence of snow or ice. It is likely that the cost of installing a small parabolic aerial (0.6-1m diameter) of effective performance at 12GHz would be several times that of a conventional service-area u.h.f. receiving aerial. Also, of the two, the paraboloid might deteriorate the more rapidly.

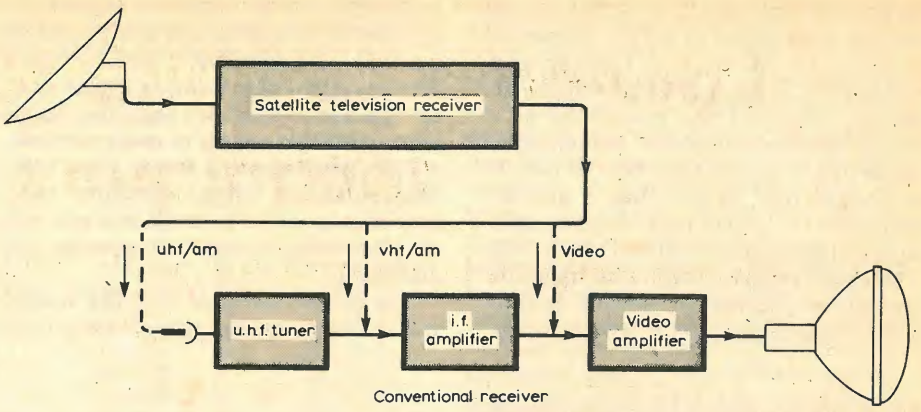
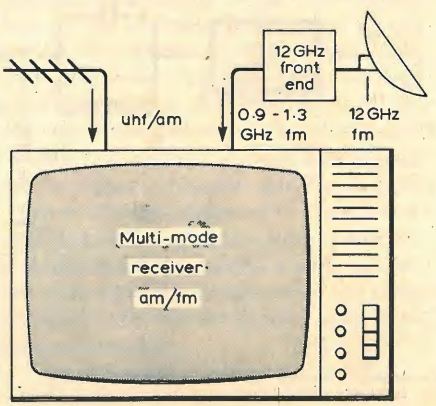


Fig.2. *There is a number of basic receiver configurations which could be adapted to interconnect a 12GHz f.m. receiver / adaptor with a conventional u.h.f. / a.m. receiver. An adaptor providing a u.h.f. / a.m. output could be nected directly to the aerial socket of an existing receiver. Alternatively, an output at the i.f. of the main receiver could feed into the i.f. amplifier section. Output at video frequency would be attractive in reducing spurious signals but would require the provision of an 'isolated' socket, possibly using an optical coupling arrangement.*

Fig. 3. *The development of multi-mode television receivers, capable of accepting an f.m. signal between, say, 0.9-1.3GHz would provide one of the more attractive configurations for domestic satellite receivers.*



During the Canadian 'Hermes' experiments, a 60cm dish aerial and NHK-NEC receiver achieved good results inside a building, "seeing" the satellite from behind a double-plated window. The windows attenuated the signal by about 2dB. An "attic" experiment was unsuccessful.

12 GHz front-ends

The development (for other applications) of effective microwave solid-state techniques which appear to lend themselves reasonably well to quantity production techniques, makes it possible to contemplate with some confidence a generation of 12GHz receivers. Perhaps the most daunting requirement is a low-cost reasonably stable and spectrally pure microwave 'source' to provide the local oscillator. Fortunately, in the early 1960s, the British scientist J.B. Gunn discovered that certain diodes can be caused to oscillate at s.h.f. The stability of these can be improved with a high-Q cavity. More recently, progress has been made in the development of microwave transistors, such as the gallium arsenide (GaAs) field-effect devices.

For a 12GHz 'front-end' adaptor the power output of the local oscillator needs to be only a few milliwatts but, unless automatic frequency correction is employed, the frequency must be stable within about ±0.1MHz.

The UK has been assigned channels 4, 8, 12, 16 and 20, so a tunable converter would need to cover a tuning range of some 400 MHz. However, it is likely that the microwave oscillator would be fixed in frequency; channel selection would be achieved by varying the first intermediate frequency with a.f.c. applied to the second oscillator. It has been suggested that the first i.f. for a 12 GHz satellite receiver would be in the region of 1200 MHz and a second i.f. about 140 MHz. Both these frequencies are close to amateur service allocations (with high local field strengths in residential areas). Gunn diodes could be manufactured economically in large quantities, also low-cost forms of high-Q cavities would seem feasible. An alternative approach would be to use a crystal-controlled chain, or, rather more promising (since higher fundamental frequencies are possible), a surface acoustic wave oscillator. If the cost of Varactor diode multipliers, step-recovery diodes and microwave GaAs field-effect-transistors fall, it may become possible to produce relatively stable microwave sources within the cost-range of consumer equipment.

Until recently the possibility of providing an effective 12GHz low-noise signal amplifier at acceptable consumer prices would have seemed remote, and most tentative designs have been based on feeding the signal directly to a diode

mixer, with the object of achieving an overall noise figure of 6-8 dB. However, continuing advance in bipolar and field-effect microwave transistors no longer rules out the possibility of a signal frequency amplifier, reducing the noise figure to perhaps 4-6dB or less. It is notable that, in less than a decade, estimates of 12GHz noise figures have dropped from about 12dB to about 7dB. The constructional technique based on a single planar metallic sheet with suitable simple cut-outs, etc., would appear to present few problems to mass production. Such approaches would enable quantity-production of 12GHz converters which could be attached directly to the aerial feed waveguide; such methods would appear to make possible a G/T figure-of-merit better than 7dB, with sufficient 'image rejection' etc., and would leave a small margin for deterioration or less-than-precise installation.

The power levels of satellite transmission currently make frequency-modulation a virtual necessity; the satellite adaptor would need to provide an output either at video frequency or as an amplitude-modulated u.h.f. signal, or be incorporated in a complete multimode receiver. In practice it seems more likely that a special a.m./f.m. television receiver would be developed which would accept a.m. signals at Bands IV and V (and possible Bands I and III) and f.m. signals from the 12 GHz converter over the range 0.9-1.3 GHz. Many configurations for domestic or small-

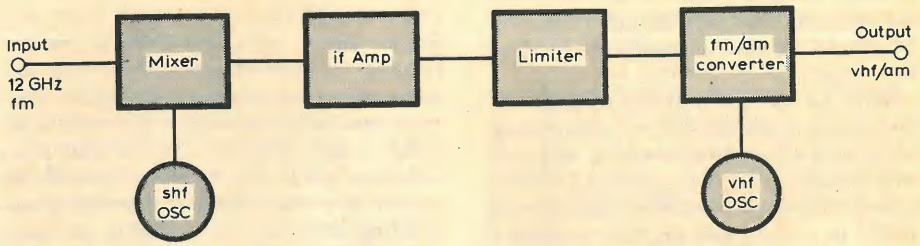


Fig. 4. *Block outline of the experimental NHK 12GHz satellite front-end developed with a view to providing a low-cost approach. The 12GHz converter, using a Schottky diode mixer and Gunn diode oscillator, has a planar circuit mounted in a short section of waveguide with all circuit elements fabricated by pressing or etching, and with no precision machine processing. A very simple form of f.m. / a.m. conversion provides an output at v.h.f.*

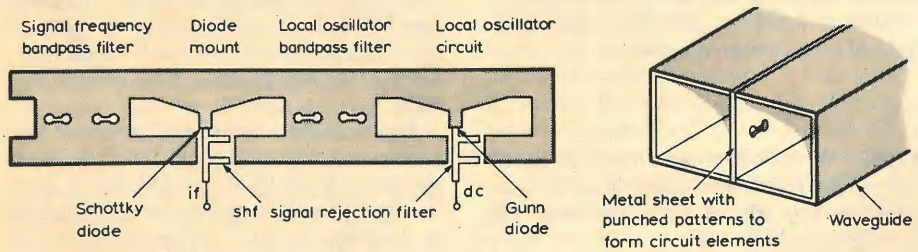


Fig. 5. *Details of the 12GHz converter with planar circuit developed by NHK for an experimental low-cost satellite receiver. In essence it is a metal sheet with patterns punched-out to form circuit elements. A laboratory unit has a claimed noise figure of 4.5dB and conversion loss of 3.4dB.*

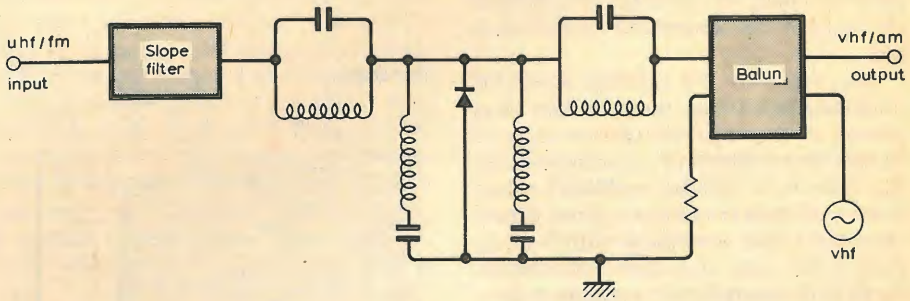


Fig. 6. *Circuit diagram of the simple form f.m. / a.m. converter used in the experimental NHK low-cost design. This provides a v.h.f. / a.m. output suitable for use with a conventional television receiver.*

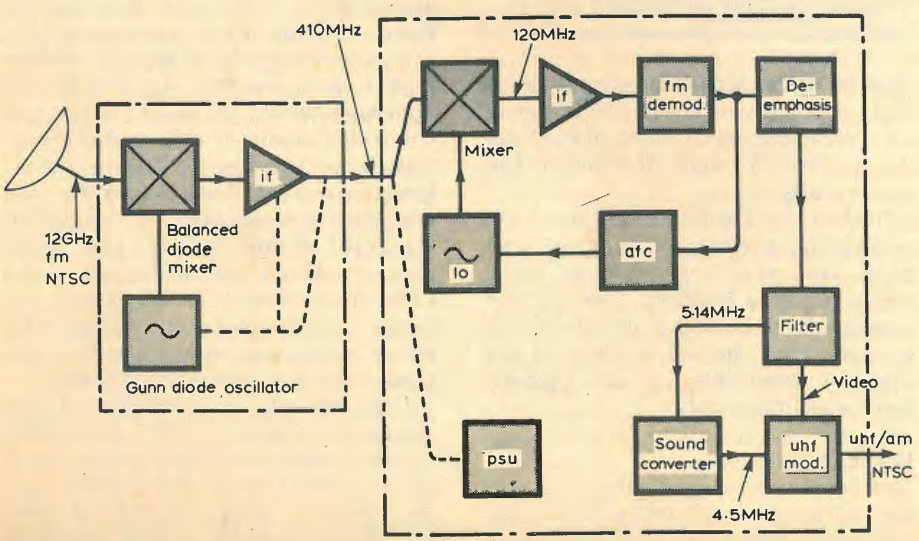


Fig. 7. *Block outline of the satellite receiver developed by Mullard Research Laboratories (now Philips Research Laboratories) and demonstrated in Canada, receiving 525-line NTSC transmissions from the Hermes satellite. This uses a Schottky-diode balanced mixer in the microstrip form followed by a 40dB u.h.f. amplifier. In the second unit the signal is demodulated and then remodulated to provide a u.h.f. / a.m. output. Au automatic frequency control loop in the second unit can function over a band of ±5MHz to compensate for frequency variation in the Gunn diode s.h.f. local oscillator.*

community distribution systems are possible.

NHK 12 GHz f.m. receiver

One of the most interesting designs for a 12GHz f.m. receiver yet to appear stems from the NHK Technical Research Laboratories in Japan. This provides a high-sensitivity microwave receiver using circuits and constructional techniques which make it attractive for quantity production at low cost. Fig. 4 shows the block diagram. The 12GHz converter uses a planar circuit mounted in a short section of waveguide with all circuit elements made by pressing or etching, so eliminating the need for precision machine processing. It is claimed to result in a down-converter with a Q value several times that of a filter in a conventional microwave integrated circuit. The metal sheet can be of the order of 0.3 to 0.5 mm in thickness. The Schottky mixer diode serves as the impedence matching between high-impedence waveguide and the diode which is directly mounted on the planar circuit. A Gunn diode is used as the local oscillator.

The receiver also incorporates a low-cost f.m./a.m. converter to allow the 430 MHz output to be fed directly to the aerial socket of a u.h.f. a.m. receiver without any video and sound amplifier and modulator. In effect, this f.m./a.m. converter uses the non-linear characteristic of the mixer diode to produce amplitude variation of the output signal proportional to the f.m. deviation of the input signal.

A laboratory unit has a noise figure of 4.5dB, conversion loss of 3.4dB, bandwidth of 100MHz, differential gain 5 per cent or below, and differential phase of 2° or less. The achievement of such a low noise figure without an s.h.f. amplifier is remarkable.

A receiver developed by NEC from the original NHK design was shown in London at IBC '78, and performance claims were met during the Canadian experiments.

MRL satellite receiver

A design developed at the Mullard Research Laboratories (now known as Philips Research Laboratories) in conjunction with Philips, Eindhoven, adapted for 525-line NTSC system, was one of a number of models demonstrated with the CTS 'Hermes' satellite tests during 1976. These receivers used 1.6 or 1.2m parabolic aerials of metal-coated, glass-reinforced, polyester plastic construction. As with the NHK receiver, they have been designed for linearly polarised signals and would need to be preceded by an orthogonal mode-transducer in order to operate with circular polarisation.

Figure 7 shows the basic arrangement of the MRL converter. To frequency-change from 12GHz to 410MHz a microwave unit, mounted close to the aerial, uses a Schottky-diode balanced mixer in microstrip form, followed by a 40dB u.h.f. amplifier. An 11.7GHz Gunn-diode local oscillator provides about 10mW output. It is stabilised by an aluminium cavity, integral with the converter, and with dielectric temperature compensation to keep the output accurate to within ±5MHz. This is within the range of the automatic frequency control system applied to the second local oscillator in the main unit located alongside the standard receiver. This second unit has an i.f. of 120MHz and is demodulated to the video baseband before remodulation with a.m., together with the associated sound channel. The noise figure is about 7dB, and, when used with a 1.6m parabolic aerial (43dB gain), can provide good reception from a received signal of about −105.5dBW with a receiver bandwidth of 36MHz. The tests underlined the practical importance of the additional signal attenuation which results from heavy rain.

Such a design would appear especially suitable for small community systems.

Table showing correspondence between channel numbers and assigned frequencies for the 12GHz satellite broadcasting band.

Channel No.	Assigned Frequency (MHz)	Channel No.	Assigned Frequency (Mhz)
1	11717.48	21	12111.08
2	11746.66	22	12130.26
3	11765.84	23	12149.44
4	11785.02	24	12168.62
5	11804.20	25	12187.80
6	11823.38	26	12206.98
7	11842.56	27	12226.16
8	11861.74	28	12245.34
9	11880.92	29	12264.52
10	11900.10	30	12283.70
11	11919.28	31	12302.88
12	11938.46	32	12322.06
13	11957.64	33	12341.24
14	11976.82	34	12360.42
15	11996.00	35	12379.60
16	12015.18	36	12398.78
17	12034.36	37	12417.96
18	12053.54	38	12437.14
19	12072.72	39	12456.32
20	12091.90	40	12475.50

Note: UK channels are 4, 8, 12, 16 & 20. orbit position 31° W, polarisation left hand circular.

Proposed broadcast satellite parameters for the frequency band 11.7-12.5GHz

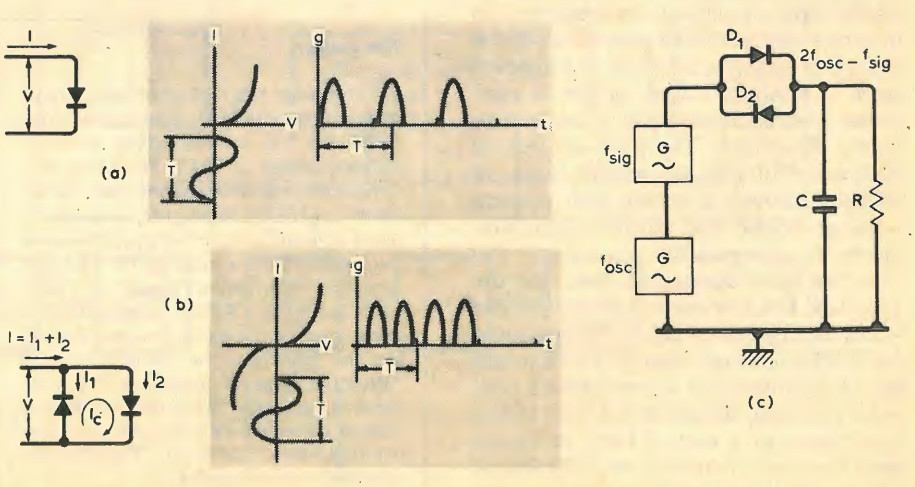
Type of modulation		fm
Number of lines		625
Sound sub-carrier frequency		6MHz
Peak-peak deviation		13.3MHz
Peak deviation of sound sub-carrier		50kHz
Receiver equivalent rectangular noise bandwith		27MHz
Angle of elevation	15°	40°
Luminance signal-unweighted noise for 99% of worst month	34dB	33dB
Sound signal weighted noise ratio for 99% or worst month	51dB	50dB

Fig 8. *(a) Basic arrangement of conventional diode mixer. (b) The anti-parallel diode pair harmonic mixer. (c) Basic form of the harmonic mixer. c Basic form of the harmonic mixer. Cohn* et al. *have all shown that harmonic mixing not only reduces the frequency of an s.h.f. local oscillator, but also reduces the effect of oscillator noise side-bands and provides inherent self-protection against diode burn-out. However, careful selection of diode pairs is needed to obtain the full benefits. Total conversion loss can be comparable to that achieved with similar diodes with fundamental mixing.*

Harmonic mixing

The problems presented by a simple diode mixer include the unavoidable conversion loss, local oscillator radiation and 'image' reception. While these problems can be reduced by careful choice of diode, by the use of a double-balanced configuration and by choice of i.f., not all such refinements lend themselves readily to low-cost consumer equipment. An arrangement which might offer attractions for this application is harmonic mixing with an anti-parallel diode pair.[1]

Harmonic mixing offers the advantage of a lower frequency 'source' with consequent easing of stability problems. However, in most arrangements it results in conversion loss 3-5dB greater than that of fundamental mixing. The anti-parallel diode configuration reduces conversion loss by suppressing the fundamental mixing products and results in a lower noise figure by reason of the suppression of local oscillator noise sidebands. It also suppresses direct video detection and provides in-



herent self-protection against diode burn-out.

These properties do not depend on the use of either filters or balanced circuits using hybrid junctions. However, careful selection of matched diode pairs is necessary to obtain the full advantages. Experimental harmonic mixers, reported by Cohn, Degenford and Newman have used a pair of GaAs Schottky barrier diodes shunt-mounted across a slot line. In one experiment an existing microstrip mixer was modified to accommodate a series-mounted anti-parallel diode pair to evaluate second-harmonic mixing at 12GHz using a 7GHz local oscillator. An 8dB total conversion loss was comparable with that achieved when using fundamental mixing at 12GHz, although no attempt was made to optimise the signal and i.f. impedance matching.

It has yet to be determined whether harmonic mixing with anti-parallel diode pairs would be suitable for low-cost microwave receivers.

Receive filters

Since a low-cost satellite receiver will require to operate with physically small aerials and relatively unsophisticated techniques, it will be important to make the best possible use of the available signal power. In any receiving system, the effective noise performance can be improved by restricting the pre-detection bandwidth. This is normally done by matching the bandwidth of the intermediate-frequency amplifier to the signal bandwidth, using i.f. 'filters' such as the familiar single or double-tuned i.f. transformer or, its modern equivalent, the surface-acoustic-wave filter.

With frequency modulation there is no simple definition of the bandwidth, since, theoretically, the sidebands extend to infinity. Thus, any bandwidth restriction involves some loss of higher-order sidebands, and so introduces a degree of non-linear distortion. The practical effects of such non-linearity are more noticeable in systems employing a sub-carrier for the transmission of the sound channel.[2]

A. N. Kent shows that, while bandwidth reductions may be expected to improve the received carrier-to-noise ratio in a satellite receiver, if the spectrum of the modulated carrier is restricted unduly, truncation gives rise to signal distortion. The first subjective indication of this is usually buzz on sound, although a visible beat pattern between sound and chrominance sub-carriers is also possible.

It has been suggested that, for the proposed UK standard of deviation, the −3dB bandwidth of the i.f. filter should be 27MHz, though clearly there might be a temptation for set-makers to consider reducing bandwidth a little below this figure, at a risk of buzz on sound and truncation 'noise' or differential phase and amplitude distortion.

To remove the effects of energy dispersal on the satellite transmission a suitable correction filter is necessary in the receiver.

U.h.f. reception

The Indian SITE experiment has shown that u.h.f. low-noise f.m. television receivers for satellite broadcasting do not present excessive design problems. However, since u.h.f. satellites are, in practice, likely to be used only in countries not already exploiting these bands for terrestrial broadcasting, it has been urged that more attention should be given to the development of receivers capable of providing reliable operation in difficult environments. Domestic and community receivers should be able to withstand the effects of heat, humidity, dust and insects. Poorly tropicalized circuit boards still give trouble, and some components are vulnerable to humid conditions; inductors and transformers at high voltage may suffer from 'green spot' corrosion or puncture; variable potentiometers may be affected by moisture; push-button switches by dust; springs by rust, heat and humidity; rubber deteriorates rapidly.

U.h.f. reception has the advantage of established low-cost, low-noise receiving techniques; however, it has the disadvantage that much larger aerial structures are required to obtain gains in excess of 20-25dB. For the SITE experiment, aerials with 3m diameter parabolic reflectors were used, constructed from expanded aluminium with a helical feed. Behind each aerial was a 'head-end' unit providing an i.f. output at 70MHz. A second 'tail-end' converter was used to demodulate the 70MHz f.m. signals to provide a video feed to the 22-in black-and-white receivers used in the Indian villages. The resulting video s:n ratio of about 45dB resulted in good subjective picture quality. The 3m u.h.f. parabolic aerials represented no major problem for community receivers but would be regarded as too large for domestic installations.

During the SITE experiments, successful reception of the 860MHz f.m. signals was reported from Sheffield and Dublin[3] despite the effective radiated power being at least 30dB below that of the primary lobe. The free-space attenuation of the signals, with a vertical arrival angle of about 22° was of the order of 183dB and the field strength of the order of 3.3μV/m. Receiving aerial gains well in excess of 20dB were desirable (a 5ft dish at Sheffield had an estimated gain of 19dB) and low-noise first amplifiers were used.

Significant variations of signal strength were recorded by the station at University College, Dublin; partly due to local weather conditions, but also possibly due to variations of transmitter power.

Satellite transmitter power was 80W with 51dBW effective isotropic radiated power (e.i.r.p.) towards the coverage area (about 21dBW towards the UK).

Economic considerations

The technology for 12GHz reception in the home or for community distribution or as feeds for low-power broadcasting transmitters and transposers thus offers no insurmountable problems. It is, however, impossible to predict with any great degree of confidence how much more a combined v.h.f./u.h.f./s.h.f. a.m./f.m. television receiver would cost the viewer, or. for example, what would be the further cost if one of the five UK 12 GHz channels were to be used for a multiplicity of sound radio programmes. It is reasonable to suppose that, at 1977 values, the additional costs would not be less than £100 and might be as high as £250.

These figures, though substantial, amount to little more than some unfortunately-placed viewers might currently be prepared to pay for an elaborate aerial for a conventional u.h.f. receiver if there were no other way they could receive television programmes.

However, this possible scale of charges would appear differently to a viewer already receiving four u.h.f. television programme channels and perhaps one or two v.h.f. programme channels.

It is this financial factor, more than any other, that still casts a doubt on the implementation within the next decade of satellite broadcasting in the UK.

The author

Pat Hawker has held an amateur transmitting licence (2BUH, then G3VA) since 1936 and first contributed an article to *Wireless World* in 1941. Following wartime special communications work for the British and Dutch intelligence services he spent 20 years in technical publishing and journalism before joining the IBA Engineering Information Service in 1968. He is author of "Amateur Radio Techniques" and "A Guide to Amateur Radio" etc and took over the monthly column "World of Amateur Radio" in 1969. He became interested in the development of space communications while Communications Editor of *Electronics Weekly* in the mid-sixties.

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A low-cost digital frequency meter

Frequency measurement to 200MHz with 1kHz resolution

by **M. Tooley**, B.A. and **D. Whitfield**, B.A.

This article describes a low-cost, 200MHz digital frequency meter having a 5½-digit readout with a resolution of 1kHz. The unit, which is designed for 'hands-off' operation and requires only power and signal inputs, is suitable for addition to existing equipment or may alternatively be used as an instrument in its own right. The entire circuit is assembled on a single printed circuit board, as shown on the front cover.

THE authors' aims were to construct a frequency meter which would operate up to 200MHz with a 1kHz resolution, have a high sensitivity (less than 100mV) and be easy to operate with a minimum of preset adjustments. It also had to use readily available components, operate from a single, unregulated power supply and be assembled on a single, compact printed-circuit board.

In order to build the meter with the minimum number of devices, the authors used a four-stage counter, a latch, a display driver i.c. and, although it was a t.t.l. design, a mixture of t.t.l., c.m.o.s. and e.c.l. devices. The design philosophy was that of employing the best type of device for each particular circuit application, bearing in mind such factors as speed of operation, power consumption, ease of interfacing, and cost.

Principles of operation

The block diagram of the frequency meter is shown in Fig. 1. The input signal is first amplified using a high-gain wideband amplifier, and then applied to a fast divide-by-four bistable arrangement. Since the input amplifier and pre-scaler both use e.c.l. devices, it is necessary to incorporate a level translator in order to interface correctly with the next stage, which is a high speed Schottky t.t.l. signal gate. The divided-down input signal is gated with a clock signal at 250Hz derived from a c.m.o.s. 1 MHz crystal oscillator and divider chain. Repetitive sampling is provided by means of a conventional astable oscillator using a timer i.c. A control logic arrangement is used to produce reset, transfer and latch enable signals.

The output of the signal gate is passed to high-speed t.t.l. decade counter and conventional c.m.o.s. decoder/latch and seven-segment l.e.d. display. The output of the first decade divider is then fed to a four-stage t.t.l. decade counter, decoder and latch housed in a single i.c. package. This i.c's output is used to drive four further seven-segment l.e.d. displays directly, and these are strobed in sequence by means of a clock and logic incorporated in the i.c. The final "half" digit is obtained by means of a bistable latching arrangement which operates on the 'carry' output of the main divider. The last seven-segment indicator is wired so that it displays the value '1' when enabled by a 'carry' output.

Input amplifier and prescaler

The amplifier and prescaler section of the counter comprises three distinct stages; the input amplifier, the prescaler and the level translator. The first stage

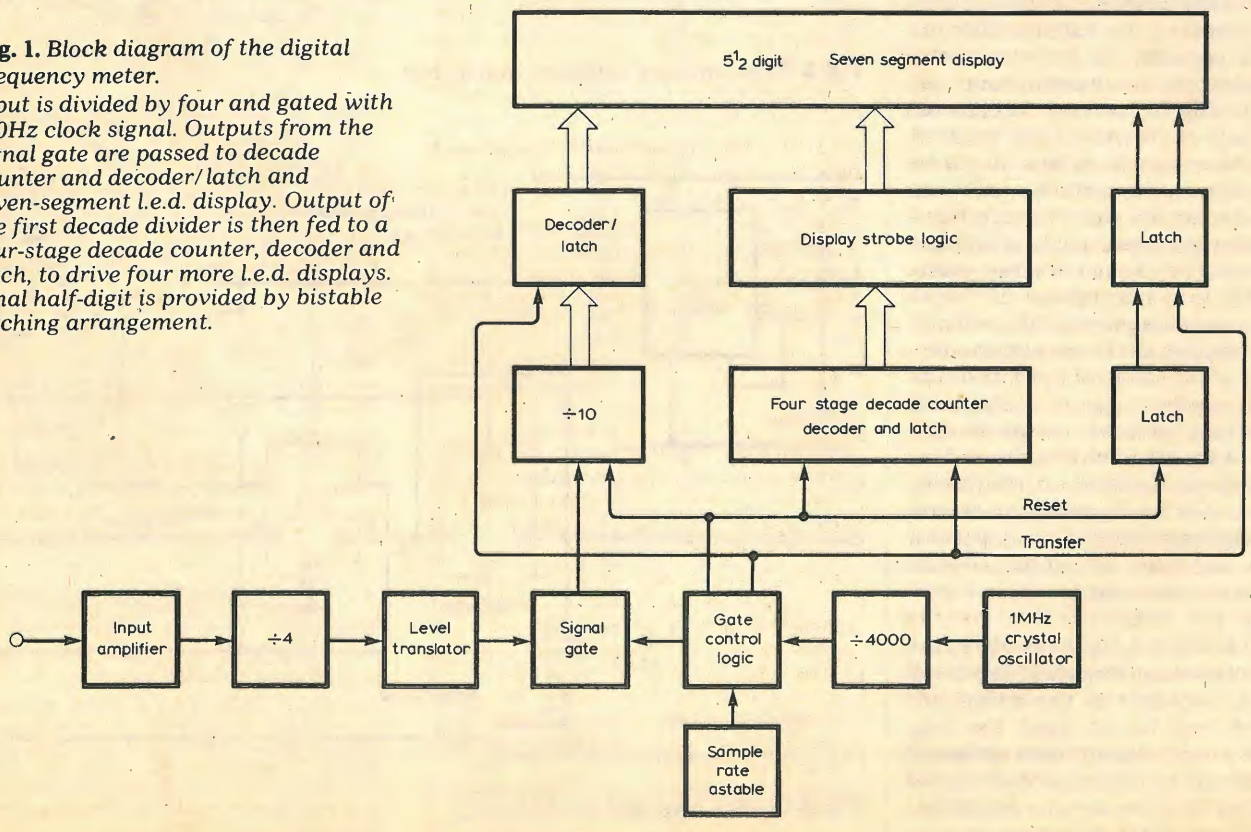

Fig. 1. *Block diagram of the digital frequency meter. Input is divided by four and gated with 250Hz clock signal. Outputs from the signal gate are passed to decade counter and decoder/latch and seven-segment l.e.d. display. Output of the first decade divider is then fed to a four-stage decade counter, decoder and latch, to drive four more l.e.d. displays. Final half-digit is provided by bistable latching arrangement.*

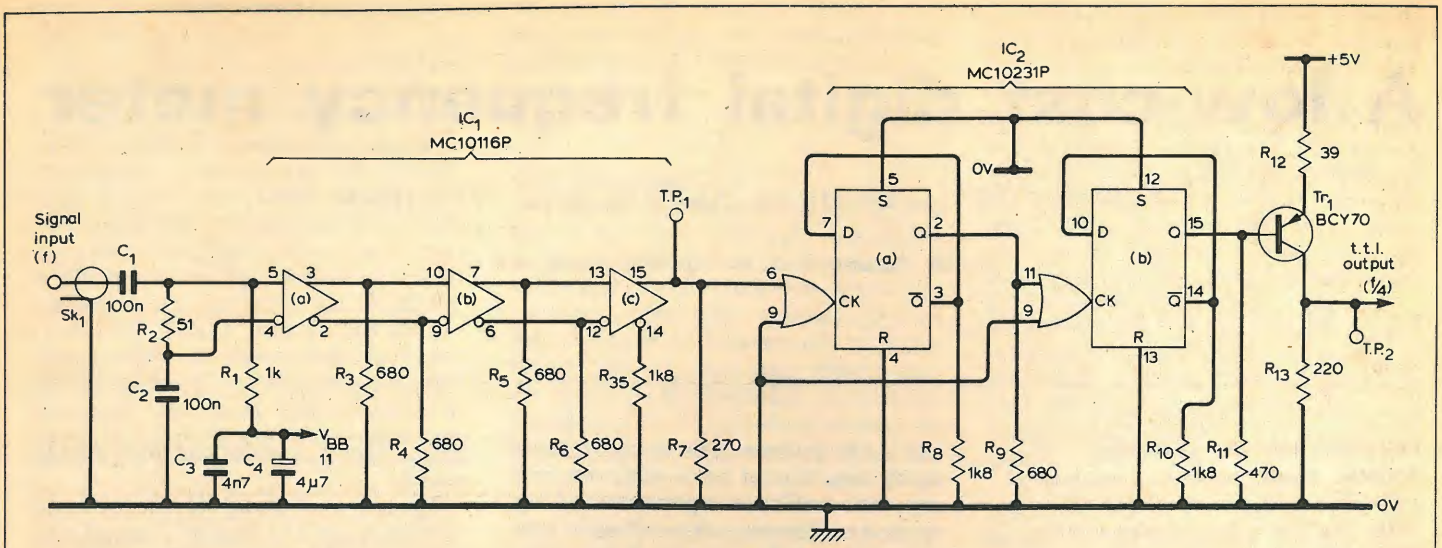

Fig. 2. *Input amplifier and prescaler.*

determines the overall counter sensitivity, the second stage limits the maximum count rate and the third stage allows the hybrid operation which results from the aims of the design. (See Refs. 1 & 2). The circuit diagram is shown in Fig. 2.

All signal interconnections in this unit are terminated by low-valued resistive loads. These resistors are necessary to provide matching and minimize overshoot and undershoot on the signal lines; this can quite easily be up to 100% of the signal amplitude and can, even at quite modest frequencies, seriously affect the performance of the circuit. It is possible[3] to calculate the exact values of load resistors required to minimize the ringing on the signal lines. This is normally only found to be necessary when the absolute maximum in performance is deemed essential. The factors affecting the calculations include the physical dimensions of the lines themselves, the track layout, the p.c.b. material and the stray reactances. In practice, however, the resistor values given in the circuit have been found to provide a good compromise and are appropriate for the short interconnections used in the construction of circuits of this type. They have also given similar results in a number of different prototype circuit layouts. If desired, for the best possible performance, the terminating loads may be optimized individually using a signal source and oscilloscope, suitable examples of which are mentioned in the performance section of this article. Such measures will be beyond the needs and/or the resources of many constructors and may, in any case, yield little or no improvement in circuit performance.

An MC10116 e.c.l. triple-line receiver[4] is used in the input amplifier. The three wideband amplifiers in the device are cascaded in a broad-band limiting amplifier configuration, with differential interstage connections. The input is matched to 50 ohms and the offset voltage developed across R_2 acts to prevent

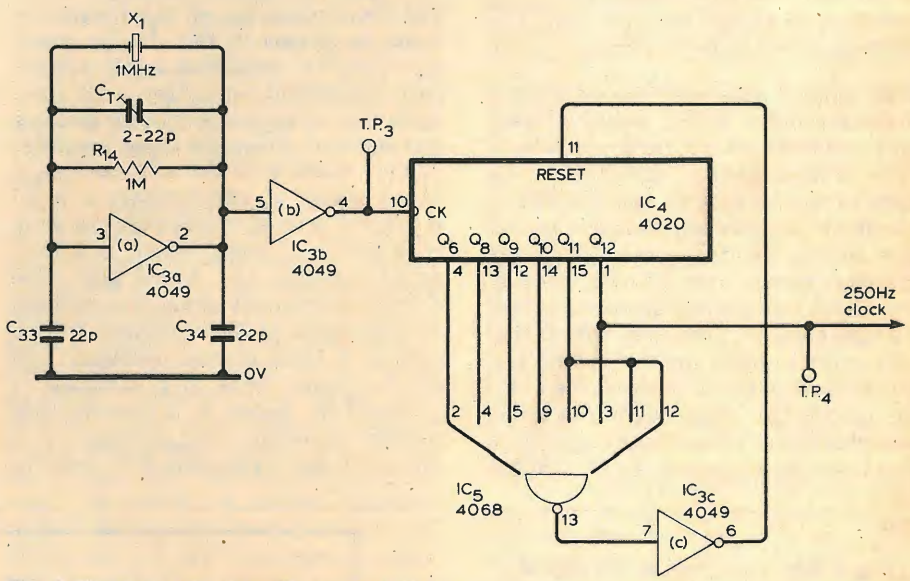

Fig. 3. *Time standard oscillator and divider.*

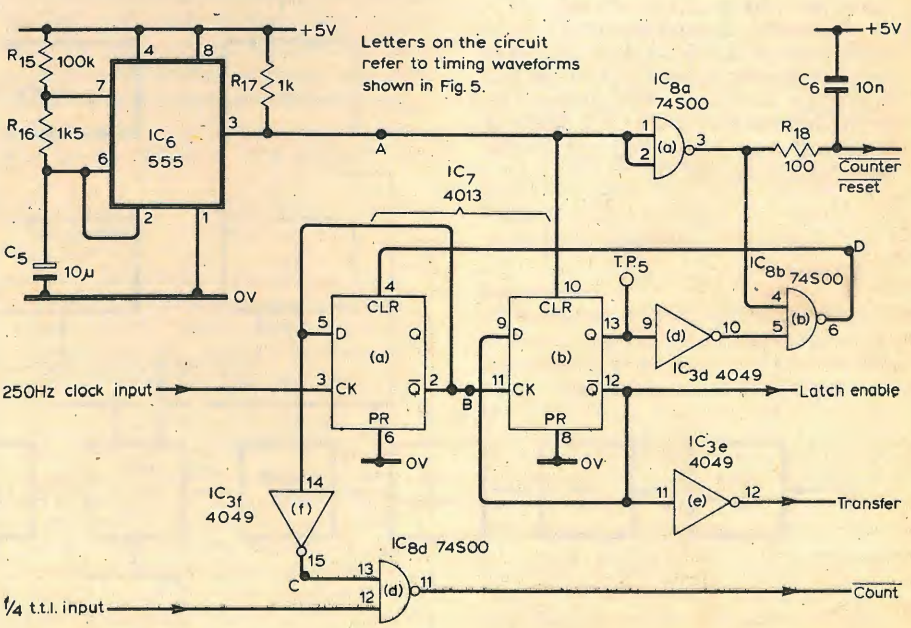

Fig. 4. *Control logic and signal gate.*

the amplifier being over-sensitive at low frequencies, where external signals and noise may be a problem.

The prescaler uses an MC10231 e.c.l. dual high speed D-type flip-flop connected as two cascaded, divide-by-two stages to provide a prescaling factor of four. The output from the second stage of IC_2 is a signal of approximately 800mV peak-peak with an associated d.c. offset, and this signal is made t.t.l.-compatible by the action of Tr_1.

For reliable operation the e.c.l. stages require a minimum supply voltage of approximately +5.1V. However, performance measurements indicate that optimum performance is achieved with a supply of approximately +5.6V. This value is a trade-off between increasing count rate and decreasing sensitivity with respect to supply voltage.

Time standard oscillator and dividers

A six-digit frequency counter incorporating a divide-by-four prescaler and providing a display resolution of 1kHz conventionally requires a signal sampling window of 4ms. To provide such a signal directly, to the required accuracy and stability, is impractical in this type of application. An alternative approach, using a higher frequency standard and a divider chain, has therefore been adopted. The circuit diagram is shown in Fig. 3.

A 1MHz crystal oscillator is used as a reference and the 250Hz signal required by the gate control logic is produced by dividing this down by 4000. The oscillator and divider circuits are comprised exclusively of c.m.o.s. logic in order to improve stability, guarantee statability, reduce power dissipation and reduce package count in comparison with equivalent t.t.l. or e.c.l. designs; all for a reduced component cost (see Refs. 5, 6 & 7).

The oscillator circuit uses a single inverter, IC_{3d}, in a conventional feedback arrangement. The frequency of oscillation is set by the crystal, X_1, and the fine frequency adjustment is provided by TC_1. R_{14} completes the d.c. path around the loop, while maintaining a high Q.

The output of the oscillator is buffered by IC_{3e}, and then applied to the input of a 14-stage ripple counter, IC_4, which is arranged, by using IC_5 to decode a count of 8000 and generate a reset pulse, to divide by 4000. The resulting waveform at Q12 has a mark: space ratio of approximately 1:1 and a p.r.f. of 250Hz.

Control logic and signal gate

It is the control logic and signal gate which bring together the otherwise isolated units to produce a digital frequency meter. The control logic sets the sampling rate of the instrument and performs all of the necessary housekeeping functions, ensuring, for example, that the display counters are all reset to zero before the input signal is re-sampled. The signal gate, by commands from the control logic, provides the counting/display circuits with the number of pulses which are appropriate to the display resolution and the input signal frequency being sampled. The circuit diagram for the control logic and signal gate is shown in Fig. 4, and a timing diagram is given in Fig. 5.

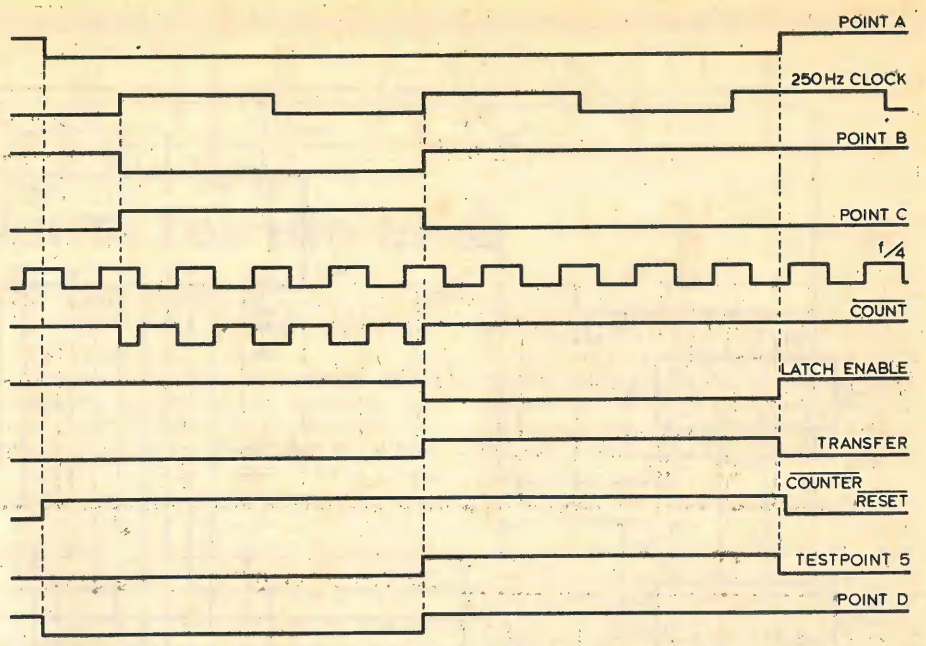

Fig. 5. *Control logic and signal gate timing diagram.*

A precision monolithic timer, IC_5, is arranged as a control astable with a low period of 10ms and a high period of approximately 700ms. The signal sampling sequence is initiated by a negative transition of the control astable. This transition causes the next positive edge of the 250Hz clock to invert the output states of IC_{7a}, driving the Q output high and enabling the signal gate, IC_{8d}. The signal gate itself is a Schottky t.t.l. device[8], which allows gating to be possible at speeds well above the nominal 50MHz required by this design. The next positive clock transition reverses the change of state at the outputs of IC_{7a}, inhibiting the signal gate. This change, in turn, drives the Q output of IC_{7b} high, enabling the display latches and inhibiting IC_{7a} until the start of the next sampling period. The positive transition of the control astable completes the display latching and, after a short delay effected by R_{18}/C_6, clears the display counters ready for the next sampling period. The whole circuit then waits for the next negative astable transition, when the whole sequence is repeated.

The sampling rate is set by the combination of R_{15}, R_{16} and C_5. R_{15} has been chosen to give a sampling rate which is long enough to allow the display to be easily read, yet short enough to allow alterations to be made to the signal frequency without the display delay becoming tedious. The sampling rate may be increased or decreased by reducing (down to a limit of 25kΩ) or increasing, respectively, the value of R_{15}. Alternatively, R_{15} could be replaced by a combination of a fixed and a variable resistor.

Components

Resistors (all 10%, ¼W)

1	1k	17	1k
2	51	18	100
3 to 6	680	19	1k
7	270	20	1k
8	1k8	21	1k
9	680	22 to 28	100
10	1k8	29	1k
11	470	30	100
12	39	31 to 34	270
13	220	35	1k8
14	1M	36	470
15	100k	37	470
16	1k5		

Capacitors (μF unless otherwise stated)

1	0.1	10	10
2	0.1	11	4n7
3	4n7	12	4.7
4	4.7	13	4.7
5	10	14	4.7
6	10n	15 to 28	4n7
7	4n7	29 to 32	4.7
8	4n7	33	22p
9	4.7	34	22p

Integrated circuits

1	MC10116P	9	74196
2	MC10231P	10	4511
3	4049	11	ZN1040E
4	4020	12	7474
5	4068	13	DL704
6	555	14 to 18	DL707
7	4013	19	μA7805UC
8	74S00		

Transistors

1	BCY70	6	2N3704
2 to 5	2N3706	7	BSY88

Diodes

1 to 3	BYX36-300	5	BZY88 C6V2
4	BZY88 C15		

Miscellaneous

1MHz crystal.
Printed circuit board.
20pF trimmer capacitor.
Coaxial socket.

Counters and display

The overall functions of the counters and display are to count the number of pulses from the signal gate during the

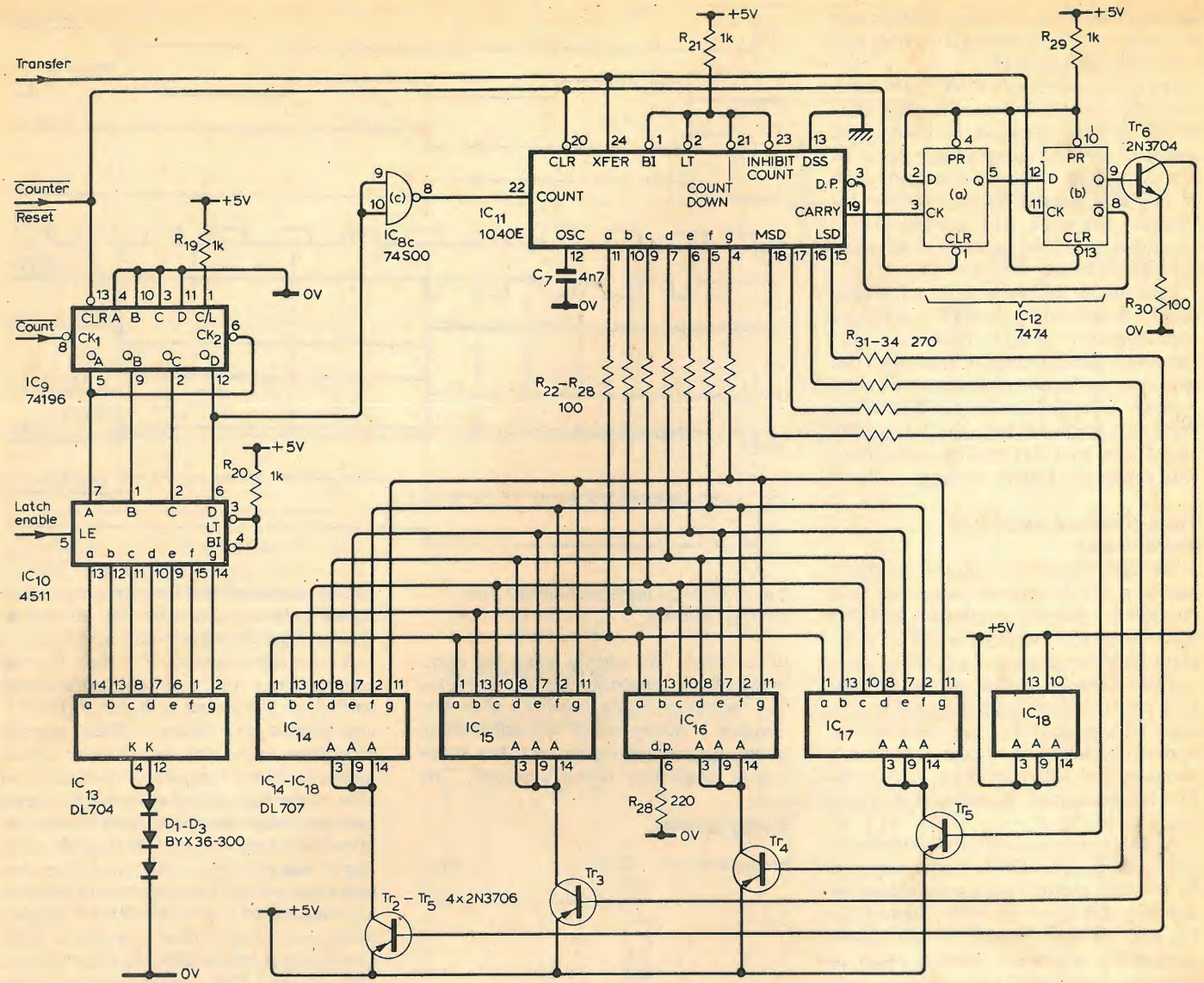

Fig. 6. *Counters and display.*

sampling period, store the result and decode it to drive the display segments. The display resolution is determined by the gating period and the degree of prescaling, while the display length determines the maximum frequency which may be indicated. Figure 6 gives the circuit diagram for the counting and display circuits. Since the original design aim was to produce a 200MHz counter with a display resolution of 1kHz, a 5½-digit display structure was chosen in order to avoid the penalties of cost, circuit complexity, package count and power dissipation which result from the use of a full-range leading digit. The display unit itself makes use of low cost indicators, with the proviso that they should be available in both common anode and common cathode styles, and features leading-zero suppression on the four leading digits in order to minimise power dissipation.

The count pulses produced by the signal gate are applied to a 50MHz t.t.l. decade counter, IC_9 and the b.c.d. counter outputs are latched by IC_{10} at the end of the sampling period. IC_{10} also performs the decoding and segment driving of the least significant digit display, with suitable level shifting being provided by diodes D_1-D_3.

The count sense from IC_9 is inverted by IC_{8c} and then applied to a four-digit universal count/display device, IC_{11}. This device contains a four-decade counter, memory latches, segment decoders, drivers and display strobe circuits. In addition, the device has zero suppression facilities and it contributes greatly to the reduction in the package count. The maximum count rate of IC_{11} is 5MHz and the carry output is used to produce the leading half-digit display.

IC_{12a} acts as a single-bit counter and IC_{12b} serves as a single-bit display latch. The $\bar{Q}$ output from IC_{12b} is used to ensure correct operation of the zero blanking circuits over the range 100MHz to 109.999MHz.

The second part of this article will describe the power supply for the frequency meter and will give details for its construction. P.c.b. track and component layout details will also be given.

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Printed circuit board

A double-sided, roller-tinned and drilled p.c.b. is available for the digital frequency meter for £6.50 inclusive from M. R. Sagin, 23 Keyes Road, London NW2.

NEWS OF THE MONTH

Electronics implants for the deaf

ADVANCES in electronics are greatly increasing the importance of cochlear implants in the fight against deafness. A cochlear implant enables the remaining nerves of hearing to be stimulated by electrical impulses which are heard by the deaf person as sounds. It does not involve the replacing of a damaged organ by living tissues, as does a kidney or heart transplant, but it is the product of a combination of both medical and electronics research.

The subject of cochlear implants was presented at the RNID (Royal Institute for the Deaf) Conference held at Brighton in September, by Mr Ellis Douek, consultant otologist to Guy's Hospital, London. Mr Douek pointed out in his conference paper that despite present developments there are few aspects of research into hearing loss which are less understood. "For instance, the relationship between surgeon and scientist is not one that can be developed rapidly. Their training and experience has been so different that it requires a long process of fusion through working together before there is an adequate meeting of minds . . . problems of this kind mean that there are few places in the world where such work has been feasible." He hoped to show that a new operation that can be learnt and carried out anywhere, does not yet exist.

The advances, according to Mr Douek, are applicable to persons who are totally deaf and cannot be helped by amplification — to those who have 'nerve deafness'. In cochlear implants the problem lies in making sounds meaningful and worth listening to, even though knowing that someone is talking to you has considerable value in its own right. There are four centres in the world where teams are working on this problem; the other three being in Paris, Los Angeles and San Francisco.

The implant research in London is partly funded by the Medical Research Council and is being undertaken by Mr Douek, Professor A. Fourcin of University College London, Dr B. Moore of Cambridge University and Dr S. Rosen from the USA. Other Guy's Hospital members undertaking the task are Mr G. P. Clarke, Dr L. H. Bannister and Dr H. Dodson.

So far at Guy's the team have succeeded, by implanting an electrode onto the inner ear of a number of patients, in obtaining results as good as those of teams abroad, using a much simpler and safer technique. They have also managed to process the sound of speech to allow through to the patient only what can be heard, rather than a range of signals, some meaningful, some not. At the present time a patient can hear only the low tones of speech and is unable to hear middle or higher tones, meaning that he must also lipread in order to discriminate speech.

However, the improvements which are observed are that the rhythm of speech is well perceived, the stressed word in a sentence is hardly ever missed and the patient is able to distinguish between rise and fall in speech — enabling him to tell if you are stating a fact or asking a question. The patient can also more easily control his own voice.

The team has two hopes for the future: firstly that they may be able to control the higher tones so that they can offer what would sound like true speech, and secondly, that the equipment be miniaturised and driven by radio transmission to be totally inconspicuous and usable at distances even greater than the voice will carry. The latter is now possible because of advances in electronics, communications technology and component miniaturization.

Product liability and UK apathy

A SURVEY carried out earlier this year by the British Safety Council said that nearly 70% of the top executives in Britain are ignorant of the product liability laws soon to be drafted into the country. In response to this lack of knowledge, James Tye, director general of the British Safety Council, and Bowes Egan, a leading safety and consumer law analyst, have written the first European book on the subject. The 240-page book* is entitled 'Management Guide to Product Liability' and is published by the British Safety Council.

The survey showed that more than half of the UK's firms believe the introduction of product liability will mean Britain adopting an absurd legal regime from the USA, and that more than half of the British industrialists are completely unaware of the strict liability issues and problems that have developed in the USA over the last twenty years. It also showed that two-thirds of Britain's firms are ignorant of the influential EEC Directive on product liability, and that as many as 71% are not conversant with the findings of the English and Scottish Law Commissions. According to the survey more than half of Britain's manufacturing companies do not employ a quality assurance department to carry out regular product liability audits.

In view of these findings, and the fact that product liability is just around the corner for UK manufacturers and suppliers, the British Safety Council warns that British firms may face a more rapid, sustained and expensive onslaught of product liability claims than even the USA has had to experience.

The authors of the book, speaking at a conference in November, described how, because of the differences between the American and British legal systems, the product liability developments in the USA over the last 20 years are likely to occur in Britain unless UK companies are prepared to learn from the USA's experience and prepare in advance for the introduction of strict liability for defective products. James Tye explained how many American companies had 'gone bust' either through high court awards or crippling insurance premiums, and claimed that the best product liability insurance was to manufacture and supply safer products and to set up facilities to monitor product histories and consumer experience. Bowes Egan, seemingly trying to describe UK companies' apathy on the subject, explained how many industrialists claim that the introduction of strict liability will mean steep price increases for consumers, which will place British firms at a commercial disadvantage in competitive world markets. He argued, however, that their book would assist UK manufacturers, designers and importers to minimize the effects of product liability in this country and even turn them into a commercial advantage. Importers are included in the above because it is not necessarily the manufacturer who is liable, it could equally well be the importer, for he may be the one responsible for a defective product appearing in the UK market.

In summing up the value of the book James Tye described it as: "a detailed audit system which represents more than 350 safety steps to avoid the product liability minefield".

*Price £8.50 + 50p post and packing.

Hobby electronics exhibitions are taking off in Europe

AT THE TIME of writing, the Breadboard Exhibition was just starting in London — perhaps the first hobby-electronics exhibition in England, if you don't count the radio amateur exhibitions by the RSGB and the ARRA. However, this new move is not restricted to the UK alone. In Dortmund, West Germany, in February '78, an exhibition called Hobby-Tronic was a tremendous success, according to the German journal *Funkshau*, and the organisers have decided to repeat it annually. A similar show was planned for September in Stuttgart. Austria also held their first exhibition of this kind in October '78. This was entitled Hobby-Elektronik 78. For this occasion, says *Funkshau*, the Austrian magazine, *ELO*, held a circuitry competition called "The electronic unit with that something extra for 300 Austrian schillings". The Netherlands are also expected to follow suit with an exhibition of their own.

International copyright views aired

AT RECENT meetings of the copyright protection bodies, it was the considered opinion that a compensating royalty would be the best way to compensate the owners of exclusive rights (e.g. authors, performers, composers and producers of phonograms and videograms) for the damage caused to their interests by home tape-recording—these royalties being made on both recording equipment and on blank audio and audio-visual tapes and cassettes. This was the view expressed by the sub-committees of the International Union for the Protectionof Literary and Artistic Works (Berne Union), the Intergovernmental Copyright Committee and the Intergovernmental Committee of the Rome Convention for the Protection of Performers, Producers of Phonograms and Broadcasting Organisations at meetings held in Paris during September. The meetings were sponsored by Unesco, the World Intellectual Property Organisation and the International Labour Office.

The London-based, International Federation of Producers of Phonograms and Videograms (IFPI) were among eleven other international non-governmental organisations and, according to the IFPI, the Committees' recommendations to national legislators concerning private recording and home tape-recording were principally due to their efforts. Gillian Davies, IFPI's assistant director general said in a press report released by the IFPI, "I noted with particular satisfaction that the sub-committees decided during the meeting, that the conclusions of the previous 1977 Working Group, together with their own current deliberations, should be understood to apply not only to the audio-visual field but also to sound recordings. In effect this means that their recommendations to remedy the alarming problem of home sound recording on cassettes with blank tape will be included in the final version of their report to be submitted next year to the sessions of the Berne Union and the Intergovernmental Copyright Committee".

The IFPI report says, "On the subject of private recording in the home, the sub-committee reached the conclusion that while certain recordings could be made for personal use in good faith, and such activity was not to be compared with offering illicitly made copies for sale, nevertheless the owners of the rights suffered a loss in each case that should at least be mitigated as it could not be avoided".

The IFPI are also claiming that recordings should be treated for tax and duty purposes in the same way as books and films.

Because it was obviously impossible to prevent enormous numbers of uncontrolled recordings, while still respecting individual privacy, the sub-committees recommended a system consisting of a single, standard compensatory royalty on the sale price of recording equipment, and on the blank supporting materials, to compensate the professional groups. This system would not deprive the professional groups of their rights in the case of unlawfully-made recordings being put on the market under the pretext of private use.

On the subject of private use, according to the report, it was considered that the provisions of the Multilateral Copyright Conventions, dealing with the rights of reproduction and public performance, were already adequate to serve as a basis for national legislations—contracts negotiated between the parties concerned ensuring legal security for videocopies and videographic works made for public use.

In the education field, it was noted that, because the use of material for teaching purposes could be checked more easily than in the case of home-recording, the solutions to be applied should differ from that of private use. Where there were to be exceptions, these were to be accompanied by a compulsory licence in order to provide fair remuneration.

The sub-committees stressed the urgent need to identify practical measures to deal with the endless multiplication of recording capacity involved with the rapidly increasing number of cassettes, audio-visual tapes and discs available to users at declining cost, and it was pointed out that these practices were liable to affect not only the television bodies, but also the phonographic and cinematographic industries, whose markets would also suffer. It was also decided that the use of videograms for cable distribution systems, or c.c. tv to hospitals and other establishments, was likely to accelerate the process.

In conclusion, the sub-committees requested the secretariats to draw up for consideration by national legislators, an inventory of the situations they had examined relating to videogram copyright problems, together with their recommended solutions. They intended eventually to see the publication of papers and documents on the subject.

Post Office monopoly will be broken — General Secretary, EETPU

FRANK CHAPPLE, general secretary of the Electrical, Electronic, Telecommunications and Plumbing Union said in an interview published in the November issue of the Post Office Engineering Union journal, that he thought the Post Office monopoly would be broken. He believed that the UK's current monopolies had tended to become over-bureaucratised and therefore less efficient.

According to the report, Frank Chapple has a plan. To quote Mr Chapple, "The Post Office should supply standard equipment. You couldn't break up mainframe equipment: the basis should remain in their hands. Even in the US you need one mainframe supplier"; and the POEU journal, "The Post Office could, and should, maintain its monopoly role in the area of providing the basic network — what Frank Chapple wants to see is the Post Office getting off the end of the line: it's in the area of equipment interconnection that the Post Office should get out".

The interviewer and author of the report, Chris Naylor, claimed that Mr Chapple likened the current position of the Post Office to a hypothetical stance by the Electricity Industry: "It's like saying that the Electricity Supply Industry should have a veto on what you plug in to the wall sockets!" Mr Naylor thought that his views made sense. "If there are technical grounds for their position I'd like to know what they are. There are none that I know of," said Mr Chapple, according to the report. Mr Naylor qualified this by suggesting that what he was saying was that the Post Office provided lengths of wire, so did it really matter what was connected to them?

In his article Mr Naylor used the example of mains current being sent down the Post Office lines to show that it did matter what was connected to them and asked whether, if the Post Office stopped taking a year or two to examine equipment to make sure that it was OK, the manufacturers would make devices which could not safely be connected to the PO lines. Mr Naylor believed that to be a question that the Post Office and the manufacturers should answer.

After indicating that System X would only require an estimated one-tenth of the workforce necessary to manufacture earlier exchanges, Mr Chapple gave examples of some recent heavy redundancies, and suggested that the situation had been made worse by the Post Office's decision to go for System X. "We've never argued that we should stop technical progress because we're losing jobs, but we are looking for alternative forms of employment — and that presupposes that manufacturing must become more efficient and more technological." The report continued, quoting Mr Chapple, "If we're going to get any relief, private enterprise must enter into it. We really need some stimulus. Sooner or later the Post Office will have to surrender to consumer choice about equipment to be plugged in. They will have to surrender because consumers will demand that this be the case, but if our manufacturers have got no means of producing; and if, by that time, the workforce is dispersed there will be no way in which we can compete with the foreign producers of equipment. If it is accepted now, there is a chance that we will be able to stimulate production. If it loses its monopoly at a time when it's effectively destroyed our own manufacturing capability we're finished."

During the course of his interview, Frank Chapple suggested that "the Government should do an appraisal", and when asked what could be done by those who felt the Post Office's monopoly should be broken, he suggested "political lobbying", says the report.

Underwater tv system used on Christos Vitas

A LOW-LIGHT, s.i.t. (silicon intensified target) tube television system was used on the stricken oil tanker Christos Vitas as part of a structural damage survey which was attempted on board the vessel recently.

The tv system was manufactured by Marine Unit Technology who believe that this was the first occasion on which a s.i.t. camera has been used underwater in a salvage operation of this kind. Although the divers who were using the camera were only in the water for a very short time, they were able to survey part of the hull of the tanker before bad weather ruled out further diving activities, because the system was able to provide them with some good quality pictures.

The decision to use the Marine Unit Camera Team was taken by the Ministry of Defence.

Moving map

IN a high-speed military aircraft, the distance covered during the time it takes for the pilot to look at his instrument panel, locate the relevant instrument, read and assimilate the information, look back out of the cockpit and re-focus his eyes could be nearly a mile. Clearly, it is not a good idea to rush about at Mach 2 without a reasonably accurate knowledge of where one is going, and for this reason, electronic displays have been developed and are being used in increasing numbers in both military and civil aircraft.

The Ferranti Comed (short for Combined Map and Electronic Display) is the latest development of the moving map, first seen in the early '60s. A 35mm film strip contains maps of the area of interest, these being presented on a 5.5in display in the cockpit, the relevant part of the film being selected by the navigation sensors – accelerometers, etc

– normally fitted to the aircraft. In addition to the film, a scan-converted radar view of the ground can be superimposed, together with a good deal of information normally obtained from separate instruments – communications channel in use, fuel state, time, time to destination, etc. The changing position of, for example, the artificial horizon is simulated by tilting the film by servo. A television view of the ground ahead can be displayed, obtained by low-light or infra-red camera tubes.

Microwave landing system standard

A SPECIAL COMMITTEE has been formed by the Radio Technical Commission for Aeronautics (RTCA) to prepare a Minimum Operational Performance Standard (MOPS) document for time-reference scanning-beam microwave landing systems (m.l.s.) airborne receiving equipment. This document, which will describe both the operational requirements and the technical standards for the equipment, is expected to follow the lead of similar documents which have been adopted by many nations as the standard for the certification of avionics equipment as recognised by the International Civil Aviation Organisation (ICAO).

According to Aero Line — an American newsletter, published by Aeronautical Radio Incorporated to inform the public of the activities of the Airlines Electronic Engineering Committee (AEEC) — the RTCA Committee emphasized the development of m.l.s. airborne receivers as the next logical step in the introduction of m.l.s. The newsletter says, "The timeliness of this decision is tied to recent ICAO actions to adopt TRSB (see p45, June 1978 issue) as the international standard for m.l.s."

Radio communications to be used on 'Golden Hind'

THE "Eye of the wind", a 150-ton brigantine (a two-masted vessel with square-sailed fore-mast and fore and aft main mast) which left Portsmouth at the end of October to make a two-year round-the-world voyage to celebrate the 400th anniversary of Sir Francis Drake's circumnavigation of the world, will be using radio communications equipment supplied by companies in the GEC-Marconi Electronics group. Operation Drake, as the voyage is called, is being carried out by parties of experienced explorers, scientists and young explorers.

Marconi Marine has provided a 400W Transocean/Pacific s.s.b. radiotelephone to satisfy the vessel's requirements for m.f. and h.f. communications with shore-stations around the world, and this equipment is being powered by the ships a.c. mains. The company has also supplied a 24V d.c.-operated Falcon II m.f./h.f. radiotelephone as a back-up set, should the mains generator fail. For communications within 40 miles of the coast, the vessel will use the companies Argonaut S v.h.f. radiotelephone. As if this is not enough, at least when compared with the communications which Drake had, or rather didn't have, Marconi have also provided the vessel with Survivor II survival craft radio equipment, for emergency purposes. Furthermore, v.h.f./f.m. communications for the overland expeditions which the parties are making are being provided by three UK/VRC353 radios supplied by Marconi Space and Defence Systems Ltd. According to Marconi, the UK/VRC353 is the world's most advanced vehicle radio. It has been produced in quantity for the UK Ministry of Defence and is the only v.h.f./f.m. radio system to be installed in fighting vehicles of the three armed services. During Operation Drake these radios will be used to provide communications between the ship and the explorers' base camps.

Operation Drake is primarily a new opportunity for 'youth explorers'. The voyage is to be divided into nine, three-month phases, with the experienced explorers, the scientists and the 24 selected young explorers changing over at the end of each phase. The ship will be visiting sites throughout the world where historical, scientific and medical research will take place and the aim of the operation is to involve both the youth and scientists of the countries visited to ensure a mutual exchange of ideas and expertise. During the sea voyages the young explorers will be given practical training and lectures to prepare them for the scientific work.

The operation is being paid for by sponsors from commerce, industry, charities, individuals and the armed forces in various countries. HRH The Prince of Wales has agreed to be patron of the venture.

Approach radar for Singapore airport

TELECOMS, the Telecommunications Authority of Singapore, have announced that they have awarded Nippon Electric Company Ltd, of Tokyo, Japan, with a contract for the provision of an approach control radar (ACR) system to be installed at their new international airport, presently being constructed at Changi.

The new system will consist of a primary surveillance radar and a secondary surveillance radar and will be integrated into the long range surveillance radar and display system (LORADS) which is also being installed at the site. With the primary radar the ACR system will have a range detection coverage from 1/3 nautical mile to 64 nautical miles, and with the secondary radar this will be extended to 128 nautical miles. The system will also operate up to an altitude of 40,000 feet.

Air traffic controllers, after taking over control from other controllers responsible for the long range radar, will use the ACR system to ensure that aircraft land safely at the airport.

According to NEC, one of the most significant features of the new system is its ability to track and automatically display aircraft positions with identifications — by using alpha-numeric symbols displayed on a 58cm diameter video screen. This screen also displays the flight altitude and aircraft speed.

Mr Ng Chee Meng, acting general manager for Telecoms, said at a ceremony where the contract was signed, that the integration of the ACR system with the long range radar would provide greater operational flexibility and efficiency for air traffic control. It is hoped that the ACR system will be in operation by September 1979, and integrated with the long range system two months later.

NEC, who won the contract in the face of strong competition against European and American manufacturers who have traditionally supplied air traffic control systems to Singapore, believe that upon completion of the two projects the installation will be one of the most modern air-triaffic-control systems in the world.

News in Brief

Hacker Sound Ltd, well known in the field of portable radios and music centres, has been acquired by **Motoradio Ltd,** the Blackburn-based manufacturer of car-entertainment equipment. The first step has been to move Hacker's production facilities from an old factory at Maidenhead to Motoradio's modern plant in Bournemouth. This is all part of an expansion scheme by Motoradio. In future Motoradio's own equipment production will be centred at Blackburn where there are plans to double the size of the existing factory.

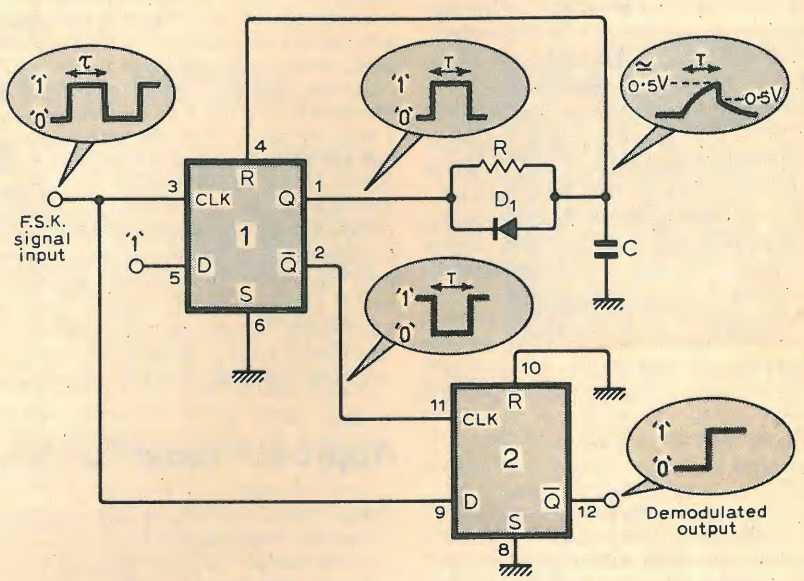
The 6th International Salon "Audiovisual and Communication", the international market place for sight and sound, will be held in the Palais des Congres, CIP Paris, Porte Maillot from 22-27 January, 1979. In addition to exhibits and presentations on the stands — with special emphasis being on sound systems, magnetoscopes, video-discs, security and surveillance systems, electronic games and teletext — there is to be a forum entitled "Illustration of the Audiovisual".

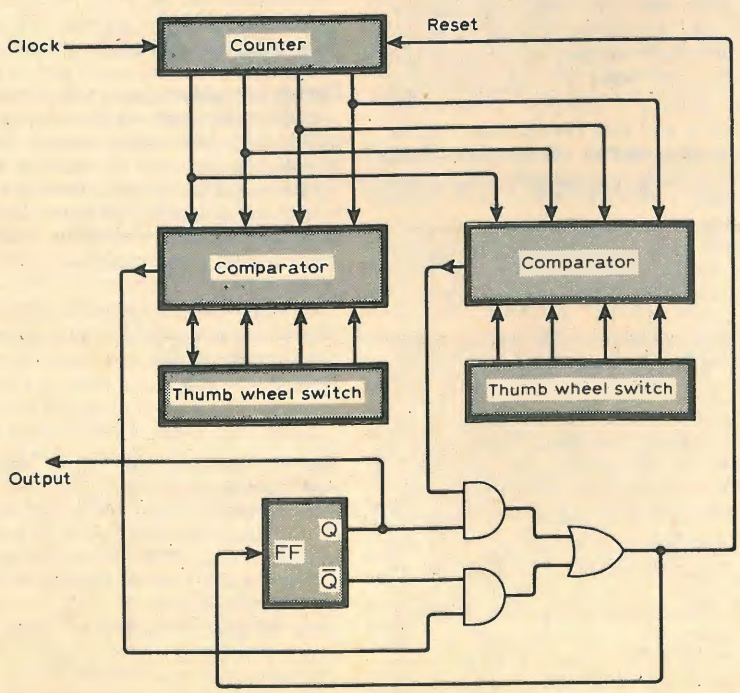
CIRCUIT IDEAS

F.s.k. signal demodulator

This circuit was designed to demodulate an f.s.k. signal which carries serial binary data using pulse width modulation. The circuit uses a 4013 with the first flip-flop arranged as a monostable multivibrator which is triggered on the positive edge of the input waveform. The monostable period is determined by the time it takes the voltage across the capacitor to reach the threshold voltage of the reset input. The time constant of this voltage is RC. Diode D_1 discharges the capacitor when the Q output is reset to 0. If the input mark period is greater than the monostable period, a 1 is clocked into the second flip-flop. If the converse is true, a 0 is clocked into the second flip-flop. Therefore, the Q output of this flip-flop is a 0 for the low frequency and a 1 for the high frequency. The monostable pulse length T is given approximately by $0.693\,RC$ if the reset input threshold voltage is 0.5 of the supply voltage. The expected variation of T is about ± 30% so R needs to be variable.

G. Prusiewicz
Cambridge





Programmable duty-cycle frequency divider

Simple frequency division using flip-flops is sometimes unsuitable because of their 50% duty cycle output. This circuit is more flexible because the duty cycle can be programmed. Two digital comparators compare the output of a counter with numbers set by the thumb wheel switches, and a flip-flop alternately presents the outputs of the comparators to the reset input of the counter. The output of the flip-flop therefore has on and off periods equal to the switch numbers multiplied by the repetition time of the clock input to the counter.

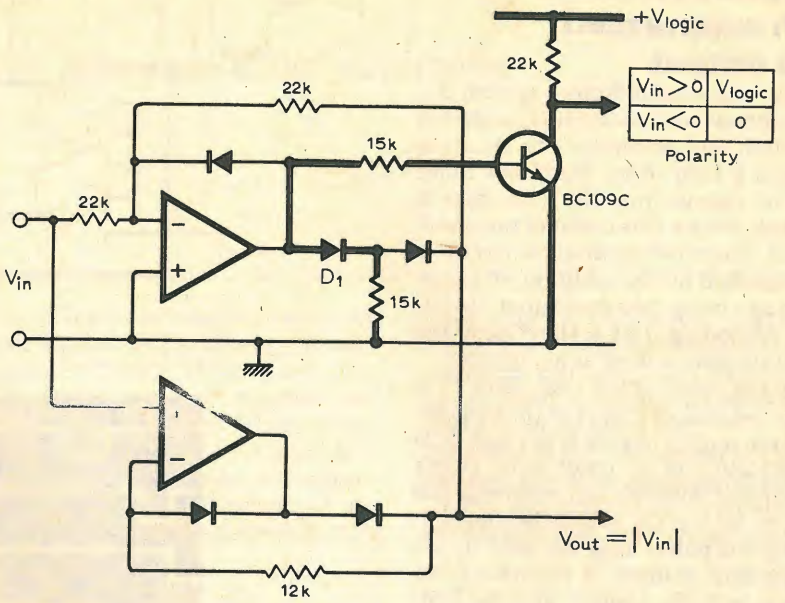
K. R. Srinivasa Murthy
Bangalore
India

Polarity indicator

In applications where the polarity of a signal applied to a perfect rectifier needs to be detected, the conventional method is to use a comparator. This system adds undesirable switching noise to the signal, and may oscillate for low-level signals. A small modification, as shown, to a commonly used perfect rectifier circuit offers a more reliable indication of polarity. This circuit will operate with low frequency signals of less than 1mV pk-pk.

The additional voltage drop across D_1 ensures that the transistor switches correctly as the polarity of the input signal changes. Frequency response of this rectifier is not quite so good as the unmodified circuit. The 22kΩ collector pull-up resistor is suitable for driving c.m.o.s. from any logic supply voltage. For t.t.l., the pull-up resistor should be changed to 3k9 to drive one input. For precision applications, the op-amps should be offset nulled.

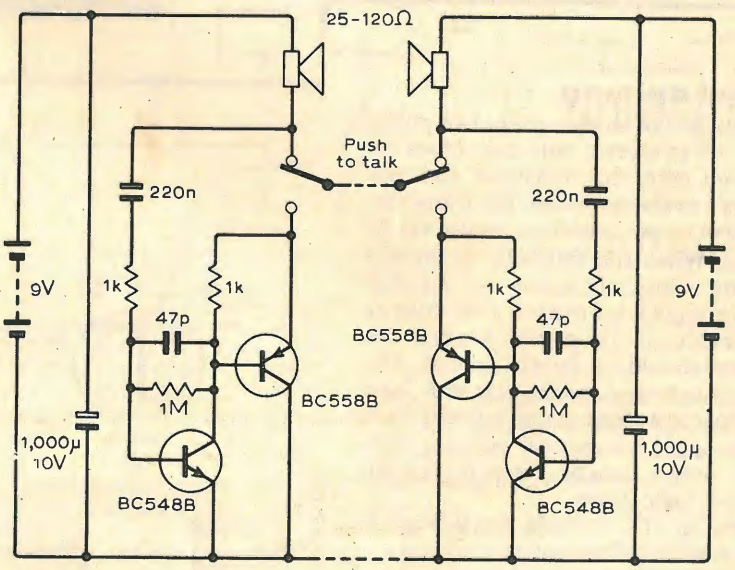
T. Hughes
University of Cape Town
South Africa



Simple two-wire intercom

The circuit shows a simple battery powered two-station two-wire intercom which does not dissipate any standby power. If NiCd batteries are used, trickle charging at one station will also charge the other through the loudspeakers.

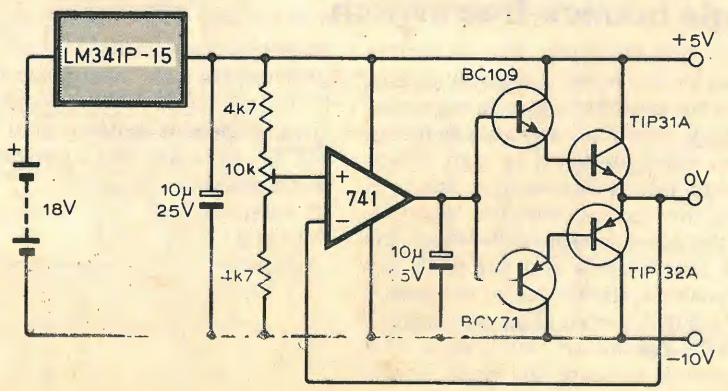
Ole Holmskov
Hoerning
Denmark



Triple rail power supply

When it is necessary to interface logic circuits such as t.t.l. to a calculator chip which uses a cold-cathode display, one solution is to use level translators. However, this may involve a large number of components. The alternative is to run the t.t.l. from a displaced-voltage power supply. The circuit shown gives outputs of 5V and −10V although these can be easily changed. The supply compensates for any differences between the load currents, although the efficiency is at maximum when both currents are equal.

G. Robinson,
C. P. Harwood &
R. Daniel
Brunel University

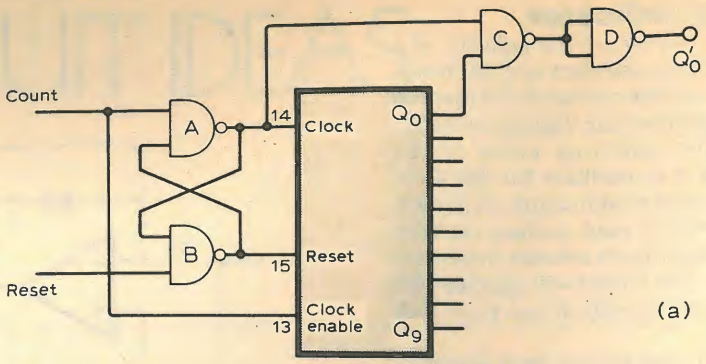


Decade counter with suppressed zero output

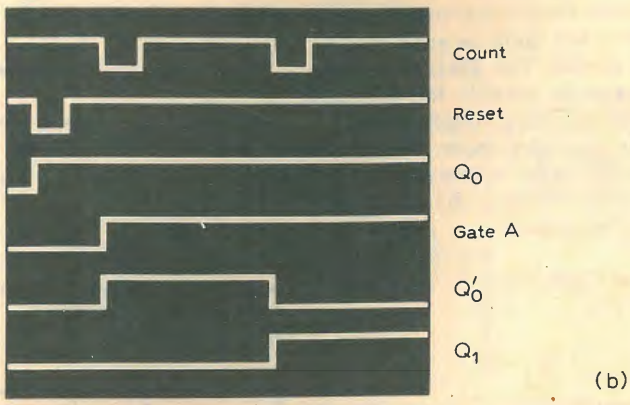
At least one output from a typical decade counter, such as the 4017, is always activated, and normally the Q_0 state becomes a 1 on reset. There are times when no output from the zero state is required, while a true count of ten is still wanted. The most economical circuit is accomplished by the addition of a bistable stage using two dual-input NAND gates. Decoding uses a third gate and the fourth gate is used as an inverter.

With the circuit in the reset state, Q_0 is a 1, but because of gate A of the bistable is at 0 the output of gate C is 1 and Q'_0 is 0. Application of an input pulse resets the bistable without incrementing the counter, so the Q'_0 output becomes 1. Subsequent pulses step the 4017 in the conventional manner. A negative pulse resets b both the counter and the bistable.

D. Price
Knockholt
Kent



(a)

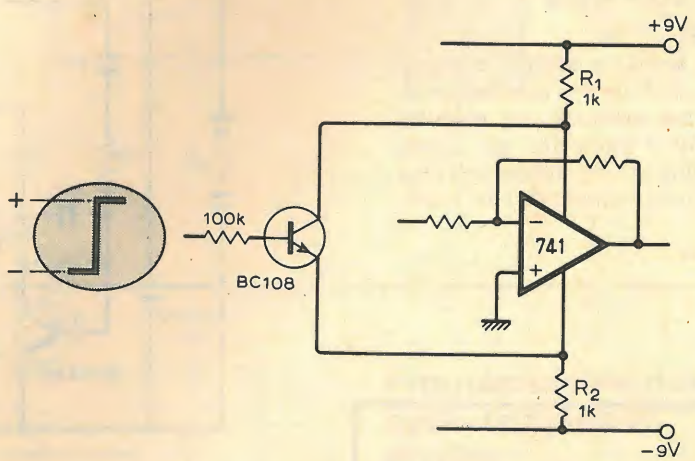


(b)

Gated op-amp

If the output of an operational amplifier needs to be gated, this can often be achieved with one transistor and two resistors as shown. When the transistor is off the op-amp receives power via R_1 and R_2. When the transistor is on, the op-amp supply is removed. As this arrangement increases the source impedance of the power supply, the op-amp should be lightly loaded. The full rail voltages appear across R_1 and R_2which will draw more current than the op-amp. The general purpose transistor shown can be a p-n-p type for opposite logic levels.

M. Feeney
Morpeth
Northumberland

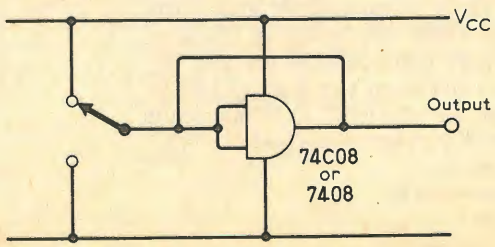


Simple bounce-free switch

A single non-inverting gate or buffer wired as shown forms a bistable circuit because the positive loop gain is greater than unity. Whilst the switch is in the up position, the output will be high. When the switch leaves this position and is in transit, the output remains high because the input is still high. When the switch first makes contact with the lower position, the output of the gate is momentarily shorted. This situation is however remedied within a few nanoseconds because the input is also taken to ground which drives the output of the gate low. Thereafter, if the switch contact bounces, the output will stay low because the input is low.

This single non-inverting gate arrangement is simpler than the usual SR flip-flop, and the annoying pull-up resistors are eliminated.

P. Seligman
Victoria
Australia



Versatile sound generator

New i.c. offers numerous audio waveforms

The SN76477N sound generator i.c. can synthesize a large number of sounds by generating an audible tone, a low-frequency modulation signal and noise, all of which are programmed by external components. For complex sequences of sounds, these programming inputs can be controlled by external circuits. This article describes the device and outlines an evaluation circuit.

LOW-COST sound synthesizer is intended for use in games, indicators, alarms or any application which requires an audible signal. The 28-pin i.c. is half analogue (low frequency oscillator, voltage-controlled oscillator, noise filter, attack/decay circuit and amplifier) and half I^2L (noise oscillator, noise generator, envelope select, and mixer).

The i.c. operates by generating three sound functions which can then be filtered, mixed, and shaped to produce almost any natural or imaginary sound. A block diagram of the device is shown in Fig. 1.

The low frequency oscillator, l.f.o., is based on a comparator with current sources that charge and discharge an external capacitor as shown in Fig. 2. This oscillator normally operates between 0.1 and 30Hz although it can operate up to 20kHz. The frequency is controlled by an external resistor and capacitor, and is $0.64/RC$ Hz. Because the capacitor is charged by a constant current source, a triangular waveform is produced at pin 21. However, if an exponential waveform is desired, a resistor may be connected across the capacitor. The comparator has a reference voltage of 2.5V and switches at this point to generate a square wave which is fed to the mixer.

The v.c.o. in Fig. 3 is similar to the l.f.o. and operates at frequencies from 1Hz to 20kHz. An additional comparator is provided so that two voltage controlled

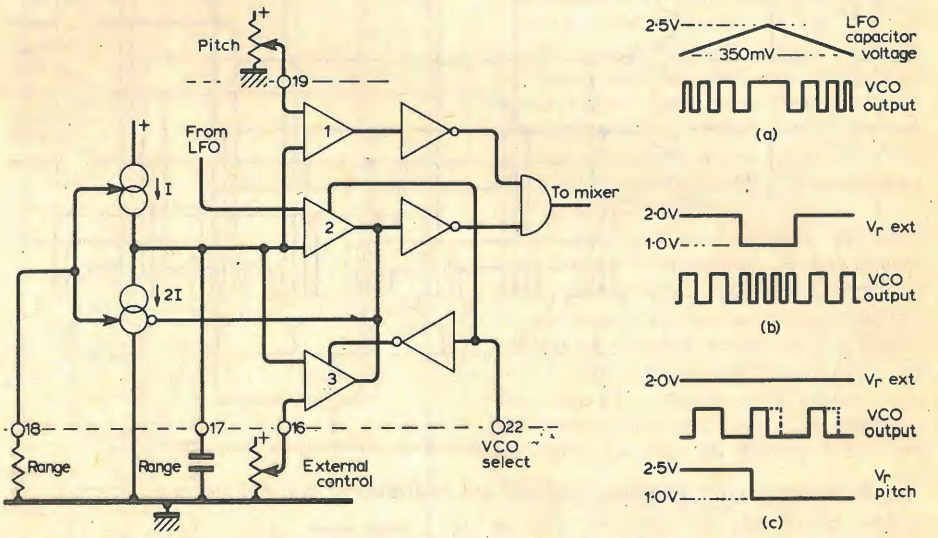


Fig. 3. *Voltage controlled oscillator. The output waveforms show (a) frequency modulation, (b) external voltage control and (c) pitch control.*

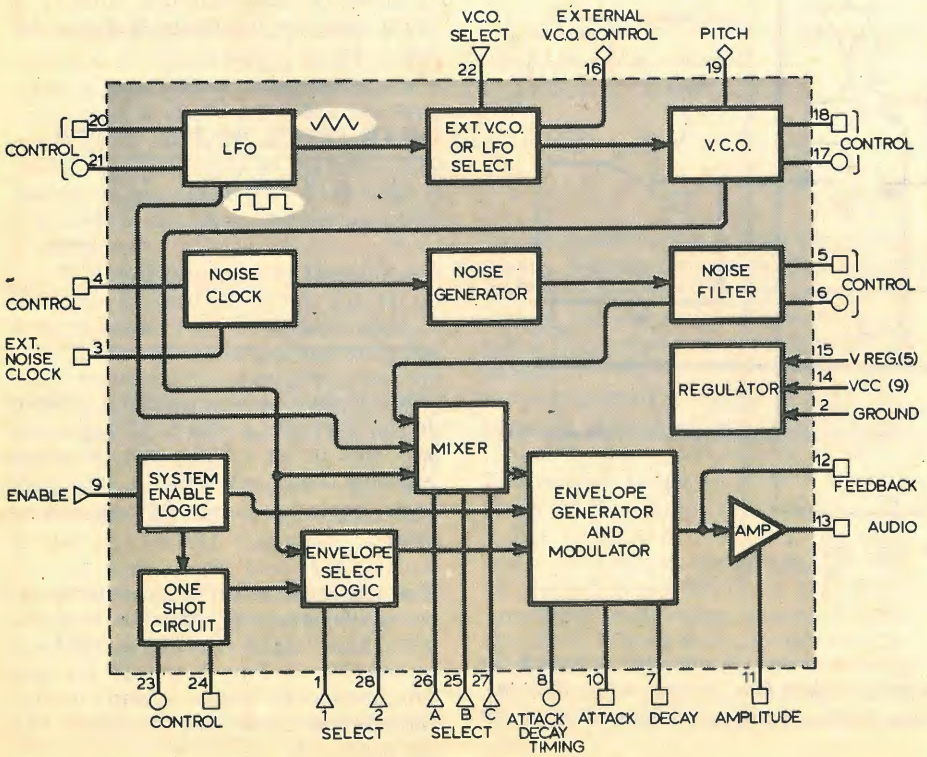
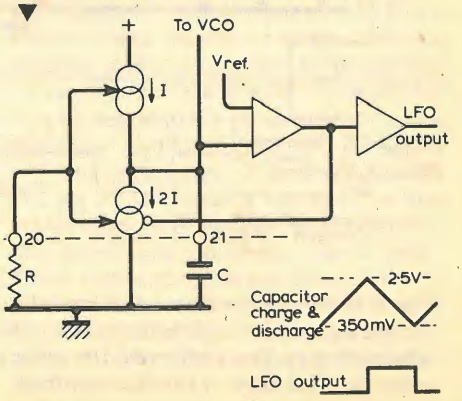


Fig. 1. *Block diagram. The circles, squares, triangles and diamonds denote programming by capacitors, resistors, logic levels and analogue signals respectively.*

Fig. 2. *Low frequency oscillator. An exponential waveform can be fed to the v.c.o. by placing a resistor across the capacitor on pin 21.*



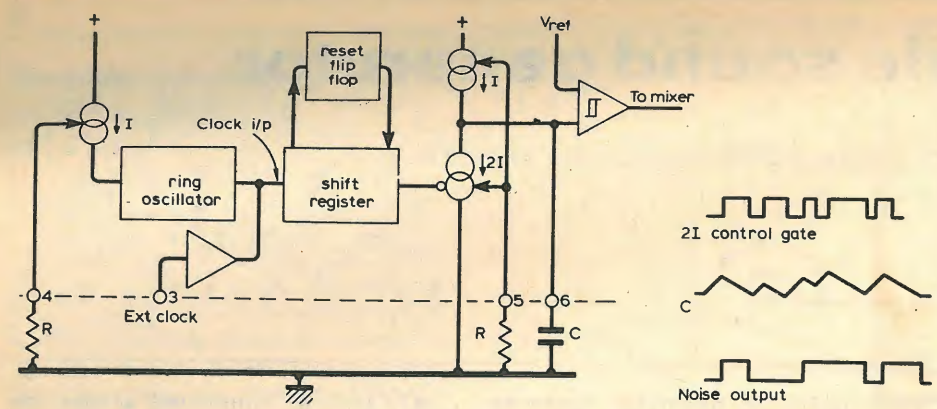


Fig. 4. *Noise generator and low pass filter. The nominal resistor value at pin 4 is 47kΩ although this can be* increased to 100kΩ.

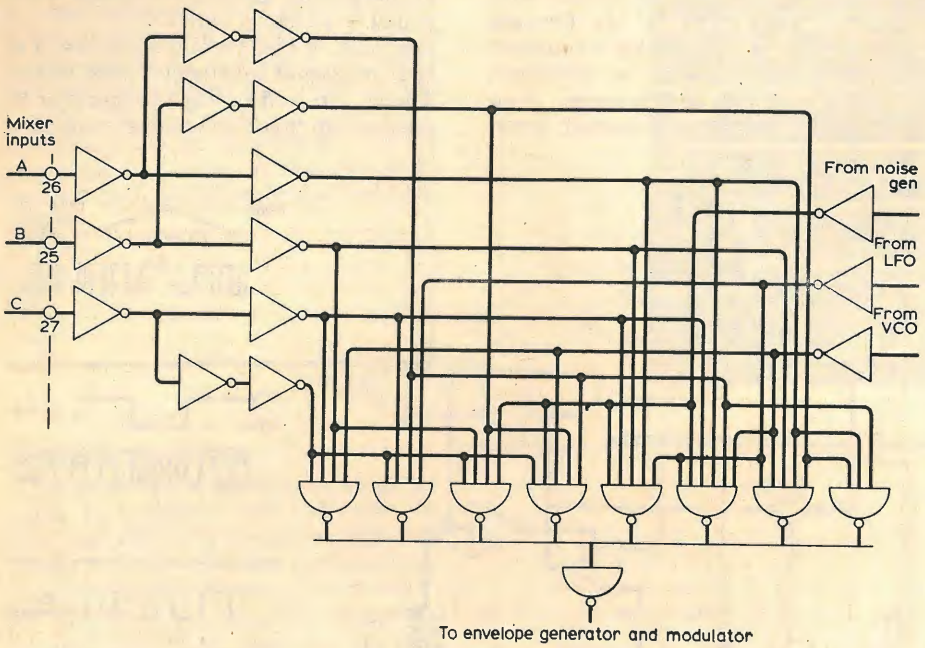


Fig. 5. *Mixer circuit. The input signals are multiplexed and not summed.*

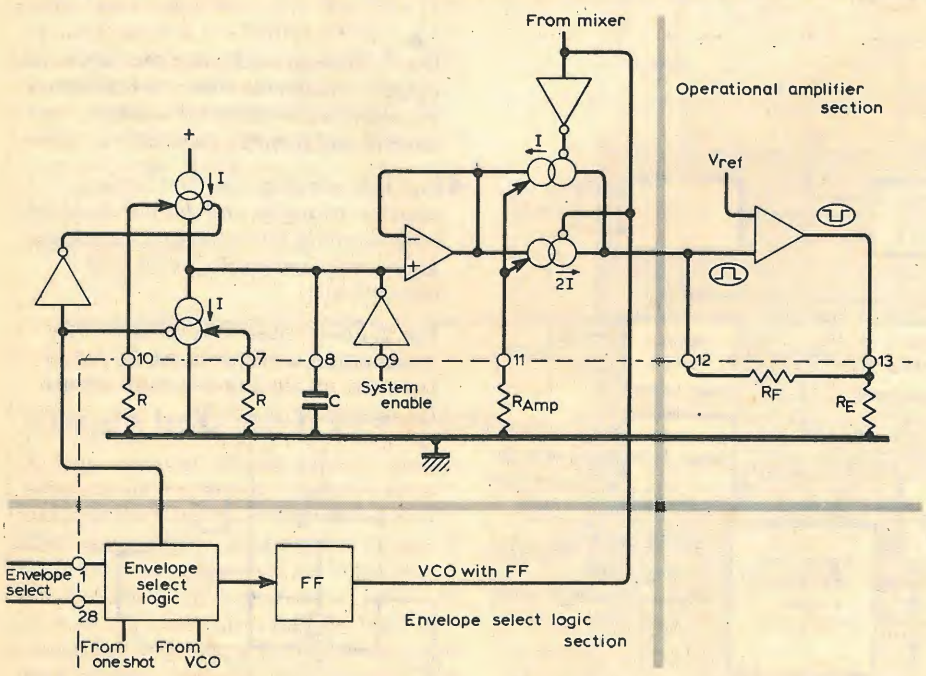


Fig. 6. *Envelope generator and modulator. With mixer only or one-shot selected, the attack ramp starts when the system enable pin is taken low. If v.c.o. or v.c.o. with alternating cycles is selected, the attack ramp starts on each positive edge or every other positive edge of the v.c.o. output.*

inputs can be used. A logic 1 on pin 22 enables comparator 2 so that the v.c.o. is controlled by the l.f.o. triangular output. A logic 0 on pin 22 enables comparator 3 so that the v.c.o. can be controlled by an external voltage on pin 16. Comparator 1 is used as a pitch control and only affects the mark-to-space ratio of the v.c.o. output. The minimum output frequency is set by the external resistor and capacitor on pins 18 and 17, and is $0.64/RC$. The control voltage, which should be 0 to 2.5V, will give a 10:1 change in frequency which increases towards 0V.

The external resistor should be greater than 4.7kΩ to prevent an excessive charging current. Because the v.c.o. can be controlled by the l.f.o., an additional external control input can be provided at pin 21.

The noise generator is formed by a ring oscillator, shift register, and a low-pass filter as shown in Fig. 4. The oscillator frequency is controlled by an external resistor at pin 4, and can be inhibited by taking pin 4 to +5V. In this case an external 5V pk-pk oscillator can be fed into pin 3 and used to clock the shift register. This technique is useful if a slower or more precise clock is needed. The shift register produces pseudo-random white noise which is passed through a variable bandwidth low-pass filter, with a 3dB frequency of $1.28/RC$. If filtering is not required, the capacitor at pin 6 can be omitted, but a resistor of at least 4.7kΩ must be left at pin 5.

The mixer is a NAND gate multiplexer which selects one or a combination of the inputs and feeds the output to the envelope generator, see Fig. 5. The mixer output is an AND function and therefore does not sum the input signals to produce simultaneous sounds. A truth table for the mixer is shown below.

C (pin 27)	B (pin 25)	A (pin 26)	output
0	0	0	v.c.o.
0	0	1	l.f.o.
0	1	0	noise
0	1	1	v.c.o./noise
1	0	0	l.f.o./noise
1	0	1	l.f.o./v.c.o./noise
1	1	0	l.f.o./v.c.o.
1	1	1	inhibit

These inputs can be selected by external logic circuits, three changeover switches, or by a rotary switch with a suitable diode network. In each case, logic levels of 0 and +5V should be used.

The envelope select logic determines the envelope which is given to the signal after the sound sources have been mixed, Fig. 6. Pins 1 and 28 are programmed with logic levels and the truth table below shows the envelopes that are produced.

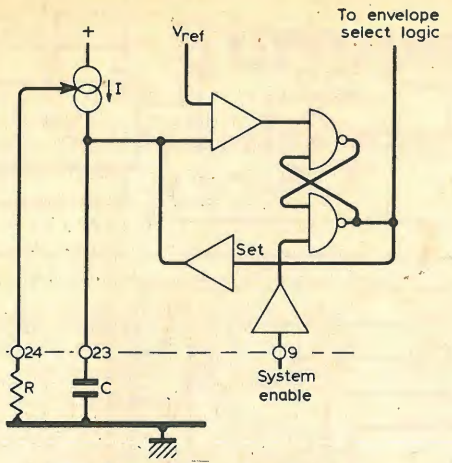


Fig. 7. *One-shot circuit.*

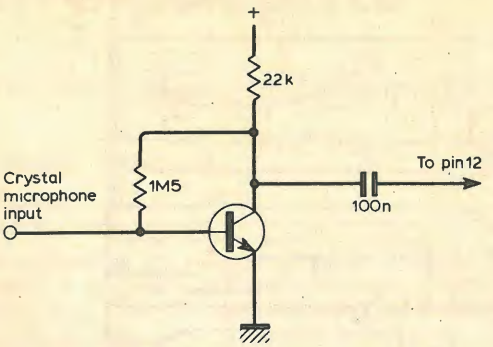


Fig. 8. *Microphone interface.*

Pin 1	Pin 28	Output
0	0	v.c.o.
0	1	mixer only
1	0	one-shot
1	1	v.c.o. with alternating cycles

Again, the input can be programmed by switches or other logic circuitry. When mixer only is selected the output is not shaped. The external resistors at pins 10 and 7 set internal currents which charge and dischage the external capacitor at pin 8.

Because these linear charging ramps are used to alter the rise and fall times of the envelope, the resistors and capacitor can be used as attack and decay controls. If these controls are not required the resistor at pin 10 must still be used. As in the l.f.o., if exponential attack and decay slopes are required, a resistor can be connected across the capacitor.

The system enable circuit in Fig. 6 acts as an on/off switch for the sound output when a logic 1 or 0 is applied to pin 9. This input is also used to set the one-shot circuit in Fig. 7 with a negative-going edge. Pin 9 has an internal 15kΩ pull-down resistor so that if the input is not used the circuit will be permanently enabled.

For momentary sounds, the one-shot latch can be used which has a duration determined by the RC time constant at pins 23 and 24. The comparator switches when the capacitor voltage reaches the 2.5V reference voltage, and the circuit is then reset. Pin 9 must be held low for the duration of the one-shot, and can only be used when the correct envelope select logic has been programmed. Any attack time which has been set will occupy part of the one-shot period. However, any decay time which has also been set will not occupy part of the one shot period, but will be added at the end.

The output stage in Fig. 6 is an op-amp designed to interface with external sound modulators or further amplifying stages. Because the output is an emitter follower without a load resistor, pin 13 should have a resistor connected to earth, and ranging in value from 2.7 to 10kΩ.

Peak output voltage is $3.4R_F/R_G$ where R_F is the feedback resistor at pin 12 and R_G is the gain resistor at pin 11. The output range is limited to 2.5V pk-pk before clipping takes place.

The resistor at pin 11 is the main control for output amplitude, and may be varied from 27kΩ to 220kΩ for amplitude modulation. Feedback resistor R_F is intended to compensate for external variations, but further filtering can be added to the output if a suitable feedback circuit is used instead of the resistor.

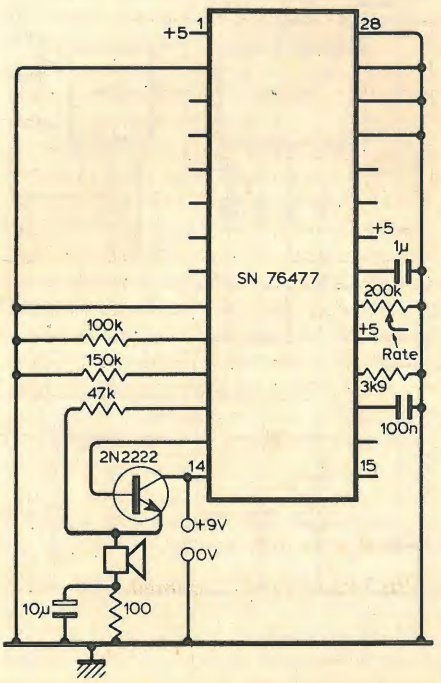


Fig. 9. *Practical circuit for producing a siren/phasor gun sound.*

More complex sounds

Although the i.c. can synthesize a wide variety of sounds by simple programming, highly complex waveforms can be produced with the aid of external circuitry. When two sounds are required simultaneously a square wave oscillator can be used to switch the mixer select lines at a frequency of between 20 and 100kHz. If different output amplitudes are required, the mark-to-space ratio of the oscillator output can be altered.

For applications where several amplitudes, frequencies or envelopes need to be programmed, a shift register or counter can replace the manual switch or potentiometer, and sequentially connect preselected resistor values. For more ambitious programmes a 1K r.a.m. could be used, for example, to play 16 different 16-note tunes.

Although the device does not have an external input for the mixer, which would be useful for interfacing the i.c. with other sound sources, external signals can be fed in via pin 12. An example of this is the circuit in Fig. 8 which can be used to add a voice signal to the sound output.

Practical circuits

The simple demonstration circuit in Fig. 9 produces a "siren/phasor gun" sound. For more varied waveforms, however, it is worthwhile constructing an evaluation circuit such as the example in Fig. 10 which allows waveforms to be gradually synthesized using manual switches and potentiometers. The three mixer select inputs have an optional square wave generator as described earlier, and the low frequency oscillator can be sequentially programmed using a decade counter.

From experience, it is preferable to set all of the time constants to the mid-values, and start by programming the mixer and envelope select logic. Once the approximate waveform is achieved the noise, modulation and tone can be adjusted, followed by the more subtle effects of attack/decay and amplitude.

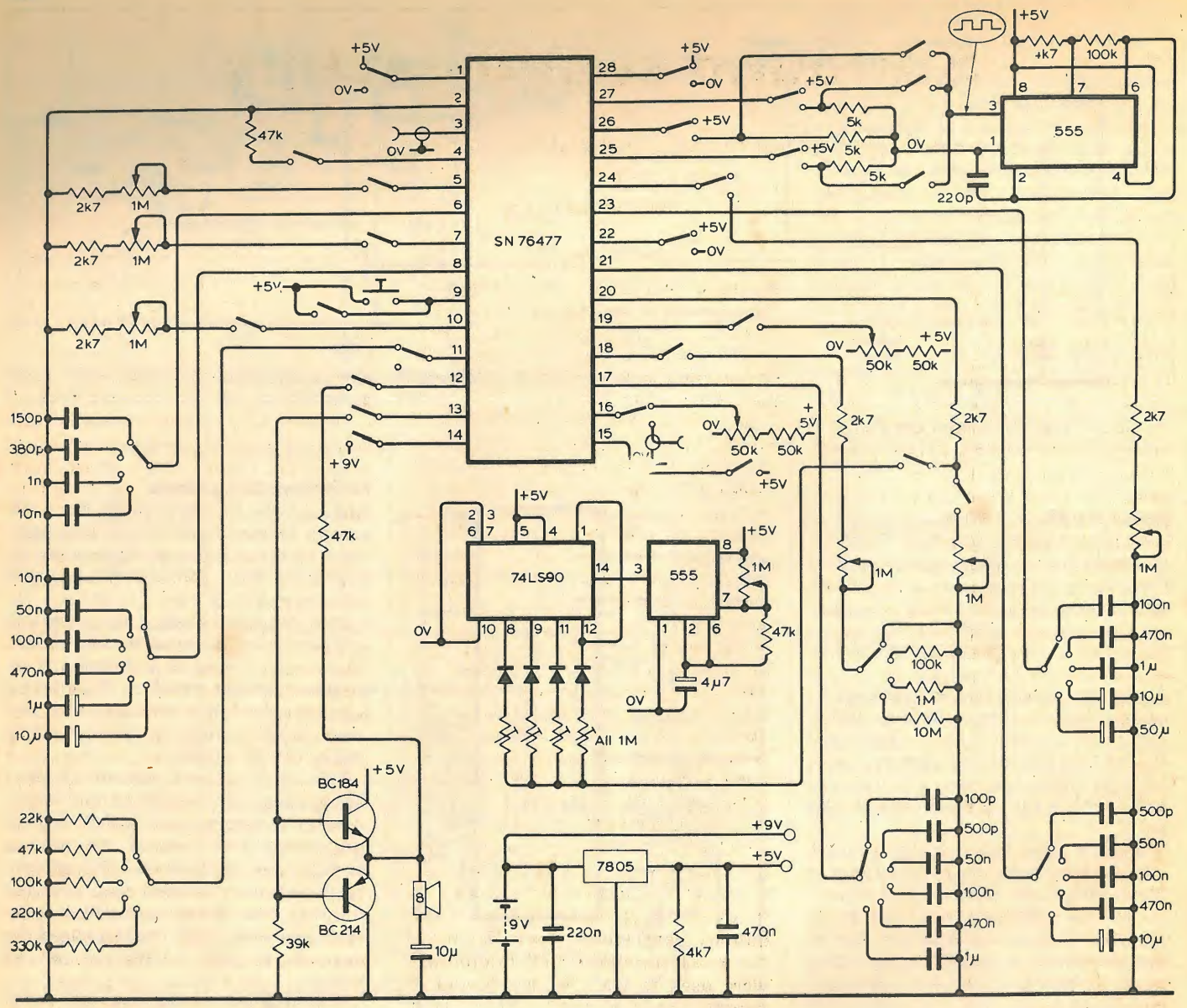


Fig. 10. *Evaluation circuit. The 555 square-wave generator can be used to multiplex the mixer output, and the counter can be used to sequentially switch resistor values. Diodes are used so that the 74LS90 cannot source current into pin 20.*

For miscellaneous waveforms and sound effects the 76477 is a very versatile and economical device. However, following some experiments with an electronic organ design, general stability problems make the i.c. unsuitable for use in an electronic instrument. Nevertheless, the prospect of interfacing the device to a microprocessor may well lead to a new breed of sound-effect generators.

Printed circuit board

A glass fibre p.c.b. is available from M R. Sagin at 23 Keyes Road, London N.W.2 for £4.50. The board, which is based on the evaluation circuit in Fig. 10, accommodates p.c.b. mounting slide switches and pre-set potentiometers.

We understand that the SN76477N can be supplied by Technomatic Ltd, 17 Burnley Road, London N.W.10.

News in brief

The Executive Vice President of Matsushita Electric has announced that **Matsushita Electric (UK) Ltd** is to increase the range of the products made in Wales, and that it has completed negotiations to take over a government-owned factory next door to its existing colour tv factory in Pentwyn, Cardiff. The company will eventually be producing National Panasonic music centres and Technics stereo radio tuners in the new factory.

Dexcel Incorporated of California has appointed **Nore Microwave Ltd** as its exclusive agent for microwave transistors and associated products in the UK. The Dexcel product line consists of GaAs f.e.t.s of both low noise and medium power types, silicon bipolar transistors, GaAs f.e.t. amplifiers and oscillators, all in the frequency range up to 18GHz.

A new magazine called 'Sounds Vintage' is to be published bi-monthly, starting in January, and will be devoted to information, articles, news, views, advice and general information related to the 'hardware' and 'software' of vintage sound. Subjects covered will include: vintage wireless sets, acoustic gramophones, cylinder machines, the work of pioneers, records and cylinders, servicing and renovating and collector's information. Subscriptions from Subscription Department, Sounds Vintage, 28 Chestwood Close, Billericay, Essex.

Learned Societies, academics, universities and individuals in industry throughout the world were recently invited to nominate candidates for the **Fifth Marconi International Fellowship.** The Fellowship, a $25,000 grant commemorates Guglielmo Marconi's creative contributions to scientific discovery, engineering and technology. The special subject chosen for the 1979 Fellowship is 'Outstanding advances in satellite and space technologies — relevant to improving world communications'. The grant will be made to an individual in recognition of his or her outstanding contribution in this field and it will be used to commission work, preferably by the recipient.

Surround sound patents

Will the future of surround sound depend on patent bargaining?

by Adrian Hope

The modern history of surround sound has been the subject of regular reports in these pages. Inevitably, less has been written on the past history of multi-channel sound, and the patent literature contains a number of surprising revelations. It is also fruitful at the same time to examine the more modern patent literature, because this helps put into perspective current claims, disputes and commercial alliances in the surround-sound field. Moreover an understanding of the patent situation, both ancient and modern, may also be of value to those involved in the production of surround sound equipment and interested either in patenting their own ideas or ensuring that they do not encroach on ideas covered by current patents.

A PATENT IS A BARGAIN struck between the inventor and whichever country grants him the patent. The inventor discloses full details of invention to the patent office of the country in question — virtually every industrial country has a patents system — and if the patent office adjudges the idea novel a temporary monopoly is granted to the inventor.

Then, for a limited period of time, the inventor has the opportunity of preventing others from using the same idea. But simultaneously, as part of the bargain, the patent office publishes the details of the patented invention to the public. The disclosure document or patent, is from the moment of publication, a free source of information to the public. (The Holborn Science Reference Library off Chancery Lane in London, has a full set of patents from most industrial countries, including, of course, the UK. Copies of these may be bought, at a price dependent on length, or at a flat fee of 95 pence if the patent is British.)

Once the patent has expired, either by reaching the end of the statutory period or by failure of the inventor to pay any renewal fees that are necessary, the invention as disclosed by the published document passes into the public domain. Under the new UK laws a British patent will last 20 years in conformity with many other countries. (The previous term was 16 years.) It is, therefore, a safe bet that any technical information contained in any patent over 20 years old will belong to the public. Generally speaking, that information cannot then be re-patented by the inventor or anyone else. It is clear, from the patent records, that a surprising number of audio ideas applicable to surround sound are well and truly part of the public domain.

As early as 1878, October 22nd to be precise, Thomas Alva Edison completed the filing of an important patent application in Britain. This issued as BP1644/1878, and it contained, just ten months after the invention of recorded sound, a passage that pre-empted the idea of multi-channel recording. Edison sketched and described a cylinder recorder with four separate cutter heads, simultaneously tracking different parts of the same cylinder. "Four persons may speak simultaneously and have records made in separate, parallel lines upon one cylinder, and the phonogram will reproduce the sounds the same as though it contained the record of but one voice," said Edison. Who says four-channel recording is new?

In 1881, a system was demonstrated by Clement Ader at the Paris Electrical Exhibition which effectively anticipated much of the modern binaural and dummy-head stereo work. Eighty of the newly-invented Bell telephones were used to transmit the sound of music from the orchestra of the Grand Opera through to listeners at the Exhibition. According to a contemporary report, a "new acoustic effect" was discovered by accident. It was found that if the listener took two, rather than one, telephone earpieces, and put one to each ear, the sound heard took on a new dimension. A "special character of relief and localisation" was experienced, for the simple reason that the sound fed to the listener's left ear was originating from one microphone and the sound fed to the right ear was originating from another microphone, spaced from the first. Presumably the most realistic effects were heard by those listeners who had by pure chance picked telephones connected to a pair of microphones spaced apart by a distance comparable to that between the ears of the human head. Although there is no record of a patent filed on this process, it surely represents the first disclosure of binaural stereo, albeit by direct wire transmission.

Incidentally, at the turn of the century cylinder recordings were made by the simple expedient of putting the artist in a room, facing a bank of several dozen cylinder recording machines. That way, without recourse to duplication which for cylinders was then technically difficult, or dubbing which degraded quality, one recording could produce several dozen cylinders. American recording engineer Jerry Bruck has argued that at least some of those recording machines must inevitably have had their horns spaced apart by the ideal distance for a crossed-pair recording. All that remains now is to find the right pair of cylinders from the same recording session and dub them together onto tape as left and right-channel sound records of the original performance...

Probably the earliest disclosure of, and patent on, a multi-channel recording is to be found in BP23620 of 1911. This patent, granted to Augustus Rosenberg of High Holborn, London, proposed a cinema sound recording and reproduction system which enabled "two synchronous sound-records (to) be obtained, one from each end of the front of the stage, or scene of the incidents to be recorded". The sound records were to be "produced photographically side by side upon a single strip" with reproduction through "sound reproducing devices placed at or near each end of the screen", to produce sound from the screen "in accordance with the movements of the apparent source of sound from side to side of the picture". Particularly important is the suggestion in this 1911 document that "the number of sound records employed is not limited to two".

It is interesting here to digress forward in time and note that Fred and Ralph Walker of New York patented the Cinerama film and sound system as long ago as 1937 (BP518905) with the object of "increasing the illusion of being in and surrounded by an environment by producing binaural sound effects".

In USA patent 1855149 of 1927, W. Bartlett Jones of Chicago described in some detail the now well-known effect of binaural sound, and suggested that the two channels of sound necessary could be either separately transmitted by using two radio wavelengths, or by adoption of multiplex techniques "so that a single wavelength may be used to broadcast two effects". Bartlett Jones then went on to suggest that the two channels of sound could be recorded using either a film record, or a disc with one effect on each side or a double or side-by-side groove. Alternatively, and most important, he went further to suggest that the disadvantages of recording separate channels in separate

grooves "may be avoided by providing the two effects in one groove. Two types of sound groove are now employed, one varying vertically and one varying horizontally. A groove may be made which varies vertically for one effect and which varies laterally for the other effect."

Thus by 1927 the notion of recording surround sound using binaural techniques and the vertical-horizontal modulation of a single groove was already old. Indeed, the notion of recording two channels of sound in a single groove modulated both laterally and vertically was already old in 1920. In July of that year, Samuel Waters of Washington filed USA patent 1520378, which claimed an acoustic gramophone using a pick-up with orthogonally related components, to track a groove modulated by orthogonally related vibrations. But again, Waters was interested only in vertical-lateral modulations and, like Bartlett Jones seven years later, was interested in keeping the two channels of sound separate. Incidentally, Waters was concerned with improving signal to noise ratio, rather than reproducing sound in three dimensions.

IT WAS IN 1931 that Alan Blumlein filed BP394325, which disclosed the principle of 45:45 modulation and while not claiming surround sound, as such, laid the foundation to modern surround-sound matrixing. Blumlein was the first to think of two channels as a means of transmitting or recording a composite of information for subsequent reconstruction into a usable format. Although concerned mainly with two-microphone recording and two-loudspeaker reproduction, Blumlein did suggest in passing the possibility of using "four or more loudspeakers" in a vertical pattern and microphones arranged "one above the other ... to provide significance of vertical as well as horizontal movement of the sound source".

Contrary to popular misconception, Blumlein did not describe quadraphonics or four loudspeakers in a quadrangle. What he did was reveal, and take advantage of, the psycho-acoustic phenomenon whereby the human ear/brain combination will hear a phantom spread of sound when facing two loudspeakers reproducing two channels of information containing amplitude variations to provide directional clues. Ironically although it is on Blumlein's patented approach to signal matrixing that modern surround-sound encoding is based, it is the illogical extension of Blumlein's pair-blend loudspeaker stereo ideas to a quadrilateral that has led so many surround sound designers into blind alleys. As Blumlein surely well knew, pair-blending works properly only when the listener faces the loudspeaker pair, and in a quadraphonic set-up only one loudspeaker pair can be faced at a time.

Even before Blumlein filed his patent application, Arthur Keller of Bell Labs in New York had filed an application which issued as USA Patent 1910254. This document, dated 1929, discloses an alternative approach to multi-channel signal recording and transmission and has subsequently been developed and adopted by JVC and Nippon Columbia.

Keller used a modulator to combine or multiplex the separate sound channels, by displacing them in the frequency scale "to form a progressive series of bands separated by suitable intervals". The multiplex approach was refined by William Livy of EMI, in BP612163, filed in 1946. Livy proposed a solution to the problems produced by speed fluctuation during reproduction of a multiplex disc. He proposed that a high frequency carrier be recorded on the disc along with the programme, and used on replay "to lock the oscillator in the reproducing apparatus in synchronism, so that if the speed of the record varies the frequency of the oscillator will likewise vary in the same ratio". In 1954, Kenneth Hammon of Ohio filed US patent 2849540, which developed the Livy idea further, to improve quality and frequency range, and relied on a 30kHz carrier.

Peter Scheiber of New York is generally acknowledged as the first to use a matrix technique of Blumlein descendence to encode four signals into two channels. The Scheiber master patents BP1328141 and 1328142 are now under the CBS wing, and it is interesting to note that a computer error allowed them both to lapse for a while, due to inadvertent non-payment of renewal fees! In fact CBS holds an extensive string of patents and more are continually issuing. BP1347993 and 1347994 are conveniently representative of the basic SQ system, and BP1303021 is similarly representative of the basic QS system. The Tate signal-dependent decoder is described and patented in BP1514162 and USA patent 3944735, again under the CBS wing. BP1402320 covers the Variomatrix decoder which is, of course, Sansui's signal-dependent process. (The Sansui circuit has been used by the BBC to enhance Matrix H decoding.)

Other important patents applied for early in the 1970's included USA 3417203 and British patent 1356843, both in the name of David Hafler. The last-mentioned is particularly interesting because it disclosed the basics of the so-called Hafler system for producing four-speaker stereo with a loudspeaker matrix. But Hafler prior-published the substance of BP1356843 in *Hi-fi News*, and therefore invalidated this aspect of the patent.

MOVING UP TO DATE, the original Ambisonics patent was BP1369813, which contains subject matter similar to BP1411994. This latter patent claimed the BMX matrix developed by Duane Cooper in the USA and has for several years been under the wing of Nippon Columbia. The BBC, incidentally, has patents on a BMX-style matrix eg. BP1414166. Something of a puzzle is British patent application 34839/74 by the BBC. Although secret, this has been publicised as containing a claim to the use of a Sansui Variomatrix decoder with a phase shifter of 60°. If the report is correct, here is a novel approach to patent novelty — like claiming patent monopoly on a well known flagpole tilted to 60°!

Patents continue to issue on matrix encoding, multiplex and combined matrix-multiplex techniques from a world-wide range of companies. Examples of patents for extra-channel radio transmission systems are BP1367429 from Siemens and BP1377138 from Matsushita. It is likely that the Siemens patent may prove the master patent on phase quadrature three-channel transmission. The stream of issuing patents continues still because there is a lag between application and publication, and we are still reaping the dubious benefits of research enthusiasms now several years old. Almost certainly it is the number of mutually conflicting patents now issued that has produced a more adult approach by the competitive companies. Such a tangled web of conflicting patent rights has developed that, as with radio in its infancy, a degree of patent pooling has become inevitable if progress in the field is to continue without the largely unnecessary expense and delay of litigation.

Recently for instance CBS has received patents in the UK on modifications of the SQ system which involve the transmission and recording of extra channels of information in "discrete" manner (BP1504391 and 1504392). This suggests an overlap of patent monopoly between CBS and the string of firms more traditionally associated with the multiplex approach to multi-channel recording and transmission. The original Ambisonics – NRDC British patent 1369813 has now been followed by BP's 1494751 and 1494752 which respectively protect the concept of frequency-dependent decoding for improved sound localization and variable decoding to match the performance of a system to the shape of the room and number of speakers used. The Calrec sound field microphone, now being used by both the BBC and IBA, is clearly based on another NRDC-Ambisonics patent, BP1512514. Other patents based on Michael Gerzon's work are believed to be in the pipeline to grant. The BBC, IBA, Nippon Columbia and NRDC are already informally pooling patent rights and with the rights of Scheiber and Tate aligned with the giant CBS and the interests and allegiances of Sansui and JVC currently ill-defined, the commercial future of surround sound must depend as much on patent politics as system performance. □

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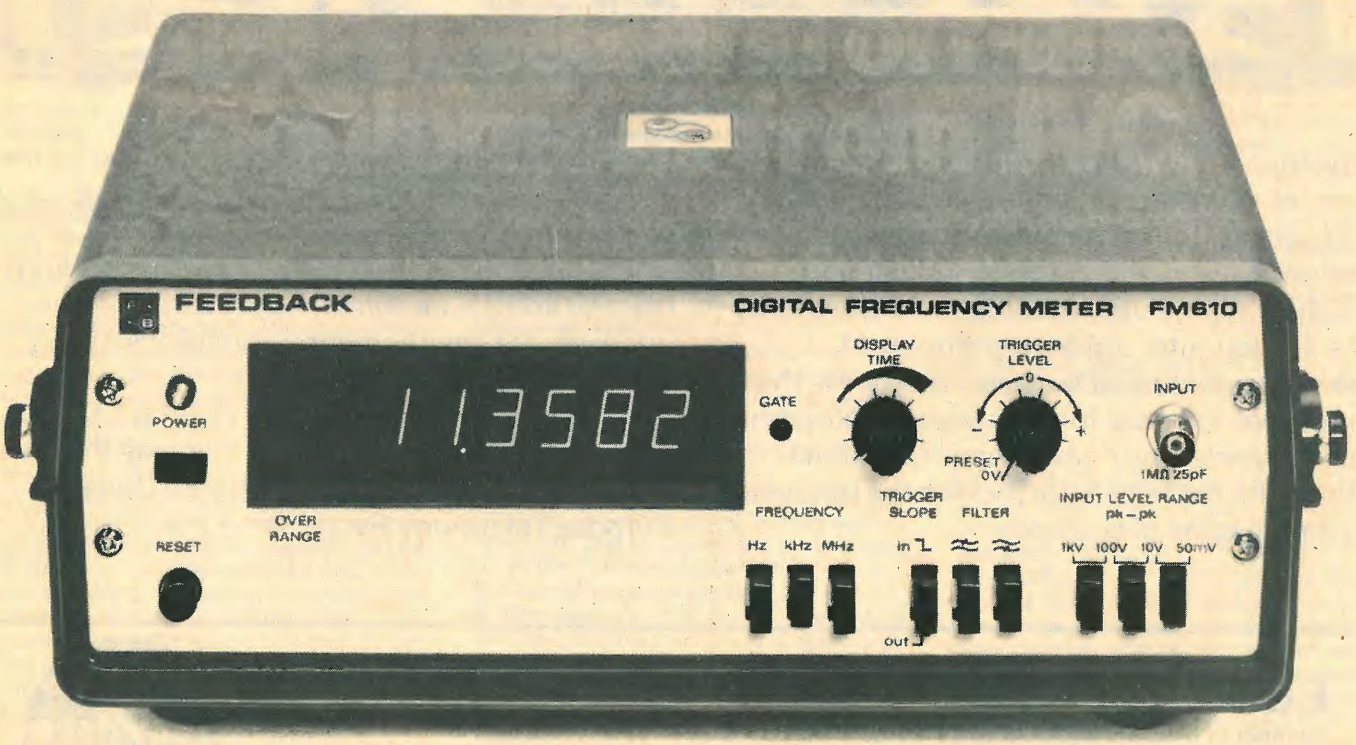

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LETTERS TO THE EDITOR

ENGINEERS, GET OUT OF BRITAIN

I am amazed to see "Mixer" treating the news that "A" level students shun careers in industry with such levity (October issue). Lack of really first-rate people in engineering is probably one of the greatest problems facing British industry today. Nevertheless, one cannot blame either the students or their teachers for this attitude. The fact is that engineering is not regarded as a respectable profession in Britain, an attitude which is repeatedly emphasised by the salaries offered for senior, responsible engineering jobs.

I am a graduate in electrical engineering with twelve years' post-graduate experience, spent partly in R&D and partly in production engineering. In 1972 I chose to leave Britain because I saw no prospect of ever having a reasonable standard of living there. Here in Belgium, I have a basic salary of about £19,500. Even allowing for differences in cost of living, taxation etc., I would need a basic salary of about £15,000 to maintain the same standard of living in the UK. Judging from job adverts currently appearing in the national and technical presses, I would be extremely fortunate to get an offer of £8,000. I for one am quite happy to stay here where professional, graduate engineers are regarded as social and professional equals to doctors, lawyers, etc., and I would recommend any Britons unfortunate enough to have chosen engineering as a career to seriously consider leaving the country.

I know of no other country in the world where engineering is so poorly regarded and remunerated as in the U.K. The blame must largely rest with the engineers themselves, of course, for accepting the disdain with which their profession is seen by management and public alike. I am, however, sure of two things: British industry will be unable to attract top students until and unless the engineering profession be given corresponding status to that of the "respectable" professions; and British industry will not make the long talked about recovery until and unless top students can be persuaded to choose careers in industry.

J. W. Pepper
Brussels
Belgium

3D TELEVISION

Professor D. A. Bell, writing about three-dimensional television in the November issue, dismisses the two colour (anaglyph) process for "entertainment television." But what about the odd 20% of television time which is intended to be educational rather than entertainment? I have always maintained that a 3D picture in mono is much more informative than a 2D colour picture and there are many programmes which would be more immediately comprehensible by the use of the anaglyph system. Perhaps we could persuade the BBC to include pieces of red and green transparent toffee paper in an issue of the *Radio Times* and give us a "Tomorrow's World" in 3D? Just once!

Meanwhile perhaps readers would be interested to hear of my own private method of obtaining true stereoscopic pictures from an ordinary 2D television set. I have some scores of pairs of photographs of most celebrated people and places, taken over the last two or three years. The secret is to watch for an angular change between subject and camera and then to take two photographs in quick succession – perhaps a half to one second in time apart. Briefly the conditions arise when (1) the camera is seen to 'crab' round the subject, which it frequently does on set, in architectural scenes, and from helicopters; (2) when advantage is taken of small changes of angle of close-up heads – these might require several shots to find a suitable pair; and (3) when the object is turning on a turntable. It is almost essential that the camera is motorized, and it is better if it has an interlens shutter. The exposure with a 125 ASA film – which may be colour – is of the order of 1/30th second at f3.5 at normal brightness of picture. The television camera must not be zooming at the time, of course. The process requires alertness and deftness, and a sympathetic family.

John T. Lloyd
Glasgow

RELATIVITY AND TIME SIGNALS

Dr Essen (December letters) deserves an answer. Dr Griffiths doesn't supply it. However, I was fortunate enough to tune in to the following radio conversation between a Martian (M) and an Earthling (E). It might help if I quote it.

M: I don't understand this relativity theory that you chaps have dreamed up. Can you suggest an experiment?
E: Yes. When you are ready send me twenty pulses at one second intervals by your clock and I will do the same to you by my clock.
M: I received twenty pulses but they were not at one second intervals.
E: Of course not. I received twenty also but after making the necessary Doppler correction I find that the interpulse interval was $(1-v^2/c^2)^{-\frac{1}{2}}$ where v is your velocity.
M: How did you know my velocity?
E: Easy enough. You are on your usual carrier frequency so I could find your velocity by doing a Doppler correction to it (relativistic of course).
M: I'm sorry but it seems to me like a circular argument.
E: Of course it is! If it wasn't there would be some loose ends somewhere. The only way to keep an argument free from paradox is to make it circular!
M: It seems to me there is only one thing we *do* agree about. There were no missing ticks!
E: Ye . .es. Are you sure you sent twenty?
M: Of course I am. I can count. Once round my fingers and toes!
E: Er . . . . . but you're a Martian. . . . . .

G. F. Filbey
School of Physics
Polytechnic of the South Bank

RAILWAY PUBLIC ADDRESS

I was not at all distressed to read of Mixer's travails with the public address system at London Bridge Station; in fact, I was rather gleeful. For we have the cure to the problem, in fact have had it for years. It's our Speech Enhancer, which was originally developed to counter Soviet jamming of Israeli radio broadcasts, and which worked very well at it during the Yom Kippur War of 1973.

What the Speech Enhancer does is to reduce the level of vowels relative to consonants. In English, as in most languages, the vowels contain the energy and the consonants contain the information. The difference in energy ranges from 20dB to 60dB, or occassionally more. How much energy is there in a stop?

Fairly consistently, at the 90% intelligibility level, we get improvements of 12-13 dB in intelligibility in white noise, for the same peak signal level. Translated, this means that for the same amplifier power, you get the same intelligibility at the 90% level if you increase the white noise by 12-13 dB, or alternatively, for the same environment, you can cut the amplifier peak power by a factor of 20 or so.

With normal speech the intelligibility falls off slowly so that if the noise goes up 6dB, you might catch one word out of two. With the Speech Enhancer, it falls off abruptly, so that if the noise goes up 3dB, you won't understand anything. The speech has a different quality than normal speech; it tends to cut through and demand attention.

Now the pitch. We should be delighted to sell Speech Enhancers to the British Railways, or to anyone else in Britain. (By the way, they are low power devices which consume about one watt and go between the microphone and the amplifier. There is only one control — a pot used to adjust input level — and one indicator, a l.e.d. which flashes when the optimum peak input level is passed on speech bursts.)

Yale Jay Lubkin
Ben Franklin Industries Ltd
Casey Creek, Kentucky, USA

On page 98 of the October issue "Mixer" says: ". . . it must surely be possible to design something that is at least intelligible." Of course it is!

Soon after the war British Railways installed at Liverpool Street, Charing Cross, London Bridge, and probably other stations, public address schemes that worked really well. The design and installation work was, if I remember correctly, by Rediffusion Limited. The essence of the scheme was that it employed many low output loudspeakers close overhead, instead of the few high power horns that had been used before. Another feature of the Rediffusion design was that it included a form of a.g.c. which boosted the

output when locomotives (steam in those days) were puffing hard or blowing off.

The important point is that the Rediffusion job worked well. Then, perhaps 10 or 12 years ago, although the installed equipment was, so far as I could tell, still working well, it was ripped out and replaced by something else. Although this "something else" still uses a multitude of small speakers it has never been properly intelligible since the day it was commissioned.

C. H. Starr
London SE14

SYNTHESIZED F.M. TRANSCEIVER

Over the past few months I have been reading, with interest, some of the modifications which have been carried out to the two-metre f.m. transceiver which I designed (November and December 1977). From what I have read it seems that the v.c.o. is causing certain people some trouble (I myself have built nine of these units with practically no trouble). However, the following points on the v.c.o. may be of some use:

1. The number of turns, and hence the Q of L, is critical as this sets the V/MHz sweep of the v.c.o. and hence the loop gain; increasing Q is likely to lead to loop instability, but reducing Q prevents the necessary swing (22—24MHz) and will lead to a 'sloppy' lock. The type of ferrite slug has to be selected with care, as some of the ferrite slugs available may only be used up to 3MHz.

2. The emitter follower buffers are

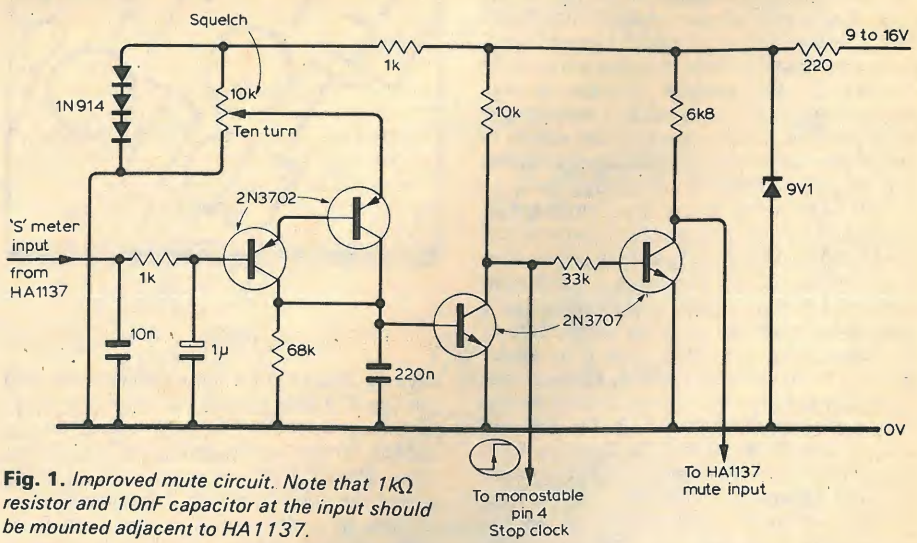


Fig. 1. *Improved mute circuit. Note that 1kΩ resistor and 10nF capacitor at the input should be mounted adjacent to HA1137.*

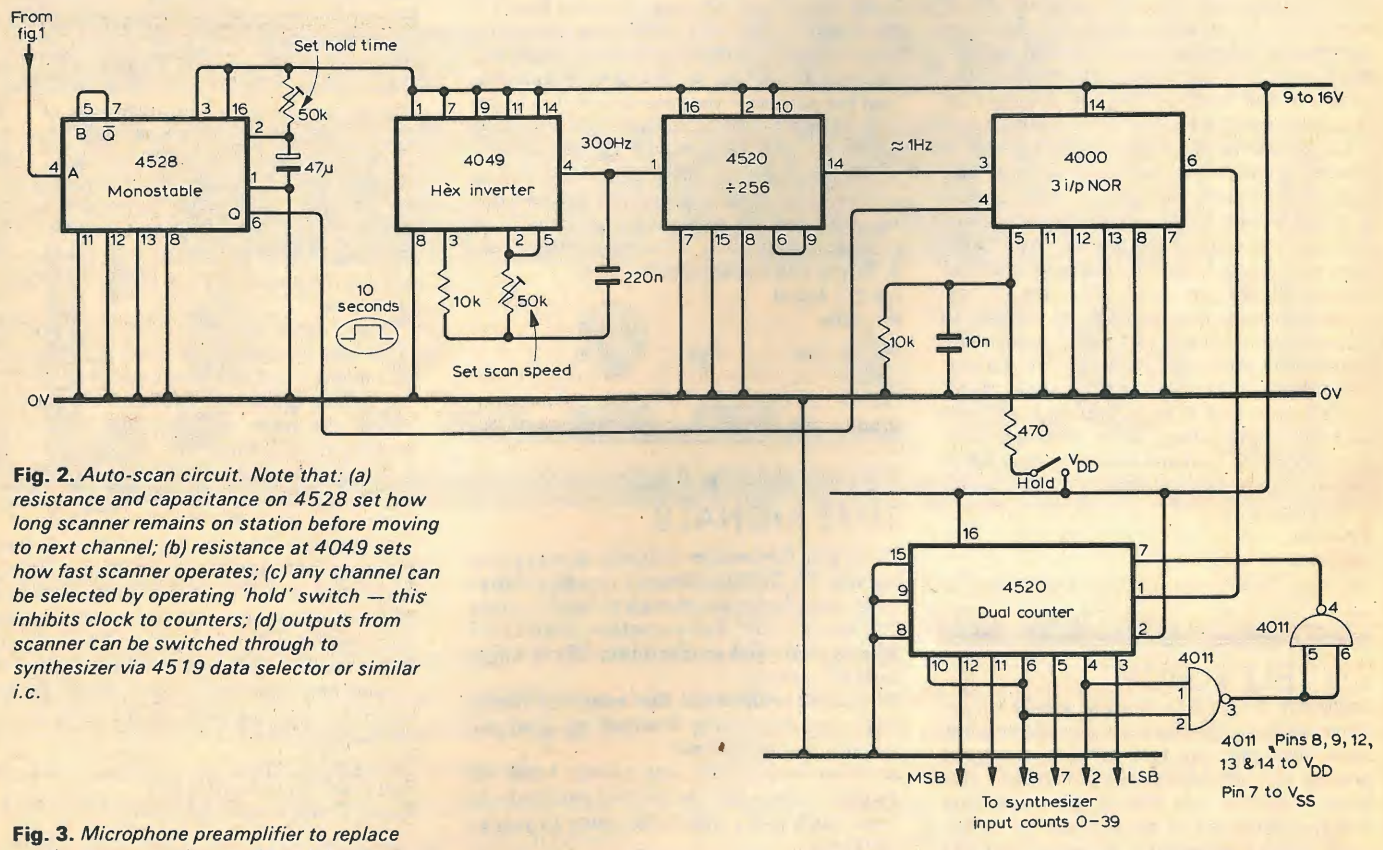


Fig. 2. *Auto-scan circuit. Note that: (a) resistance and capacitance on 4528 set how long scanner remains on station before moving to next channel; (b) resistance at 4049 sets how fast scanner operates; (c) any channel can be selected by operating 'hold' switch — this inhibits clock to counters; (d) outputs from scanner can be switched through to synthesizer via 4519 data selector or similar i.c.*

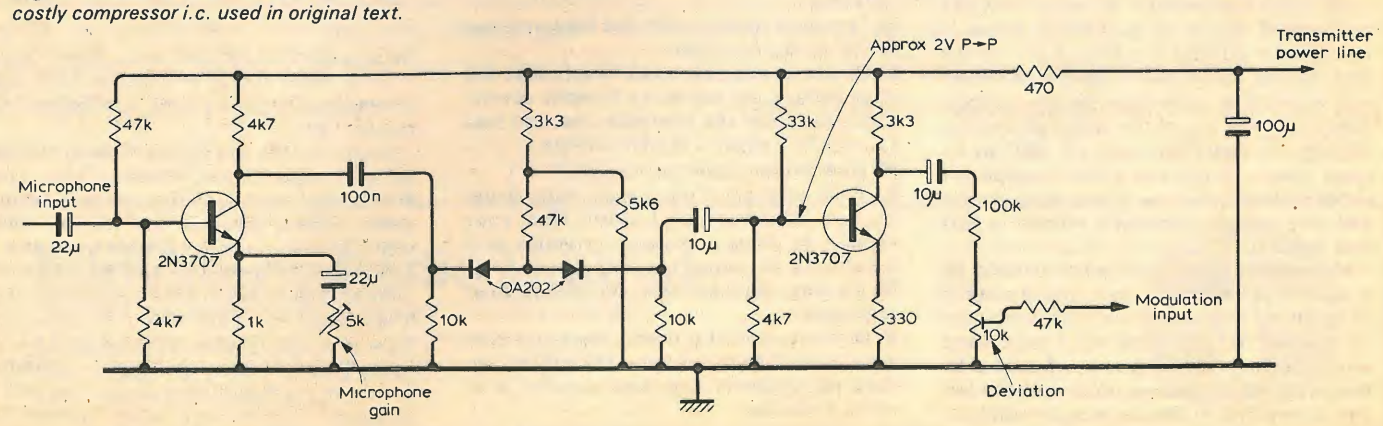


Fig. 3. *Microphone preamplifier to replace costly compressor i.c. used in original text.*

necessary to isolate the receiver/transmitter inputs from the input of the 7ALS74. Otherwise the first multiplier could have a tendency to be unstable.

3. Regarding the pull-up resistor between the 74LS74 o/p and the 4059, it was found that this resistor pulled the t.t.l. o/p up to 80% of the c.m.o.s. supply and was quite adequate. Although I did try a transistor interface (in grounded base), I found there was no improvement in performance. The use of a pull-up resistor to interface t.t.l. 5V logic to c.m.o.s. level is quite normal practice, and has no detrimental effects on either device.

4. It should also be noted that the output pulse of the 4059 divider is very narrow (160ms) and only occurs about every 1ms; in consequence it may be difficult to see this pulse on lower-grade oscilloscopes. To overcome this I suggest connecting a flip-flop or monostable to the output to pulse stretch.

5. The supply to the v.c.o. must be absolutely noise free, otherwise a noisy output will result.

The quadrature detector crystal was found to be adequate for n.b.f.m. stations. Unfortunately the use of repeaters combined with operators using wide deviation can lead to the overloading of the crystal. To overcome this problem in the prototype the 10.7MHz crystal was replaced with a 10.7MHz ceramic filter to give [illegible] ope.

[illegible] this modification adversely affects the operation of the mute circuit and the modification shown in Fig. 1 was incorporated.

This circuit is also used to stop the autoscan circuit (Fig. 2) which then holds on the channel in use for approximately 10 seconds, during which time "hold" can be selected — otherwise the scan continues.

Fig. 3 shows a circuit which is now in use in the author's transceiver to replace the costly microphone compressor. This circuit seems to work as well as the i.c., but is still under evaluation.

The phase output pulses for the 4046 (pin 1) can be used to inhibit the transmitter output until the loop settles, if this is thought necessary. In the prototype this was not incorporated as it took approximately 80ms for the changeover to complete (relays and RC time constants, etc.) by which time the loop was stable.

However, some time ago these phase pulses were used to trigger a monostable to give a transmitter lock out, in the event of the synthesizer losing lock.

I hope that the above points are of some interest to would-be constructors, and I am glad to see (gauging by the number of letters I have seen regarding the design) that there are still some real radio amateurs around and not just black box operators as I was beginning to believe.

T. Forrester
St Annes
Lancs

INTELLIGENT MACHINERY

Your editorial on intelligent machines (November) seems to me a bit gloomy. Any machine that claims to even minor intelligence ought to be able:
(1) to query data you put into it on the ground that there is probably something wrong with it — even today it seems assumed that you can put nonsense into a computer and it somehow becomes transmuted into sense on the way through its learned bowels;
(2) to tell you after looking at the data that you are asking the wrong questions; and
(3) if it is to be used by the majority of R&D people such as I have met with these past 40 years, the ability to tell you that you are running up a blind alley.

Nor should one suppose that computers of any kind will put people out of work. I have yet to find a firm installing one who did not find that they employed more people than before just because the thing did queer effects about once a year and the time involved in clearing them up made the extra staff necessary. Me, I shall wait and see, always prepared to have a good laugh.

Philip Smethurst
Bolton
Lancs

BICYCLE DYNAMOS

In his original Circuit Idea Mr Pollard seemed to be dealing with bicycle dynamos in general. Now, however, it seems from his comments on my letter in the October issue that he is concerned with two specimens of H. Miller make.

Regarding the first, of eighteen years ago, which burnt out its tail lamp, perhaps I can help him. I had a look at such a one, said to be of about that age, which had stamped on it "6 volts 3.6 watts." It has an 8 pole magnet, incidentally. The use of bulbs which do not take a total of 0.6 amps or more at 6 volts would produce the effect he observed.

As for the second, which doesn't give more than 5 volts, and so on, if the magnet is in order (which it seems to be) his trouble is presumably a short-circuited coil, i.e. a short part way along the coil system. It is suspicious that he gives the d.c. coil resistance as 2.5 ohms, by the way: the old dynamo I saw had 3.2 ohms according to an Avo.

It is quite useless for Mr Pollard to postulate the necessity for electronic changeover circuits and extract profundities when his total argument is based on one faulty specimen. He should begin by requesting the makers to exchange what he has for a good one, and then move on to bicycle dynamos in general before writing further.

P. Short
University of Newcastle-upon-Tyne

MOBILE CB DANGERS

I would like to add my voice to those of the many (I hope) people who are opposed to the introduction of citizens' band in the United Kingdom.

My reasoning is not so much against the use of home based stations, but against the possible introduction of mobile stations. Communication while on the move is indeed a serious business, and I believe it is frowned upon by our police force. Mobile communication has even prompted research into its effects on a driver's decisions, e.g. an Open University production "Just an accident?" on October 2nd, 1978 was a documentary on research carried out by a university research group. The group was conducting experiments on many drivers, where a driver had to negotiate a course, consisting of driving through two posts. The posts were situated at such a distance apart that the car would either not go through them, and thus knock them down, or they were not spaced so close so that the car would clear them. After a control experiment (i.e. without any communication with the driver) the car was fitted with a transceiver. The driver was then asked to negotiate the course while answering questions. It was found that there was a 40% increase in the number of times each driver tried to get through a gap that was too small for the car.

If these results are compared with those situations a driver usually encounters in a busy city or crowded streets, then I believe if that driver were engaged in communication on a c.b. mobile rig, his chances of having an accident would dramatically increase. This situation would also apply to radio-telephone systems and even amateur communications while mobile. I am not trying to abolish mobile communications, but if dozens of inexperienced c.b. users suddenly take to the road I feel the accident statistics would suddenly rise. I think that experienced communicators (amateurs and professionals) should be allowed to continue, but surely the convenience that mobile c.b. might bring is heavily outweighed by the cost of people's lives.

C. Riley
Woodthorpe
Nottingham

HI-FI IN THE HOTHOUSE

The controversy over subjective vs. objective assessment of audio equipment continues noisily. In the hope that, if nothing else, it will result in a quiet spell of contemplation, may one of the engineering profession's geriatrics drag a hitherto ignored factor in to the debate?

The subjective lads always have one distinctly frayed around the edges "ace" up their sleeves, which gets dragged out whenever the objective arguments start to get a bit too conclusive for comfort. "Ah!" they say "But why is it that transducers often measure well and nearly identical to one another — yet invariably sound different?"

Why, indeed. Well, since I'm a little too old to derive comfort from burning joss sticks and reciting magical incantations like "Musicality, musicality, musicality . . ." let's have a look at pickup cartridges since these are invariably held high as the arch villains in the scenario.

A recent commission gave me the chance to investigate some conflicting measurements on a range of cartridges imported into the UK — chiefly a sharp difference between those supplied by the manufacturer and those checked by the UK agency. It didn't take long to spot that the curves supplied with the cartridges were plotted at an ambient temperature of 24°C which for those who still yearn for the pre-EEC era, is close to 75° F. For your average British home, this is near hothouse conditions! It came as no surprise, then, that at some 5°C lower the amplitude response fell right out of acceptable limits. A further few degrees lower still, and we started to get tracking problems. How did they sound, though? Pardon the pun, but not so hot. Subjective impressions clearly reflected the varying response which took the form of either a h.f. peak for higher temperatures to a falling response for cooler ones. With most of the samples, the variation was as much as 2dB per degree C.

My curiosity aroused, I started to check all the other makes of cartridge I could get hold of and, with a few exceptions, all exhibited a significantly temperature-conscious res-

ponse curve. More surprising, the worst of all were the moving coils with one popular model, widely acclaimed in the hi-fi press, exhibiting a considerable variation in h.f. response with quite small fluctuations in temperature. Again, at what one would accept as being a modest summer ambient temperature, two versions of the same model refused to track satisfactorily at a little over the manufacturer's maximum recommended stylus pressure.

It needs no imagination to see how one can easily arrive at sharp disparity between what one measures in the clinical coolness of a laboratory and what one actually hears in the warm comfort of a living room; or for that matter, why the same cartridge will sound inexplicably different one day compared with the next. I have looked at current published reviews in the popular hi-fi press and nowhere do I see any reference to ambient temperature at the time of measurement. Even more important, amplitude variations over typical ranges of working temperature do not appear to be investigated at all. Needless to say, the identity of the chief offenders is the concern of my client. But any comments, pundits?

Reg Williamson
Norwich

FINANCING NEW IDEAS

Your editorial "Ideas for sale" in the September issue touches closely a spare time activity of mine. I have been involved for many years in creating electronic products, forming companies and either selling the products, the companies or both, or trying to. Raising capital for electronic product enterprises or failing to raise it. Succeeding or failing, and even going into liquidation.

I consider myself an expert on all the negative aspects of the above, all the pitfalls, the problems and what causes them. I am getting a glimmering, after 28 years, of how to be an expert in the positive aspects.

My spare time activity is putting all this experience and know-how into a book on the subject, a sort of guide to the young technical innovator of the future. I am not doing it for money; I do not expect to make a profit from it. Taking this attitude I may well accidentally discover just one secret of success and actually make a profit, but it is not the motive. The motive is to try to help others who should not have to go through such negative financial climates as we have experienced in the UK for the past twenty years.

Your comment that to start with half the required capital could well be worse than nothing is an understatement, it is a gold plated guarantee of total failure.

There are many case histories but one is a good example of the whole British financial sector attitude. A small company had a good potential, agreed by all. A British financial source rated it first class but then only wanted to put up half the figure calculated by the principals as necessary. The small company was persuaded to go to Holland and see a Dutch source. The Dutch carefully examined the project and agreed it was first class but insisted on putting *twice* the amount the principals had calculated. The project was a success and the Dutch were right for the original calculation was well out, not by over estimating but by under estimating.

UK technical promoters are preconditioned to ask for less than they need for the fear that if they ask too much they will be turned down. The financiers then cut this requirement again. The British built-in ingredient for small business suicide, as evident from the lists of companies going into liquidation.

I would like to hear from any of your readers who care to write to me with simple factual accounts of their experiences in this field. Not only the failure accounts but the successes as well – there must be some. With their permission I would like to edit their experiences into the book in order to offer a much broader view than just my personal knowledge.

H. E. Tracey
78 Broadwalk Court
Palace Gardens Terrace
London W8

ELECTRICAL NOISE IN AUDIO

With reference to James Moir's article "Electrical Noise in Audio Engineering" in your August 1978 issue, Mr Moir is certainly correct in concluding that any signal-to-noise specification should be referenced to an appropriate specification. Mr Moir, however, unintentionally does a dis-service to the goal of bringing some order to the present chaotic situation by leaving the impression that there are very few instruments available capable of measuring noise with the CCIR 468-1 weighting curve and the quasi-peak metering method of DIN 45 405. In addition to the two instruments mentioned by Mr Moir, I have learned of the following others:

Radford ANM3 Audionoisemeter
Sennheiser UPM550 Universal Level Meter
Siemens U2004 Noise Measuring Set
Siemens U2133 Psophometer

In addition, there are older instruments no longer manufactured which have used the quasi-peak method with either the 468-1 weighting network or the older CCITT P.53 weighting network that are still in use or can be located from time to time:

Grundig MV5 Millivoltmeter and KM5 Filter/analyzer (CCITT P.53 weighting)
Sennheiser RV55 Vacuum Tube Voltmeter and FO55 Weighting Filter (CCITT P.53 weighting, modification kit for CCIR 468-1 weighting available)
Siemens U2033 Psophometer (CCIR 468-1 weighting)
Siemens U33 Psophometer (CCITT P.53 weighting)

Any reader knowing of other instruments with the quasi-peak capability is invited to advise this writer, c/o *Wireless World*.

Dolby Laboratories makes a fairly persuasive case for their proposed CCIR 468-1 weighted/average reading meter standard on the grounds that quasi-peak meters are not easily obtained. My personal view remains, however, that such a new standard is not needed and wider use of the existing instruments would assist in creating additional demand for instruments with the quasi-peak capability. Why create further confusion when an already adequate standard exists?

A. L. Henrichsen
Arlington
Virginia, USA

Mr Moir replies:
My thanks for Mr Henrichsen's list of instrument makers supplying meters meeting the CCIR-468 requirements. When I noted the names of the only two meters of which I have actual experience I expected that I would be inundated by literature from other manufactures drawing attention to their products but I was disappointed.

I appreciate his comment on the CCIR ARM weighting etc. I do not know the price of most of the meters Mr Henrichsen lists, but the Dolby ARM 468 weighting adapter plus an average responding meter scores heavily on price. If it is assumed that an average responding meter is available and need not be purchased, and this must be true of every laboratory, then the Dolby weighting network costs around £150 whereas a meter to the CCIR requirements costs around £800. It is this aspect that makes me believe that we may end with two 'standards' with the nationalised bodies using the CCIR meter and industry using meters meeting the Dolby proposals.

SYNTHESIZED F.M. TRANSCEIVER

After several unsuccessful attempts to procure the three b.c.d. adders required in T. D. Forrester's frequency synthesiser (November 1977), a brainwave revealed that two binary adders can be used instead.

It works because the three intermediate counter sections of the 4059 divide-by-N counter can be preset to a binary 15 instead of a binary 9, while their place values are still 1, 10 and 100. Careful analysis revealed that in this case there is never a carry from the 10s to the 100s, so the third adder that only accommodates the carry can be omitted.

The only snag is that the pin connections of the 4560 (b.c.d.) and the 4008 (binary) adders do not match. This means redesigning the board.

Michiel van der Vlist, PAoMMV/G5CGD
Driebergen
Holland

K FOR KONFUSION

Reference your note to J. E. Chester's "Spelling for technical jargon," (October letters), I fear that you are confusing mice for pussy cats.

Your say, correctly, that the lower case letter k stands for 1000 in SI units and then go on to say that the upper case K has been adopted for 1024. Has it? My SI units have it as degrees Kelvin and no matter how much "adoption" the binary people make, one should keep to SI units for all symbols large or small.

A constant battle is with firms who produce instruments which measure resistance and have ranges marked in degrees Kelvin (e.g. 1000K); they think it is 1000k ohms (certainly not 1024.10^3 ohms).

I hope that *Wireless World* will not compound the felony of condoning k = 1024 when mentioning SI units in the same text.

John Freeman
SHAPE
Belgium

A.M. BROADCAST RECEPTION

With reference to Mr McLeod's letter in the November issue, on a.m. broadcast reception, I would like to point out that while I agreed with him on his points about a.m. reception, the word "reception" should be taken more into consideration. I am an electronics engineer and in a year I repair many hundreds of radio sets, television receivers, and cassette players, etc., all of different makes and places or origin. Mr McLeod goes on about transmission, but I feel the BBC and IBA do a great job on sound transmission. Unfortunately the British set manufacturers undo it all again.

Many times I've had a German tv set on the bench and a British set on at the same time, and the difference between the two on sound is unbelievable. British manufacturers seem bent on thinking the British public all have cloth ears. There is no, or very little, h.f. response on British television sets, while on German sets you can hear cymbals and all the h.f. notes as clear as day. Surely in this day and age with f.m. sound on television this should be no problem to achieve.

But again getting back to radio, if you take a British radio (made in Japan, of course) and a German radio receiver of the same price, the same stupid problem is there on a.m. and f.m. The British set is pathetic on sound reproduction. No l.f., no h.f., response at all on a.m. or f.m. So come on Britain, start designing better a.m. and f.m. detector stages and let the British public hear what a good job the BBC and IBA do of sending sound. They don't send out sub-standard sound, so why on earth do we have to listen to it?

C. E. Linskaill
Penicuik

SPEAKERS CORNERED

I refer to your leader in the April 1978 issue of *Wireless World* concerning the lack of communication between loudspeaker manufacturers and reviewers. Historically loudspeaker manufacturers have been reluctant to provide a sample of their product – as you rightly say, the result of many hours and pounds of research – just to have it slated in a review which may or may not be simply the result of somebody's personal pique.

We are all aware of the sometimes ridiculous specifications issued by manufacturers, such as 'frequency response 30-20000 Hz' with no reference to amplitude deviations within that bandwidth, and 'power handling 50 watts'. A single loudspeaker can be given a rating of 20W to 150W, depending upon whether a sine wave, warbled tone, or pink noise is used, or whether the reading is in mean, continuous or peak music power. And of course, the power rating is totally meaningless if no indication of efficiency is given.

Scientifically, the loudspeaker is complex – probably accounting for the proliferation of books, papers, articles and lectures on this subject. If one forgets transducer engineering, which covers magnetics, fluidics, elasticity and all the other fields of physics, to build a complete system involves three totally different sciences: the conversion of a signal to the voice coil, electricity; the movement of the speaker cones, mechanics; and the movement of air, acoustics. Not only are these three different fields, but they are often in total conflict with one another.

Added to this is the fact that the majority of speaker manufacturers in the British consumer field are cottage-industry systems engineers. Most of them use the same transducers over and over again, simply jiggling around with the box and crossover design. They only have to change the type of wood used for the enclosure and a couple of components in the crossover to get an entirely different subjective result, although the actual specification remains the same — which one is correct?

When an amplifier is evaluated, the measurements are displayed on meters, or pen recorders and are therefore absolute. When a television receiver is evaluated, there is an internationallly accepted test card, so again the results are absolute. There is not and never has been a test card for loudspeakers. Dare I say it? If there were a meaningful set of parameters for speaker manufacturers to adhere to, the majority of them would be out of business.

I have been involved in domestic loudspeakers, but my main field is in studio monitoring where a pair of speakers can cost around £3000. The specification may be impeccable, but may not sound correct to customers having a system installed in their particular environment. Spectrum analysis shows that the response is no longer flat — due to room reflections and absorption — the response more closely resembling a cross section through the Alps. This can easily be corrected with filters, but as is often the case, the resulting perfectly flat response sounds dull and uninteresting — and more to the point — the quality of the final recording suffers. Once again we are back to our original series of compromises. Studio monitoring is the most critical application any loudspeaker will have to endure, but if one way is acoustically correct and the other musically perfect — the latter is the reason why people buy loudspeakers and that is the one you settle for.

Having contented oneself with these apparently conflicting facts, no matter whose loudspeaker you listen to — no matter how weird and wonderful his explanations are, he is bound by exactly the same laws of physics as any other manufacturer — and they are extremely stubborn and reluctant to change.

Impulse response I can handle, as I can third harmonic distortion — but heaven know what in creation absurd terms like 'cardboardiness' and 'fluffiness' mean. One has no idea of the room acoustics in which the speaker is being evaluated, nor the source of music. One review actually stated that they used BBC Radio 3 transmissions. With the utmost respect to the BBC, who do put out some of the highest quality broadcast material in the world, under the best conditions, assuming that no GPO lines or tape recorders are used, you are lucky to get anything below 40Hz or above 15kHz out, with a dynamic range of 35dB and distortion of around 0.5%. Any engineer will tell you that those are perfectly acceptable specifications, but to value and subsequently slate a speaker with that source is rather like evaluating a camera lens in the fog. As was pointed out by the supplier of that information, using most commercial pressings as an alternative source is like doing the same evaluation with the lens cap on.

Assuming near perfect sources e.g. live broadcasts from p.c.m. transmissions, direct cut and special sampler discs and studio master tapes, I would still hesitate to condemn any loudspeaker since that would inevitably involve my personal taste.

One reviewer once printed an oscillogram of a sine wave of 50Hz at 50 watts mean power. When I queried his reasons for doing this, he said that the manufacturer's specification stated 50 watts as the power handling capability. True — but the fact that the speaker handled that signal is academic, or, to be more precise, is totally meaningless. A 50W sine wave into a loudspeaker capable of producing 91 dB, with 1 watt at 1 metre, is equivalent to music at around 120 dBA if the energy spectrum is considered — not a very meaningful test for a bookshelf loudspeaker. To be fair to reviewers — I quote equal meaninglessness from the specification sheet of a well known manufacturer" This is accomplished by a unique form of horn loading which involves an acoustic doubling process that converts the wavelength from inches into feet."

It is unlikely that manufacturers, reviewers and—most important of all — users of loudspeakers will ever agree any more than music lovers will, and it is them after all that keep us all in business.

S. J. Court
Court Acoustics Ltd
London NW6

RTTY "INTERFERENCE"

Were other r.t.t.y. enthusiasts as stunned as I was to read Pat Hawker's comment: "A general appeal to r.t.t.y. enthusiasts is that they recognise the high interference-potential of this mode and keep contacts reasonably short. . ." (October issue)? In shocked amazement I read it again and again but could extract no other meaning than that which had numbed me at first sight.

With the adoption of the 170Hz shift standard, r.t.t.y. has a far smaller interference-potential than any telephony mode. Lest it be argued that r.t.t.y's 100% duty cycle is more troublesome than s.s.b., it must be noted that r.t.t.y. can be "notched out" whereas s.s.b. can not. Of course one often hears complaints from telephony users about the large number of r.t.t.y. stations that position themselves haphazardly about the bands, particularly on 80 metres, but these are commercials often using wide shift. R.t.t.y. users have long confined themselves to a narrow band, usually 20kHz wide at the top end of the c.w. segments. I have yet to hear one operating outside these agreed segments. Complaints about telephony stations, who abandon their "meadows" to invade our little "backyard plot", are frequently heard and well justified.

The failure of the French move to secure "exclusive" r.t.t.y. allocations has little relevance. The facts are that we have "gentlemen's agreement" segments which r.t.t.y. operators stick to but some s.s.b. stations do not. I am opposed in any case to any pressure on any user of a permitted mode to "keep contacts reasonably short" as this will do little to encourage self training of the licensee in the use of the less common modes.

D. A. Duff G3VYV, B. S. Smith G8IAT, and P. R. Chamberlain G4GQO
Preston
Lancs

Australian activity

Amateur 432 MHz television transmissions have been made from a Piper Cherokee light aircraft flying over Port Philip Bay near Melbourne by VK3ZTV and VK3YLK and including 144 MHz liaison communication.

The number of amateur licences in Australia and New Zealand remains significantly higher, in terms of percentage of total population, than in the UK. There are almost 9000 amateurs in Australia and associated territories, of which over 5250 are "full" licences; 2600 "limited" technician licences, and over 1000 hold the recently introduced "novice" licences. There is a general feeling, despite some initial criticisms of the examinations and administration of the novice permits, that these are proving both useful and successful. Few of the many problems being encountered with Australian Citizens Band operation (official licences for this now number over 150,000) are reflected in the far more responsible novice operation, and new facilities including a segment in the 28 MHz band and v.f.o. operation are being introduced.

Russian satellite RS-1 is up

THE FIRST Russian space satellite to carry an amateur radio transponder was launched on October 26, 1978 into a circular orbit at a height of about 1050 miles (period 120.295 minutes) and an inclination of about 82.55°. The design input to the transponder is 145.8 to 145.9 MHz with the output between 29.3 to 29.4 MHz (although some reports suggest the bandwidth is restricted to 29.36 to 29.4 MHz). A beacon transmitter radiates on 29.4 MHz. The new satellite, designated RS-1, is stated to have its transponder switched off on Mondays and thursdays.

Vintage station?

For many years the Science Museum in South Kensington had a static exhibit in its telecommunications gallery showing a representative 10-watt amateur "experimental" station of the late 'twenties; however, the transmitter section appears to have disappeared from public view during one of the periodic re-arrangements. But now a complete pre-war station of the rack-and-panel type is being installed at the Wireless Museum at Arreton Manor, Newport, Isle of Wight, alongside a modern, compact transceiver.

The museum has recently been granted the special call-sign GB3WM and will operate on all h.f. bands and also on 144 MHz through the Hampshire repeater GB3SN. The operators will use both s.s.b. and c.w., as it has been found that the public today is showing renewed interest in watching morse being used.

William Orr, W6SAI, has pin-pointed 1936 as a pivotal year in the development of the modern amateur station, listing such developments as increased 28 MHz activity and the dawning recognition of the role on ionospheric variations on long-distance communications: the growing use of stable variable frequency oscillators in lieu of crystal control: the introduction of the beam-power tetrodes including the 6L6 and the 807; the coming of factory-made bandswitches, amateur-bands-only communications receivers such as the National NC101X. It would certainly be difficult to find any other single year offering such advances.

WORLD OF AMATEUR RADIO

RSGB progress

Although the Radio Society of Great Britain was founded (as the Wireless Club of London) as early as 1913, it was around 50 years ago that, following the "fusion" between the main society and its own activist "Transmit and Relay" section and under the presidencies of Captain Ian Fraser, G5SU (later Lord Fraser), and Gerald Marcuse, G2NM, during 1928 and 1929, its role became firmly concentrated on amateur radio with a membership of little more than 1000.

The latest annual report and accounts of the society show a striking recovery from the financial problems which it faced a few years ago, in common with many other societies, as a result of the steep rise in the rate of inflation. During the year to June 30, 1978, it has achieved a record surplus of over £50,000; an all-time membership high of over 21,000 (some 2500 overseas); and a headquarters staff of more than 20. During the year it recruited over 3000 new members, but some 1800 others withdrew.

In a sample survey of the use made by members of the various services, it was found that over 50 per cent of Class B licensees use the v.h.f./u.h.f. repeaters, compared with 36 per cent of Class A. Over 60 per cent of Class A licensees use the QSL Bureau, compared with about 40 per cent of members holding Class B licences. About 40 per cent listen to the GB2RS news bulletins but only about 10 per cent attend conventions; 44 per cent of "receiving" members make use of slow morse transmissions; dropping to around 30 per cent for Class B and a surprisingly high 19 per cent for those who have already passed their Morse test and hold Class A licences.

The Home Office has invited the society to send an official advisor (Roy Stevens, G2BVN) with the UK delegation to WARC 1979 next September.

Licences for 15 more v.h.f. repeater stations have recently been issued to the society.

BARTG and BATC news

The British Amateur Radio Teleprinter Group has now published an attractive new 32-page third edition of their useful guide to r.t.t.y. without tears: "RTTY – the easy way." A new active lowpass filter and a simple "autoprint" circuit are included for the first time and the presentation of diagrams alongside text has been improved by the editor, Brian Hodgson, G3YKB. Over 1200 copies of the second edition were sold in two years. The new edition is available (90p) from: Alan Butcher, G3FSN, 70 Hughenden Avenue, High Wycombe, Bucks. Over 400 enthusiasts attended the 1978 BARTG convention at its new venue in Harpenden. Some 37 British stations using 145.3 MHz v.h.f./r.t.t.y. have been logged in a two-month period by G8GOJ in Croydon.

About 200 people attended the British Amateur Television Club convention in London at which one of the highspots was a video recording of Australian ATV activities; another was a talk on digital video techniques by Ian Lever (IBA). A useful leaflet "All about NBTV" (narrow-bandwidth television) is available from the chairman of the Narrow Bandwidth Television Association: D. B. Pitt, 1 Burnwood Drive, Wollaton, Nottingham (Tel: Nottingham 282896). Geoff Brown, GJ8ORH, is now active from Jersey on 432 MHz with 80-watt high-definition transmissions.

In brief

DK0TE is a new 28.2575 MHz beacon station located near Constance in West Germany . . . . There are 4325 licensed radio amateurs in Norway . . . . On the occasion of the 50th anniversary of the Norwegian society (NRRL) a challenge cup was presented for annual competition, as a result of an offer by King Olaf V of Norway . . . . Moonbounce (e-m-e) contacts on 144 and 432 MHz have been made for the first time by Yugoslavian amateur stations . . . Moonbounce contacts are also reported between UA3LBO and UR2BU . . . . A French amateur tv contact was made by F9UP and F8MM over a distance exceeding 400 km on 1255 MHz . . . . French amateurs F8DO and F1CVJ have made contacts on 24 GHz over distances up to 16 km using MA49628 Gunn diodes with an output of about 10 mW . . . .

PAT HAWKER, G3VA

Electronic organ tone system — 3

Filter circuits and stop cards

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

This article completes the testing procedure from part 2, and covers the filter circuits which are housed on special printed circuit boards. A description of the stop cards concludes the design of the basic system.

TO SET THE TRIMMER, as described at the end of part 2, adjust for minimum frequency change when the lower end of the 10MΩ resistor is forced to 2.5V (by a temporary connection to the mid-point of a 10k:10kΩ potential divider across the supply). The remaining components and wired connections are then assembled, leaving the output bus connections to last. The gating is most conveniently checked with the filter cards connected because the collectors must be taken to a positive supply. Fig. 22 and 23 show an assembled gate card.

Filter characteristic The principal harmonic of a square wave is the 3rd, which is 9½dB down on the fundamental. After passing through a 12dB/octave filter, the 3rd harmonic is reduced to —27½dB (a level exceeded by most organ pipes) and the higher harmonics become negligible. To minimise keying thump due to the d.c. component of the gated signal, it is necessary to restrict the response below the lowest working frequency f, as shown by the nominal filter response in Fig. 24.

To offset the 12dB/octave slope in the working range, i.e. from f upwards, the input signal must increase with frequency, which requires that the gate input resistors R_n decrease with frequency. The design output characteristic is shown in table 6. The power increases considerably at low frequencies, as with most pipe organ stops, presumably to compensate for the falling sensitivity of the ear. A constant level below 65.4Hz is arranged to limit the output-amplifier power. The regulation, which may be varied by changing the grading of R_n values, may also be varied for individual harmonic components of particular stops by RC sections after the filters.

The filter response of the circuit is within about 1dB of Fig. 24 over the working range but, even with an exact response, deviations of about ½dB would be expected from table 6 as R_n values are restricted to the E24 series.

Table 6. Filter output levels.

Note	f_o Hz	Output mV r.m.s. at f_o	$2f_o$	$4f_o$	$8f_o$	$\geqslant 16f_o$
C	32.7	800	800	400	200	100
C′	34.6	800	755	378	189	100
D	36.7	800	713	356	178	100
D′	38.9	800	673	336	168	100
E	41.2	800	635	317	159	100
F	43.7	800	599	300	150	100
F′	46.2	800	566	283	141	100
G	49.0	800	534	267	133	100
G′	51.9	800	504	252	126	100
A	55.0	800	476	238	119	100
A′	58.3	800	449	224	112	100
B	61.7	800	424	212	106	100

This characteristic embodies a constant 6dB/octave slope from C=65.4Hz to C=523Hz, and applies to each SNB over its operating range.

Above about CK5, where R_n has fallen to a nominal 40kΩ, the divider output resistance ceases to be negligible, and the highest outputs (3 ref, 4 ref, 5 ref) have a non-unity mark to space ratio which somewhat reduces the fundamental content. The additional circuits up to GK6 have a constant value of 10kΩ for R_n and therefore a falling output.

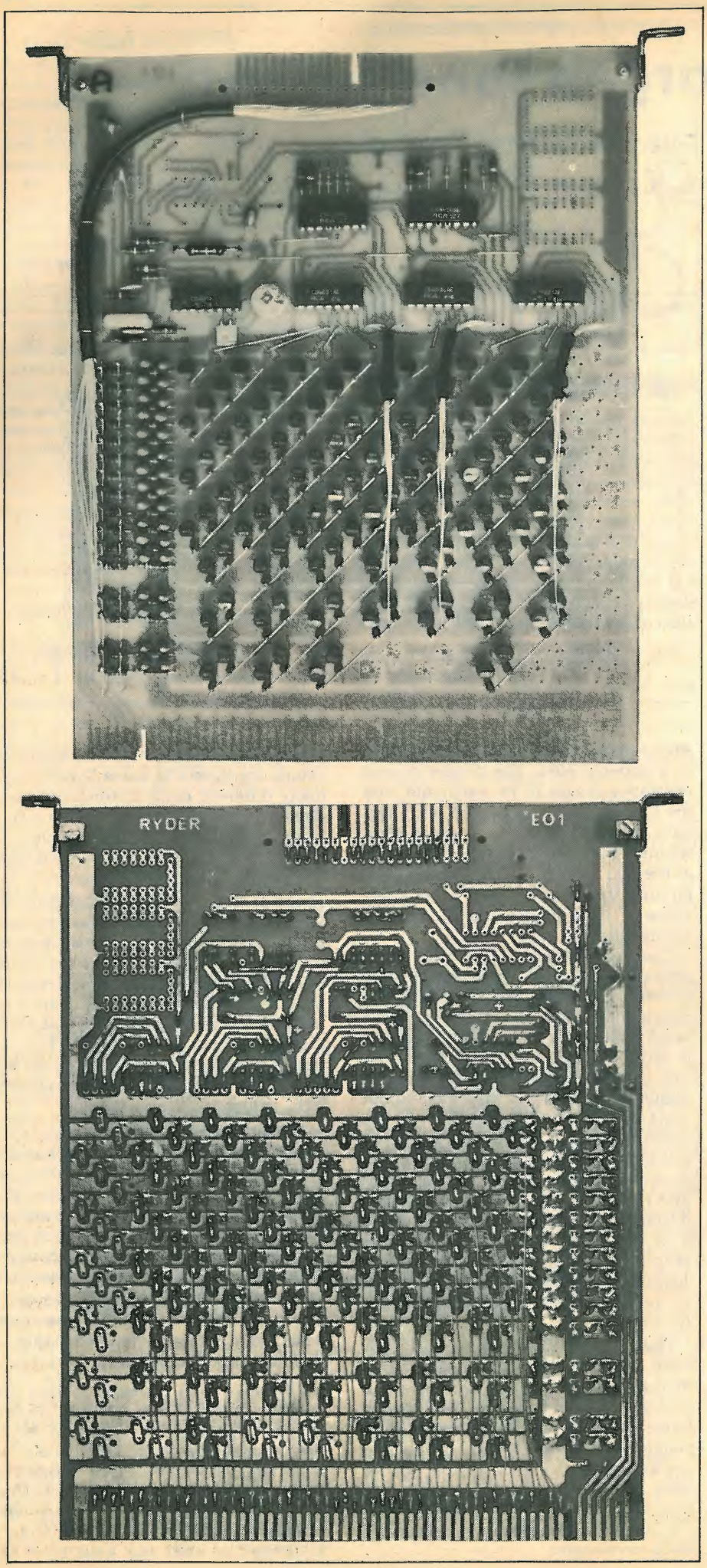
The input stage of the filter must provide a d.c. path for gate-collector current, and is in effect a damped-resonant circuit as shown in Fig. 25. To avoid inductors a gyrator configuration is used as shown at the left of Fig. 26. The capacitive element is C_1, and the inductive element, in this case about 100H, is formed by C_5, R_4, R_5, and the transistor, which should be a high-gain selection. The damping is deliberately increased, and adjusted by R_6, which also holds the transistor in conduction. Resonance occurs approximately when $R_4.R_5 = X_1.X_5$, where X_1, X_5 are the reactances of C_1 and C_5. Because the gates are in effect current sources, they do not contribute significantly to the damping.

The high-pass combination C_2R_2 provides an additional 6dB/octave at low frequencies, and C_3R_3 provides the same at high frequencies. The 741 output forms the sine-wave bus, SNB, and the components to the left of the dotted line are duplicated for each of the two or three SQB sections, so that the signals mix at the output of the common 741. Fig. 27 shows one method of deriving the bias voltages.

Component values The component values are shown in Table 7. Although many different combinations are possible, the choice is limited by the standard range of capacitor values. A minimum R_n value of 10kΩ is used, and in most cases the lowest frequency, f_H, of the H bus is that corresponding to CK3, where R_n at 12dB/octave becomes 640kΩ. For L buses, f_L corresponds to CK1, but R_n generally differs from 640kΩ because of the requirements in table 6. If R_b is the input resistance to produce 100mV at the filter output, then $R_n = 100R_b$/required mV out. The R_b design value of 640kΩ is also increased for the lower buses to reduce the variety of R_n values.

The fundamental component of the square-wave divider output has an amplitude of approximately 2.25V r.m.s. and, if the load consists of C_1 alone, the fundamental is $2.25X_1/R_n$. This is almost exact at frequencies well above f, and here the second-stage gain becomes almost equal to X_3/R_2 so that the filter output is $2.25X_1.X_3/R_n.R_2$. However, if the response of Fig. 24 has been achieved, this expression will apply at all frequencies from f upwards.

The value of C_1 is chosen to limit the voltage swing at the h.f. end of the range. Capacitor C_3 is chosen for a reactance close to 470kΩ at f_L, and R_3 is made equal to this reactance so that the second-stage gain at f_L is 3dB down on X_3/R_2. The value of R_2 is given by the expression above, for each SQB, and C_2 is chosen so that the gain from R_2



◀ **Fig. 22.** *Assembled gate card.*

Fig. 23. *Assembled gate card viewed from copper side. Current p.c.bs have a slightly modified input layout.*

▼

onwards is 6dB down on X_3/R_2 at f, i.e. f_L, f_M or f_H. To restore the overall gain, the resonant action of the input stage increases its output voltage by 6dB on $2.25X_1/R_n$. These proportions give a reasonable match between the slope of the resonance curve near to f and that of R_2C_2, R_3C_3. The choice of R_4 and R_5 is an uncritical compromise between damping and mean voltage swing at the SQB. The values are related to X_1, X_5 as already noted, and R_5 can be adjusted to use a standard value for C_5. This analysis permits component values to be calculated within 10%, except for R_6 which is found by trial, starting with a value close to $4X_1$. The use of 5% capacitors and 2% resistors minimises the need for adjustment on test, but is not essential.

Filter test and adjustment A test circuit is shown in Fig. 28 which uses an isolated gate. The inputs at f and $4f$ can be taken from gate-card divider outputs as listed in the test columns of table 7, or from any stable source at the correct frequency and voltage levels (see previous article for connections required to gate card). The mV column shows the expected SNB r.m.s. output, which is the same at both frequencies because of the 16:1 resistor ratio, although it exceeds 100mV for those buses where R_b exceeds 640kΩ.

The waveform should be monitored to see that it is a sine wave, and that the test layout is not picking up excessive hum. Input resistor values may be varied if required, keeping to the 16:1 ratio, for more convenient output levels. The output can be checked at other frequencies within the range of the SQB. For a given input resistor, an octave change should result in a 4:1 output change, and half an octave should cause a 2:1 change. Deviations of 1dB can be considered negligible.

Adjustment consists of setting R_2 for the h.f. gain, R_5 for the peak response frequency, and R_6 for the damping. Although a uniform deviation of any particular SNB from table 6 could be catered for in later mixing, the R_2 adjustment is needed to equalize the SQB sections. This is made first at $4f$, then R_5 is adjusted for maximum output at f,

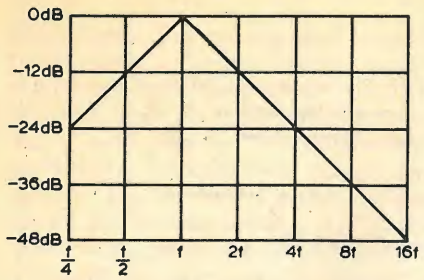


Fig. 24. *Nominal filter characteristic. This applies to each SQB section with respect to its operating frequency f.*

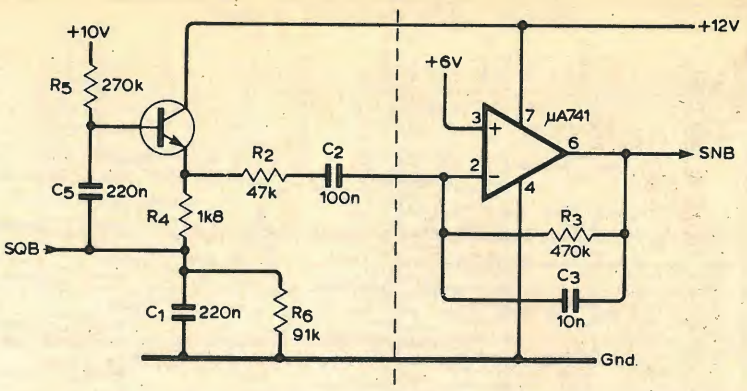
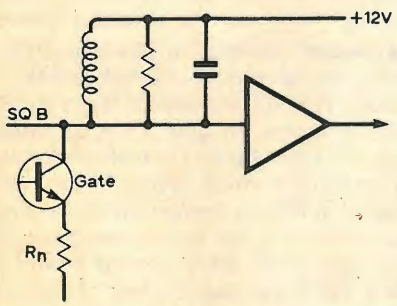


Fig. 26. *One filter section. The values shown are for 1UL where f=32.7Hz.*



◀ **Fig. 25.** *Equivalent circuit of the first filter stage.*

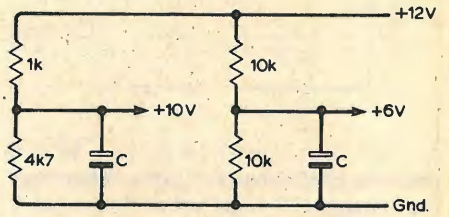


Fig. 27. *Filter bias voltages. The resistors are common to all three cards and are mounted separately. C represents one capacitor on each filter card.*

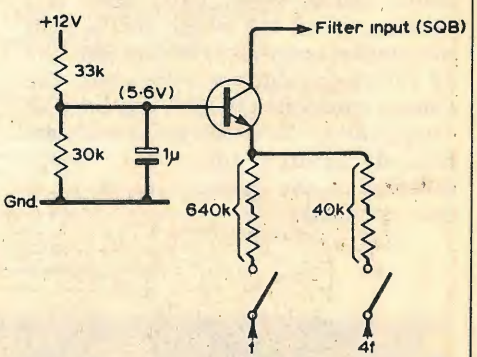


Fig. 28. *Filter test circuit.*

Table 7. Filter card component values.

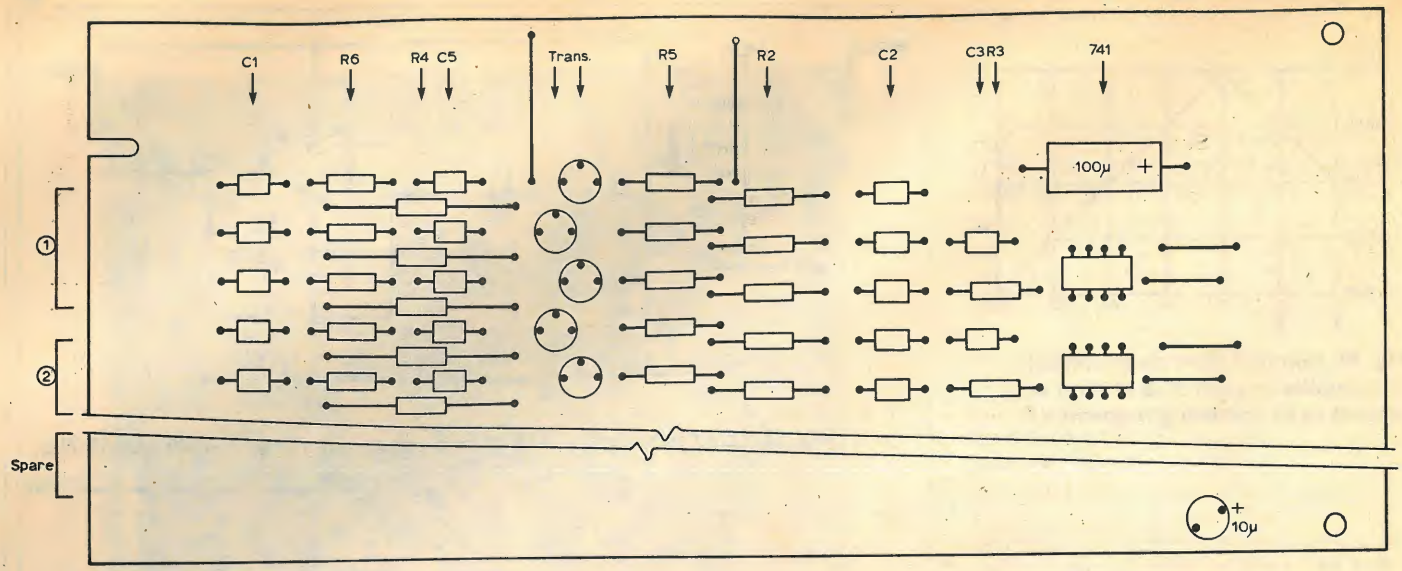
Bus	f Hz	Pn	C_1 nF	R_6 kΩ	R_4 kΩ	C_5 nF	R_5 kΩ	R_2 kΩ	C_2 nF	C_3 nF	R_3 kΩ	Po	Test Card	Test Nos.	Test mV
1UL	33	14	220	91	1.8	220	270	147	100				C	01, 04	800
1UM	65	15	100	82	1.8	100	330	51	33	10	470	5	C	02, 08	400
1UH	131	16	100	43	1.8	47	200	51	15				C	04, 16	100
2UL	65	19	100	82	1.8	100	330	100	22				C	02, 08	400
2UH	262	20	100	22	1.0	15	240	27	15	4.7	510	6	C	08, 32	100
4UL	131	25	100	47	1.8	47	180	120	10				C	04, 16	200
4UH	415	26	47	22	1.0	33	100	27	10	2.2	560	8	G'	08, 32	160
8UL	262	31	100	56	1.8	15	150	82	6.8				C	08, 32	100
8UH	1047	32	22	22	1.0	15	82	24	4.7	1.5	390	9	C	32, 128	100
5UL	164	37	100	39	1.8	33	160	110	10				C	05, 20	200
5UH	654	38	47	33	1.0	15	91	27	4.7	1.5	620	10'	C	20, 80	100
3UL	98	43	150	33	1.8	68	160	91	15				C	03, 12	200
3UH	392	44	68	22	1.0	33	82	24	10	3.3	470	11	C	12, 48	100
6UL	196	49	150	82	1.8	22	120	100	6.8				C	06, 24	100
6UH	784	50	33	22	1.0	15	91	30	4.7	1.5	560	12	C	24, 96	100
1SL	65	14	100	82	1.8	100	330	100	22				C	02, 08	400
1SM	208	15	150	27	1.8	15	180	33	15	4.7	510	5	G'	04, 16	80
1SH	523	16	100	22	1.0	10	100	22	6.8				C	16, 64	25
2SL	131	19	100	47	1.8	47	200	120	10				C	04, 16	200
2SH	415	20	47	22	1.0	33	100	27	10	2.2	560	6	G'	08, 32	160
4SL	262	25	100	56	1.8	15	150	82	6.8				C	08, 32	100
4SH	1047	26	22	22	1.0	15	82	24	4.7	1.5	390	8	C	32, 128	100
8SL	523	31	47	47	1.8	10	130	91	3.3				C	16, 64	100
8SH	2093	32	15	16	1.0	4.7	91	18	3.3	0.68	430	9	C	64, 256	100
5SL	327	37	100	56	1.8	10	150	75	6.8				C	10, 40	100
5SH	1308	38	22	20	1.0	6.8	110	22	3.3	1.0	470	10	C	40, 160	100
3SL	196	43	150	82	1.8	22	120	100	6.8				C	06, 24	100
3SH	784	44	33	22	1.0	15	91	30	4.7	1.5	560	11	C	24, 96	100
6SL	392	49	68	47	1.8	10	150	110	3.3				C	12, 48	100
6SH	1568	50	15	20	1.0	6.8	110	33	2.2	0.68	620	12	C	48, 192	100
Spare		55										13+10V		pin 3	
		56										13 +6V		pin 4	

Pn and Po are input and output connection numbers. Values shown for S buses also apply to T buses.

and R_6 is set to equalize this with the 4*f* level. A major change of R_6 will necessitate a further adjustment of R_5. If components of a wider tolerance are used, it may be necessary to tailor R_3, and to equalize the SQB at a different level from table 7.

Assembly The component layout is shown in Fig. 29. Filter capacitor centres are all 0.4in so capacitors with a 0.3in lead spacing are opened out. Components should not project more than 10mm from the board surface, and leads not more than 2½mm from the underside. Fig. 30 shows an assembled filter card.

A suitable framework is needed to mount the rear edge-connectors, and to support and locate the cards. Fig. 31 shows the centres used in the prototype to accommodate the 19 cards of the basic system, plus a spare card position in an overall width of 17in. The cards are summarised in table 8. Actual distances



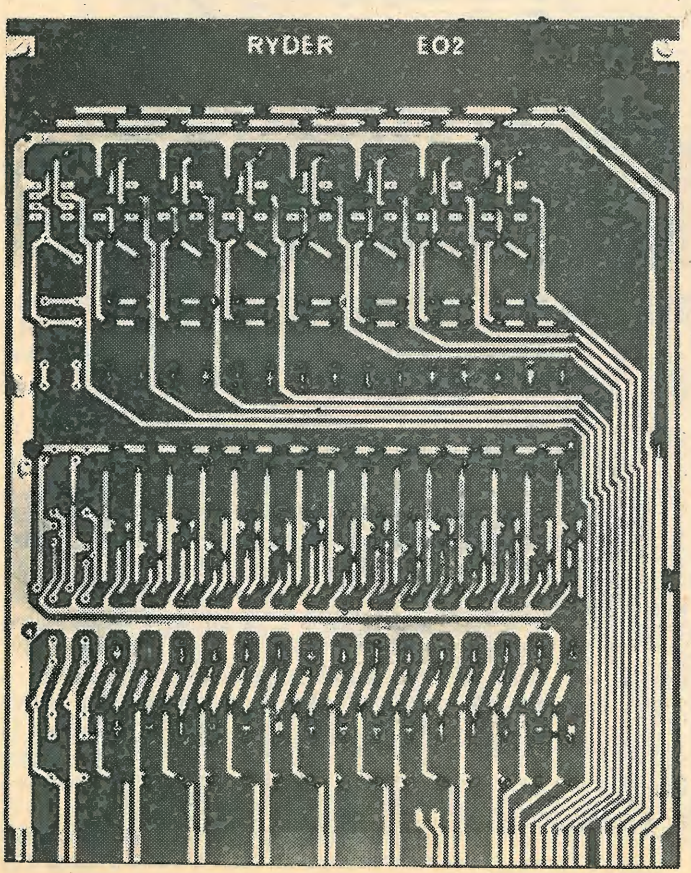
between card faces are 1.6mm less than the centres.

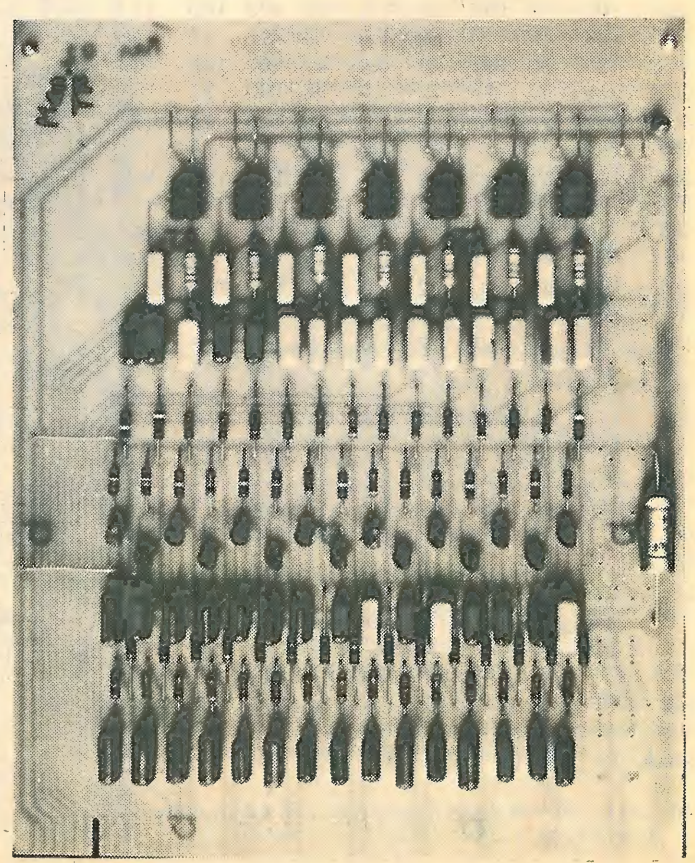
The bus wiring at the rear of the rack, shown in Fig. 32, uses 24 s.w.g. wire. A heavier gauge is desirable for the supply connections and, as shown, the +12V and ground lines each connect to two adjacent positions. The SQB wires are connected to every gate card, and sleeving is needed where the U SQB runs behind connectors SF and SM. The 12 reference connections, and the vibrato connection if used, can be in 33 s.w.g., and in the prototype these were routed through small wire loops attached at the upper fixing point of each connector.

Fig. 29. *Filter card E02 layout showing the components for harmonics 1 and 2. The remaining harmonics follow the pattern of 2 in the sequence 1, 2, 4, 8, 5, 3, 6. The lowest set of tracks is a spare.*

Fig. 30. *Assembled filter card and track layout. Since the photograph was taken, the tracking has been modified slightly to relocate the large capacitor.*

Gate-card testing To check the gate cards, tested filter cards should be in place. Fig. 33 shows an adjustable keying source to give 5.6V, or lower values for amplitude control as referred to in the previous article. The 10kΩ resistor provides protection for testing, but without it the output resistance is low enough to drive several inputs at once. The mean base current of a gate is small, and the 100kΩ pull-down resistor provides the main d.c. load at the K input. Therefore, the drop across the 10kΩ resistor is roughly 17.6/11 = 1.6V. Apart from keying faults, major departures from table 6, with the keying input at 5.6V, may be caused by incorrect R_n





values, wrong collector connections, or application for the wrong frequency.

Stop cards The circuits and physical construction so far described are largely interdependent. Subsequent circuitry and additions can be designed in many ways, according to the constructor's preference. To complete the present section, Fig. 34 shows a d.c. coupled circuit for the stop cards, SM, TM, and UM. The R_m resistors can be arranged in a square two-way matrix. Mixing of harmonics takes place at the virtual-earth input of the amplifier. The 10kΩ resistors limit the open-circuit voltage across the 4016 switches and define the charge on series capacitors where used, but care should also be taken in the layout to minimise shunting capacitance. In this configuration, with an effective source resistance of 5 to 10kΩ, distortion in the switches is negligible. A shunt-muting circuit, which may be used to suppress earlier noise and residual breakthrough, is shown in Fig. 35. One 4016 section inverts the KD

Table 8. Summary of p.c. boards.

Qty.	Function	Type	a mm	b mm
12	Gate cards (C to B)	E01 (special design)	14	4½
3	Filter cards (SF, TF, UF)	E02 (special design)	10	2½
3	Stop cards (SM, TM, UM)	Veroboard	14	2½
1	Master osc. card (MO)	Veroboard	10	2½
1	Spare position		10	2½

Columns a and b give maximum projection of components, above and below, to suit Fig. 31.

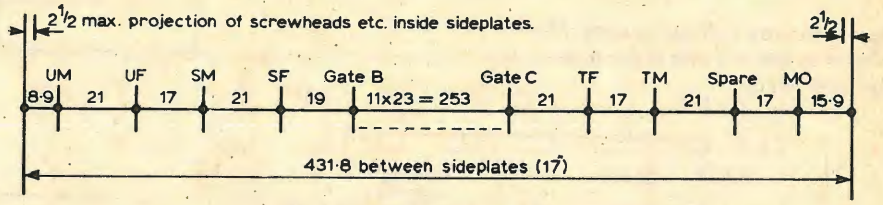
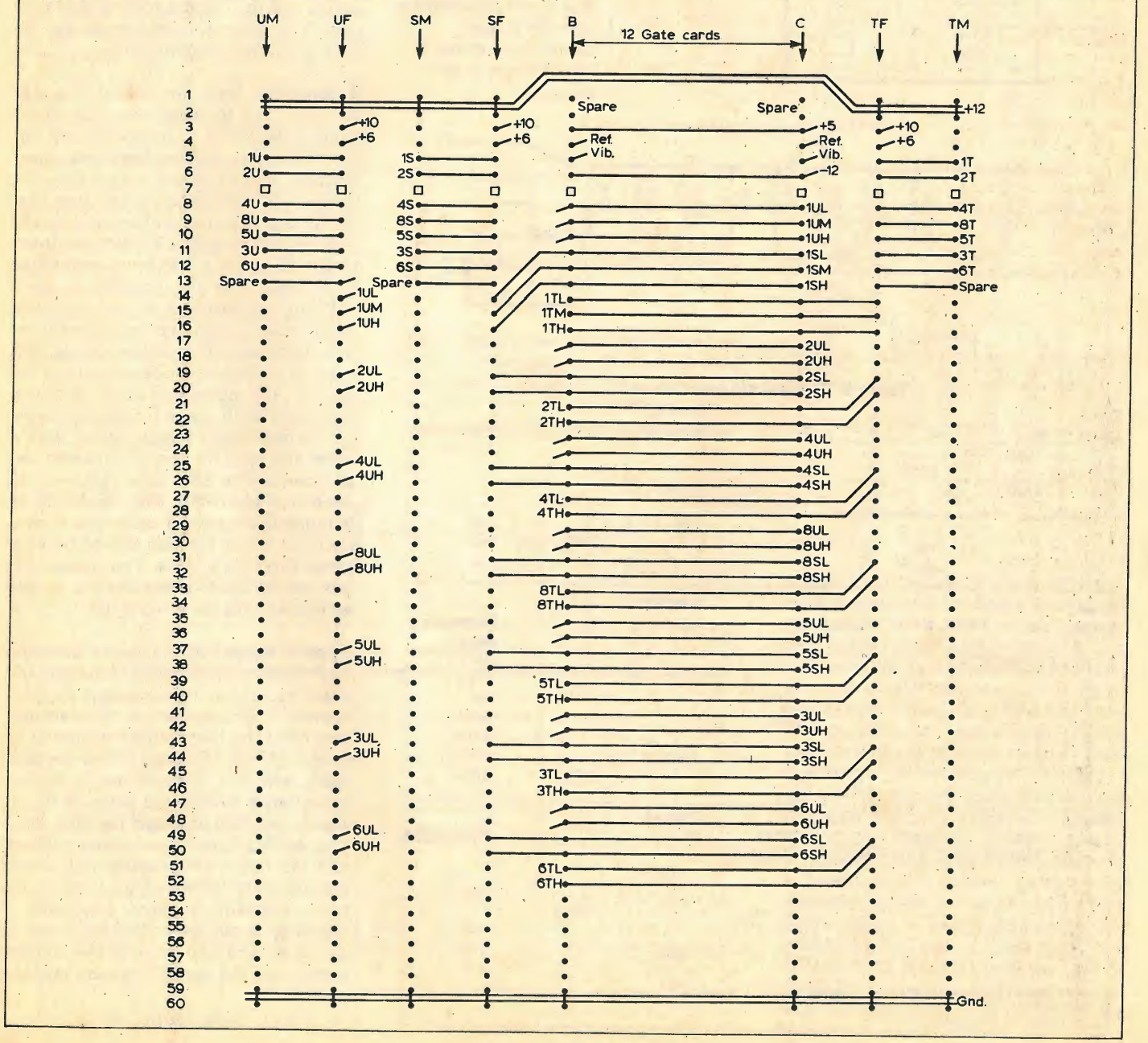


Fig. 31. *Recommended card spacing in mm. This is a rear view with the component side of the cards to the right. S, T and U are swell, great and pedal, F is the filter card, M is the stop card, and MO is the master oscillator.*

Fig. 32. *Bus wiring viewed onto the connector pins. MO and the spare card position are to the right. The square boxes represent the polarising key.*



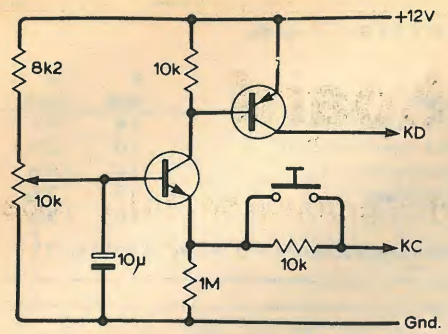
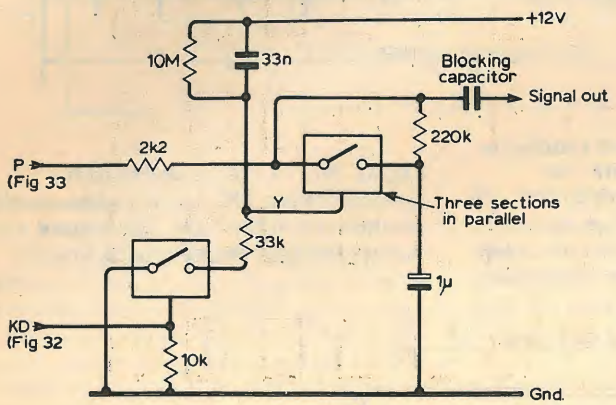
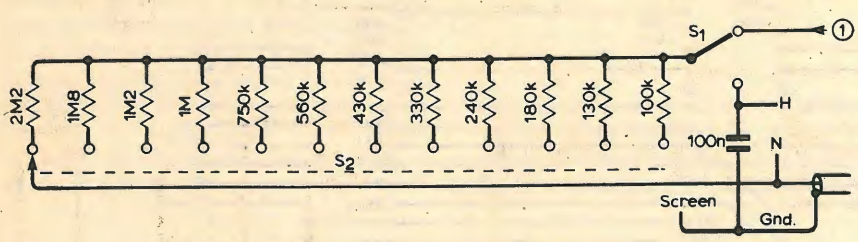


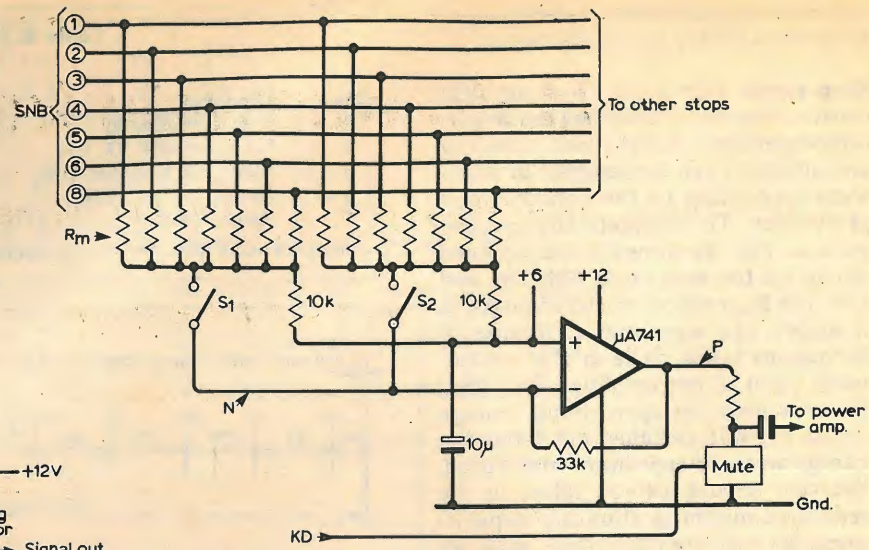
Fig. 33. *Keying voltage source. The resistor in the KC line is for test purposes only.*



◀ **Fig. 35.** *Muting circuit using a 4016 quad bilateral switch.*

Fig. 36. *Section of an attenuator box. Separate switches S_1 and S_2 are provided for each SNB, and connections H and N are common to all sections.* ▼





▲ **Fig. 34.** *Stop circuit for one department. Resistors R_m vary from 100kΩ to open-circuit. Switches S_1 and S_2 are each ¼ of a 4016. The 33kΩ feedback resistor may be changed to suit the power amplifier.*

Table 9. Typical stop mixtures.

Dept. Label	8′	4′	2′	SWELL Mutations	1⅓′	Harmonics
1	100k/33n					
2		180k				
3	1M8			240k/3n3		
4			180k/3n3			
5				240k/1n5		1M
6		1M			240k/1n5	1M
8		4M7				1M

Dept. Label	8′	4′	2′	GREAT 1⅓′	1	Harmonics (solo)
1	100k/15n					2M2
2		240k				1M8
3	1M8					1M
4			330k			560k
5						330k
6		2M2		750k/470p		330k
8					560k	560k

Dept. Label	16′ I	16′II	16′ III	PEDAL 8′	4′	Harmonics
1	47k/47k*	100k/100k*	180k/22n			
2				180k		
3						1M
4					330k	
5						1M
6				2M2		1M
8						1M

Where two components appear together, they are connected in series. The 16′ marked* also have 100n from the mid point to +6V.

signal, and the muting control signal at point Y is delayed after key-release by the 10MΩ/33nF combination.

Attenuator box For initial voicing, and later use to supplement the fixed stops, it is useful to be able to set up repeatably any desired harmonic combination, and to switch each harmonic without disturbing the level setting. Fig. 36 shows resistor values for a 12-position switch giving 2½dB steps down to 27½dB below a 0dB level defined as $R_m = 100k\Omega$. It is also possible to use a 2M2 log potentiometer and a 100kΩ fixed resistor, with appropriate calibration. To obtain the most open scale, 0dB must be at the anti-clockwise end of the control. The necessary seven sections, preferably with space for adding more, can be built into a screening box with a cable and plug for use on different departments. The SNB lines can be in 33 s.w.g., but the N line, Fig. 34, should be in miniature screened cable, and N connections inside the box should be kept away from SNB lines. The attenuator box can be made selectable via a 4016 section as with the fixed stops.

Typical stops Table 9 shows the fixed stops used, with couplers, in making the demonstration recording, supplemented by occasional use of an attenuator box. The list includes examples of simple l.f. roll-off using series capacitance, and h.f. roll-off using shunt capacitance to the mid-point of R_m. It should be taken as a starting point only. The voicing is not particularly refined, and the range of combinations which can usefully be wired as fixed stops is considerably greater, especially if coupling is not used. Voicing must in any case take into account the characteristics of the speaker system and the room itself.

To be continued

Alphanumeric keyboard

An inexpensive, easily-made device, using a novel method to produce an ISO-7 code.

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

The most comfortable way to "talk" to a computer or microprocessor is via a keyboard which includes a full alphanumeric character set. This article describes the construction of an inexpensive keyboard together with a circuit which encodes the key-strokes into an ISO 7-bit coding.

WE ARE ALL familiar with the standard typewriter QWERTI keyboard. Most of us, unthinkingly, assume that this layout of keys has been chosen for good ergonomic reasons. Motion study would seem to give this the lie; the middle finger of the left hand is not the best choice for operating the most used key in the majority of European languages. It has been suggested that the word "typewriter" was thinly disguised in one line of keys so that semi-skilled salesmen could demonstrate the machine more easily. The true reason is lost in the mists of time, but in designing a keyboard for home use, there is no reason why this layout should be followed slavishly. Most of us seldom use a typewriter and an alternative pattern of keys, if there are good electrical or mechanical reasons, is acceptable.

In addition to the 64 printing characters, the standard teletype includes 32 non-printing characters, known as control characters. While it is not essential to have these it is a good idea to include them in a keyboard so that it is compatible with standard equipment. The octal representation of the characters in Fig. 1 shows that they follow a pattern which suggests that some simple form of encoding could be used. For example, two eight-input priority encoders could be used to give direct encoding of 64 cross-point switches, a further encoder being used to complete the story with the other 32 switches. This would be rather cumbersome, so an alternative of using 32 switches with a 3-level shift – control, punctuation numbers, letters — was chosen. Two extra keys – carriage return 015 (0001101) for end of message, and "rubout" 177 (1111111) are included to facilitate connexion to the processor. The final arrangement of keys is shown in Fig. 2.

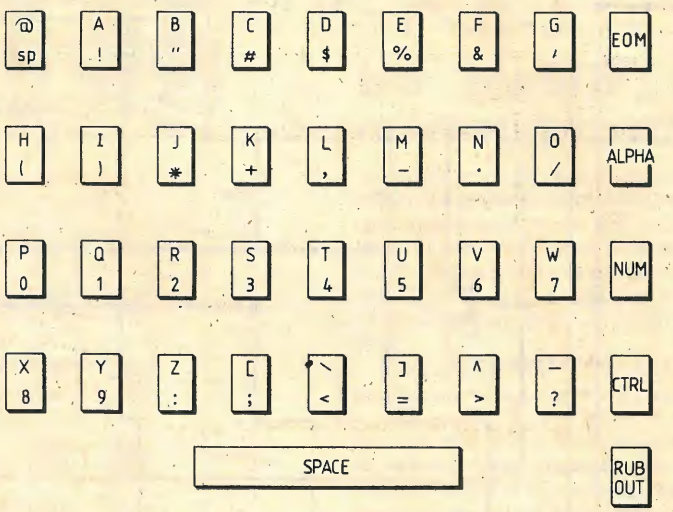


Fig. 2. Arrangement of keys.

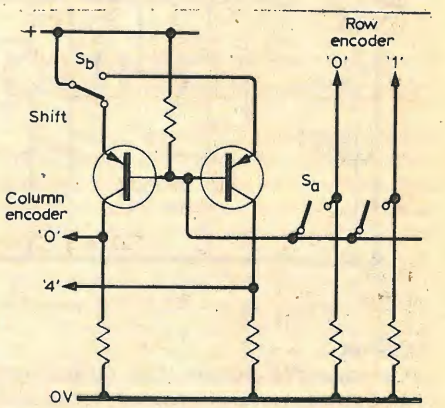


Fig. 3. Two-transistor switching to allow a single switch to drive columns and rows.

Fig. 1. Binary and octal representation of ISO7 character set. The columns are read first, followed by the rows. For example "8" is represented by 070 in octal, or 0111000 in binary; "K" is 113, or 1001011.

				0	0	0	0	0	0	0	0	1	1	1	1
				0	0	0	0	1	1	1	1	0	0	0	0
				0	0	1	1	0	0	1	1	0	0	1	1
				0	1	0	1	0	1	0	1	0	1	0	1
			COL. / ROW	00	01	02	03	04	05	06	07	10	11	12	13
0	0	0	0	NUL	FE_0 (BS)	TC_7 (DLE)	CAN	sp	(	0	8	@	H	P	X
0	0	1	1	TC_1 (SOH)	FE_1 (HT)	DC_1	EM	!	)	1	9	A	I	Q	Y
0	1	0	2	TC_2 (STX)	FE_2 (LF)	DC_2	SUB	"	*	2	:	B	J	R	Z
0	1	1	3	TC_3 (ETX)	FE_3 (VT)	DC_3	ESC	#	+	3	;	C	K	S	[
1	0	0	4	TC_4 (EOT)	FE_4 (FF)	DC_4	IS_4 (FS)	£	,	4	<	D	L	T	\
1	0	1	5	TC_5 (ENQ)	FE_5 (CR)	TC_8 (MAK)	IS_3 (GS)	%	−	5	=	E	M	U	]
1	1	0	6	TC_6 (ACK)	SO	TC_9 (SYN)	IS_2 (RS)	&	.	6	>	F	N	V	^
1	1	1	7	BEL	SI	TC_{10} (ETB)	IS_1 (US)	'	/	7	?	G	O	W	−

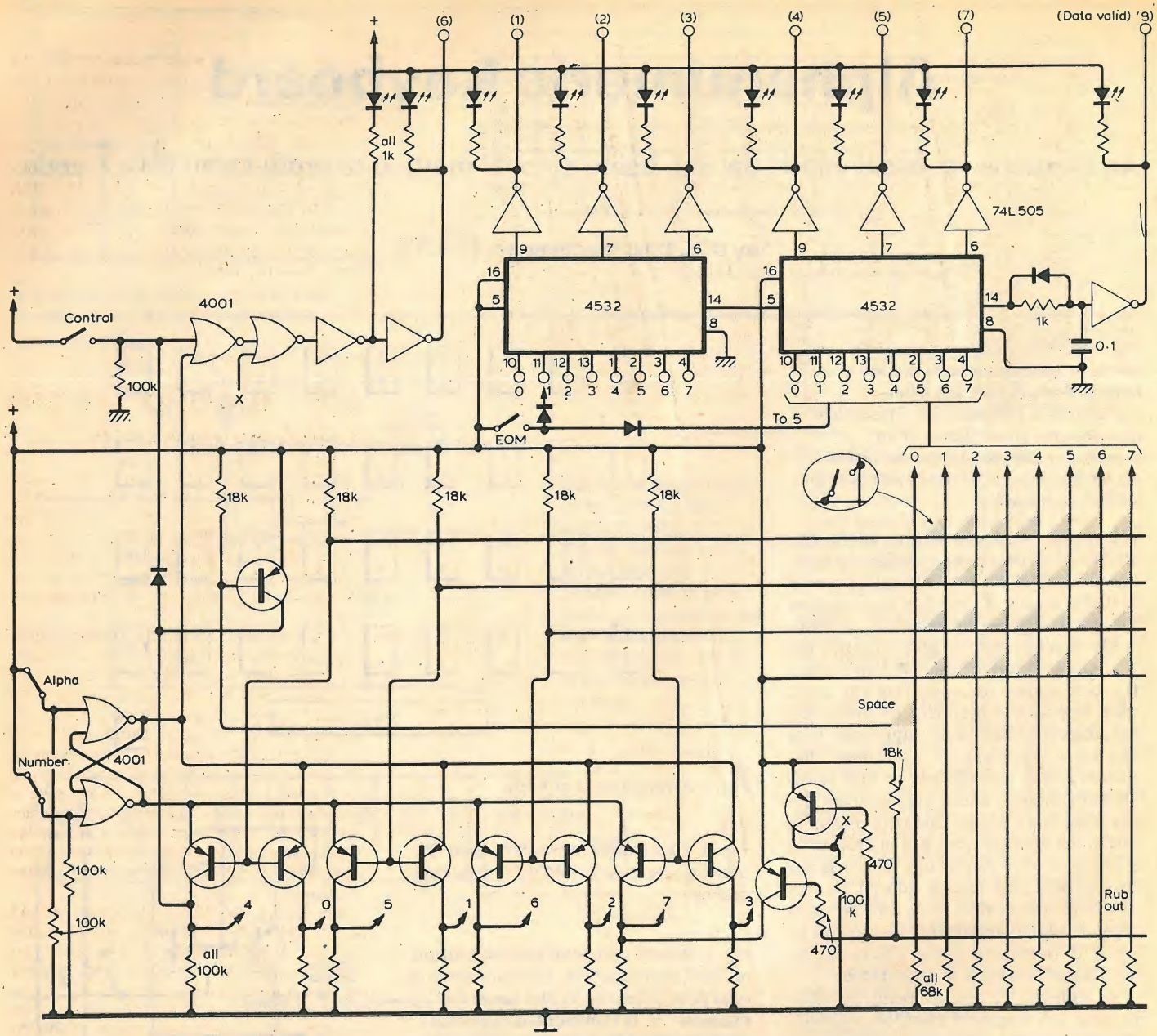


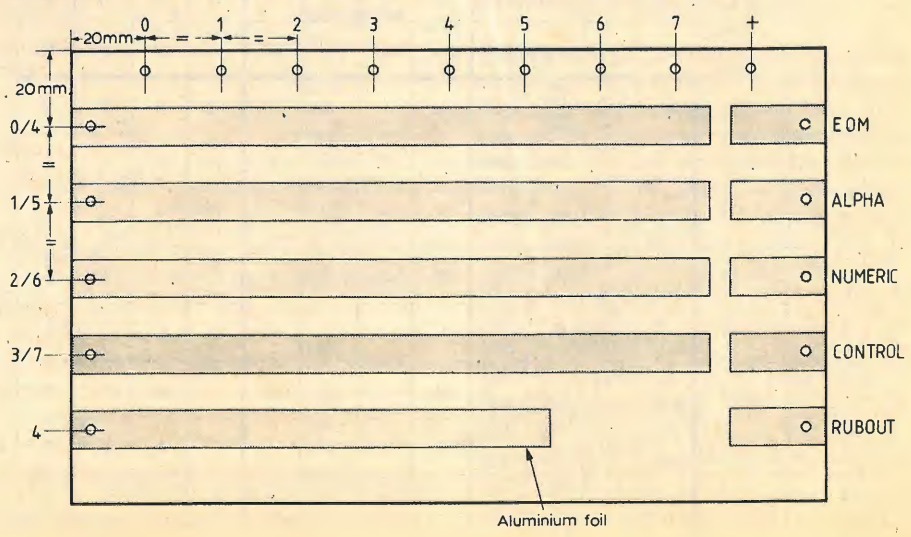
Fig. 4. Complete circuit diagram.

Circuit

To conserve power, the circuit was designed to use mainly c.m.o.s., although there is no reason why it should not be implemented in t.t.l. The vital component is the encoder, RCA type 4532. When any of the inputs is connected to a logical 1, the three output lines are encoded so as to identify the highest line (numerically) taken to logical 1. Thus, taking line 6 high results in the output 110. Additionally, an output line is provided to verify that an input is present.

In order to drive the inputs of two encoders positive by means of a simple cross-point switch, a transistor inverter is used, as in Fig. 3. When S_a is open the row input is at 0V and the transistor Tr_1 is switched off, so that the column encoder input is also at 0V. When the switch is closed, Tr_1 is bottomed, taking the column encoder input positive. As the base/emitter voltage is only 0.6V, the row encoder input is also positive. "Shift" is accomplished by means of S_b, which allows either Tr_1 or Tr_2 or to conduct. In the complete circuit of Fig. 4, the shift switch uses an RS flip-flop to latch either "alpha" or "number". The "control" switch overrides this latch temporarily. The "end of message" switch generates 015 via two diodes while "rub out" actuates both 7 lines.

Fig. 5. Base-board layout.



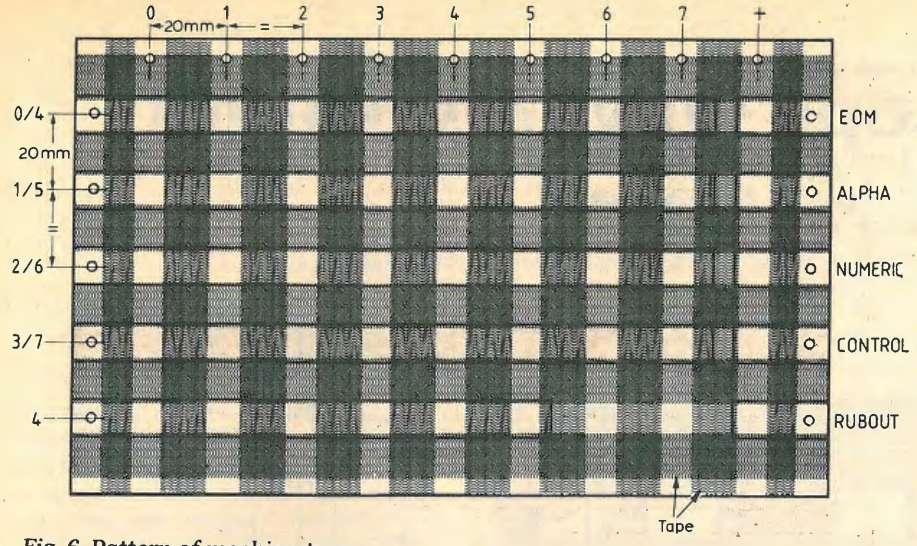


Fig. 6. Pattern of masking tape.

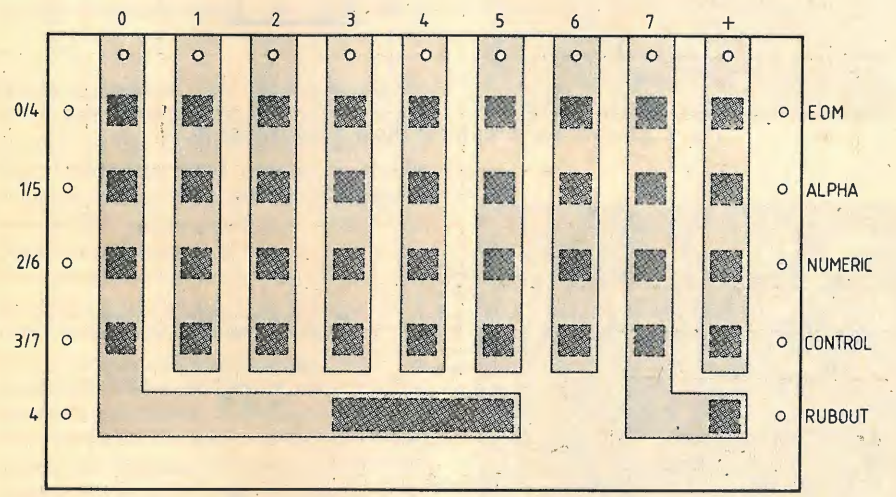


Fig. 7. Upper switch contacts.

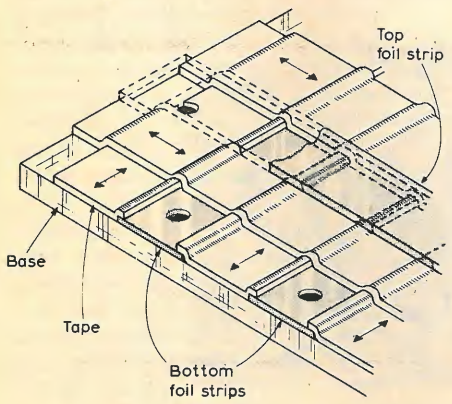


Fig. 8. Sketch of keyboard construction.

Key bounce is a perennial problem with mechanical switches. In this circuit it is overcome by the provision of a "data valid" bit which goes to 1 after the data has settled. It is derived as follows. The "input present" output from the column encoder is used to enable the two encoder. Its input present line, in turn, delayed by 100μs in a C R before being fed to the output via a gate. The l.e.d. is connected to each output line so that the outputs can easily be monitored.

Key switches

Switches tend to constitute the main stumbling block in keyboard construction. However, it is possible to construct a simple and reliable keyboard very cheaply using aluminium foil and adhesive tape. The constructional steps are as follows:

- Cut a base board 120×200mm from a suitably strong insulating material such as 3mm perspex, as shown in Fig. 5.
- Cut 1cm wide strips of aluminium foil and glue them to the base board as shown taking care to keep the upper surface free from glue.
- Stick 12mm wide masking tape along the "lands" between the strips of foil just covering the edges of the foil, both horizontally and vertically, leaving 8mm uncovered squares at each cross-point as in Fig. 6.
- Cut the upper switch element as shown in Fig. 7. Secure into position over the contact areas with tape.
- Make contact to each of the switch strips using a nut and bolt.

Although this form of switch sounds very crude, I have checked switches to over 1000 presses and found them to operate reliably.

Components

Because of the digital nature of the circuit and the wide noise margin of c.m.o.s., the component values are not at all critical so that wide tolerance resistors may be used. The diodes are all 1N4148. The transistors used in the prototype were BCY72, but almost any silicon p.n.p., e.g. OC200, 2N3702, BC308, etc., may be used. The circuit is designed to run from a single 5V supply, which should be bypassed by a capacitor of about 100μF. □

US mobile radio market growth

AN international market research report* published recently says that the US mobile radio equipment market will double over the next decade. In 1977 the market figure was $1,900 million (down $500 million from the 1976 figure) but it is expected to expand to $2,500 million by 1980 and to $3,700 million by 1985.

Although declines in citizen's band radio and marine v.h.f. radio are expected to cause a slow growth during 1980 the report says that the market will recover to attain an 8% annual compound growth rate thereafter. Factors which will undoubtedly affect the market in the future include the transmission of digital messages, the widespread use of voice scramble devices and the emergence of a consumer f.m. scanner market. Other factors will be the implementation of cellular systems (especially on the newly opened 800 to 900MHz band) and of course the microprocessor.

The report examined equipment in the study under the categories, public safety services, industrial radio services and land transportation services, and gave growth figures for these categories and for the services within these categories (fire, police, taxicab, etc). From the figures given to *Wireless World* for average annual growth (in % 1 year) for the periods 1976-80 and 1980-85, one sees an overall drop from 15 to 10% respectively for the total land mobile market with these drops being fairly evenly spread over almost all of the services. The more noticeable changes are in the fire service (up 50%), the police service (down almost 50%), and the railways (up about 30%).

In addition to the normal problems encountered in the mobile radio market — frequency spectrum congestion, foreign competition and government regulations, to name but a few — the US participants, according to Frost & Sullivan Inc., who produced the report, will be especially plagued by price pressures "as many more manufacturers and suppliers participate in the market".

The average unit price of land-mobile radios is expected to reduce from its 1976 figure of $850 to $700 in 1985.

With c.b. radios the story is very different. The forecast predicts that they will penetrate deeper into the vehicle market than the current 9% for automobiles, 60% for long-haul trucks, and 5% for small trucks. The study also points out that the microprocessor and other l.s.i. circuits are being used more and more in c.b. radios.

* The Mobile Radio Market, reference 556, by Frost & Sullivan Inc., New York.

Oscilloscope waveform store

by R. H. Fastner

During the time it took to develop this instrument and prepare the article, Motorola stopped production of the MC1407, used as controller for the analogue-to-digital converter in Fig. 3 of the article in the October issue. The following modifications will function as a complete replacement, with no changes to the p.c. board.

Comparison, formerly the function of $IC_{1(b)}$, is performed by an NE529 or the 'k' package version of the NE527: a possible alternative is the LM361 'h' package. All these are 10-lead metal-can types and should be used with a "MON-10LN" pad. An NE531 will replace the amplifier section of the original IC_1. The capacitor C_4 should be removed from the board. A new capacitor of 20pF should be inserted on the new, small board, shown in the accompanying illustrations, which can be plugged into an i.c. socket in the original IC_1 position.

The power supply circuit shown is suitable for the instrument.

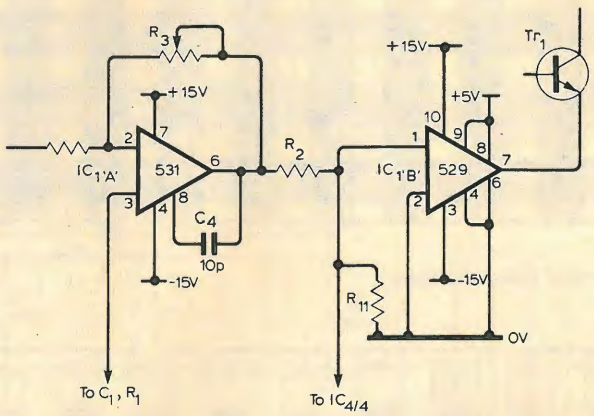


Fig. 1. Alternative circuit for the a-d controller (IC_1).

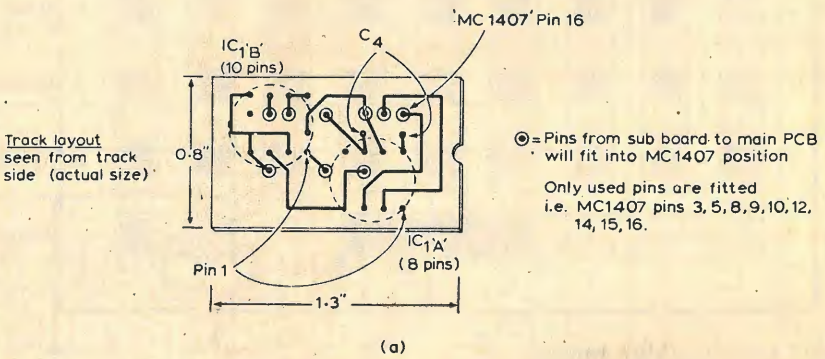


Fig. 2. Printed-circuit board for the circuit of Fig. 1. Board will fit into original IC_1 position. NE531 is on right.

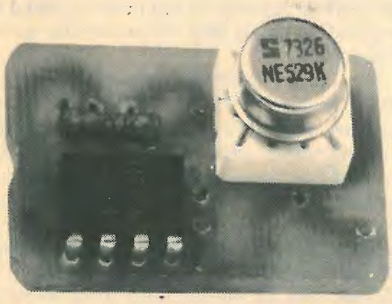


Fig. 3. The new board. The NE531 is an 8-pin d.i.l. version in this prototype.

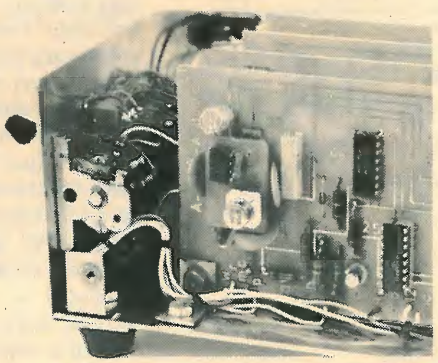


Fig. 4. New board plugged into original MC1407 position.

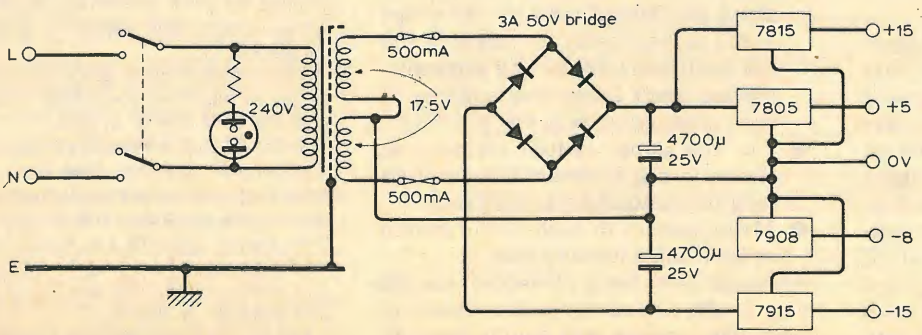


Fig. 5. Power supply for waveform store.

The Chatterbox — 2

Circuit details, construction and use

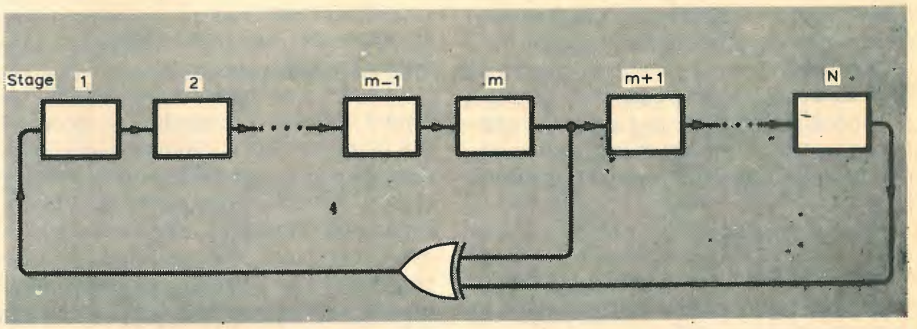
by Ian H. Witten M.A., Ph.D., M.I.E.E. **and Peter H. C. Madams,** B.Sc., M.Sc.
Department of Electrical Engineering Science, University of Essex

Last month's article discussed the processes of electronic speech synthesis and outlined the general design principles of the Chatterbox, giving a complete circuit diagram. The authors now conclude with further description of the circuitry, notes on construction and advice on how to operate the synthesizer.

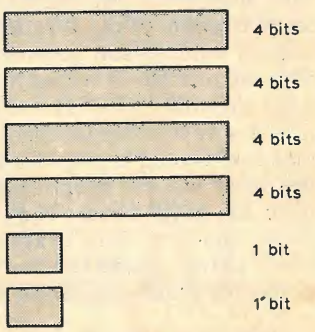
Noise generator. The digital feedback shift register, which is used as the noise source for the Chatterbox, is shown in Fig. 13(a). The final output from the register is exclusive-ORed with an intermediate output, and fed back to the beginning. Because it has only a finite number of states, this configuration will generate a repeating – and hence non-random – string of bits: however, if the intermediate feedback point and the number of bits, say N, in the register are carefully chosen, a maximal-length sequence of 2^N-1 bits is obtained before repetition begins. We chose the 4006 c.m.o.s. 18-bit shift register chip to implement the generator because some intermediate outputs are available (see Fig. 13(b)) and it is much cheaper per bit than full parallel-output registers.

Arranging 4006 chips into a low-cost maximal-length feedback shift register presents some problems. The clock rate needs to be at least 20kHz to ensure white noise. Clocked at this rate, a 16-bit maximal-length register repeats every three seconds or so, and this repetition in the noise is unfortunately just noticeable. Although 17-bit and 18-bit maximal-length registers do exist, it is just not possible to configure the several small shift registers of the 4006 in a way which makes the appropriate bit accessible. However, a computer simulation has shown that an 18-bit register with feedback from stage 17, although not maximal length, produces 253921 bits before repeating the cycle. This is only slightly less than $2^{18}-1$ (262143), and so the sequence generated is very close to maximal-length. With the 22.5kHz clock that is used, the sequence repeats every 11 seconds.

It is important to start a feedback shift register in the correct state. For example, the one in Fig. 13(a) will certainly not produce noise if started with each stage containing zero, since the feedback bit will be zero also. Unfortunately, when power is turned on the c.m.o.s. shift register that we used invariably comes up in the all-zeros state. Hence a spare gate is placed in the feedback path acting as an inverter, so that the all-ones state is the one which cycles indefinitely without producing noise. The all-zeros state leads into the repetition sequence of 253921 cycles.



(a)



(b)

Fig. 13. *(a) N-bit exclusive-OR feedback shift register; (b) shift registers in the c.m.o.s. 4006 i.c.*

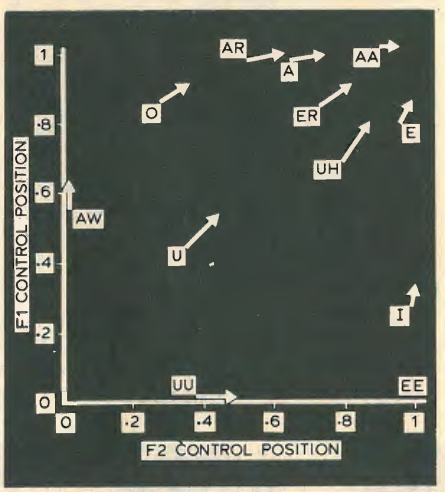


Fig. 15. *Distortion of vowel positions due to square root law of filter resonances.*

Formant filters. The formant filters form the heart of an analogue speech synthesizer like the Chatterbox. They should be constant-bandwidth, constant d.c. gain, second-order resonators with centre frequency controllable over approximately half a decade range. In order to keep the cost of the device low, we used the two operational amplifier active filter configuration of Fig. 14 instead of the more commmon ring-of-three design, which incidentally is rather easier to control. The transfer/function of this can be shown to be

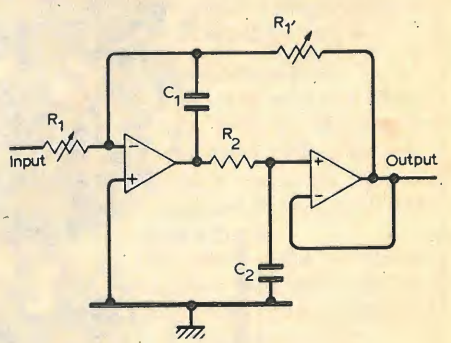


Fig. 14. *Formant filter.*

$$H(s)=\frac{-1/C_1R_1C_2R_2}{s^2+\frac{1}{C_2R_2}s+\frac{1}{C_1R_1'C_2R_2}}$$

which characterizes it as a low-pass resonance with d.c. gain of R_1'/R_1, bandwidth of $1/2\pi C_2R_2$ Hz, and centre frequency of $1/2\pi\sqrt{C_1R_1'C_2R_2}$ Hz. By tracking R_1' with R_1, we can ensure that

the d.c. gain remains constant, and the centre frequency follows $1/\sqrt{R_1}$. Moreover, neither is especially sensitive to slight departures from exact tracking of R_1' with R_1.

The inverse square root variation of formant frequency with R_1 caused us some concern. It is important to ensure that the joystick has an audible effect on the sound quality right across its operating range, so that control is not concentrated in one corner.

Suppose we let k travel from 0 to 1 to represent the position of the joystick in one dimension. The potentiometer is linear; suppose its resistance swings from R_A to R_B. Then at position k, the resistance is $R = (1-k)R_A + kR_B$, and the frequency of the resonance is proportional to $1/\sqrt{R}$. It is easy to show from this that if the resonant frequency travels from f_0 to f_1, its value at position k is

$$\frac{f_0}{1-k.[1-(f_0/f_1)^2]}$$

Now we can plot the positions of the vowels on a two-dimensional plane, with the dimensions representing the degrees of freedom of the joystick. Fig. 15 shows a comparison between the vowel positions for a hypothetical linearly controlled filter ($f \sim 1/(k + \text{const})$) – the vowels are labelled in the positions they would occupy for this – and the filter we are proposing. The distortion due to the square-root law is shown by arrows. The diagram is obtained using standard formant frequencies for a male voice, and ranges of 200-750Hz and 750-2250Hz for formants 1 and 2 respectively.

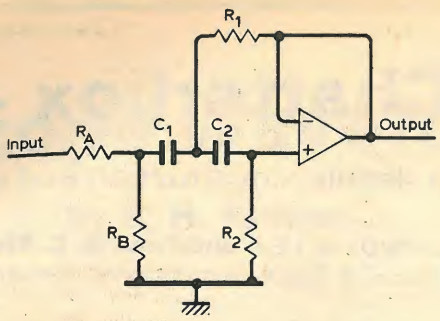


Fig. 16. *Sibilance filter.*

The effect of the transformation is to crowd the vowels towards one corner of the plane, which is disadvantageous – distinguishing between vowels would clearly be easier if they were maximally separated. However, the crowding is not severe, and the simplicity of the two-amplifier filter compared with others having more suitable relationships between resonant frequency and potentiometer position was considered to outweigh the disadvantage of uneven vowel distribution.

The bandwidths of the formant filters must be chosen carefully. Published figures for formant bandwidths are surprisingly low – around 50 to 100Hz. However, low bandwidth gives a high magnification factor Q, especially in formant 2 where the resonant frequencies are higher, and since the gain in the first stage of the filter depends on Q, this is undesirable, because limiting will occur unless the signal levels are extremely low. In practice, we have found that the audible effect of synthesized speech does not depend critically on low formant bandwidths, and we chose to make the first formant bandwidth 110Hz and increase the second formant bandwidth slightly to 160Hz.

The component values used in the prototype Chatterbox are shown in Table 2. They give a range on formant 1 which spans slightly lower frequencies than required by the vowels of Table 1, and a formant 2 range which is rather higher than that required. This is because if the formant ranges intersect, or come close to intersection, the combined amplification of both filters can cause limiting to occur in the second filter. The problem cannot be avoided simply by turning down gains, for then the amplification when the formant frequencies are separated is so small that the signal gets lost.

Sibilance filter. To make the sibilant sounds "ss," "f" and "sh," the signal generated by the noise source must be filtered and attenuated. A second-order high-pass resonance is an appropriate filter, with the position of the resonance determining the type of sibilance. It is necessary also to make "f" a much weaker sound than the other two, so we sought a filter where we could change the attenuation at the same time as controlling the resonant frequency. The circuit of Fig. 16 does nicely. Capacitor

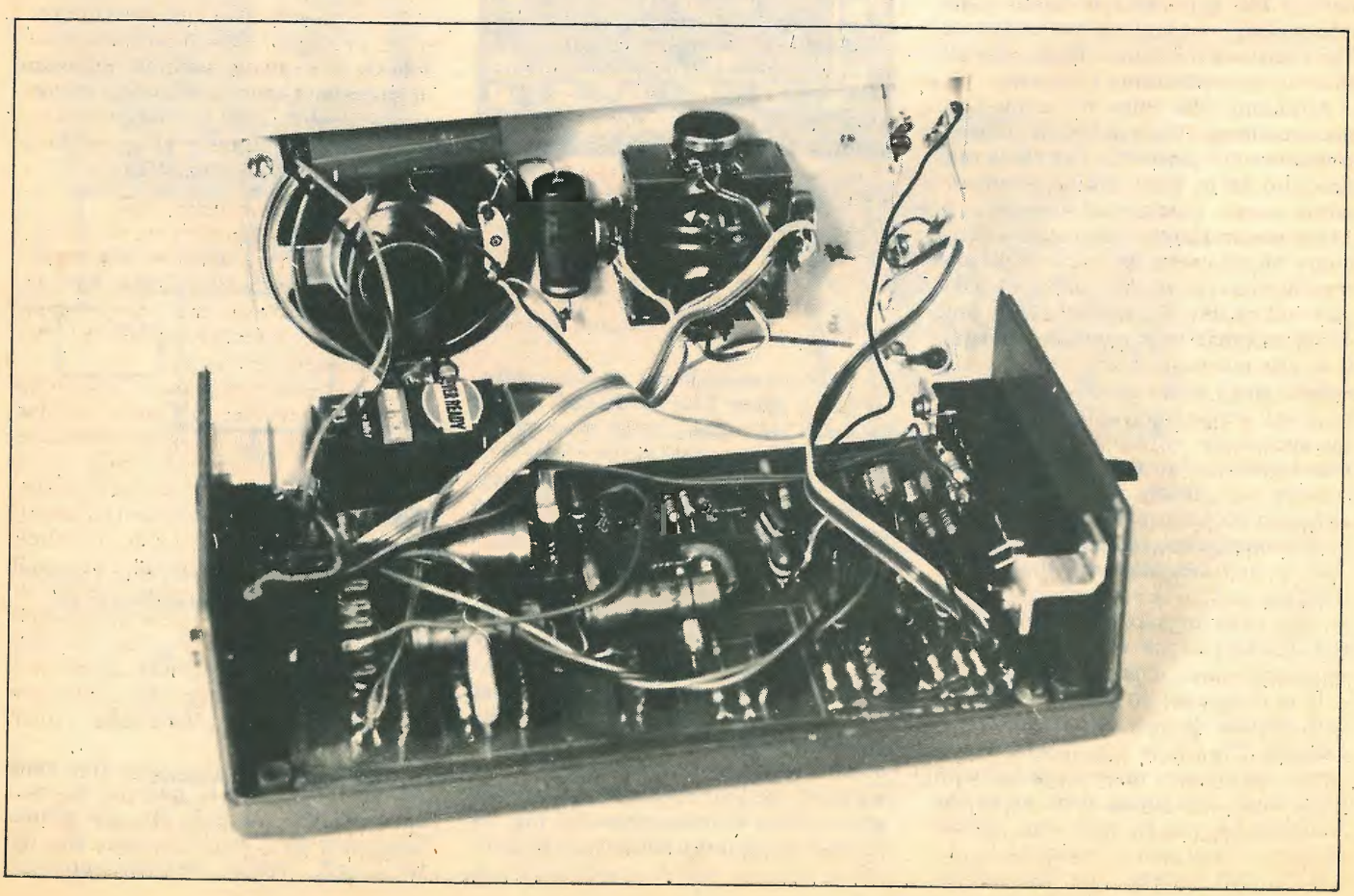


Fig. 17. *Inside the Chatterbox.*

Table 2. Component values for the formant filters

	Formant 1	Formant 2
R_1, R_1'	10kΩ linear potentiometer in series with 1.2kΩ	10kΩ linear potentiometer in series with 1.2kΩ
C_1	47nF	2500pF
R_2	15kΩ	15kΩ
C_2	100nF	68nF
calculated bandwidth	110Hz	160Hz
calculated range of resonant frequencies	180Hz-550Hz	940Hz-2850Hz
range required by vowels of Table 1	300Hz-750Hz	750Hz-2250Hz

Table 3. Component values for the sibilance filter

	s	f	sh
R_A	220	220	220
R_B	22	22	22
C_1	1000pF	2200pF	6800pF
R_1	1kΩ	1kΩ	1kΩ
C_2	820kΩ	820kΩ	820kΩ
R_2	1000pF	1000pF	1000pF
calculated gain	1/10	1/10	1/10
calculated bandwidth	390Hz	280Hz	220Hz
calculated resonant frequency	5560Hz	3750Hz	2130Hz

C_1 controls the resonant frequency, and R_A/R_B controls the attenuation. The transfer function is

$$H(s)=\frac{s^2}{(1+\frac{R_A}{R_B}+\frac{R_A}{R_2})s^2+[(1+\frac{R_A}{R_B})\cdot\frac{1}{R_2}\cdot(\frac{1}{C_1}+\frac{1}{C_2})+\frac{R_A}{R_1C_2R_2}]s+\frac{1+R_A/R_B}{R_1C_1R_2C_2}},$$

and if we choose $R_B \ll R_A$, $R_B \ll R_2$, $R_B \ll R_1$, and $R_B \ll R_1C_2/C_1$, this has passband gain of R_B/R_A, bandwidth of $(C_1 + C_2)/2\pi R_2C_1C_2$, and centre frequency of $1/2\pi\sqrt{C_1R_1C_2R_2}$.

We had to experiment with the centre frequency and bandwidth to find suitable sibilant sounds. We finally settled on resonances at around 2100Hz for "sh," 3700Hz for "f" and 5600Hz for "ss," with fairly high Qs – compared to the resonant frequencies – bandwidths of 200 to 400Hz. These are on the verge of what is realizable with the circuit before capacitor values become ridiculously small and resistor values ridiculously high. Table 3 shows the component values used.

The different sibilances are obtained by switching different R_A, R_B, and C_1 networks into the input of the filter. A 4016 c.m.o.s. analogue gate is employed just before C_1, controlled by the appropriate noise touch switch, and the other side of C_1 in each of the three networks is commoned into the remainder of the filter. Fig. 12 shows the details of control. Because of the low input impedances of the R_A, R_B, C_1 networks, the output from the noise generator is buffered with a unity-gain amplifier stage.

Touch switches. There are five touch switches on the Chatterbox, for voicing, aspiration, and three sibilant sounds, S, F, and SH. The voicing switch, which is operated by the heel of the hand that grasps the joystick, is replicated on both sides of the box to cater for left- and right-handed people.

The touch switches operate by detecting the skin resistance when two adjacent contacts are touched together. They are made possible by the extremely high input impedance of c.m.o.s. gates. Since only a tiny current is drawn by the gate, an extremely high pull-up resistance (10MΩ) can be used to keep its input asserted. Then even a high skin resistance is able to overcome the pull-up resistor and bring the gate input to ground. In fact, the conductance of people's skins varies quite a lot. Although the values shown work for most people, if the touch-switches fail to work for you just moisten the skin a little.

The whisper and sibilant controls are "ORed" together and the result turns off the clock that drives the noise generator, so that if none of them is operated, no noise gets through to distract attention from the voiced sounds.

Construction

The prototype model was made in a box 19cm × 11cm × 6cm, with the joystick, touch controls, and a small loudspeaker on the top, and the pitch potentiometer control protruding from the left-hand side. Fig. 17 shows the inside of the box. A single printed circuit board, mounted on the base, contains all the components. This is joined to the controls on top by ribbon cable. Two PP3 batteries provide an internal power supply, with provision for connection to an external one via a socket. An amplifier/recorder jack output is also included.

The left-to-right motion of the joystick controls formant 2, from minimum (left) to maximum (right), and the down-and-up motion controls formant 1, from minimum (down) to maximum (up). It is important to keep the leads from the joystick potentiometer as short as possible, since any noise on them will be amplified by the filters.

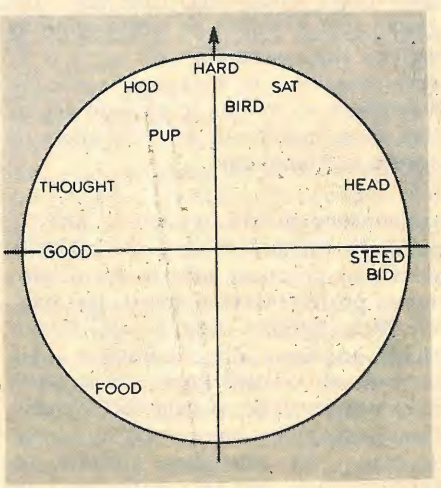


Fig. 18. *Approximate vowel positions.*

Setting up. The component values given in Fig. 12 should provide acceptable ranges and bandwidths for the formant filters, the sibilance filter, and the sound source. However, it is necessary to adjust the relative levels of the voicing, aspiration and sibilance channels by suitable choice of resistor values.

First, adjust the levels of voicing and aspiration by substituting different values for the 47kΩ and 82kΩ resistors at the input to the first operational amplifier. It is best to examine the output of the amplifiers with an oscilloscope, so that as large a gain as possible is obtained without clipping occurring anywhere along the formant chain. The tests should be made at different positions of the joystick, because this radically affects the Qs of the filters.

Then adjust the two input resistors to the final operational amplifier to achieve a pleasing balance between sibilance and voicing. Finally, set the feedback resistor for this stage to produce maximum output voltage without clipping in the audio amplifier.

Making the Chatterbox talk

The best way to learn about the Chatterbox is to play with it. However, people sometimes have difficulty getting started, so here are some suggestions to help familiarize you with the controls and their effects.

First, identify the vowel positions (Fig. 18). Remember that there are far more vowels in English speech than the *a*, *e*, *i*, *o*, and *u* of English writing!

Now experiment with pitch variations while a steady vowel is being produced. Try a rising pitch, a falling pitch, a rise and then a fall, and a fall followed by a rise. Correct control of pitch is essential to make the speech sound natural.

Try some diphthongs next, as in "go," "toy," and "play" (Fig. 19). These are made up as a slide from one vowel position to another.

Finally, turn to the noisy sounds. One pair of touch contacts produces aspiration, and the sound is affected by the joystick position. You should be able to

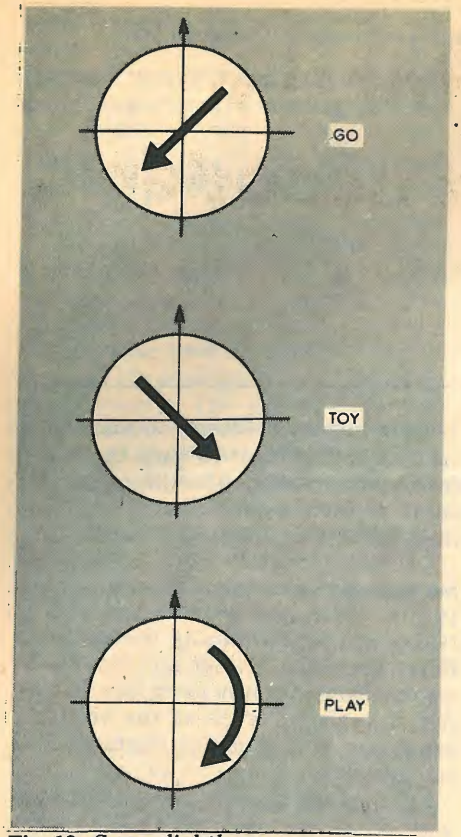


Fig. 19. *Some diphthongs.*

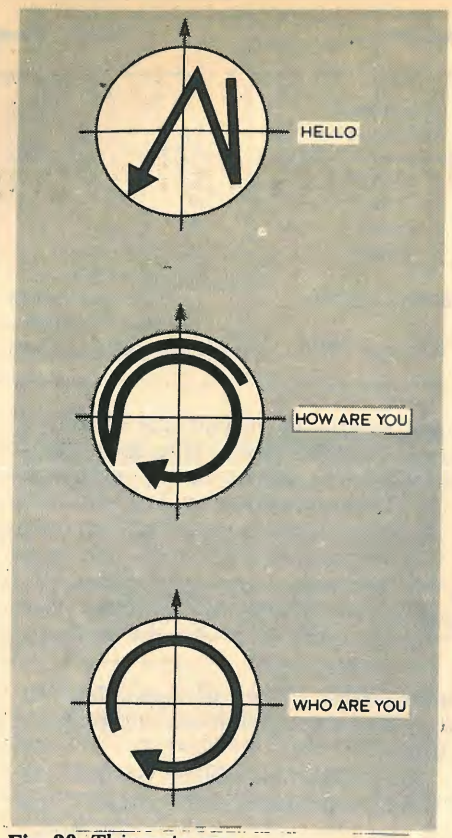


Fig. 20. *Things to say.*

use it to whisper the vowels and diphthongs learned above. The other pairs of contacts produce the sounds at the beginning of "ships," "fish," and "salt." It is possible to make "t" as in "eat" with a very short burst of "s." However, it's quite difficult to integrate these noises with the vowel-like sounds to get proper words like "delicious." No wonder babies take so long to learn to talk! Fig. 20 shows some things to say.

The Chatterbox in use

The Chatterbox has found an exciting application as a stumulus for retarded and autistic children. (It has also been used with a young child, blind from birth.) As you may know, such children find it difficult to interact with other people and often prefer to play with machines. The Chatterbox with its relatively rich structure of controls and noises, proves an interesting device for them.

Dorinda Bath, at the University of Nottingham, has conducted some experiments with retarded and autistic children who were functioning at a mental age level of two years. They were given the toy and instructed to "play with it and see what it does". While playing with the pitch potentiometer, trying to balance the toy on its joystick, chewing it, and so on, they usually triggered one of the touch switches by accident. From then on it was a matter of discovering which of the controls worked by themselves and which operated in consort with others. Three levels of activity were defined:

level I: making a noise by touching one of the controls;

level II: performing two related actions simultaneously (e.g. voice switch and joystick);

level III: performing three actions simultaneously i.e. voice switch, joystick, and pitch potentiometer).

Many of the children discovered by themselves not only level II but also level III activity. However, because the possibilities for co-ordinated control at level III usually outstripped the child's manipulative powers, because her hands were so small, she often involved the adult experimenter *on her own initiative* to help her ("you touch these buttons while I move this"). Thus the Chatterbox served as a catalyst for valuable interpersonal relations. This is especially important for the autistic child, who withdraws from contact with humanity and does not respond to friendly advances from other people.

As a consequence of her experiences with the Chatterbox, Dorinda suggested that it would be worthwhile to explore the possibilities of using it in child therapy, to increase auditory awareness as well as to expand attention span in children with disorders of speech and language.

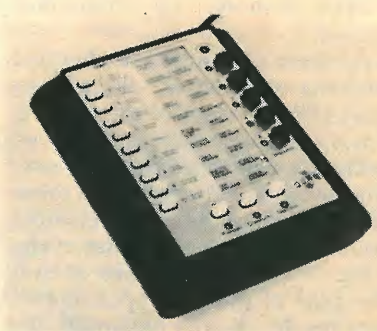
Acknowledgements. We would like to thank all the people who contributed ideas and practical help to the Chatterbox project: Chris Corbett, Kel Fidler, Rick Jenkins, Bob Mack, Roger Moore, and especially Bob Booker, John Brazier and Richard Pope, whose hard work went well beyond the call of duty. The spectrograms were made by Linda Shockey. We are very grateful to Dorinda Bath for her enthusiasm in using the Chatterbox with emotionally retarded children.

Two-way cable tv system for tv entertainment

A new bi-directional cable tv system is shortly to become operational in the USA. It allows viewers to select special film programmes, to actively participate in educational courses and quiz games, and even to shop using their tv set. It also enables subscribers to contact the police in an emergency.

A network using this concept has been developed jointly by Pioneer Electronic Corporation and Warner Cable Corporation, a subsidiary of Warner Communications, and will eventually cover about 300,000 households (an estimated one million people) in an area around Columbus, Ohio. Previous systems have only enabled a relatively small number (a few thousand) subscribers to participate in programmes. All the subscribers in the network are directly connected to the programme transmission centre by a bi-directional digital communications system. From this centre, each subscriber can receive up to 30 regular tv programmes, up to ten pay-tv programmes, and by using a pushbutton control unit, participate in various other programmes.

A pay-as-you-see facility enables viewers to pay for extra programmes or facilities as and when they want them. It does this by monitoring the use of each subscriber's tv console by computer, and using the data obtained to invoice them for the extra programmes and facilities used.



L.e.ds on the viewer's push-button remote control unit, shown in the accompanying photograph (actual unit size is about 4×6in), can be illuminated if, for example, the viewer gives the correct answer in a multiple answer test following an educational programme. This facility can be applied to tv shopping as well as to educational subjects. Anyone wishing to order a particular product simply presses the appropriate response button and the computer notes the order and prepares a purchase note, which is passed directly to the supplier's warehouse.

Facilities are also available with the system to provide a subscriber with teletext-type data; for example, up-to-date information on his or her water, gas and electricity consumption.

Character rounding for the Wireless World teletext decoder

2 — Installation of Board 4 and further improvements

by J. H. Hinton, M.Sc.

Improvements to J. F. Daniels' original decoder design represent a further stage in evolution. Unlike some commercial l.s.i. decoders, the unit now offers complete compliance with the specification together with useful test and demonstration facilities.

THE ASSEMBLY of the new board is eased by the use of plated-through holes, and no special precautions are necessary in its construction beyond ensuring that the capacitors stay within a height of 5/16in above the board.

To simplify the wiring-in as far as possible, the board has been laid out in a half-depth format to mount above the rear halves of Board 3 and the analogue board. The seventeen links to rear pads on the component side of Board 3 go to the corresponding numbers on the lower side of the new board, while the other connexions go to its upper side. The existing leads to the front panel should be disconnected from the boards to be reconnected as a final stage of re-assembly. "Extra-flexible" wire is strongly recommended for the new wiring and also for replacement where single-strand wire was used originally, since this is liable to weaken or break when the decoder is "unfolded" a few times.

The complete assembly of four boards can just be fitted inside the 2⅜in headroom of the original cabinet, if carefully spaced. Board 2 should be mounted ¼in above the chassis and VR_3 removed. $C_{12,13}$ may have to be hung over the front of the board or replaced by smaller diameter types so that Board 1 can be fitted ½in above it. A gap of ⅝in between Boards 1 and 3 may be needed to clear VR_1 and VR_2, depending on the type used, but ⅜in is sufficient between Boards 3 and 4. The analogue board should be mounted ½in above Board 1. To avoid risk of short circuits, it is simplest to use insulated spacers throughout with fibre washers under nuts and screw heads where necessary.

With four boards, the heat dissipation is considerably greater than in the original design and it is suggested that a row of moderate size holes is drilled through the chassis and cabinet base at the front and in the top of the cabinet at the rear, to encourage airflow between the boards.

In the following, pad designations on Board 4 are suffixed by U (upper) or L (lower), while those on Board 3 retain their C (component side) and W (wiring side) prefixes.

Installation

(1) Remove existing wires between W30 and Board 2 "white output", and between C5 and edge connector 5 on Board 1 (EC 1, 5).

(2) Isolate the following points on Board 3 by breaking the track leading from them:— IC_{104}, pins 11, 13, 14, 15 (noting that the track from pin 11 runs along the upper side of the board under the i.c. before going through it close to pin 1) (108, 1), (105, 15) and edge connector C22.

(3) Connect a 22nF capacitor between C34 and C36; link (117, 2) to (101, 4) and IC 117, pin 3 to pad C22.

(4) Support Board 4 with its underside upwards and link with 1in lengths of wire all the pads on the underside of Board 4 to their same-numbered partners on the component side of Board 3, with the exception of 42L, which is taken to a 5V supply capable of providing 530 mA, and 43L (0V) which is linked to pad C36.

(5) Link edge connector 13U on Board 4 to (108, 1) on Board 3; 20U to (124, 8); 29U to (113, 11); 31U to (121, 6); 33U to (105, 15); 35U to (104, 15); 36U to (104, 14); 37U to (104, 13); 38U to (104, 11).

Boards 3 and 4 may now be bolted together.

On board 2, break the two track connexions on the underside of the board going to IC_{42}, pin 7 (dot count 6) and transfer them both to (42, 9) (dot count 7). Take a lead from (57, 3) (Flash) to 39U on Board 4 and check the polarity of C_{12} and C_{13} (shown incorrectly on the instructions supplied with some kits) — the two outside ends are both negative and the inner ones positive. The rate of flash may be slowed down by increasing these capacitors to 220μF.

At this stage the Roll mode and Write pulse modifications described in Daniel's follow-up article (*W.W.* Feb. 1977) may conveniently be carried out, together with the one for interleaved magazines, if required.

Turning now to Board 1, remove IC_1 (7493) and take a lead from its former pin 2 hole to pad 12U, and from pin 11 hole to 14U. Isolate (4, 13) by cutting the track leading from it on the underside of the board, remove C_2, and connect 17U to EC1, 17; 21U to EC1, 21; 34U to (7, 13) and 5U to EC1,5. The now spare NOR gate (4, 13) may be used to cure the 'jumpiness' in the setting of picture width and margin by connecting it in place of inverter (6, 12), with the additional input fed from (10, 11); it is also recommended that R_3 be changed to 270 ohms and (12, 11) be transferred to 0V. The four boards may now be bolted together.

On board 4, link the EC pads on the upper right hand edge to their partners immediately below on the analogue board, and connect 25U to the cut-hole signal fed to the video interface board from the "newsflash" switch on the front panel. Link to 0V the unconnected front pin of the used section of the "Teletext" switch. If required, connect the "upper-case only" switch between pads S_{1a} and S_{1b} alongside IC_{201}, and the "Disable Rounding" switch between pad S_2 (between IC_{212} and R_1) and 0V, both switches being open for normal operation.

Held graphics

The rendering of held graphics can be improved by two modifications to Board 3 which can be added on their own or in conjunction with the new board. When a graphics symbol is held over a control character which changes the display colour (a set-after change), a narrow band of the new colour may be visible at the right hand edge of the graphic because the signal which changes the colour has a shorter propagation path through the logic than the Y character signal. This can be overcome by introducing a compensating delay into the colour signal as follows:—

(1) Cut the track links and insert 100 ohm resistors on the underside of the board between (105, 3) and (110, 10) (red), (105, 13) and (110, 11) (green) and (105, 6) and (110, 3) (blue).

(2) Connect three 560pF capacitors on the top side of the board from IC_{105} pins 3, 6 and 13, to 0V. This value was found to be optimum on the prototype but may vary between individual decoders.

When a graphics symbol is held over the 'graphics hold' control which sets the Hold mode (being previously unset) the time taken to establish the mode may give rise to a gap at the left hand edge of the symbol (visible for example on Oracle, Page 111) which can be cured by adding a 390pF capacitor from (122, 13) to 0V; its effect is to delay the blanking effect of the control character signal fed to (116,5) until the hold signal to (116, 4) has caught up with it.

General

The type of capacitor used here or elsewhere in the modifications (apart from C_{201}) is not critical, provided that miniature high-K ceramic varieties with a tolerance of −20% to +80% such as the Mullard C629 series (yellow square plates with a green band along the top) are avoided.

The new board continues the practice in both the original design and Board 3 of leaving unconnected the pins of unused active-low i.c. inputs. Unlike c.m.o.s., where a free input may float to almost any level depending on leakage resistances, the internal base resistance of the t.t.l. input stage is sufficient in practice to hold it up in the high state against any capacitance coupling inside the package; although an external pull-up is recommended by i.c. manufacturers. Used inputs which would otherwise be left floating under some switch conditions, such as (201, 1) and (214, 9), are provided with pull up resistors to overcome possible coupling through the stray capacitance of the wiring. Since the breakdown rating of a t.t.l. input is only 5.5V as against 7V for the main supply pin, inputs must never be directly connected to the positive rail without a protective series resistance.

The reduction in gap between characters with the seven clock period cell gives a narrower picture for the same clock frequency and while this can be reduced to 7Mhz to fill up the screen, the author prefers the narrower picture as being more readable.

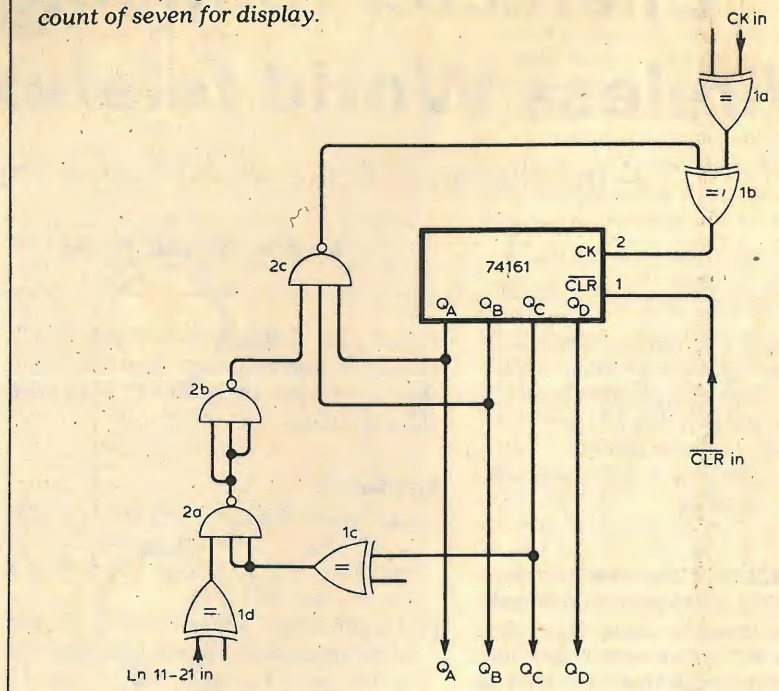
With the use of ±2% close tolerance components for C_{201} and R_{201}, rather than having a preset adjustment, the unit should work immediately provided that no faults are present. The action of character rounding can be observed and checked most easily on double-height characters; pre-rounding and post-rounding can be disabled separately by shorting (210, 9) and (210, 1) respectively to 0V.

The seven clock period character cell and upper case only converter can be added separately to the *W W* decoder or used independently in other display applications.

The circuitry to switch between a dot-count modulus of eight for acquisition mode and seven for the display cell can be made up from three i.c. packages as shown in Fig. 5. It is necessary to use a synchronous counter, and to switch over the exclusive-OR gate by a dot — count 3 signal derived from a single gate rather than the 7442 four-to-ten-line decoder IC_{42}, because the propagation time round this loop via either Q_A or Q_B must be less than half a clock period. The conversion of lower-case alpha symbols to upper case also requires three i.c. packages as shown in Fig. 6. However, the availability on Board 4 of spare gates in the character-rounding logic enabled this conversion to be incorporated with the addition of only one 7400 package, at the cost of not preserving the long dash (Row 0 column 6 in the code table).

It is important to observe the distinction between the 0V line and earth or chassis. While many older sets which used half-wave h.t. rectification directly from the mains with the chassis taken to neutral were relatively safe when connected correctly, newer ones often use a bridge arrangement where the chassis is live on alternate half cycles. It is essential that the decoder metalwork is taken to a true earth, and that a double-wound mains isolating transformer of adequate rating is used during commissioning and until the decoder is securely in its cabinet with all coaxial cable braiding well insulated.

Fig. 5. *Circuit to accommodate a dot-count of eight for acquisition and a count of seven for display.*



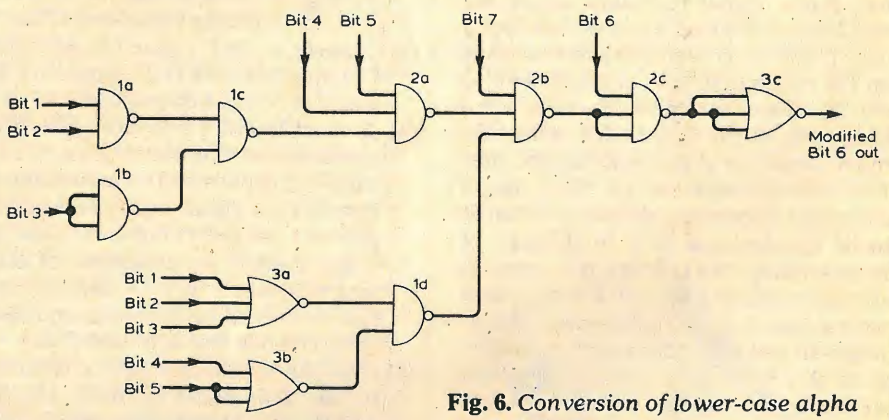


Fig. 6. *Conversion of lower-case alpha symbols to upper-case.*

Acknowledgements

I would like to express my thanks to Richard Russell for building a prototype and for valuable help over interfacing to his Board 3 circuitry; also to Messrs Catronics Ltd for their assistance in designing the printed circuit layout and supplying prototype boards.

Lack of space prevents publication of the printed-board pattern and the interboard wiring diagram of the complete decoder, including the wiring to this latest board. However, readers are invited to send a stamped, addressed envelope for copies, which are offered free of charge.

Microcomputer design

6 — The Z80 microprocessor explained

by Phil Pittman, B.Sc. in association with NASCO Ltd

Having considered some of the generalities of microcomputer hardware and software in previous articles, and also some parts of a particular practical system, this six-part series concludes by looking more closely at the central processing unit — in this case the Z80 microprocessor. Although some of the following information has been given in previous articles (November and December 1977; January, February and August 1978), it is being repeated here for completeness and greater detail.

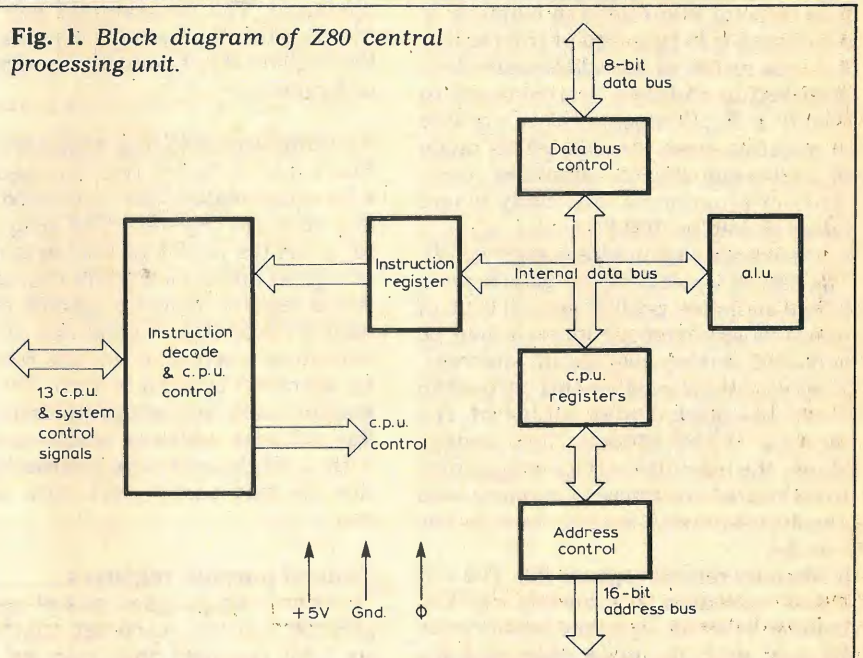
A BLOCK DIAGRAM of the internal architecture of the Z80 central processing unit is shown in Fig. 1. The diagram shows the major elements in the c.p.u. and it should be referred to throughout the following description. First let us look at the c.p.u. registers. The Z80 c.p.u. contains 208 bits of read/write memory that are accessible to the programmer. Fig. 2 illustrates how this memory is arranged into eighteen 8-bit registers and four 16-bit registers. The registers include two sets of six general purpose registers that may be used individually as 8-bit registers or in pairs as 16-bit registers.

Special purpose registers

1. Programme counter (p.c.). The programme counter holds the 16-bit address of the current instruction being fetched from memory. The p.c. is automatically incremented after its contents have been transferred to the address lines. When a programme jump occurs, the new value is automatically placed in the p.c., overriding the incrementer.

2. Stack pointer (s.p.). Any portion of external r.a.m. may be dedication as a stack area. This is used as a method of sequentially storing or retrieving data on a last-in first-out (l.i.f.o.) basis. The s.p. holds the 16-bit address of the current top of stack. Data can be "pushed" onto the stack, 16-bits at a time, from specific c.p.u. registers or "popped" off the stack into specific c.p.u. registers through the execution of PUSH and POP instructions. The data popped from the stack is always the last data which was pushed onto it. Any stack push or pop automatically modifies the s.p. in such a way that the s.p. always contains the address of the current top of stack. The stack is frequently used to save

Fig. 1. *Block diagram of Z80 central processing unit.*



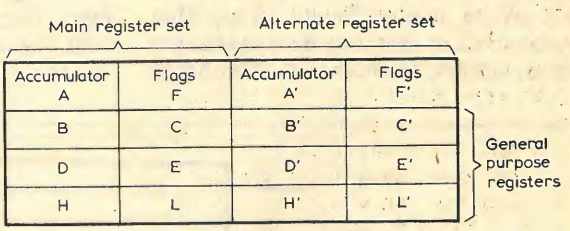


Fig. 2. *Arrangement of registers in the Z80 c.p.u.*

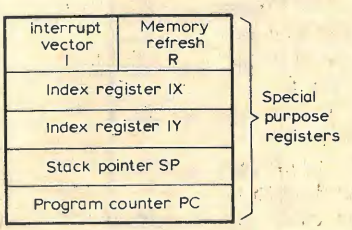
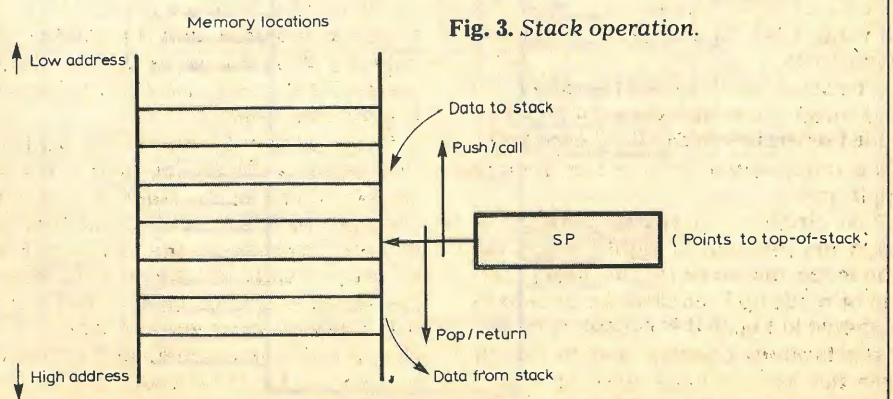


Fig. 3. *Stack operation.*



programme counter contents before certain types of jumps (calls) so that the programme can later return to the same place again by popping the old value back to the p.c.

The stack allows simple implementation of multiple level interrupts, unlimited subroutine nesting and simplification of many types of data manipulation. Fig. 3 indicates the operation of the stack.

3. Two index registers (IX and IY): the two independent index addressing modes. An index register is used as a base to point to a region in memory in which data is to be stored or from which it is to be retrieved. An additional byte is included in indexed instructions to specify a displacement, either positive or negative, from this base. This mode of addressing greatly simplifies many types of programme, especially where tables of data are used.

4. Interrupts page address register (I). The Z80 c.p.u. can be operated in a mode where an indirect call (a special type of jump) to any memory location can be achieved in response to an interrupt. The I register is used for this purpose to store the high order 8-bits of the memory of the address. This feature allows the interrupt service programme to be located anywhere in memory with absolute minimal access time to the routine.

5. Memory refresh register (R). The Z80 c.p.u. contains a memory refresh counter to enable dynamic memories to be used with the same ease as static memories. While a discussion of dynamic r.a.m. is beyond the scope of this article, it is sufficient to say that dynamic r.a.m. stores its data as charges on capacitors. In order that this charge does not decay it is necessary to provide a partial address for the blocks of memory cells, plus certain clock pulses, within a specified minimum time. These are the functions provided by the Z80. The 7-bit refresh register is automatically incremented after each instruction fetch. The data in the refresh counter is sent out on the lower portion of the address bus along with a refresh control signal while the c.p.u. is decoding and executing the fetched instruction. This mode of refresh is totally transparent in that it does not slow down the c.p.u. operation. The programmer can load the register for testing purposes, but this register is not normally used by the programmer.

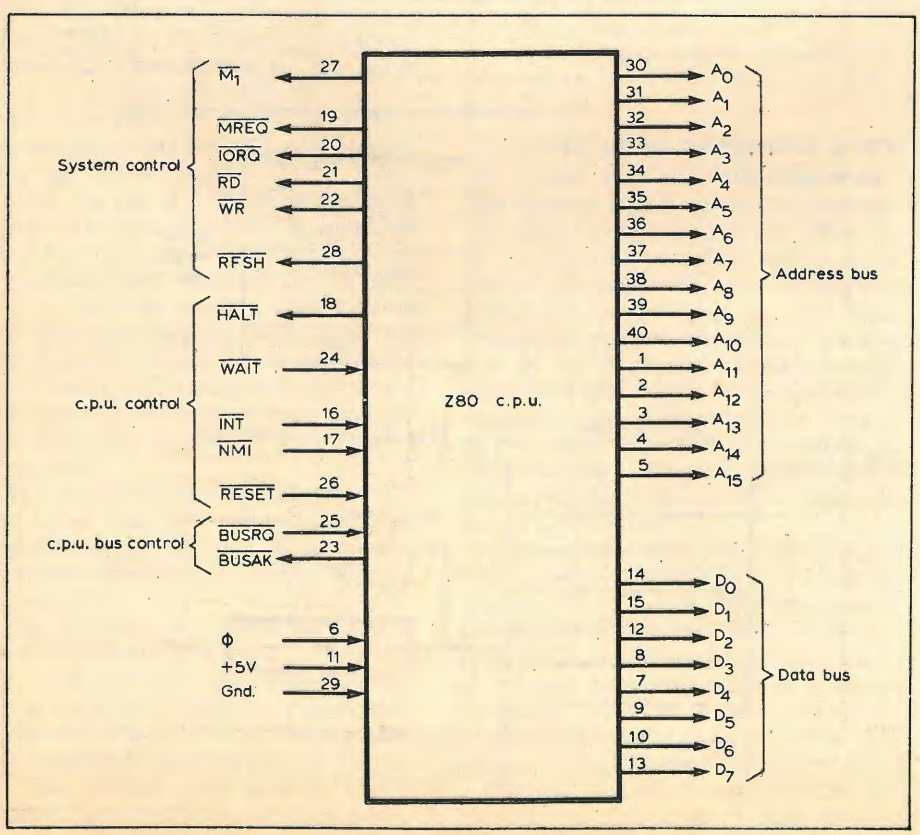
Accumulator and flag registers

The c.p.u. includes two independent 8-bit accumulators and associated 8-bit flag or status registers. The accumulator holds the results of 8-bit arithmetic or logical operations while the flag or status register indicates specific conditions for 8- or 16-bit operations, such as indicating whether or not the result of an operation is equal to zero. The programmer selects the accumulator and flag pair with which he wishes to work with a single exchange instruction so that he may easily work with either pair.

General purpose registers

There are two matched sets of general purpose registers, each set containing six 8-bit registers that may be used individually as 8-bit registers or as 16-bit register pairs by the programmer. One set is called BC, DE and HL while the complementary set is called BC′, DE′, and HL′. At any one time the programmer can select any one set to work with through a single exchange command for the entire set. In systems where a fast interrupt response is required, one set of general purpose registers and an accumulator/flag register may be preserved for handling this very fast routine. Only simple exchange instructions need be executed to go between the routines. This greatly reduces interrupt service time by eliminating the requirement for saving and retrieving register contents in the external stack during interrupt or subroutine processing. These general purpose registers are used for a wide range of applications by the programmer.

Fig. 4. *Pin numbers and functions in the Z80. The abbreviations are explained in the text.*



Arithmetic and logic unit (a.l.u.)

The 8-bit arithmetic and logical instructions of the c.p.u. are executed in the a.l.u. Internally the a.l.u. communicates with the registers and the external data bus or the internal data bus. The type of functions performed by the a.l.u. include: add, subtract, logical AND, logical OR, logical exclusive OR, compare, left or right shifts or rotates, increment, decrement, set bit, reset bit, and test bit.

Instruction register and c.p.u. control

As each instruction is fetched from memory, it is placed in the instruction register and decoded. The control section performs this function and then generates and supplies all of the control signals necessary to read or write data from or to the registers, control the a.l.u. and provide all required external control signals.

External signals

The Z80 is a single chip c.p.u. packaged in a standard 40-pin dual-in-line package. Fig. 4 shows the functions which are brought out to the external pins of the device while Fig. 5 shows how the device fits into the microcomputer circuit. All outputs from the c.p.u. with the exception of $\overline{M1}$, $\overline{RFSH}$, $\overline{HALT}$ and $\overline{BUSAK}$ have a three-state capability. With the exception of the data and address buses all signals have an active low state. The following paragraphs explain the various signals and connections shown as code names in Fig. 4 and Fig. 5.

Address bus (A_0-A_{15}). Pins A_0-A_{15} constitute a 16-bit address bus. The bus provides the address for memory (up to 64K bytes), data exchange and for i/o device data exchanges. I/o addressing uses the eight lower address bits to allow the user directly to select up to 256 input or 256 output ports. A_0 is the least significant address bit. During refresh time, the lower seven bits contain a valid refresh address.

Data bus (D_0-D_7). The 8-bit bidirectional data bus is used for data exchanges with memory and i/o devices.

Machine cycle one (M1). This indicates that the current machine cycle is an instruction fetch cycle.

Memory request (MREQ). The memory request signal indicates that the address bus holds a valid address for a memory read or memory write operation.

Input/output request (IORQ). The input-output request signal indicates that the lower half of the address bus holds a valid i/o address for an i/o read or write operation. An IORQ signal is also generated with an M1 signal when an interrupt is being acknowledged to indicate that an interrupt response vector (address) can be placed in the data bus by the interrupting peripheral. Interrupt acknowledge operations occur during M1 time while i/o operations never occur during M1 time.

Read (RD). The "read" pulse indicates that the c.p.u. wants to read data from memory or an i/o device. The addressed i/o device or memory should use this signal to gate data onto the c.p.u. data bus.

Write (WR). The "write" signal indicates that the c.p.u. data bus holds valid data to be stored in the addressed memory or i/o device.

Refresh (RFSH). The "refresh" signal indicates that the lower seven bits of the address bus contain a refresh address for dynamic memory and the current MREQ signal should be used to do a refresh operation on all dynamic memories.

Halt state (HALT). The HALT output from the c.p.u. indicates that a "halt" software instruction has been executed. The c.p.u. remains halted until reset or interrupted. During a halt, refresh activity is maintained.

Wait (WAIT). The "wait" input may be used to indicate to the c.p.u. that the addressed memory or i/o devices are not ready for a data transfer. Additional one clock cycle timing states are generated for as long as the "wait" signal is active. This signal allows any speed of memory or i/o device to be synchronised to the c.p.u.

Interrupt request (INT). The "interrupt request" signal is generated by i/o devices. A request will be honoured at the end of the current instruction if the internal software controlled interrupt enable flag is enabled. When the c.p.u. accepts the interrupt, an acknowledge signal (IORQ during M1 time) is sent out at the beginning of the next instruction cycle. The c.p.u. can respond to an interrupt in three different modes that are selected by software instructions.

Non-maskable interrupt (NMI). The non-maskable interrupt request line has a higher priority than INT and is always recognised at the end of the current instruction, independently of the status of the interrupt enable flag. NMI automatically forces the Z80 to restart at memory address 0066 hex. The programme counter is saved automatically in the external stack so that the user can later return to the programme that was interrupted.

Reset (RESET). A reset forces the programme counter to zero and initialises the c.p.u.

Bus request (BUSRQ). The "bus request" signal is used to request the c.p.u. address bus, data bus and three-state output control signals to go to a high impedance state so that other devices can control these buses. The request will be granted as soon as the current c.p.u. machine cycle is completed.

Bus acknowledge (BUSAK). "Bus acknowledge" is used to indicate to the

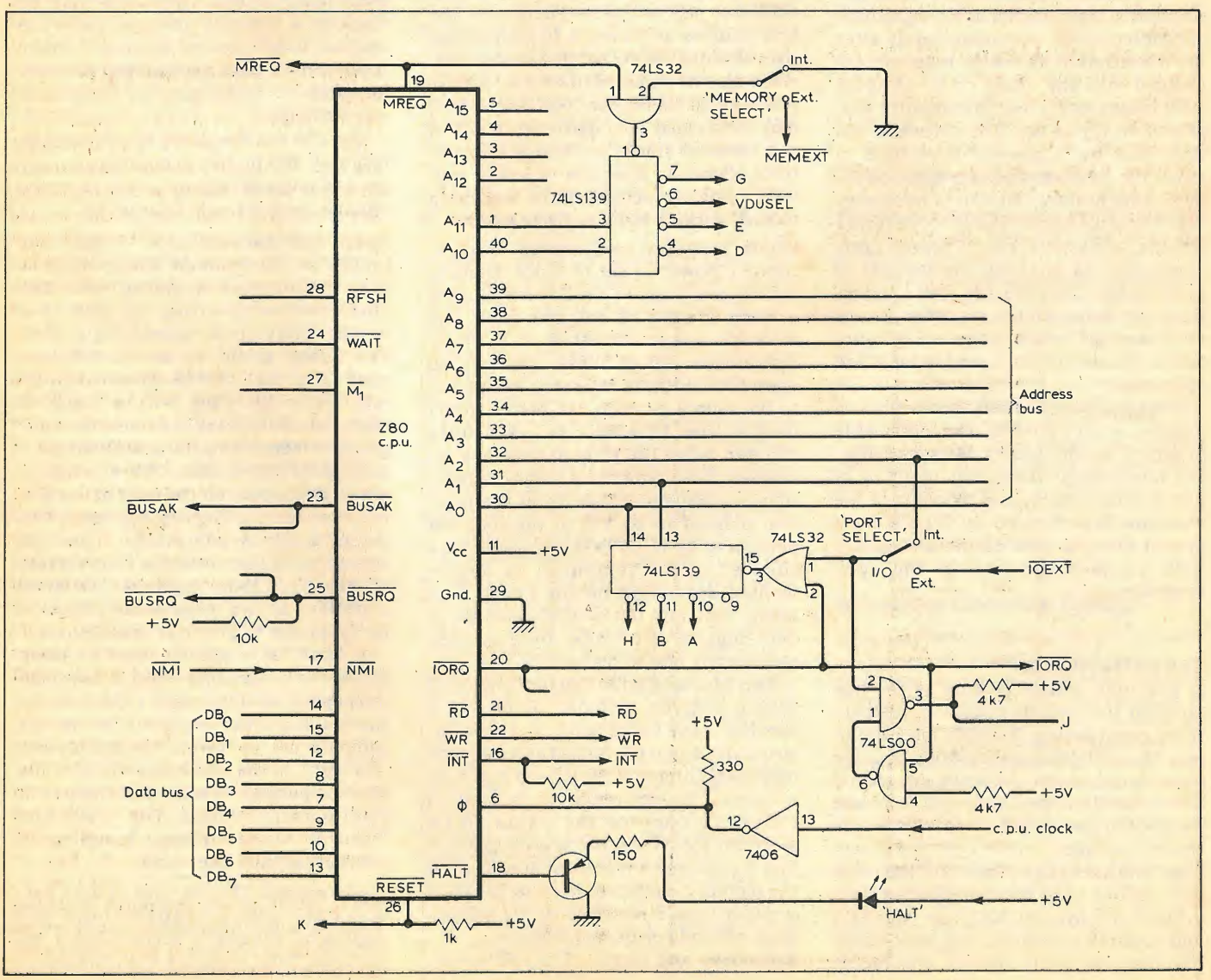


Fig. 5. *How the Z80 m.p.u. is used in the microcomputer, showing address and data buses and other associated logic.*

requesting device that the c.p.u. address bus, data bus and control bus signals have been set to their high impedance state and the external device, e.g. the d.m.a. controller, can now control these buses.

Clock (I). The Z80 c.p.u. requires a single phase t.t.l. square wave clock for timing control. The frequency of this is 2.5 MHz for the standard Z80 or 4.0 MHz for the Z80A.

As shown in Fig. 5 the c.p.u. clock is driven from a conventional t.t.l. buffer with a 330Ω pull-up resistor, as required by the package. The input to the buffer can be selected from points on the video r.a.m. frequency divider chain (August issue, p.56), which is driven from a 16MHz crystal. A link has been provided to allow the clock frequency to be set to 1, 2 or 4MHz.

The logical design of the microcomputer has been arranged to exploit the non-maskable interrupt facility of the Z80, mentioned above, for a very special purpose – to provide a single step action for programme development work. By utilising external logic to interrupt the processor a fixed number of M1 cycles after a known command has been executed, the execution of the programme can be halted by causing the interrupt to occur during a particular instruction. The software arranges successive instructions in a programme to be interrupted, and immediately after the interruption all major registers are mapped into the video r.a.m. (August 1978 issue) and are consequently displayed on the tv set. The software will then wait for a specific keystroke to move the next instruction into the interrupting position. All this is necessary because instructions can be of differing lengths, and unless a huge search table is provided to establish the lengths of each of the 158 different Z80 instructions, the software has no other means of "knowing" which bytes are instructions, which are data and which are operands.

The particular method chosen for this system is to cause a non-maskable interrupt on the fourth M1 cycle after the low-to-high transition of bit 3 of port 0. The counting and blocking of the interrupt is performed by 74LS74 integrated circuits and associated gates. This system is also reset by the c.p.u. reset signal.

The instruction set

A previous article in this series has outlined the various groups of instructions constituting the Z80 instruction set. The following paragraphs provide more detail on the facilities offered by the instruction set, although it is not possible to give full descriptions in the space available.

Load and exchange. These are the main instructions used for transferring data around the system between registers and memory locations. Any 8-bit quantity may be freely moved around by

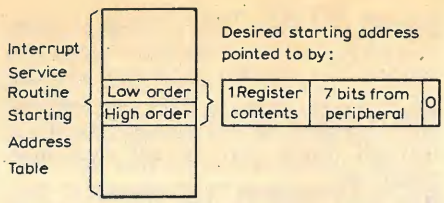


Fig. 6. *Interrupt response.*

utilising one of a variety of addressing modes with the basic "load" (LD) instruction. Register to register transfers are the simplest but in a register-to-memory or memory-to-register operation the memory address may be provided in one of a number of ways. The data may be part of an instruction, in which case it is fetched from the programme memory in the normal way. Alternatively, a 16-bit data memory address may be provided as part of the instruction. A common method of addressing data memory with the Z80 is to make use of the various 16-bit registers (IX, IY, BC, DE, HL) to contain data addresses.

Sixteen-bit quantities may also be transferred by the Z80 in a single instruction. For example 16-bit data to be placed in a 16-bit register may be included as part of the instruction, or the first address at which a 16-bit register pair of values is to be transferred between may be included in an instruction. Also any 16-bit register (excluding s.p.) may be pushed or popped on or off of the external stack. Exchange instructions allow the selection of either register bank or accumulator and also include various 16-bit register swaps.

Block transfer and search. An extremely powerful set of block transfer instructions exist in the Z80 for moving a block of data of any size from one memory area to another in a single instruction. All of these instructions operate with three registers: HL points to the source location, DE points to the destination location, BC is a byte counter. After the programmer has initialised these registers a single instruction can transfer a byte from the location pointed to by HL to the location pointed to by DE. These two points are then either incremented or decremented depending on the instruction being used, and the byte counter BC is decremented. The next byte is then transferred, and so on until BC = 0.

The block search instructions will search a given memory block for a specific data value with a single instruction. Again HL is used as a memory address pointer and BC is used as a byte counter. The accumulator is used to contain a copy of the value to be searched for. When the search instruction is executed it will sequence through the memory, updating HL and BC until it either finds a match with the accumulator contents or BC reaches zero.

Arithmetic and logical. The Z80 is capable of performing a wide range of 8-bit and 16-bit arithmetic and logical operations, as listed earlier. In all of these instructions except increment and decrement, the specified 8-bit operation is performed between the data in the accumulator and the specified source of data. This source may be any of the c.p.u.'s 8-bit registers, memory address by (HL), (IX + d) or (IY + d) or "immediate" data contained as part of the instruction. The result of the operation is placed in the accumulator, with the exception of the "compare" instruction which leaves the accumulator unaffected. All of these operations affect the flag register as a result of the specified operation.

The facilities of the flag register and instruction set allow arithmetic operations for multiprecision b.c.d. numbers, multiprecision signed or unsigned binary numbers, and multiprecision two's complement signed numbers.

A group of 16-bit arithmetic instructions allow various operations between the Z80's 16-bit register, frequently using HL as a 16-bit accumulator. These simplify address calculations or other 16-bit arithmetic operations.

Bit manipulation. The ability to set, reset or test individual bits in a register or memory location is needed in almost every programme. These bits may be flags in a general purpose software routine, indications of external control conditions or data packed into memory locations to make memory utilisation more efficient.

The Z80 has the ability to set, reset or test any bit in the accumulator, any general purpose register or any memory location with a single instruction.

Jump, call and return. A "jump" is a branch in a programme where the programme counter is loaded with the 16-bit value specified by one of a number of available addressing modes. The "jump" group has several different conditions that can be specified to be met before the jump will be made. If these conditions are not met, the programme merely continues with the next sequential instruction. The conditions are all dependent on the data in the flag register. Jump addresses may either be determined from information contained as part of the instruction or from certain of the c.p.u.'s 16-bit registers. The latter capability allows programme jumps to be a function of previous calculations.

A "call" is a special form of jump where the programme counter contents are pushed onto the stack (addresses by the stack pointer register) before the jump occurs. A "return" is the reverse of a "call", in that the value on top of the stack is popped directly into the p.c. to form a jump address. The "call" and "return" allow for easy handling of subroutines and interrupts.

Input/output. The transfer of data between the microcomputer and the peripheral devices is accomplished via the c.p.u. 8-bit registers with the aid of

instructions from the i/o group. An eight-bit port address may be specified either as part of the instruction or as the contents of register C. Special block i/o instructions of the Z80 allow the transfer of complete blocks of data directly between an i/o port and memory with a single instruction similar to those for block memory moves.

Flags. Each of the two Z80 c.p.u. flag registers contains six bits of information which are set or reset by various c.p.u. operations. Four of these bits are testable; that is, they are used as conditions for jump, call or return instructions. For example, a jump may be desired only if a specific bit in the flag register is set. The four testable flag bits are:

1. *Carry flag (C).* This flag is the carry from the highest order bit of the accumulator. For example, the carry flag will be set during an add instruction where a carry from the highest bit of the accumulator is generated. This flag is also set if a borrow is generated during a subtract instruction. The shift and rotate instructions also affect this bit.
2. *Zero flag (Z).* This flag is set if the result of the operation loaded a zero into the accumulator. Otherwise it is reset.
3. *Sign flag (S).* This flag is intended to be used with signed numbers and is set if the result of the operation was negative. Since bit 7 represents the sign of the number (a negative number has a 1 in bit 7), this flag stores the state of bit 7 in the accumulator.
4. *Parity/overflow flag (P/V).* This dual purpose flag indicates the parity of the result in the accumulator when logical operations are performed, and it represents overflow when signed two's complement arithmetic operations are performed. The Z80 overflow flag indicates that the two's complement number in the accumulator is in error since it has exceeded the maximum possible (+127) or is less than the minimum possible (−128) number that can be represented in two's complement.

There are also two non-testable bits in the flag register. Both of these are used for b.c.d. arithmetic. The "half carry" (H) flag is the b.c.d. carry or borrow from the least significant four bits of the a.l.u. This is examined by the Z80's special "decimal adjust accumulator" instruction used when performing decimal arithmetic. The "subtract flag" (N) is also used by the decimal adjust instruction to indicate if the previous arithmetic instruction was an addition or subtraction.

The flag register can be accessed by the programmer and has the following format:

S	Z		H		P/V	N	C

Interrupt response. The purpose of an interrupt is to allow peripheral devices to suspend c.p.u. operation in an orderly manner and force the c.p.u. to start a peripheral service routine. Usually this routine is involved with the exchange of data or status and control information, between the c.p.u. and the peripheral. Once the service routine is completed, the c.p.u. returns to the operation from which it was interrupted.

The Z80 has two interrupt inputs, a software maskable interrupt and a non-maskable interrupt. The non-maskable interrupt (n.m.i.) cannot be disabled by the programmer and it will be accepted whenever requested by a peripheral device. This interrupt is generally reserved for very important functions that must be serviced whenever they occur, such as impending power failure. When the Z80 receives a non-maskable interrupt it performs an automatic subroutine call to a predetermined memory address (0066 hex).

The maskable interrupt (INT) can be selectively enabled and disabled by the programmer. This allows the programmer to disable the interrupts during periods where his programme has timing constraints that do not allow it to be interrupted. The Z80 can be programmed to respond to maskable interrupts in any one of three possible modes.

Since the Z80 was evolved from the 8080A microprocessor, i.e. the 8080A's instruction set and internal register organisation is a sub-set of the Z80's, one of the Z80's interrupt modes is identical to that of the 8080A. In this mode, when the c.p.u. acknowledges an interrupt, it expects some external hardware to supply an instruction to the data bus. The c.p.u. then executes this (usually a jump or call) rather than getting the next instruction from the programme memory. This means that an 8080A can easily be replaced by a Z80 in a system without necessarily modifying the interrupt system, especially as 8080A programmes are upward compatible, at the binary machine code level, with the larger Z80 instruction set.

For simple interrupt requirements the second mode of Z80 interrupt response is quite attractive. In this mode, whenever an interrupt is accepted the c.p.u. performs an automatic subroutine call to a predetermined address (0038 hex).

The third mode of Z80 interrupt response is the most powerful. In this mode the interrupting device is required to identify itself by supplying an 8-bit number (vector) to the c.p.u. when the interrupt is acknowledged. (Note that the Z80 activates both $\overline{M1}$ and $\overline{IORQ}$ simultaneously to signify an interrupt acknowledge cycle.)

With this mode the programmer maintains a table of 16-bit starting addresses – one for every interrupt service routine. The table may be located anywhere in memory. When an interrupt is accepted, a 16-bit pointer must be formed to obtain the desired interrupt service routine starting address from the table. The upper eight bits of this pointer are formed from the contents of the c.p.u.'s I register, which must have been previously set up by the programmer. The lower eight bits of the pointer are supplied by the interrupting device. Using the pointer to the table, and the table contents, an indirect call can be made to any memory location. This is illustrated diagrammatically in Fig. 6. All of the devices in the Z80 peripheral family are designed to operate in this mode of interrupt response. The programmer is able to specify a unique 8-bit interrupt vector to each peripheral, which it supplies to the c.p.u. during interrupt acknowledge. Interrupt priority is established by a "daisy-chain" connection through the peripheral devices.

References

1. The Zilog Z80/Z80A c.p.u. Technical Manual.
2. The Zilog Z80 Assembly Language Programming Manual.

Later this year we hope to publish a complete constructional design for a scientific computer using the Z80 m.p.u. as a processor.

WW diary overseas

The publishers of the Wireless World diary, T. J. & J. Smith of London SW19, do not supply direct to the public. If you want a copy you will have to get a bookseller, such as W. H. Smith, to order through the trade. If you live abroad from the UK, *Wireless World* can supply you. Send £1.50 to WW Diary, Room 25, Dorset House, Stamford Street, London SE1 9LU. The latest edition includes new sections on standard frequency transmissions, time code transmissions, UK broadcasting stations, and enlarges the address and telephone number section for electronics organisations by 75%.

Microelectronics design

Designing with single-chip microcomputers is the subject of one of the papers to be presented at the Microsystems '79 conference and exhibition this year, January 31 to February 2. Other topics covered are bubble memories, microprocessor interfacing, architecture of 16-bit processors, high level languages and costing m.p.u. software. The event will be at the West Centre Hotel, Lille Road, London SW6 from 09.30 to 18.00 hours each day. Conference details from IPC Science and Technology Press Ltd, Westbury House, Bury Street, Guildford, Surrey GU2 5AW (Tel: 0483 31261). Exhibition details from Iliffe Promotions Ltd, Dorset House, Stamford Street, London SE1 9LU (tel: 01-261 8000).

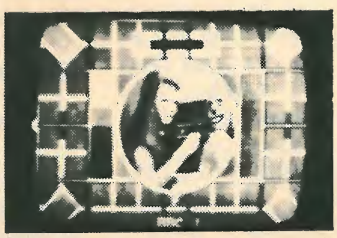
NEW PRODUCTS

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

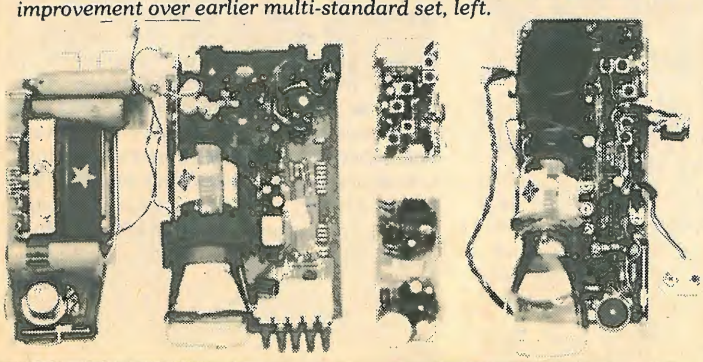
Microvision redesigned as competition looms

"Is it worth watching"? is the question most often asked about the Sinclair Microvision. Certainly there is enough brightness and contrast in its picture for comfortable viewing, though for outdoor use the screen needs shielding. Sinclair make no claims about spot size being reduced in proportion to screen size for their latest version of the Microvision, though a press release did suggest that the picture is "as bright *and sharp* as that of a full-sized household set viewed from around 15 feet" no doubt due to response peaking. Two months earlier, Sinclair had released details of a video monitor, based on the Microvision, which claimed a resolution of 325 lines.

First announced in January 1977, following what Sinclair called a 12-year half-million pound program (News, March 1977 issue), the Microvision type 1A was marketed later that year after a further NEB loan capital injection of £1.95 million in July, bringing the NEB holding to 73.3% from 43% and under an NEB appointed managing director. Now, nearly two years later, Sinclair say they have spent a further £1 million on Microvision and what emerges is the 1B, a UK-standard set priced at about £100, much lighter at 550 grams than the original, with half the number of components, only two knobs to twiddle, and one main printed circuit board (instead of four) laid out for automatic assembly – though not yet made that way. Integrated circuits – three are made specially for Sinclair by Texas because of the low supply voltage of 6V – are down from five to four. "Most normal detector i.cs take as much as the tv itself!" Sinclair point out. Printed inductors allow a much simpler tuner design. Encased in an ABS rather than the steel box of the 1A the set is remarkably tolerant of being held, and in areas of good signal strength will work happily without an aerial.



Re-designed Sinclair TV receiver, above and below right, is big improvement over earlier multi-standard set, left.



The set seems well-positioned to withstand onslaught from Japanese competition, expected from Matsushita in spring (at £150 and "not a pocket set" according to Sinclair). What seems odd is that after spending all this money in developing a set specifically with a small picture, Sinclair then exaggerate its picture size, referring to its "2in screen"! The picture is actually 46mm diagonally. Sinclair Radionics Ltd, London Road, St Ives, Huntingdon, Cambs, PE17 4HJ.

WW 301

Oven timer premature?

Asked why their microprocessor oven timer didn't have a facility for programming more than one temperature, General Instrument Microelectronics told us that wasn't what the customer wanted. "We could have put all the bells and whistles on we could think of," a spokesman said, "but we had a pressing market slot to fill." The customer, a large U.K. oven manufacturer (you'll only need to scan makers blurbs to find out which), appeared to want to get into the market quickly with a novelty, rather than to wait and do the job properly. But it would seem to be only a matter of a short time before the job is done properly — possibly by a competitor. Pity the poor oven buyer.

But General Instruments conscience is no doubt relieved by the more general applications of the device. The 28-lead four-bit microprocessor accepts instructions from keys which increment or cycle the display, depending on how long they are depressed. The 28-pin AY-3-1250 links to a four-digit display indicating any function selected and has three outputs for which on and off times can be programmed. Facilities include 12/24 hour operation, a "minute minder" and temperature setting. The 40-pin AY-3-1251 has data entry through a 10 × 4 keyboard and displays the "minute minder," oven temperature, on/off time and hot plate temperature permanently in a total of 14 digits.

In case you're worried about mains failure a standby battery automatically takes over and a 200kHz oscillator takes over timing. GIM's address in the U.K. is 1 Warwick Street, London W1R 5WB.

WW 302

Radio 4 converter for m.w. sets

Ambitune is the name given to a neat and simple long-wave converter for medium-wave sets, which will be invaluable to Radio 4 listeners, come November 23. The converter measures 9cm square by 2.5cm thick and sits beside or beneath a m.w. set, inserting the up-converted

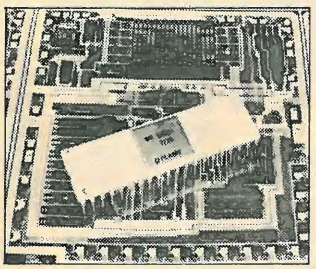
"200kHz" signal at around 900kHz via a ferrite rod aerial assembly. The oscillator circuit is designed for operation down to 2 to 3 volts, and the makers say that a 9-volt manganese alkaline battery (as supplied) will last for 700 to 900 hours. Tuned circuits are alterable. Price is £6 including battery, v.a.t. and postage. Ambit International, 2 Gresham Road, Brentwood, Essex.

WW 303

16bit microcomputer = minicomputer cpu

"A complete minicomputer control processor in one 40-pin package" is how Fairchild describe their 9440 Microflame product. The 9440, whose intrinsic memory capability is 32,768 16-

bit words, is said to bring full minicomputer capability to microprocessors, in distributed processing, process control, telecommunications and personal computers. The device, together with t.t.l. memories, combines Fairchild's Isoplanar oxide-isolation technique with integrated injection logic "to enhance both speed and density". Thomas Longo, chief technical officer, explained "These devices can achieve switching speeds comparable with low-power Schottky t.t.l. and packing densities up to 250 gates/mm^2". Ad-



ditional i.s.i. circuits include a 48-pin 9441 for controlling external memories and a 9442 circuit to expand the input/output bus for interfacing. Microflame forms part of two microcomputers – Spark-16 and Blaze-16 – and a Fire package includes programs ranging from simple loaders to Fortran compilers. Future improvements in density and performance are expected to expand the range of applications. Fairchild Camera & Instrument (UK) Ltd, 230 High Street, Potters Bar, Herts EN6 5BU.

WW 304

Wattmeter takes 20 times overload

Clive Green says he made the mistake of not having a development contract for the work his company did on the model 2601 power meter. He spent £10,000 on the strength of the MoD saying they needed 50 and in the end only buying 12: "one took the word of a major in the British Army." But he's got high hopes anyway for the meter, as it extends from d.c. to 520MHz and up to 300 watts for 5 minutes in 30 (50 watts continuously). "There's nothing else indicating true r.m.s. that covers that range of power and frequency." And other r.f. wattmeters overload too easily, he argues. His oil-cooled load will absorb 1000 watts for a few seconds. Accuracy depends on frequency and range but is within 3 ±1.5% f.s.d. using a calibration from Green Electronic & Communication Equipment Ltd, Newnham Industrial Estate, Plymouth PL7 4LU.

WW 305

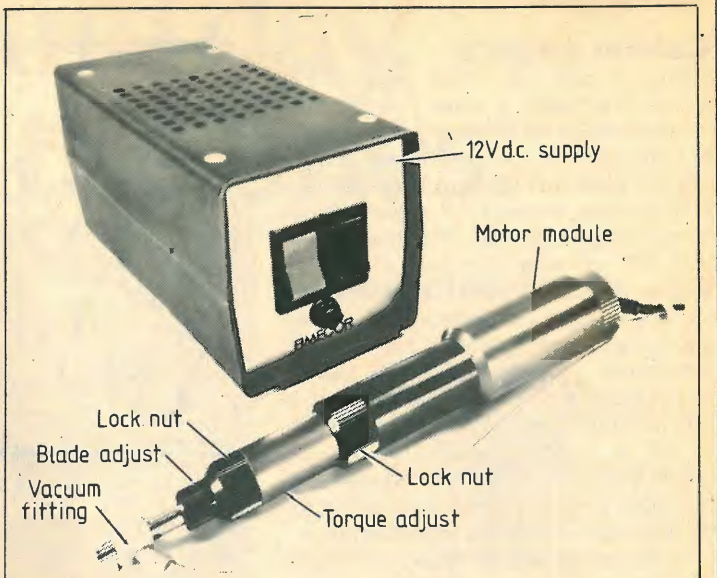
Electric screwdrivers are modular

A kilopond is a non-SI unit used in some European countries for kilogram-force, equal to 2.2lbf or 9.8 newtons. Perhaps you already knew, but it's used in describing torque values in a range of electric screwdrivers recently introduced into the U.K. from Switzerland. There are two *Fimecor* ranges, one covering torque values up to 0.35kpcm (550 series), and the other – more versatile (220 series) with interchangeable modules – having torque values up to 12kpcm (pictured).

Torque variation is between 2 and 3-to-1 for the four members of the 220 series, and as well as the torque modules, the motor module and screw-holding sleeve are interchangeable. Screws are held by suction in one of about 40 different sizes of sleeve and driven, in either direction, by blades of the "Phillips" type, hexagonal "allen" type (male and female), or one of a variety of slot types. A spare motor comes with each screwdriver and accessories include foot-operated switches, adjustable suspension and vacuum pumps.

The 550 series are smaller, lighter in weight and combine the vacuum pipe with electric supply, resting on a pressure switch in the power supply housing when not in use. One model in the series has speed variable from 400 to 900 rev/min; the rest are fixed at 600 rev/min. Made by SSIH Equipment SA of Bienne – previously known as Fine Mecanique SA – they are imported by SSIH Equipment (UK) Ltd at 67 Saffron Hill, London EC1N 8RS.

WW 306 series 220
WW 307 series 550



WW 306

555 in cmos

Intersil's new c.m.o.s. equivalent of the 555 timer was developed "behind the company's back," according to Geoff Coole, N. European sales manager. Initially turned down at Intersil, the idea for a c.m.o.s. 555 was nevertheless pursued as a "back-of-an-envelope" design, later to surface unofficially as part of a test pattern on a wafer production line. Thus when priorities had altered and a need for the device eventually recognised, it had already been developed.

The need, of course, stems from the high current consumption of the bipolar 555. The new circuit requires a supply rating of 80μA – less than one twentieth of that for the bipolar version – and it will operate for 3,750h from two 300mAh cells. The metal-gate m.o.s. process gives the device a working range of 2 to 18V (the bipolar 555 needs at least 4.5V). And because there is no problem of spike generation due to "crowbar" currents in the output driver of the bipolar devices the control and supply voltage decoupling capacitors are not required to eliminate the supply transients. Prices are higher than the bipolar type, so it's not competing with currently-supplied 555s. Small in-line single timers cost 56 pence in quantities of a hundred (71 pence TO99) and dual timers cost £1.08. Intersil Inc., 8 Tessa Road, Richfield Estate, Reading, Berks RG1 8ND.

WW 308

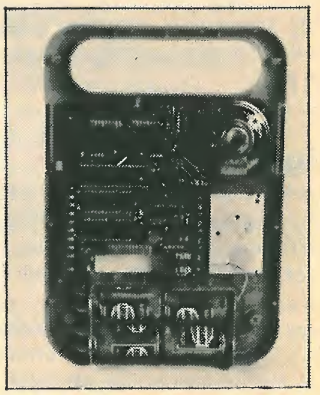
Smoke clouds i.c. choice

Shortly after RCA announced its smoke detector i.c. TA10451, which integrates f.e.t.-input with gate protection and subsequent bipolar amplification, National Semiconductor sounded off about theirs. Both requiring an ionization chamber, the National device LM1801 also requires an f.e.t. sensing element — the NS5301 is sold with the i.c. for "$1 per set" in large volumes. National feel their bipolar-only approach is more cost-effective and their i.c. includes a power transistor capable of producing 85dB in a horn. Both have a standby current around 7 to 8μA. RCA Solid State, Sunbury-on-Thames, Middlesex TW16 7HW and National Semiconductor Ltd, 301 Harper Centre, Horne Lane, Bedford MK40 1TR.

WW 309 (RCA)
WW 310 (NS)

Inexpensive speech synthesis

Speak & Spell is Texas Instruments talking learning aid for seven-year-olds and upwards. It uses a speech synthesis circuit together with two 128K r.o.ms, each with 100 seconds of speech storage capacity, and a version of the TMS 1000 microprocessor. Based on linear predictive coding, the key to the system is the ability to squeeze a multi-stage filter onto the synthesizer chip. A periodic or random sequence of pulses, for voiced/unvoiced sounds, is applied to a ten-stage time-varying digital lattice filter modelling the vocal tract, via an amplitude modulator, and then to an 8-bit d-to-a converter, amplifier and loud-



speaker. Filter coefficients are usually up dated every 20ms, a rate that results in speech of good quality and with reasonable r.o.m. demands. (Increasing this rate would model the vocal tract more closely but would need increased storage.) Texas say a UK version will be available soon but if you can't wait Dixons and Wallace Heaton shops stock the U.S. model.

WW 311

SIDEBANDS by Mixer

Caveat emptor

I suppose any law which can't be enforced is a waste of time. Police radio, for instance, is for the police force and is not intended for those who have missed LBC on their way up from Capital Radio and become hooked on reports from bored coppers passing the time of day with MP, or whatever it is. If you do happen on one of these intimate little chats, you are supposed to blush primly and tune somewhere else. No one will prosecute you, even if your guilty secret is discovered, because the radio is not permanently and deliberately fix-tuned to the police frequency and, unless you have just liberated two million quid from the bank, you don't intend to make use of the information.

Working on this premise, a firm in Surrey is marketing an American device which is broadly tuned to cover much of the X and K bands which, it is pointed out, covers several radar frequencies and also, just as a matter of passing interest, the frequency used in police radio speed indicators. The publicity says that this is all right provided that you switch off the instant you become aware that you are in a beam. You mustn't, of course, slow down to a legal speed, because that would make use of the restricted information.

If, then, as the distributors themselves point out, you mustn't listen and if accidentally you do, you mustn't take any action as a result, then the whole operation tends to lose its point. One cannot say there is an incitement to break the law, but since, to use the device, you have to break the law, I think that sales of the instrument should be stopped. You will notice that I haven't mentioned its name: I have no intention of advertising a device which so blatantly flouts the spirit and possibly the letter of a law which is intended to stop us killing each other on the road.

Sight and sound

More in sorrow than in anger, Jim Palm, editor of the radio programme 'Rail', writes to tell me that if I were trusting enough to travel by train occasionally (actually, they aren't his exact words — he's a rail enthusiast — but I'm writing this) I would discover that v.d.us are in use at some stations and even in the National Railway Museum restaurant in York.

Well, I'm delighted to hear about the station installations, but I must confess to a feeling of unreality about the restaurant. I do realize that the sort of place I frequent isn't to everyone's taste, but if I peer through the tobacco smoke long enough, I find I can easily read the menu on the black board (it used to be white, but Filthy Fred the owner is sometimes a bit lax about washing his hands after scooping the chips off the floor). Anyway, it does show that things can be done properly if British Rail only puts its mind to it. I mean, v.d.us in the local caff would save all that yelling back to the kitchen "Adam an' Eve on a raft, twice". Each customer could have a terminal and simply punch out his order, with the absolute minimum of fuss and no hint of embarrassment if he just wanted Two Meat Balls.

Infinite bafflement

It'll soon be Christmas. Actually, as you read this, assuming anyone ever does, it has lately been Christmas, but it's still early November here. I thought that, this year, I would capitulate gracefully and buy my daughter a decent record player and radio. So I began negotiations with her in good time and took great care to explain all the jargon for her, recommending the features that were essential and going fully into all aspects of tracking weight, rumble, tuner sensitivity and power output, with particular reference to quality of reproduction and reliability. Having covered the field in some detail, and being conscious of a job well done, I lobbed the ball into her court and asked which one she would like. She pondered for a long moment and said "Can I have a white one, please?". Well, that's women for you.

I have no reason to think that this point of view is uncommon. Lots of people must want something that produces a pleasant sound and will not lose a second's sleep if the t.h.d. is 0.01% or a hundred times worse. The music centres offered to the public now are, in my opinion at least, technology gone mad. A non-technical user who simply wants to hear some music is faced with what must be a truly forbidding array of knobs, toggles, lights and meters, many of which mean less than nothing to him and are not used. A neighbour of mine, for example, has labelled the Dolby on-off switch on his tape-deck "soft" and "harsh" and uses it as a tone-control. It also makes a good scratch filter, he says – meaning hiss, I suppose. What he uses the "Normal-FeCr-CrO_2" switch for, I hate to think.

I daresay that if people read the instruction books they eventually come to realize that their boxes of electronics are wonderful, but I doubt very much that they care a jot. And if I'm right, what a waste of resources! All this wizardry, completely and utterly useless, because unwanted. It was a lot cheaper to have aspidistras.

Decisions, decisions . . .

It seems, of late, that no sooner do I extricate myself from the horns of one dilemma – an extremely uncomfortable position to find onself in — than another comes trotting in the door, nostrils flaring and headgear rampant.

It's only a little problem, really, this latest one, but it is giving my thrifty northern soul a good deal to think about. I've just been promised a large set of records and I can't decide whether to have discs or cassettes. Now, you might think that if that's all I have to worry about there is any amount of more pressing matters you could mention, like what Yorkshire is going to do without Boycott as skipper, and how one can stop next door's dog from desecrating the clematis, but I do assure you that it looms large in my mind.

You see, I only have to glance in a cursory manner at a disc and it instantly becomes a mass of scratches. I have tried most of the products which are supposed to prevent this happening, but the only effect so far is a large stain on the carpet where I spilt a bottle of magic jollop, claimed to reduce static, but also excellent as varnish remover.

So, if I have discs, I daren't touch them. I suppose I could record them on cassettes, but I then have two recordings and the cost of cassettes isn't negligible. Alternatively, of course, I could choose recorded cassettes, but I don't think that reproduction from them, on any machine I can afford, is as fresh as from an undamaged disc. There you have it, then. Between the Devil and the deep blue sea. It's a worrying world we live in.

Night and day, these are the ones.

Darkness

EEV Ebsicon

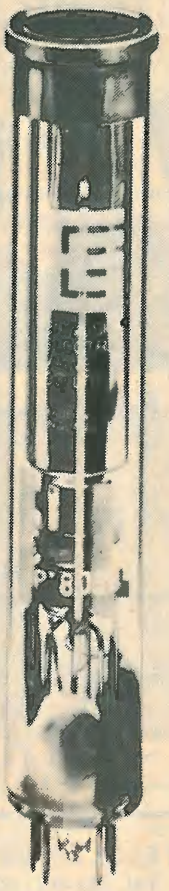
The CCTV photoconductive tube from EEV using the silicon intensifier target principle which extends sensitivity into very low-light ranges.
The Ebsicon makes CCTV operation possible in hitherto 'impossible' situations. TV reading of X-ray fluoroscopic images is a typical example.

Low-light levels

EEV Sidicon

Where conditions are moderately difficult EEV's new high sensitivity Sidicon is ideal. It is available in three quality grades, has excellent 'blooming' characteristics and precision silicon diode array target.

Normal light levels



EEV Vidicon

Unbeatable for reliability, the EEV Vidicon is electro-statically or magnetically focused, has separate or integral mesh and a range of photo-surfaces based on antimony trisulphide.

No matter what your working conditions are, contact us at Chelmsford to find out more.

EEV

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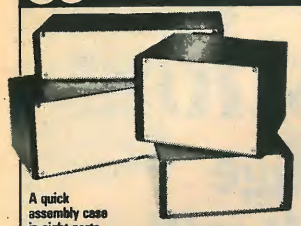
West Hyde have more than 600 different instrument cases in stock + accessories

WH MOD-4

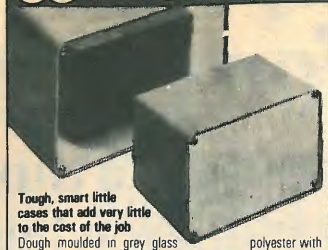


A quick assembly case in eight parts

A mass produced economy case in intensely shiny black or royal blue leather textured PVC steel with bright white steel panel. Eight pieces inc. aluminium chassis assembled with only eight screws.

	L	B	H			L	B	H	
401	178	152	76	**£4.99**	405	279	152	114	**£6.59**
402	178	152	114	**£5.35**	406	279	152	152	**£6.99**
403	178	152	152	**£5.69**	413	165	152	157	**£5.75**
404	279	152	76	**£5.99**	416	305	152	157	**£7.25**

WH CONTIL-ELF

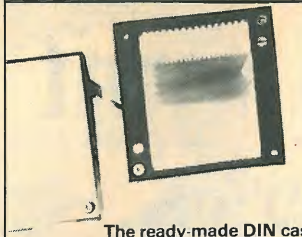


Tough, smart little cases that add very little to the cost of the job

Dough moulded in grey glass polyester with protected aluminium front panel in four sizes with feet and aluminium chassis included. The cases and chassis taper 10 mm from front to back.

	L	B	H	
Elf Long	153	101	101	**£4.50**
Elf Giant	228	76	101	**£5.95**
Elf Jumbo	203	127	138	**£6.75**
Elf	273	130	134	**£3.95**

WH CONTIL-DIN



The ready-made DIN case you have been waiting for

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

DIN 212	**£6.06**	DIN 215	**£7.56**	DIN 914	**£10.15**
DIN 213	**£6.57**	DIN 912	**£8.49**	DIN 915	**£10.96**
DIN 214	**£7.07**	DIN 913	**£9.33**		

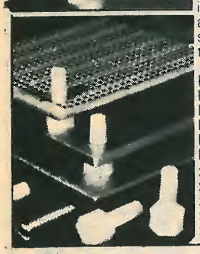
WH SWIFT

Swiftcase wins industrial design award at Hanover

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

	L	B	H	
SWF 212	432	268	88.9	**£21.75**
SWF 222	219	268	88.9	**£16.95**
SWF 312	432	268	133.4	**£25.65**
SWF 322	219	268	133.4	**£19.95**

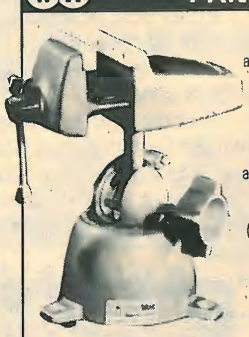
WH ILEX & SORREL



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

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

WH PANAVICE



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

300	**£10.53**
311	**£8.78**
303	**£8.58**
304	**£8.58** —vacuum base
366	**£8.78**
380	**£15.51**
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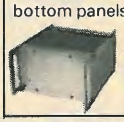
300 Standard base 10.53
311 Bench clamp 8.78
Jaws from £2.02 to £2.30

WH BRIGHTCASE

Adds sophistication to any equipment

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



	L	B	H	
BC2/121	432	268	89	**£28.95**
BC2/222	219	268	89	**£20.99**
BC3/121	432	268	133	**£31.95**
BC3/222	219	268	133	**£23.70**

WH CONTIL WOODEND

Leather textured PVC steel body with polished teak ends.

Two wooden ends and two tie bolts, result in a simple, light, inexpensive case. Ideal for Hi-Fi applications and domestic and office equipment.

	L	B	H	
WEC 801	202	240	80	**£14.50**
WEC 802	417	240	80	**£15.95**
WEC 803	550	240	80	**£17.25**

PRICES DO NOT INCLUDE 8% VAT

NOTE NEW PHONE NO. All West Hyde cases are available with substantial discounts for quantities. Most cases have discounts at 5, 10 and 25 off with discounts up to 33% at 100 off. Prices include P&P and are less 10% if collected on first two price breaks on cases only. Send for catalogue. Prices correct at press date.

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CA3039	70p	LM382	90p	SN76023N	110p	TBA750Q	200p
CA3046	60p	LM391	180p	SN76023ND		TBA800	80p
CA3060	225p	LM555	25p		125p	TBA810	100p
CA3065	200p	LM709C	40p	SN76033N	150p	TBA820	100p
CA3076	250p	LM710T05	60p	SN76227N	160p	TBA920Q	280p
CA3080	75p	LM710DIL	65p	SN76228N	180p	TCA270Q	220p
CA3084	250p	LM723T05	40p	SN76660N	75p	TCA270S	220p
CA3085	85p	LM723DIL	40p	TAA300	100p	TCA760	300p
CA3086	60p	LM733	120p	TAA350	190p	TCA4500A	450p
CA3088	190p	LM741	20p	TAA550	35p	TDA1008	350p
CA3089	160p	LM748	40p	TAA570	220p	TDA1034	450p
CA3090AQ	360p	LM1303N	100p	TAA661B	140p	TDA2002	300p
CA3123E	130p	LM1458	100p	TAA700	350p	TDA2020	300p
CA3130	100p	LM3080	75p	TAA790	350p	TL084	120p
CA3140	60p	LM3900	55p	TAD100	150p	XR320	250p
LF356	80p	LM3909N	65p	TAD110	130p	XR2206	450p
LF357	80p	MC1310P	140p	TBA120S	60p	XR2207	450p
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LM300TRS	170p	MC1314P	190p	TBA480Q	200p	XR2216	650p
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LM304	200p	MK50398	650p	TBA530Q	200p	XR4136	150p
LM307N	65p	MM5314	380p	TBA540	200p	XR4202	150p
LM308T05	100p	MM5316	480p	TBA550Q	250p	XR4212	150p
LM308DIL	100p	NE529K	150p	TBA560C	250p	XR4739	150p
LM309K	100p	NE555	25p	TBA641A12		ZN414	100p
LH310T05	150p	NE556	90p		250p	95H90	700p
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LM317K	325p	SAD1024	1500p				
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7404	12p	7440	12p	7486	25p	74132	45p	74161	55p	74188	320p
7405	12p	7441	45p	7489	130p	74135	90p	74162	55p	74190	70p
7406	25p	7442	40p	7490	25p	74136	80p	74163	55p	74191	70p
7407	25p	7443	60p	7491	40p	74137	90p	74164	60p	74192	60p
7408	12p	7444	60p	7492	35p	74138	100p	74165	60p	74193	60p
7409	12p	7445	65p	7493	30p	74141	50p	74166	75p	74194	55p
7410	12p	7446	50p	7494	70p	74142	180p	74167	160p	74195	50p
7411	15p	7447	50p	7495	45p	74143	270p	74170	100p	74196	50p
7412	15p	7448	50p	7496	45p	74144	270p	74173	80p	74197	50p
7413	25p	7450	12p	7497	120p	74145	55p	74174	60p	74198	100p
7414	45p	7451	12p	74100	80p	74147	100p	74175	60p	74199	100p
7416	25p	7453	12p	74104	40p	74148	90p	74176	50p	74293	90p
7417	25p	7454	12p	74105	40p	74150	65p	74177	50p	741500	18p
7420	12p	7460	12p	74107	25p	74151	45p	74178	75p	745112	80p
7421	20p	7470	25p	74108	100p	74153	45p	74179	120p		
7422	15p	7472	20p	74109	25p	74154	70p	74180	90p		
7423	20p	7473	25p	74118	75p						
7425	20p	7474	25p	74120	80p						
7426	22p	7475	25p	74121	25p						
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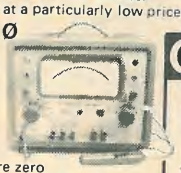

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Ideal M.P.U. system etc. overall dimensions of 12½" H x 16¾" D x 17½" W. New and boxed. **£10.75** P.P. £2-25

THIS MONTHS SNIP MOS ROM CHARACTER GENERATORS

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, This item cannot be repeated. Hurry while stocks last. brand new at only **£7.25** P+P 30p.

C90 Audio Cassettes screw type construction 40p each 3 for £1-00.
Miniature Tantalum Beads 10mf 25v and 33mf 16v 14p each 10 for £1-00
Scotch 215 Long Play Tape Brand new ¼" low noise on 1200' 5½" spools £1-50 each 4 for £5-00 + P.P. 45p.
1000 Watt fully shrouded **auto transformers** term. block connections £13-75 + P.P. £2-25 *.
Bulbs 24v 14 watt white frosted S.B.C. 8 for £1-00.
S.B.C. Bulb Holders All steel cad plated panel mount easily fixed via nut and round hole. Ideal disco displays, scoreboards etc. 4 for £1-00.
Xtal filters S.E.1. QC1121t/B miniature low insertion loss P.C. mount. C.F. 10.7 mhz with B.W of 7.5 khz. 2000Ω imp. in-out Brand new at £7-50.
Heavy Duty Flat Insulated Earth Braid 80-100 amp braided tinned copper in heavy clear P.V.C. sheath 40p per metre £5-00 for 15 metres P.P. 8p per metre.
BULGIN miniature 6 way male chassis mount socket and matching shrouded free plug. 60p each 2 for £1-00.
Red L.E.D.'s full spec. 0.2" 12p each 10 for £1-00.
Dynamic Stick Mics 600Ω with built in on/off switch complete with lead and min. jack plug £1-00 each
TO5 HEATSINKS "Thermaloy" black anodised press on aluminium finned type. 15p each 10 for £1-00.
HARDWARE PACK Don't be stuck for the right nut and bolt for the job. Pack contains B.A. Metric, Unified, Self Tap. etc. nuts, bolts, screws, washers, etc. in brass bronze and steel. All steel items plated. Average contents 400-600 pieces, sold by weight, 2-lb bag **£2.50**

ILLUMINATED SWITCHBANKS

10 WAY MOMENTORY

Features 10 individual feather light pushswitches, each with 1 n/o and 1 n/c gold wiping contact. Each switch has integral replaceable bulb and removeable lens cap which may be split for engraving etc. Switch dimensions 19 x 19 x 90mm. Easily split for single use. Undoubtably the most attractive switch you will ever see. Original cost over £15 00 per bank! Ideal M.P.U. keyboards etc. **£3.00** PP45p

8 WAY INDEPENDENT PUSH ON — PUSH OFF

Features 8 way switch assembly, each switch with 2 c/o gold wiping contacts and replaceable bulb, complete with orange 12.5x12.6mm button and lens cap. P.C. mount 0.1" spacing Same as R.S. type costing over £12 per bank! **£2.75** p.p. 35p

ELECTRONIC COMPONENTS & EQUIPMENT 66% DISCOUNT

Due to our massive bulk purchasing programme which enables us to bring you the best possible bargains, we have thousands of I.C.'s Transistors, Relays, Cap's., P.C.B.'s, Sub-assemblies, Switches, etc. etc. surplus to our requirements. Because we don't have sufficient stocks of any one item to include in our ads., we are packing all these items into the "BARGAIN PARCEL OF A LIFETIME" Thousands of components at giveaway prices! Guaranteed to be worth at least *3 times* what you pay plus we always include something from our ads. for unbeatable value!! Sold by weight

7lb £ 4-75 **14lb £ 7-50**
28lb £12-75 **56lb £21-00**
112lb £34-00 P.P. £1-00

MANY HUNDREDS OF TRANSFORMERS IN STOCK — SEND SAE FOR LIST

DIODES · DIODES ·

1N4148-1N914-types etc. mixed and untested 1000+ bag £1-50 P.P. 40p. Buy some for a friend!

CRYSTALS

Frequency	Case	
100 KHZ	B7G	£2-25
250 KHZ	B7G	£2-25
2.50 MHZ	B7G	£2-25
5.00 MHZ	HC6/U	£2-00
8.00 MHZ	HC6/U	£2-00

Standard U.A.R.T. Xtal 38.40 KHZ for 2400,1200 baud etc. £2.75*

Where cost of post and packing not indicated please add 25p per order Collection saves cost of postage but if collecting please telephone to check availability.

We are always interested in buying P.C.B.'s surplus components, test equipment, valves, etc. Phone for details

Top Grade MULLARD+PLESSY CAPS

Ultra low ripple 10 amp. smoothing
1500 mf 100v Screw Term. ____ 50p*
3300 mf 63v Screw Term. ____ 60p*
5000 mf 30v Solder Tag ____ 60p
*ex equipment but tested

REGULATOR SCOOP

LM309K +5 volt 1.2 amp TO3 package **or** MC7812CK +12 volt 1.2 amp TO3 package

£1-00 each
6 for **£5-00**

Black anodised finned Heatsink ready drilled for 1 TO3 65p each ideal for use with above.

MOTOROLA Complimentary MOS FETS
2N4351 N CHANNEL
2N4352 P CHANNEL
* low feedback capacitance
* ideal enhancement mode
* 95p each £1-50 per pair

QSL ELECTRONICS

103 Tamworth Road Croydon CR9 1SG 01 688 1833

All prices inclusive of V.A.T. Cash with order. Minimum order value £1.00. Postage quoted for UK only. Export and trade enquiries welcome. Orders despatched same day where possible. Callers welcome, but by appointment please.

HIGH EFFICIENCY SMITHS RADIAL BLOWERS

Are your hot parts sweltering? Then keep them cool with our high efficiency radial snail type blowers. Made by Smiths, designed for continuous use in expensive electronic equipment very powerful and quiet, gives massive air flow to prolong component life and reliability. Easily mounted, air aperture 2½" x 3" supplied complete with fixing bolts. Ideal linears etc. Please state 240v or 110v operation. 50hz only. BRAND NEW **£4.25** P.P. £1-10

NEW PRODUCT BULLETIN

ITA

ORBAN from USA

Dual channel multispring reverb unit. Each channel features four springs — far smoother than single spring systems. "Twang" and "boing" are virtually eliminated by incorporating a floating threshold limiter. Bass, mid-range EQ and bandwidth controls. The best compact reverb unit available.

ITAM 882

New Stereo Mixer, built to a specification not a price! Ultra low noise, —128dB. 8 inputs+8 direct outputs, 2 outputs with VU meters. 2 limiters. XLR mic inputs (balanced). 3 band EQ + mid sweep.
£395+VAT

ITAM Graphic Equalizer

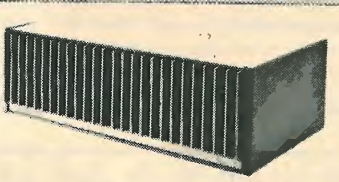
A fully professional graphic equalizer at a reasonable price. Stereo, with 10 bands per channel, 19 inch rack mounting. £280 + VAT.

AMPEX ATR-700

Now every studio can afford legendary Ampex performance and reliability. Fully professional specification including balanced inputs/outputs, Cannon connectors, variable tape speed, sel sync. The price will fit this year's budget, not next year's! Sole distribution by ITA.

OTARI DP4050 OCF IN CASSETTE DUPLICATOR

Now with 3¾ + 7½ master capability and Ferrite heads. Duplicates 6 cassettes each run at 8 times speed. Over 80 stereo C60 per hour. Unquestionably the finest in cassette copier available from the world's largest duplicator manufacturer.



QUAD

The new 405 power amplifier is now in stock. 100 watts per channel — simply the best, for £££'s less! Immediate Delivery!

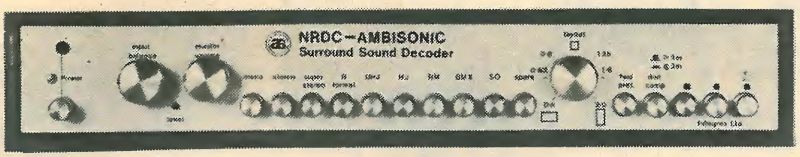
ITA

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

FRANCE. Son Professionnel, 2 Rue des Tennerolles, 92210 Saint Cloud (Paris). Tel 602 6815.

WW—103 FOR FURTHER DETAILS

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

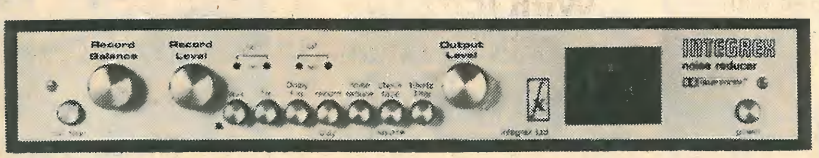
50 watts rms-channel. 0.015% THD. S/N 90 dB, Mags/n 80 dB.

Tone cancel switch. 2 tape monitor switches.

Complete kit only **£63.90 + VAT.**

Wireless World Dolby™ noise reducer

Trademark of Dolby Laboratories Inc.



Featuring:

- switching for both encoding (low-level h.f. compression) and decoding
- a switchable f.m. stereo multiplex and bias filter.
- provision for decoding Dolby f.m. radio transmissions (as in USA).
- no equipment needed for alignment.
- suitability for both open-reel and cassette tape machines.
- check tape switch for encoded monitoring in three-head machines.

Typical performance
Noise reduction better than 9dB weighted.
Clipping level 16.5dB above Dolby level (measured at 1% third harmonic content)

Harmonic distortion 0.1% at Dolby level typically 0.05% over most of band, rising to a maximum of 0.12%

Signal-to-noise ratio: 75dB (20Hz to 20kHz, signal at Dolby level) at Monitor output

Dynamic Range >90db

30mV sensitivity.

Complete Kit **PRICE: £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?

Buy it with Access
EUROCARD
BARCLAYCARD
master charge

Please send SAE for complete lists and specifications

INTEGREX LTD.

Portwood Industrial Estate, Church Gresley,
Burton-on-Trent, Staffs DE11 9PT
Burton-on-Trent (0283) 215432 Telex 377106

INTEGREX

S-2020TA STEREO TUNER/AMPLIFIER KIT

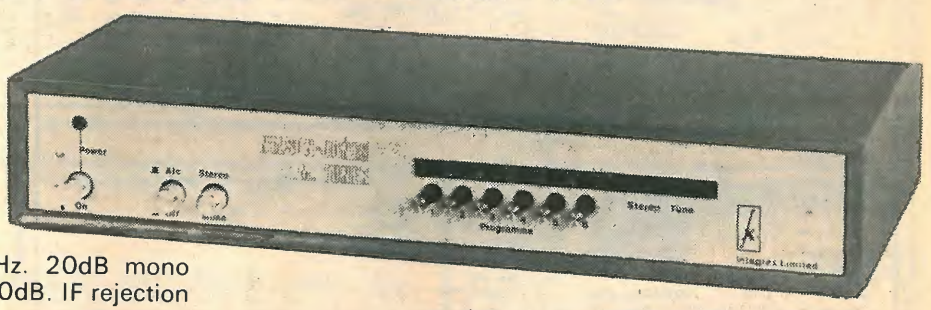
SOLID MAHOGANY CABINET

A high-quality push-button FM Varicap Stereo Tuner combined with a 24W r.m.s. per channel Stereo Amplifier.

Brief Spec. Amplifier Low field Toroidal transformer, Mag, input, Tape In/Out facility (for noise reduction unit, etc.), THD less than 0.1% at 20W into 8 ohms. Power on/off FET transient protection. All sockets, fuses, etc., are PC mounted for ease of assembly. Tuner section uses 3302 FET module requiring no RF alignment, ceramic IF, INTERSTATION MUTE, and phase-locked IC stereo decoder. LED tuning and stereo indicators. Tuning range 88—104MHz. 30dB mono S/N @ 1.2μV. THD 0.3%. Pre-decoder 'birdy' filter. **PRICE: £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.

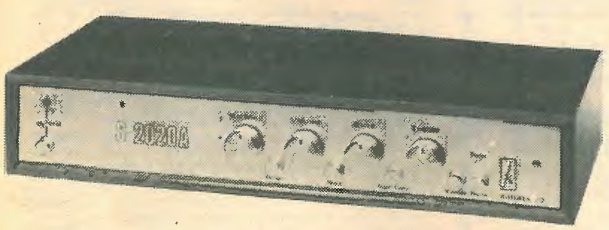
Mono £36.40 + VAT
With ICPL Decoder £40.67 + VAT
With Portus-Haywood Decoder £44.20 + VAT

Sens. 30dB S/N mono @ 1.2μV
THD typically 0.3%
Tuning range 88—104MHz
LED sig. strength and stereo indicator

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

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

High quality audio accessories

AL120 50W R.M.S.

AUDIO AMPLIFIER (With integral heat sink and short-circuit protection).

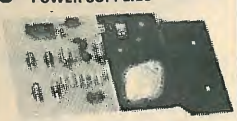
£11.95 + 8% VAT P&P 35p

OUTPUT POWER	50 Watts R.M.S.
SUPPLY	70 Watts
LOAD IMPEDANCE	8-16 Ohms
TOTAL HARMONIC DISTORTION	05% Max. (typically 02%).
FREQUENCY RESPONSE ± 1dB	25Hz-20kHz
SENSITIVITY	500mV
MAX HEAT SINK TEMP.	45 deg. C
DIMENSIONS	192×89×49mm

Introduced to fulfil the demand for a fully protected power amp. capable of driving high quality speaker systems at up to 50W, with distortion levels below 05%. Ideal for domestic use, discos, p.a. systems, electronic organs, etc. The generously rated components ensure continuous operation at high output levels.

SPM120 STABILISED POWER SUPPLIES

SPM120/45
SMP120/55
SMP120/65



£5.80 + 12½% VAT. P&P 35p.

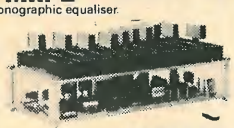
NEW

A.C. INPUTS	
SPM120/45	40-48V
SPM120/55	50-55V
SPM120/65	60-65V
OUTPUT CURRENT	2.5A
RIPPLE	1A 100mV
	2A 150mV

SPM120 is a fixed voltage stabiliser available with an output voltage of either 45V, 55V or 65V. Designed primarily for use in audio applications, the stabiliser which provides output currents up to 2.5A, operates direct from a mains transformer requiring only the addition of 2 Electrolytic capacitors to complete the s/c protection.

GE100 Mk. 2

10 Channel monographic equaliser.



£20.00 +12½% VAT P&P 35p.

NEW

CONTROL RANGE	±12dB
DYNAMIC RANGE	110dB
MAXIMUM OUTPUT	+15dB
FREQUENCY RESPONSE	30Hz-20kHz (±1dB)
POWER SUPPLY	15-0-15V
VOLTAGE HANDLING INPUT	3V R.M.S.
T.H.D.	005%

Only 155mm×65mm×50mm including the 10×10K lin slider potentiometers and knobs which are mounted on a board positioned above the circuitry. In the frequency range of 31Hz to 20kHz you can cut and boost ±12dB with the 10 sliders, each of which has its frequency marked on the circuit board. The GE100 has numerous uses including mixers, p.a. systems and discos. It will also greatly improve the sound reproduction of your existing audio equipment. Power supply for GE100, o/d SG30 £3.80.

VPS30

Regulated variable stabilised power supply

£7.60 +8% VAT. P&P 35p.

A.C. INPUT MAXIMUM	25V
VOLTAGE REGULATION	2-30V
REGULATED CURRENT	0-2A
Incorporating short circuit protection	

This NEW versatile Regulated Variable Stabilised Power Supply with short circuit protection and current limiting, is a must for all electronics enthusiasts. It incorporates adjustable voltage from 2V-30V, with a current limiting range of 0-2A. With this module there is no need to build a separate power supply for each of your projects, with the simple addition of a transformer (o/d 2033), 0-1mA (o/d 1310 or 1305), plus a suitable shunt, a voltmeter (o/d 1311 or 1306), a 470ohm pot (o/d 1896), a 4K7 pot (o/d 1899), it can be used again and again as a self-contained bench, power supply, eliminating the use of batteries and thus saving ££'s!

PA200

STEREO PRE-AMPLIFIER

£16.55 +12½% VAT. P&P 40p.

FREQUENCY RESPONSE		20 Hz to 20 kHz×1dB
TOTAL HARMONIC DISTORTION		Less than .1% (typically .07%)
SENSITIVITY INPUTS	1. TAPE	100mV/100K ohms } For an
	2. RADIO TUNER	100mV/100K ohms } output
	3. MAGNETIC P.U.	3.5 mV/50 K ohms } 500 mV
EQUALISATION		Within ±1dB from 20Hz to 20kHz
BASS CONTROL RANGE		±15dBs at 75Hz
TREBLE CONTROL RANGE		+10-20dBs at 15kHz
SIGNAL/NOISE RATIO		Better than 65dBs (all inputs)
INPUT OVERLOAD		Better than 26dBs (all inputs)
SUPPLY		35 to 75V
DIMENSIONS		300×90×33mm (less controls)

The PA200 is basically our popular PA100. Modifications have been made to make it compatible with the higher output AL120 and AL250 amplifiers.

HEADPHONES

A top quality headphone with cushioned earpads and headband. Separate balance/volume controls. Stereo or mono switch. Impedance: 8ohms. Frequency: 30-18,000Hz. o/n 884. **£8.70** +12½% VAT. P&P 70p.

A brilliant compromise between price and performance. Superb stereo reproduction for the newcomer to Hi-Fi. Impedance 8ohms. Frequency: 30-15,000Hz. o/n 885. **£4.40** +12½% VAT. P&P 50p.

BIB HI-FI ACCESSORIES

Parallel Tracking GROOV KLEEN
The very latest in automatic record cleaning. Designed to suit all modern single play decks. Simple to fit, it is extremely efficient. Complete with two types of base and three height extensions. o/n 8101. **£3.68** +8% VAT. P&P 35p.

Cassette Tape Editing Kit
Enables cassette tapes to be edited and joined easily, quickly and accurately. Kit comprises: Tape Splicer ⅛" (3.2mm), 2 Precision Tape Cutters, Tape Piercer, 9 Self-adhesive Labels, Reel of Splicing Tape, 3 Winders and removers and instructions, all in a handy wallet. o/n 811. **£2.40** +8% VAT. P&P 35p.

GROOV-STAT
The BIB Groov-Stat static reducer neutralises the static charge on records and other plastic surfaces. o/n 8103. **£5.45** +8% VAT. P&P 35p.

Cassette Head Cleaner
Essential for cleaning of tape heads, capstans and rollers. Pack contains Tape Head Applicator and tape head polisher tools. Plus bottle of special formula cleaning fluid and full instructions. o/n 832. **£0.56** +12½% VAT. P&P 35p.

ADAPTORS

AC-DC enables a large range of battery powered radios, recorders, calculators to be run off the mains (220-240V A.C.). Switchable for 6, 7.5 or 9 volts. Current rating 2,500mA. Polarity reversing switch. Universal plug incorporated. o/n 137. **£3.95** +12½% VAT. P&P 35p.

DC-DC for use in all cars, boats, etc., with pos. or neg. earth for a regulated output of 6, 2.5 or 9 volts D.C. at 1A max. For radios, recorders, etc. o/n 138. **£2.80** +12½% VAT. P&P 32p.

CROSSOVER NETWORKS

2-WAY channels for high and low frequencies to correct speakers — high to tweeters, low to woofers. Complete with instructions. Frequency: 3,000Hz. o/d 1904. **£1.10** +12½% VAT. P&P 35p.

2-WAY for 8ohm speakers up to 30 watts. Frequency: .3kHz. o/n 1905. **£1.65** +12½% VAT. P&P 35p.

3-WAY for 8ohm speakers up to 30 watts. Frequency: 800Hz and 4.5kHz. o/n 1906. **£2.95** +12½% VAT. P&P 35p.

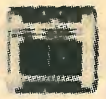
CASES

TEAK 30 designed mainly for use with our stereo 30 Audio System but has proved very helpful to home constructors. Fitted with solid uncut front and back, 32x23x8mm. o/n 139. **£5.45** + 12½% VAT. P&P 70p.

TEAK 60 for use with AL60/MK60 Audio Kit. Useful for the home constructor requiring an amplifier sleeve — has no front or back panel 42x29x9mm. o/n 140. **£7.00** + 12½% VAT. P&P 85p.

METERS

Miniature Balance & Tuning Meter
Miniature moving-coil meter for stereo balance indicator, tuning indicator for FM or similar application. Pointer at centre indicates zero or null position. Robust construction. Sensitivity: 100-0-100mA. Dimensions: 23×22×26mm. o/n 1318. **£1.95** +8% VAT. P&P 35p.



Balance and Tuning Meter
Clear view edgewise meter. Centre zero application. Sensitivity: 100-0-100uA. Dimensions: 45×22×34mm. o/n 1319. **£2.00** +8% VAT. P&P 35p.

Miniature Level Meter
Moving coil, for accurate level indication for tape recorders, amplifiers, etc. Neat design, rugged construction — will withstand five times rated value. Sensitivity: FSD: 200uA. 0dB: 130uA. Dimensions: 23×22×26mm. o/n 1320. **£2.80** +8% VAT. P&P 35p.

VU Meter
Calibrated — 20 to +3 and 0-100%, making it suitable for use as a recording level meter or as a power output indicator. Sensitivity: 130uA. Dimensions: 40×40×29mm. o/n 1321. **£2.00** +8% VAT. P&P 35p.

MICROPHONES

DYNAMIC CASSETTE
For equipment requiring a high quality microphone. Sturdy, solid moulded body in black with neat chrome surround. Pick-up pattern is omnidirectional. On/off switch. 1 metre of tough lead with floating 2.5 and 3.5mm plugs. Matching moulded strut. Impedance: 200ohms. Sensitivity: 90dB. Frequency: 90-10,000Hz. Size: 20mm dia.×120mm. o/n 1326. **£1.50** +12½% VAT. P&P 35p.

DYNAMIC MICROPHONE
Superior quality portable cassette recorder mike with built-in remote control switch and lead fitted with 5-pin 240° DIN plug (remote switch) and 3-pin DIN plug (microphone). Provides a direct replacement for those supplied with recorders. With detachable stand. Omnidirectional. Impedance: 200ohms. Freq. response: 100 to 10,000Hz. Sensitivity: 79dB at 1,000Hz. o/n 1327. **£2.65** +12½% VAT. P&P 35p.

RE-317: DYNAMIC MICROPHONE
Highly sensitive, high-grade desk or hand mike suitable for use with many popular cassette decks. Incorporates on/off switch and 1 metre lead with moulded standard jack plug. Complete with desk stand. Omnidirectional. Impedance: 5,000ohms. Freq. response: 100 at 12,000Hz. Sensitivity: (—7dB at 1,000Hz). o/n 1336. **£4.10** +12½% VAT. P&P 35p.

OMNIDIRECTIONAL CARDIOID
Powered by a 1½ volt battery located within the aluminium body. Satin silver finish with front disk protection to the diaphragm housing. On/off switch. Also with 'Busby' type windshield, "U" bracket and stem and extremely supple cable. Consumption: 0.2mA from 1½V battery providing approx. 8-10,000 hours continuous life. Impedance: 600ohms. Sensitivity: 70dB. Frequency: 30-16,000Hz. Size: 23mm dia.×267mm. o/n 1329. **£12.80** +12½% VAT. P&P 35p.

UNIDIRECTIONAL CARDIOID
Dual imp. 600 and 50,000ohms. Response 50 to 14,000Hz. Sensitivity: 54dB at 50K/ohms. Size: 1½" dia.×6½" long. Weight approx. 190gm. o/n 1328. **£10.95** +12½% VAT. P&P 35p.

STANDS

GOOSENECK CHROME FLEXIBLE HOLDERS
Length 320mm. o/n 1333. **£2.40** + 12½% VAT. P&P **35p.**
Length 515mm. o/n 1334 **£3.40** + 12½% VAT. P&P **35p.**

FLOOR STAND. Heavy chrome. Stow-away feet with rubber ends for maximum stability. Draws to a height of 5' maximum. o/n 1335. **£9.00** +12½% VAT. P&P 85p.

BOOM ARM for use with the above stand. Heavy chromed metal, it gives 30" reach from the stand. o/n 1337. **£8.00** +12½% VAT. P&P 70p.

WINDSHIELD COVERS
O/n 1531. Medium per pair **£1.20** +12½% VAT. P&P 35p. o/n 1332. Large per pair **£1.80** +12½% VAT. P&P 35p.

AUDIO LEADS

107	FM Indoor Ribbon Aerial	**£0.60***
113	3.5mm Jack plug to 3.5mm jack plug. Length 1.5m	**£0.75***
114	5 pin DIN plug to 3.5mm Jack connected to pins 3 & 5. Length 1.5m	**£0.85***
115	5 pin DIN plug to 3.5mm Jack connected to pins 1 & 4. Length 1.5m	**£0.85***
116	Car aerial extension. Screened insulated lead. Fitted plug & skt.	**£1.10***
117	AC mains connecting lead for cassette recorders & radios. 2 metres	**£0.68***
118	5 pin DIN phono plug to stereo headphone jack socket	**£1.05***
119	2+2 pin DIN plugs to stereo jack socket with attenuation network for stereo headphones. Length 0.2m	**£0.90***
120	Car stereo connector. Variable geometry plug to fit most car cassette, 8 track cartridge & combination units. Supplied with in-line fused power lead and instructions	**£0.60***
123	6.6m Coiled Guitar Lead Mono Jack Plug to Mono Jack Plug BLACK	**£1.50***
124	3 pin DIN plug to 3 pin DIN plug. Length 1.5m	**£0.75***
125	5 pin DIN plug to 5 pin DIN plug. Length 1.5m	**£0.75***
126	5 pin DIN plug to Tinned open end. Length 1.5m	**£0.75***
127	5 pin DIN plug to 4 Phono Plugs. All colour coded. Length 1.5m	**£1.30***
128	5 pin DIN plug to 5 pin DIN socket. Length 1.5m	**£0.80***
129	5 pin DIN plug to 5 pin DIN plug mirror image. Length 1.5m	**£1.05***
130	2 pin DIN plug to 2 pin DIN in-line socket. Length 5m	**£0.68***
131	5 pin DIN plug to 3 pin DIN plug. 1 & 4 and 3 & 5. Length 1.5m	**£0.83***
132	2 pin DIN plug to 2 pin DIN socket. Length 10m	**£0.98***
133	5 pin DIN plug to 2 phono plugs. Connected pins 3 & 5. Length 1.5m	**£0.75***
134	5 pin DIN plug to 2 phono sockets. Connected pins 3 & 5. Length 23cm	**£0.68***
135	5 pin DIN socket to 2 phono plugs. Connected pins 3 & 5. Length 23cm	**£0.68***
136	Coiled stereo headphone extension lead. Black. Length 6m	**£1.75***
178	A.C. mains lead for calculators, etc.	**£0.45***

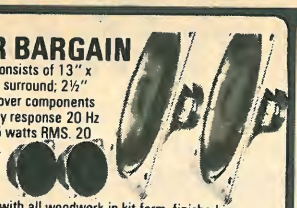
ALL ABOVE ADD 8% VAT and 35p P&P

BI-PAK

DEPT. WW1, P.O. Box 6, Ware Herts.

EMI SPEAKER BARGAIN

Stereo pair 350 kit. System consists of 13" x 8" approx. woofer with rolled surround; 2½" approx. Audax tweeter, crossover components and circuit diagram. Frequency response 20 Hz to 20 KHz. Power handling 15 watts RMS. 20 watts max. 8 ohm impedance.



£14.95 Per stereo pair + £3.40 p&p.

★ As above but complete with all woodwork in kit form, finished in simulated teak veneer, with instructions. Size approx 20" x 11" x 9½" **£28.00** Per stereo pair + £5.00 p&p.

EASY BUILD RECORD PLAYER KIT

for the D-I-Y man who requires a stereo unit at a budget price, comprising ready assembled stereo amp. module. Garrard auto/manual deck with cueing device, pre-cut and finished cabinet work. Output 4 watts per channel, phones socket and record/replay socket including 2 SPHERICAL HIFI speakers. **£19.95** p&p £4.05

BARGAINS FOR PERSONAL SHOPPERS

PORTABLE STEREO RADIO CASSETTE RECORDER UNREPEATABLE MW, LW, SW and Stereo VHF. 6 watts outpur Battery/Mains operation. **£69.95**

16o 16 VOLT MAINS TRANSFORMER, 2½ amp. **£2.50**

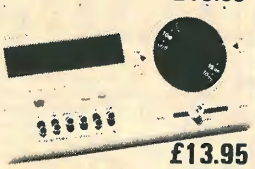
BSR Record auto deck on plinth with stereo cartridge ready wired. **£11.95**

LED 5 function men's digital watch stainless steel finish **£5.95**

LCD 5 function men's digital watch stainless steel finish **£6.95**

LCD 8 Function **CHRONOGRAPH** men's digital watch, stainless steel finish. **£13.95**

AM/FM DIGITAL CLOCK RADIO Accurate 4 Digit Electronic Clock with ½" LED display. Buzzer and snooze timer. **£11.95**



125 Watt Power Amp Module **£13.95**

Mains power supply for above unit. **£3.50**

MUSIC CENTRE CABINET with hinged smoke acrylic top, finished in natural teak veneers, size 30¼" x 14½" x 7¼" approx. **£5.95**

MULLARD Built power supply **£1.50**

DECCA DC 1000 Stereo Cassette P.C.B. complete with switch oscillator coils and tape-heads. **£2.95**

DECCA 20w Stereo speaker kit comprising 2 8" approx. bass units + 2 3½" approx. tweeter inc. crossovers **£20.00**

'VIDEOMASTER' Super Score TV Game with pistol mains operation **£14.95**

PORTABLE RADIO/CASSETTE RECORDER, AM/FM with clock. LW, MW, SW, VHF mains/battery operation. **£41.95**

7" TAPE TRANSPORT Mechanism—a selection of models from **£8.95**

SANYO Nic/cad. battery, with mains charger equivalent in size and replaces 4 SP11 type batts. Size 3¾"x 1¼" x 2" approx. p+p £1.50p **£7.50**

AM/FM STEREO TUNER AMPLIFIER CHASSIS *COMPLETE*

Ready built. Designed in a slim form for compact, modern installation.
Rotary Controls Vol On/Off, Bass, Treble, Balance.
Push Buttons for Gram, Tape, VHF, MW, LW and 5 button rotary selection switch.
Power Output 5 watts per channel Sine at 2% THD into 15 Ohm 7 watts speech and music.
Tape Sensitivity Playback 400mV/30K OHM for max output Record 200mV/50K output available from 25KHz. (150mV/100K) deviation FM signal **Frequency Range (Audio)** 50Hz to 17KHz within ± 1dB **Radio** FM sensitivity for 3dB below limiting better than 10 uV AM sensitivity for 20dB S/N MW 350 uV/Metre LW 1mV/Metre
Size approx length 16" x height 2¾" x depth 4¼" **£19.95** p&p £2.25
240 Volts AC Complete with Circuit diagram.

Complete with tuning dial

Mullard

AUDIO MODULES IN BARGAIN PACKS

CURRENT CATALOGUE PRICE £ AT OVER 25 PER PACK

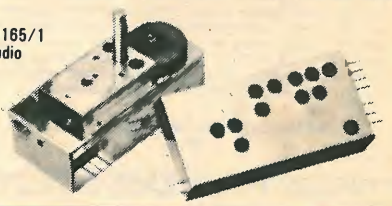
SEE OUR PRICES

THIS MONTHS OFFER
added to our bargain packs
When you buy Pack 3 at £9.95, together with a mains transformer at £1.95 and a set of controls for 95p you receive **FREE** a Mullard LP1400 Decoder to match. Listed at £11.90 p & p £2.50 **£12.85**

1 PACK 1. 2 x LP1173 10w. RMS output power audio amp modules, + 1 LP1182/2 Stereo pre amp for ceramic and auxiliary input.
OUR PRICE p+p £1.00 **£4.95**

2 PACK 2. 2 x LP1173 10w. RMS output power audio amp modules + 1 LP1184/2. Stereo pre amp for magnetic, ceramic and auxiliary inputs.
illus. OUR PRICE p+p £1.00 **£7.45**

3 PACK 3. 1 x LP1179/2 FM Tuning head with AM gang, 1 x LP1165/1 AM/FM IF module, 2 x LP1173/10w. RMS output power audio amp modules + 1 LP1182/2 Stereo pre amp for ceramic and auxiliary input.
OUR PRICE p+p £1.00 **£9.95**



ACCESSORIES

Suitable power supply parts including mains transformer, rectifier, smoothing and output capacitors. £1.00 p+p **£1.95**

Recommended set of rotary stereo controls comprising BASS, TREBLE, VOLUME and BALANCE. p+p 50p **95p**

20 x 20 WATT STEREO AMPLIFIER

Viscount IV unit in teak-finished cabinet. Silver fascia with aluminium rotary controls/pushbuttons, red mains indicator and stereo jack socket. Functions switch for mic. magnetic and crystal pickups, tape tuner and auxiliary. Rear panel features two mains outlets DIN speaker and input sockets plus fuse 20x20 watts RMS 40x40 watts peak. For use with 8 to 15 ohm speakers. **£29.90** + £2.50 p&p

SPECIAL OFFER
FOR PERSONAL SHOPPERS ONLY

FREE. 4 dimensional stereo sound adaptor, when purchasing the 20x20 Viscount amplifier.

30x30 WATT AMPLIFIER IN KIT FORM

For the experienced constructor complete in every detail, same facilities as Viscount IV, but with 30x30 output. 60x60 watts peak. For use with 4-15 ohms speakers. **£23.00** without cabinet. **£29.00** complete with cabinet. p&p £2.50 in each case.

£23.00 + £2.50 p&p without cabinet. (NOTE Cabinet not available separately.) **£29.00** + £2.50 p&p complete with cabinet.

SPECIAL OFFER Complete with case
30x30 WATT AMPLIFIER IN KIT WITH SPEAKERS

2 Goodman compact 12" bass woofers with cropped size 14,000 Gauss magnet. 30 watt RMS handling + 3¼" approx. tweeters and crossovers. **£49.00** + p&p £4.00

BUILT AND READY TO PLAY

30x30 Viscount. Available fully built and tested. **39.00** + p&p £2.50

50 WATT MONO DISCO AMP **£29.95** P&P £2.50

Size approx. 13¾" x 5¼" x 6¾"
50 watts rms. 100 watts peak output. Big features include two disc inputs, both for ceramic cartridges, tape input and microphone input. Level mixing controls fitted with integral push-pull switches. Independent bass and treble controls and master volume.
SPECIAL OFFER. The above 50 watt amp plus 4 Goodmans Type 8P. 8" speakers. Package price £45.00 + £4.00 P&P.

70 & 100 WATT MONO DISCO AMP

Size approx. 14" × 4" × 10½". Brushed aluminium fascia and rotary controls.
Five vertical slide controls – master volume, tape level, mic level, deck level, PLUS INTER-DECK FADER for perfect graduated change from record deck No. 1 to No. 2, or vice versa. Pre-fade level control (PFL) lets YOU hear next disc before fading it in. VU meter monitors output level. Output 100 watts RMS 200 watts peak.
70 watt **£57** p & p £4.00
100 watt **£65**

STEREO CASSETTE TAPE DECK ASSEMBLY

Consisting of ready built tape transport system mechanism mated to the electronics Unit is ready built for installing into cabinet of own choice Features include pause control, solenoid assisted auto stop, 3 digit tape counter, belt driven balanced fly wheel by DC motor with electronic speed control, twin VU meters. Specification Power Output, more than 0 5v, mic 65dB 10KΩ DIN 47dB 100KΩ Track 2 channel stereo record play back. Tape speed 4 8cm sec Freq response 50 1200 Hz signal to noise ratio 42dB Recording system AC bias Erasing system AC erase Bias freq 57KHz Compatible for both normal and chrome dioxide tapes Size of mechanism only 4 .," x 6 4" x 11 4" approx., included a moulded top plate as illustrated 13 4" x 9 4" approx with circuit diagram **£25.00** P&P £2 50
Opt extras Mains transformer to suite **£2.50** + £1 p & p

RTVC

323 EDGWARE ROAD, LONDON W2
21A HIGH STREET, ACTON W3 6NG
ALL PRICES INCLUDE VAT AT 12½%

All items subject to availability. Price correct at 1.12.78 and subject to change without notice.

Personal Shoppers EDGWARE ROAD LONDON W2 Tel: 01-723 8432. 9.30am-5.30pm. Half day Thursday. ACTON: Mail Order only. No callers GOODS NOT DESPATCHED OUTSIDE UK

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

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

Plays 12", 10" or 7" records, Auto or Manual. A high quality unit backed by BSR reliability with 12 months' guarantee. A.C. 200/250V. Size 13½-11¼in. 3 speeds. Above motor board 3¾in. Below motor board 2½in. with Sonotone V100 magnetic cartridge.

NEW BSR SINGLE PLAYER £22.50
Model P182 3-speeds flared aluminium turntable. Post £1
"S" shaped arm, cueing device, stereo ceramic cartridge

B.S.R. Budget Autochanger
with stereo cartridge, plays all size records **£14.95**

HEAVY METAL PLINTHS
With P.V.C. Cover. Cut out for most BSR or Garrard decks. Silver grey finish. Post £1.50
Model "A" Size 12½ x 14¾ x 7½in. **£6.50**
Model "B" Size 16 x 13¾ x 7in. **£7.50**
TINTED PLASTIC COVERS ONLY
Sizes: 14½ × 12½ × 4¼in. **£3.** 17½ × 14 × 4in. **£4.50.** 16¼ × 14 × 4in. **£4.** 15¼ × 13½ × 4in. **£3.75.** 15 × 13½ × 3in. **£3.50.** 17¼ × 9½ × 3½in. **£3.** 14½ × 14¾ × 2½in. Rosewood sides **£4.**
Ideal for record decks, tape decks, etc. Post £1.

BSR SINGLE PLAYER

Ideal replacement or disco deck with cueing device and stereo ceramic cartridge. 3 speeds. Large turntable, modern design
£17.50 Post £1

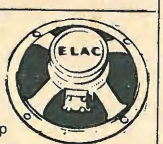
GARRARD HI-FI AUTO CHANGER Model 2025

3-speed stereo cartridge. **£14.95**
Cueing devices Post £1

SMITH'S CLOCKWORK 15 AMP TIME SWITCH

0-6 HOURS £3.30 Post 35p
Single pole two-way. Surface mounting with fixing screws. Will replace existing wall switch to give light for return home, garage, automatic anti-burglar lights, etc. Variable knob. Turn on or off at full or intermediate settings. Brand new.

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**

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

80 Ohm Coax 8p yd.
FRINGE LOW LOSS **15p** yd. Ideal 625 and colour. PLUGS **10p.** SOCKETS **10p.** LINE SOCKETS **18p.** OUTLET BOXES **8p.** 300 ohm FEEDER **5p** yd.

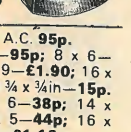
E.M.I. 13½ x 8in. SPEAKER SALE!

With tweaker and crossover. 10 watt. 3 or 8 ohm. **£7.95** Post 45p
Ditto 15 watts, 8 ohm. **£10.50** Post 65p

With tweaker and crossover. 20 watt. **£11.50**
8 or 15 ohm. 20 to 20,000 c.p.s. Post 75p

Suitable Bookshelf Cabinet
Teak finish. For EMI 13 x 8 speakers. Size 16 x 11 x 8 inches. **£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 **£4.95**
Head Demagnetiser only £4.75. Post 50p

RELAYS. 12V D.C. **95p.** 6V D.C. **85p.** 240V A.C. **95p.**
BLANK ALUMINIUM CHASSIS. 6 x 4—**95p;** 8 x 6—**£1.40;** 10 x 7—**£1.55;** 12 x 8—**£1.70;** 14 x 9—**£1.90;** 16 x 6—**£1.85;** 16 x 10—**£2.20. ANGLE ALI.** 6 x ¾ x ¾in—**15p.**
ALUMINIUM PANELS. 6 x 4—**24p;** 8 x 6—**38p;** 14 x 3—**40p;** 10 x 7—**54p;** 12 x 8—**70p;** 12 x 5—**44p;** 16 x 6—**70p;** 14 x 9—**94p;** 12 x 12—**£1;** 16 x 10—**£1.16.**
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 S.P. **30p.** D.P.S.T. **40p.** D.P.D.T. **50p.**
MANY OTHER TOGGLES IN STOCK. Please enquire.
PICK-UP CARTRIDGES ACOS, GP91 **£1.50.** GP95 **£2.50.**
SONOTONE stereo **£2.00. ADASTRA** magnetic **£6.**
WIRE-WOUND RESISTORS 5 watt, 10 watt, 15 watt **15p.**
CASSETTE MOTOR. 6 volt **£1.00.**

R.C.S. SOUND TO LIGHT KIT Mk. 2
Kit of parts to build a 3 channel sound to light unit 1,000 watts per channel. Suitable for home use. Easy to build. Full instructions supplied. Cabinet **£4** extra. Will operate from 200MV to 100 watt signal. **£17** Post 35p

R.C.S. LOW VOLTAGE STABILISED POWER PACK KITS
All parts and instructions with Zener diode, printed circuit rectifiers and double wound mains transformer. Input 200/240V a.c. Output voltages available, 6 or 7.5 or 9 or 12V d.c. up to 100mA or less. Size 3 x 2½ x 1½in. Please state voltage required. **£2.95** Post 45p

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

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

R.C.S. DRILL SPEED CONTROLLER/LIGHT DIMMER KIT.
Easy to build kit. Printed circuit
Will control up to 480 watts AC mains **£3.25** Post 35p

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

MAINS TRANSFORMERS ALL POST 75p.

250-0-250V 70mA, 6.5V, 2A	£3.45
250-0-250V 80mA, 6.3V 3.5A, 6.3V 1A	£4.60
350-0-350V 80mA, 6.3V 3.5A, 6.3V 1A	£5.80
300-0-300V 120mA, 2×6.3V 2A C.T.; 5V 2A	£8.50
220V 45mA, 6.3V 2A	£1.75
HEATER TRANSFORMER 6.3V ½ amp	£1.00
Ditto 3 amp	£1.75

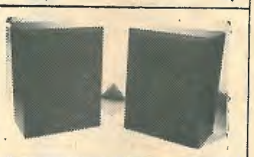
GENERAL PURPOSE LOW VOLTAGE. Tapped outputs

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

12V, 100mA	£1.00	20V, 40V, 60V, 1 amp	£3.50
12V, 750mA	£1.30	12V, 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 £6.80
12V, 1½ amp Half Wave Selenium Rectifier 25p

COMPACT SPEAKERS



Teak or White
13 × 10 × 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

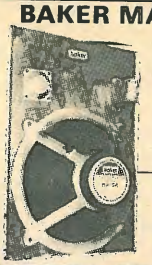
8/350V **22p**	8+8/450V **50p**	50+50/300V **50p**	
16/350V **30p**	8+16/450V **50p**	32+32/450V **75p**	
32/500V **75p**	16+16/450V **50p**	100+100/275V **65p**	
50/350V **50p**	32+32/350V **50p**	150+200/275V **70p**	

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. 1Ω 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 d.c. operation over 300 hours continuous on SP2 battery, fully adjustable swing and speed. Ideal displays, teaching electro magnetism or for metronome, strobe, etc.

BAKER MAJOR 12" £16.88



Post £1.00
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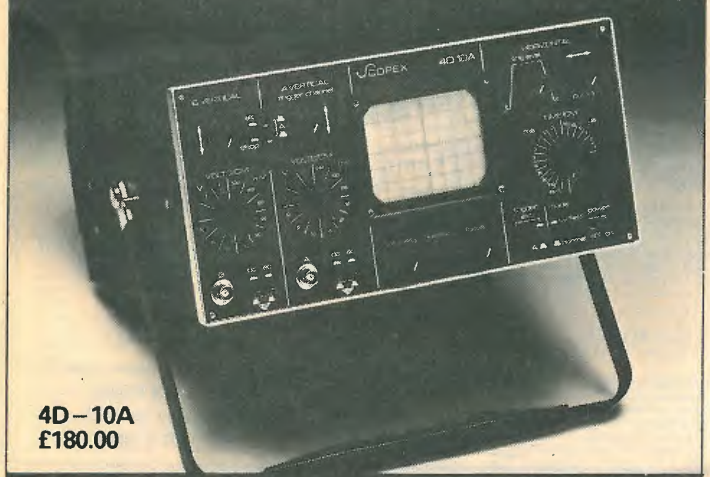

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0.68μf	50v	.09 ea	.08 ea	.075 ea
1μf	35v	.10 ea	.09 ea	.08 ea
1.5μf	35v	.09 ea	.08 ea	.075 ea
2.2μf	16v	.10 ea	.09 ea	.08 ea
2.2μf	20v	.10 ea	.09 ea	.08 ea
3.3μf	15v	.10 ea	.09 ea	.08 ea
3.3μf	25v	.10 ea	.09 ea	.08 ea
4.7μf	6v	.10 ea	.09 ea	.08 ea
4.7μf	16v	.11 ea	.10 ea	.09 ea
4.7μf	35v	.11 ea	.10 ea	.09 ea
6.8μf	35v	.11 ea	.10 ea	.09 ea
10μf	15v	.12 ea	.11 ea	.10 ea
22μf	10v	.14 ea	.13 ea	.12 ea
22μf	15v	.14 ea	.13 ea	.12 ea
33μf	10v	.15 ea	.14 ea	.13 ea
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47μf 10v A/L	14	10	.08	.06 .05
47μf 35v R/L	20	10	.08	.06 .055
100μf 25v A/L	24	10	.14	.11 .09
470μf 10v A/L	30	12	.25	.20 .18
470μf 25v A/L	25	12	.14	.12 .10
1000μf 10v R/L	62	25	.54	.48 .45
1000μf 63v TAG	50	20	.54	.48 .45
1000μF 63v TAG	70	25	.54	.48 .45
4700μf 30v TAG				

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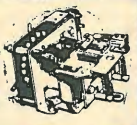

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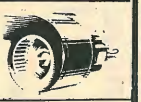

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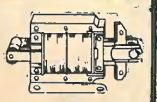

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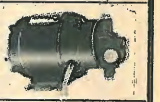

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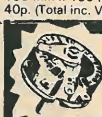

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This LSI 11 16-bit Processor Card is offered with 4K on board **memory.** Type KD11F **£425** ea.
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All motors 200 steps per revolution. 20oz. inch torque, 120V 1000-0-1000 ohm. Can be changed with care to 12/24V. Data supplied. **£8** ea.
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AIRFLOW 230V 50HZ Single Phase EXTRACTOR FAN **£4.50** ea. P&P extra.
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VARIAC 0.6 AMP in attractive small modern case with 20 terminals giving various AC & DC Voltages & Current Outputs **£16** ea. Carr. £3.25.

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Guaranteed all full spec. devices. Manufacturers' Markings.
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BC147; 2N3707; BC172B; BC251B; BC348B; BC171A/B; BC413; D10; BAX15; 1N937; BA102BE; BZX83; TIS61; 2N5040.
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1N4733A; SN7451N; BYX10-15V 0.36A; BYZ10 **15p** ea. TIP34A—**50p** ea. BD538—**40p** ea. Heavy Duty Bridge Rectifier—**20p** ea. CA3123E — **£1** ea. BDY55—**£1** ea. 2N3055—**40p** ea. TIP31B **12p** ea. BFY51 — **12p** ea. 2N5293 — **16p** ea. ZENER DIODES 4.7V Sub min — **5p** ea. TBA560CQ **£2** ea. 1N4436T-TO3 Flat Mount 10A 200piv **£1** ea. 2N5897 with 2N5881 Motorola 150W Comp pair **£2.** BU208 **£1.20** ea.
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HIGH NOISE IMMUNITY LOGIC
DUAL IN LINE 16-PIN CERAMIC, 12V Rail. Conventional TTL package. Guaranteed spec. devices. Full data. **2p** ea.
Mixed package of 50 **£1.** P&P 25p.

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Approx. 1½ metre multiway ribbon cable terminated each end with a 50-way female edge connector. Takes 0.1 printed circuit board. **£2** ea. P&P 75p.

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Photo Resistor ORP 12, **35p** ea.
Small TELESCOPIC AERIAL extending to 22½in with swivel base **40p** ea. P&P 20p.
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PHOTODIODE DETECTOR & EMITTER. Independently mounted with 4in flyleads — **50p** per pair.
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21-WAY SELECTOR SWITCH. Single pole with reset coil 240V AC coils. Additional switch contacts for auto reset, etc. **£1.45** ea. P&P 75p.
As ABOVE with additional 240V relay on base *and* full black plastic cover. **£2.45** ea. P&P £1.50.
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FRAMCO MOTORS. 115 50HZ. Input single phase, 1/12th HP: 1,450 rpm; on silent mount. As new. **£2.75** ea. P&P £1.75.
PYE DYNAMICS THICK FILM. 1 MHZ Clocking Osc 5V supply. Size 19 x 25 x 6mm. Drives one TTL load. **75p** ea.
COMPRESSOR UNIT. Compact, 115V 50HZ single phase 1.5A continuous 1.425 rpm. Outside piston housing approx. 3". **£18** ea. P&P £2.
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FAIRCHILD FND10 7 segment display 0.15, Red, Common cathode **65p** ea. P&P 15p. Info supplied.
iMULLARD TUNER MODULES — with data.
LP1171 combined AM/FM IF strip. 10.7MHZ. **£3.50** ea.
LP1179 FM front end with AM tuning and 87.4MHZ to 104.5MHZ tuning. 10.7MHZ IF **£3.50** ea. P&P 50p each unit. **The Pair £5.75.** P&P 75p.
POWER UNIT MODULE containing 2 small, 3 med. & 1 large ferrite cores; 3-TO3 power transistors, caps, resistors, high powered diodes, 9 transistors, 3 min. fuse holders, etc. **£1.50** ea. P&P £1.25.
GENERAL ELECTRIC OPTO-ISOLATORS type H15VX504 **65p** ea. P&P 15p. **10 for £5.** P&P £1.
MINIATURE REED SWITCHES 9p ea. P&P 15p.
ROTARY SWITCHES 250V 10A **10p** ea. P&P 15p.
LEDEX ROTARY SOLENOIDS 115V DC. No switch assembly **25p** ea. P&P 25p.
POTTER & BRUMFIELD TIMER RELAYS. 24/48V. Heavy duty 2 pole c/o with 5 secs. delay at 48V increasing with voltage reduction. Timing can be altered by changing value of resistor/capacitance. **50p** ea. P&P 25p.
CABLE NEATERS — neaten up your wire on a chassis with these push-on clips. 10 for **20p.** 100 for **£1.50.** P&P extra.
AUDIO AMPLIFIER BOARD. Size 4½ x 2½. Output pair of TIP31s. Circuit supplied. **£1.50** ea. P&P 30p.
DIGITAL 24 HOUR CLOCK with built-in alarm as used in BRAUN Digital Clocks. Silent running. Large illuminated Numerals. AC Mains. Size 6⅜ x 2⅜ x 2¾. **ONLY £4.25** ea. P&P 50p.
BROOKE CROMPTON & PARKINSON extractor fan assembly 115V operation. **£1** ea. P&P £2. OR TWO for **£1.50.** P&P £3.25.

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VARIACS — ex-eq. 2 amp **£8** ea; 8 amp old style **£18** ea, later style **£22** ea; 15 amp **£35** ea; 20 amp **£45** ea. 3 Phase variacs available — please enquire.

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MAINS TRANSFORMERS

All these have 230/240v 50hz Primary

Voltage		Our Ref.	Price	Post
1v	2 amp	TM 1	£1.94	.40
2.4v	5 amp	TM 2	£1.62	.45
4v	7 amp	TM 32	£2.70	.60
6v	¾ amp	TM3	.85	.40
6.5v	3 amp	TM 37	.85	.40
6.5v	200 mA	TM 21	£1.62,	.40
6.5v-0-6.5v	100 mA	TM 21	£1.62	.40
6.5v-0-6.5v	750 mA	TM 7	£2.16	.45
6.3v-0-6.3v	100 mA	TM 33	£1.62	.40
6.3v	2 amp	TM 4	£1.89	.50
8.5v	1 amp	TM 12	£1.62	.40
8.5v + 8.5 sep. winding	½ amp	TM 12	£1.62	.40
9v	1 amp	TM 5	£1.62	.45
	1 amp 'c' core	TM 6	£1.89	.40
9v	3½ amp	TM 11	£2.70	.50
	5 amp	TM 38	£3.24	.60
10v	25 amp	TM 15	£4.86	£1.25
10v-0-10v	4 amp	TM 50	£3.78	£1.25
10v-0-10v	12½ amp	TM 15	£4.86	£1.25
12v	½ amp	TM 9	£1.05	.50
13v	100 mA	TM 21	£1.62	.40
13v	¾ amp	TM 7	£2.16	.50
12v	1 amp	TM 10	£1.89	.50
12v-0-12v	50 mA	TM 19	£1.62	.40
12v-0-12v	1 amp	TM 41	£3.24	.50
15v tapped 9v	2 amp	TM 11	£2.70	.50
17v	½ amp	TM 12	£1.62	.50
18v	¾ amp	TM 13	£1.90	.50
20v	½ amp	TM14	£1.62	.50
20v (with 6v ½ amp)	2 amp	TM 50	£3.78	£1.25
20v	6 amp	TM 46	£4.32	£1.25
20v	12½ amp	TM 15	£4.86	£1.25
20v-0-20v	6 amp	TM 15	£4.86	£1.25
24v	1½ amp	TM 16	£2.12	.60
24v	2 amp	TM 17	£2.17	.60
24v + 2v 7 amp	2 amp	TM 39	£2.97	.70
24v	4 amp	TM 40	£3.78	.80
26v	1½ amp	TM 18	£2.43	.60
26v	2 amp	TM 39	£2.98	.60
30v	8 amp	TM 15	£4.86	£1.25
37v	37 amp	TM 34	£31.86	enquire
40v	3 amp	TMZ 46	£4.32	£1.25
40v	5 amp	TM 48	£5.02	£1.25
40v tapped @ 30v. 20v &10v	6 amp	TM 15	£4.86	£1.25
40v-0-40v	2½ amp	TM 48	5.02	£1.25
50v-2 amp with 6.3v shrouded		TM 22	£4.86	£2.25
50v	8 amp	TM 29	£11.65p	£1.75
60v tapped 40v & 20v	2 amp	TM 46	£4.32	£1.25
70v	4.5 amp	TM 24	£7.02	£2.50
75v-3 amp with 6.3v shrouded		TM 23	£8.10	£2.00
75V	4½ amp	TM 24	£7.02	£2.50
80V tapped 70v & 75v	4 amp	TM 24	£7.02	£2.50
80c centre tapped	2½ amp	TM 48	£5.02	£1.25
100v	1 amp	TM 25	£7.02	£1.75
100v-0-100v	½ amp	TM 25	£7.02	£1.75
200v	½ amp	TM 25	£7.02	£1.75
250v-0-250v with 6.3v 2a	50 MA	TM 36	£3.78	£1.00
250v	100 mA	TM 36	£3.78	£1.00
500v	50 mA	TM 36	£3.78	£1.00
260v	60 mV	TM 26	£3.24	£1.00
1000v (and over secs)	60 mA	TM 43	£6.50	£2.00
4 Kv	5 mA	TM 49	£4.05	.70
5 Kv	5 mA	TM 30	£7.02	£1.00
8 Kv	5 mA	TM 45	£4.05	£1.00
8.5 Kv	10 mA	TM 31	£10.26	£2.00

Full range of Mains to 120v Auto transformers available

Car Starter Charger Kit. New Version, two 10 amp rectifiers. 250W transformer and the start charge switch with instructions. Price **£9.75.** This is probably one of the most useful pieces of equipment you can have in your garage. Sooner or later you or someone will leave something on and you will heve a flat bettery, this starter will get you away usually in less than five minutes.

Interested in Tape Control. American made tape punches, really beautiful units full of sophisticated parts, designed we believe to autometically operate typewriters, and they can of course be used to operate other punch tape controlled machines. Reference number is NCR Class 461-2 reference 205 H8 R56. We believe these are 8 bit paper tape punches, powered from 115v 50HZ in very good condition with tape **£16.00,** Carriage is £3.20.

Digital Panel made for the G.P.O. for incorporation, we understand, in push-putton dialling units, this has the usual 10 digits, each of which when depressed operates a two pole switch. Really beautifully made size approx. 4 square. Price **£2.95.**

25 Watt Audio Systems in Cabinets. Comprising 8 woofer and 3 tweeter with crossover and terminal connection panel, mounted in simulated teak finish cabinet with fabric front. These are extremely good quality units comparable with those selling at twice the price. Cabinet size approx. 20 high, 10¾ wide and 8½ deep, heavy cabinet made of thick blockboard. Price **£25.00** the pair, well worth you coming to collect them but if you cannot collect them, then still worth adding £5.00 the pair for carriage.

Tilt Switch 15 amp. Meant to switch off heater should it be knocked over; this pendulum operated switch is on only when it is in the upright position. It could be incorporated in burglar alarm, car alarms, etc. Contacts look quite able to cope with 15 amp loads at mains voltage. Price **54p.**

Heating Pads. These measure 11 long x 8¼ wide and are flat. Look rather like pieces of thick blotting paper. Wire ended 250 watt or joined in series they would be approx. 60 watt each. Dozens of uses. Price **80p** or two for **£1.50.**

Loud Ringing Bell, industrial type with 6 gong, 24v DC operated. Price **£7.50.**

Switch Trigger Mat, size 24 x 18 for going under carpet, etc. Price **£2.50.**

24v Relay with latching contacts. Price **95p. Secret Switch** with key. Price **85p. 24v amp DC Power Supply.** Price **£5.50.**

Circuit Diagram. No charge, just request.

Mouth Operated switch. Probably not made with this use in mind, more likely made for washing machines to control water level, etc., this is a sensitive low pressure device which operated three 1 pole changeover, switches at different levels of pressure but all within a normal person's blowing capacity — blow gently into it and No. 1 switch operates, blow a little stronger and No. 2 operates, blow harder still and No. 3 operates. The switch is airtight so weight of water or other fluid substance could operate it. Undoubtedly a switch with very many applications. Disc type construction, this is approx. 3½ dia. x 1¾ thick — the air entry is a pipe approx 3/16 dia.—electrical contacts we estimate a 10 amp c/o a 230 volt connection by push on tags. Order ref. PS.4. Price **£1.95.** Large quantity available.

Powerful Induction Motor. 1½ stack, double ended, would drive a small lathe, drill or grinder or would power a blowing or extracting fan. Fit suitable pulleys and it would drive a pebble polisher or similar, being double ended it will drive in either direction. Can also be fixed from either end, fixing bolts are fitted and these are 1⅞ apart. Spindles ½ in diameter extend 1¾ beyond each end plate. A motor like this would cost at least £3 from makers but we have a large quantity to offer at **£2.50.** Order Ref. MM.10.

Vu Meter. Edgewise mounting, through hole size 1½ x ½ approx., these are 100 micro amp fsd and fitted with internal 6 volt bulb for scale illumination, also have zero reset. The scale is not calibrated but has very modern appearance. Price **£1.85.**

DELAY SWITCH

Mains operated — delay can be accurately set with pointers knob for periods of up to 2½ hrs. 2 contacts suitable to switch 10 amps — second contact opens few minutes after 1st contact **95p.**

SOUND TO LIGHT KIT. Based on the "Everyday Electronics" circuit, this is a very efficient little unit and when made up it is in every way equal to professional models costing many times the price. This unit is not tuned to any particular frequency it is simply dependent upon volume. This is no disadvantage in fact the effect is very pleasing. It will control up to 750w of lighting and it works well with amplifiers with outputs of 1-50 watts. The kit complete with leads and plastic case is **£4.00** only, or 10 for **£36.00,** post and VAT paid.

MULLARD UNILEX

A mains operated 4+4 stereo system. Rated one of the finest performers in the stereo field this would make a wonderful gift for almost anyone in easy-to-assemble modular form and complete with a pair of Plessey speakers this should sell at about £30 — but due to a special bulk buy and as an incentive for you to buy this month we offer the system complete at only **£15** including VAT and postage.

10 watt amps to upgrade unilex **£3.50** each

UNISELECTORS

These are pulse operated switches as used in automatic telephone switchboards, etc. The pulse moves the switch arm through one position. Except where indicated the selectors are 25 position types and 50v Coil is standard, 24v or 12v operation extra at **£2** per switch.

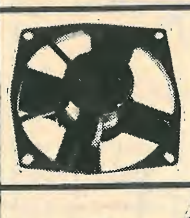
3 pole	**£5.90**
4 pole	**£6.98**
5 pole	**£8.20**
6 pole	**£9.20**
8 pole	**£11.40**
10 pole	**£13.60**
12 pole	**£15.88**
2 pole 50 way	**£8.60**
3 pole 50 way	**£11.40**

INDUCTION MOTORS

One illustrated is our reference MM11 made for ITT ¾ stack 1½ spindle **£2.25,** ½ stack model **£1.75.** 1 stack **£2.75.** 1½ stack **£3.25.**

RELAYS

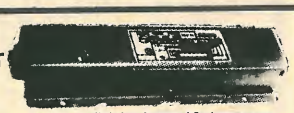
12 volt two 10 amp changeover plug in **95p** 12v three 10 amp changeover plug in **£1.28.** 12v two changeover miniature wire ended **95p.** 12 volt open single screw fixing two 10 amp changeovers **85p** 12 volt open three 10 amp changeovers **£1.25.** Latching relay mains operated 2 c/o contacts **£2.11.** Mains operated three 10 amp changeovers open type one screw fixing **£1.25.** Many other types with different coil voltages and contact arrangements are in stock, enquiries invited.



EXTRACTOR FAN

Ex-computers made by Woods of Colchester, ideal for fixing through panel — reasonably quiet running — very powerful 2500 rpm. Choice of two sizes 5 or 6½ dia **£5** and **£6.**

FLUORESCENT INVERTOR



For camping — car repairing — emergency lighting from a 12v battery you can't beat fluorescent lighting. It will offer plenty of well distributed light and is economical. We offer invertor for 21 and 13 watt miniature tube for only **£3.75** with tube and tube holders as well.

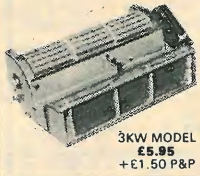
This Month's Snip

Hartley CT 436 double beam oscillascope. DC-6M8Z. Beautiful condition that may have slight faults. Manuals available. Snip price **£75.00,** carriage £5.00. **Tektronix, Marconi, Philips and other make scopes.**

PP3/PP9 REPLACEMENT MAINS UNIT

Japanese made in plastic container with leads size 2 × 1½ × 1½ , this is ideal to power a calculator or radio, it has a full wave rectified and smoothed output of 9 volts suitable for a loading of up to 100mA **£2.53.**

TANGENTIAL HEATER UNIT



3KW MODEL **£5.95** +£1.50 P&P

A most efficient and quiet running blower-heater by Solartron — same type as is fitted to many famous name heaters — Comprises mains induction motor — long turbo fan — split 2 kw heating element and thermostatic safety trip — simply connect to the mains for immediate heat — mount in a simple wooden or metal case or mount direct onto base of say kitchen unit — price **£4.95** post £1.50 control switch to give 2kw, 1kw, cold blow or off available 60p extra.

MOTORISED DISCO SWITCH

With 10 amp changeover switches, multi-adjustable. Switches are rated at 10 amp each so a total of 200w can be controlled and this would provide a magnificent display. The motors are 50V. but they are of such a low wattage, only 2 watts, that they can be driven by a resistor or condenser. voltage dropper. 8 Switch model **£5.25.** 10 Switch model **£5.75.** 12 Switch model **£6.75.**

TERMS:

Prices include Post & VAT, but orders under £6.00 please add 50p to offset packing, etc. Bulk enquiries please phone for generous discount 01-688 1833.

J. BULL (ELECTRICAL) LTD

(Dept. WW)

103 TAMWORTH ROAD

CROYDON CR9 1SG

IT'S FREE!

Our monthly Advance Advertising Bargains List gives details of bargains arriving or just arrived — often bargains which sell out before our advertisement can appear. — It's an interesting list and it's free — just send S.A.E. Below are a few of the Bargains still available from previous lists.

Telephone Ringing Mains Unit. Rather novel unit as it not only reduces mains to 50 volts but also reduces the mains frequency to 25hz., this frequency gives correct ringing note for GPO bells. These units were made for the GPO so obviously are first-class. Completely enclosed and safe to mount on the wall or stand on a shelf. Price **£3.20.**

Telephone Extension Bells in bakelite wall box, these will save you missing calls when you are out in the garden or shed, etc. Price **£3.16.**

Variable Mains Supply. A bench mounting unit which contains an isolation transformer for safety and a 2 amp variac for adaptability. With this you will be able to get continuously variable mains supply from zero to full votage at 2 amps. A real time saving device. Only price **£20.75.**

Answering Machines still available as last month's newsletter but supplies are going down rapidly and this may well be your last chance to acquire one of these.

A very large purchase this month enables us to offer a range of radio items. You will find the prices well below average:

Cassette Recorder/Player. Japanese or Hong Kong made, these have all the normal facilities record, playback, fast rewind etc., also sockets for stop/start, microphone, earphone and lead for mains as these operate from mains or HP 1 batteries. **£17.50.**

Six Transistor Pocket Radios. Medium wave only but with Radio 2 and Radio 4 changing places, Medium wave is all the average listener will want in the future. These little radios would make a lovely gift for a child. Modern design and in popular colours, please state preferred colour and give an alternative, price only **£1.50.**

AM/FM Radios. There's no doubt that FM does give better reproduction in good areas so a more adult member of the family will be pleased with one of these. The ones we have are in leatherette cases and are battery/mains radios having the mains unit built in and are complete with mains plug. These cover medium wave and VHF with optional AFC. Price **£6.75.**

8 Track to Cassette Adaptors. Cartridges are going out of popularity, cassettes on the other hand are being made in increasing numbers and cover practically every field of sound entertainment. Cassettes can be played in 8 tracks if you have an adaptor. We offer these adaptors complete in carrying case and the price is only **£8.50.**

Soft Toy Radios. Not necessarily only for the younger members of the family as these are soft and cute and have universal appeal. Dolls, poodles, elephants and rabbits each with zip compartment at the bottom where the radio fits. Medium wave only, working from PP3 batteries. When ordering please state preference and if possible give an alternative. **£4.50.**

5 Band Portable. A very impressive radio in black imitation crocodile case, size approx. 12 ins. wide, 7 ins. high and 4 ins deep. This has metal embellished carrying handle and a pullout chrome plated FM aerial, covers the following bands AM 535 to 1605 Khz. FM 88 to 108 Mhz weather band 162.5 Mhz and it has a logging scale. This battery/mains radio has the built in mains unit also serves as a charger if you use rechargeable batteries. The mains lead with plug tucks away in its own compartment, another feature is a dial indicator which shows state of batteries. A real snip at **£10.50.**

Upright Multi Band Radio. 5 Bands and again a most desirable radio, all other details similar to the one above. Only real difference being slightly smaller case, again in imitation crocodile but with soft handle and shoulder strap. Interesting point about both receivers is that if used with rechargeable batteries the built in mains unit serves as a charger. Price **£11.50.**

Extension Speaker Cabinets. A new delivery of these anables us to bring down the price quite a lot. We can now supply the smaller ones (11" x 8" x 4½" approx.) at **£1.95.** Post £1.00 and we have a larger one with a silver finish size approximately 12½" x 9" x 5½". Price of this is **£1.69,** post £1.50. If you can call and collect these cabinets you can save yourself the quite considerable postage and you only have to buy a few to get a discount as well. The quantity discount for these is a special rate of 25% if you buy four or more. Note these cabinets are very good quality (made for Rank Audio Systems) the grill material is Dacron.

Slide Switch Bargain. Double pole changeover standard size with good length of connecting wire soldered to each tag. — 10 for **£1.38.**

Motor Start Relay. The current through the motor start winding is passed through a coil which gives a slight time delay before connecting the main winding. This has heavy duty contacts and can be used for many other projects. Price **54p.**

Six Digit Counter. Mains operated, 1 pulse moves counter through one digit, not resettable but all you have to do is to make note of the numbers before the start of each count. Real bargain at **80p.**

Be Prepared for possible blackouts and interruptions in electricity supply this winter! Have some emergency lighting nearby. We still have the fluorescent outfits for operating 12" tubes from 12v car battery and the price is still the same **£3.95,** plus 50p post complete with a 21" tube.

Bleepers. 6/12 volt battery or transformer operated, ideal for using in many alarm circuits but particularly for car and motor-cycle alarms. These give a loud shrill note. American made by Delta Alarms. Price **£1.08** + 8p. Large quantities available.

Most Useful Timer. Up to 12 on/offs per 24 hours is what you can get from the Venner time switch if you fit our adaptor. The shortest on/or off time is one hour but you can use any combinations of on/off to make up the 24 hours. An obvious use for this is to control immersion heaters. These are real current consumers and even though the thermostats are working propertly, economies can be quite considerable if a time switch is used. Our Venners are all capable of 20 amp switching. There is of course many other applications for the time switch, which you will remember in its basic form follows the sun switching on at dusk and off at dawn. Price **£3.24** plus 50p post for switch with adaptor, extra for plastic case **£1.08** or metal case **£2.16** + 16p.

Safe Soiltat. For growers who use soil heating on benches, economies can be made by using a thermostat but if mains voltage equipment is used then the thermostat must be enclosed in a waterproof and earthable container. We can now supply this price **£3.78** + 28p. This container will accept the normal immersion heater type thermostat but for soil heating you want one which covers 50 deg. Farenheit and upwards, we can supply these at **£3.20.**

Motorised Light Flasher. We can offer two motorised units both capable of 2,000 watts of light. Our ½ second flasher changes every ½ second and the 2 second flasher changes every 2 seconds. Either type **£6.40.**

Frightening Fuel Bills could loose some of their sting if you fit double glazing but even if the fuel bill does not come down much you will have a more comfortable home less draughts etc. Double glazing frames, movable in the Spring, can be quite easily made using rigid PVC sheetings. We have this, it is as clear as glass and virtually as everlasting. It is easy to fit as you can cut it, bend it, nail it, etc. A recent purchase enables us to offer this at well below current price. It is 600 mm (23½" wide) and available in any length (it rolls up like lino). Price **15p** per sq. ft. Minimum order 20 sq. ft. for **£1.05** post 50p. Orders over £6.00 post free, longer lengths price negotiable.

Car Battery Power Unit made for Rank Radio. This unit has been designed to operate 6 volt battery powered equipment from a 12v car battery, it provides a reliable source of stabilized voltage and gives protection to your equipment in case of accidential reversal of connections also again excessive car battery voltage should this occur. The unit is very robust and virtually everlasting if used sensibly. It uses a negative earth circuit but it will operate in a positive earth car providing the instrument being played is not connected to the car chassis. A real bargain at **£2.20.**

Project Boxes. All those offered in a recent newsletter are still available, we have now had a much larger one size 8½ x 5½ x 3½. Price **£1.85.**

Electronic Brokers Ltd

The Test Equipment People

Calibrated & Guaranteed 12 Months

AC Voltmeters & Electronic Multimeters

ADVANCE

VM77E Transistorised Voltmeter 10Hz-6Mz. 1mV-300V I/P Z 10M Ohms **£130.00**

BOONTON

91H RF Valve Voltmeter 20KHz-1200MHz. 100μV-300V . . . **£415.00**

BRADLEY

112RF Millivoltmeter 3mV-300mV. 1-300MHz. Battery operated . . **£375.00**

BRUEL & KJAER

2409 Electronic Voltmeter 2Hz-200KHz. 10mV-1000V True RMS **£245.00**

HEWLETT PACKARD

400F AC Voltmeter 20Hz-4MHz 100μV-300V **£235.00**
411A RF Millivoltmeter 500KHz-1GHz. 10mV-10V **£395.00**

PHILIPS

PM.2503 Electronic Multimeter AC/DC Voltage and Current **£90.00**

ROHDE & SCHWARZ

U.R.V. RF Voltmeter 1KHz-2400MHz with 50 Ohms insertion unit 20mV-10V **£235.00**

SIGN

AM324 AC Voltmeter 15Hz-500Khz 1mV-300V **£60.00**

Analogue Multimeters

AVO

Model 7 . . . . . **£40.00**
Model 8 . . . . . **£55.00**
Test Set No. 1 . . . . . **£65.00**
Precision Avo **£45.00**
Leads, Prods, clips for Avo's **£4.95**

PHILIPS

PM 2412 AC/DC Volts & amps 40K Ohms/V **£60.00**

Analysers

HEWLETT PACKARD

310A Wave Analyser 1kHz-2.5MHz. 10μV-100V voltage range. >76dB dynamic range. B.F.O. and recorder O/P. Has built in AM, LSB and USB detector. **A SUPERB UNIT OF THE HIGHEST QUALITY** **£1200.00**
332A Distortion Analyser 5Hz-600kHz. 0.1%-100% also AM detector **£495.00**
333A Distortion Analyser 5Hz-600kHz 0.1%-100% also Auto Null . . **£515.00**

RACAL

409 Modulation Meter 3-1500MHz. AM & FM **£345.00**

ROGERS/SIGN

DM.344 Distortion Meter 20Hz-20KHz **£230.00**

TEKTRONIX

1L10 Spectrum Analyser Plug In 1-36MHz **£750.00**
1L30 Spectrum Analyser Plug In 925MHz-10.5GHz **£1200.00**
1L40 Spectrum Analyser Plug In 1.5-12.4GHz **£1275.00**

T.E.S.

D.566B Distortion Meter 10Hz-1MHz. 0.03 to 100% **£305.00**

MARCONI INSTRUMENTS

T.F. 791D Deviation Meter 4-1024MHz. Dev 10Hz-125KHz **£195.00**

UREI

Sonipulse 100A Acoustical Analyser 40-16KHz. 27 x 1/3 octabe bandpass filters. Microphone not included **£675.00**

Attenuators

MARCONI INSTRUMENTS

TF.1073A Series Step Attenuator DC-100MHz 100dB 50 or 75 Ohms **£75.00**
TF.2162 Step Attenuator DC-1MHz. 0-111dB 600 Ohms. **£120.00**

ROHDE & SCHWARZ

RBD Attenuator BN 33662/60 DC-600MHz. 20dB. 60 Ohms **£40.00**
DPR Step Attenuator BN 18042/60 DC-300MHz 0-100dB 60 Ohms **£90.00**

ROHDE & SCHWARZ

RBD UHF Attenuator BN33661/50 DC-2.4GHz. 10dB, 50 Ohms **£55.00**

Bridges

MARCONI INSTRUMENTS

TF.2701 In Situ Universal Bridge **£395.00**
TF.1245 'Q' Meter Supplied with TF.1246 Oscillator 40KHz-50MHz **£625.00**

WAYNE KERR

B.221 (CT.530) Univ. Bridge 0.1% accuracy **£275.00**
Q.221 Low Impedance Adaptor for use with B.221 . . . . . **£75.00**
B.521 (CT.375) Univ. Bridge 1% accuracy **£120.00**

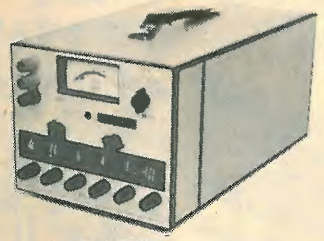
Calibration Equipment

HEWLETT PACKARD

740B DC Voltage Source & Differential Voltmeter **£850.00**
741B DC Voltage Source & AC/DC Differential Voltmeter **£975.00**

FLUKE

332A DC Voltage Calibrator 0-1111.1110V in 3 ranges. 1ppm resolution. 0.003% calibration accuracy. O/P current 0-50mA **£1350.00**
931B True RMS Differential Voltmeter 10Hz-1MHz. 0.01V-1100V . **£1,050.00**
883AB. AC/DC Differential Voltmeter 1mV-1100V **£975.00**



TEKTRONIX

184 Time Mark Generator . **£275.00**
2901 Time Mark Generator **£400.00**
2101 5nS Pulse Generator . **£525.00**

Digital Counters

ADVANCE

TC.14 Frequency Counter DC-250MHz. 9 digit **£295.00**
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-100M+12 . . . . . **£275.00**

FLUKE

1900A opt. 01 5Hz-80MHz. 25mV Sensitivity with battery option . . . **£215.00**
1941A Industrial Counter/Totaliser 5Hz-40MHz **£120.00**
1980A Communications Counter 5Hz-515MHz. 15mV sensitivity 6 digit. Battery operated **£295.00**

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**

A copy of our trading conditions is available on request

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49-53 Pancras Road, London NW1 2QB
Tel. 01-837 7781. Telex: 298694

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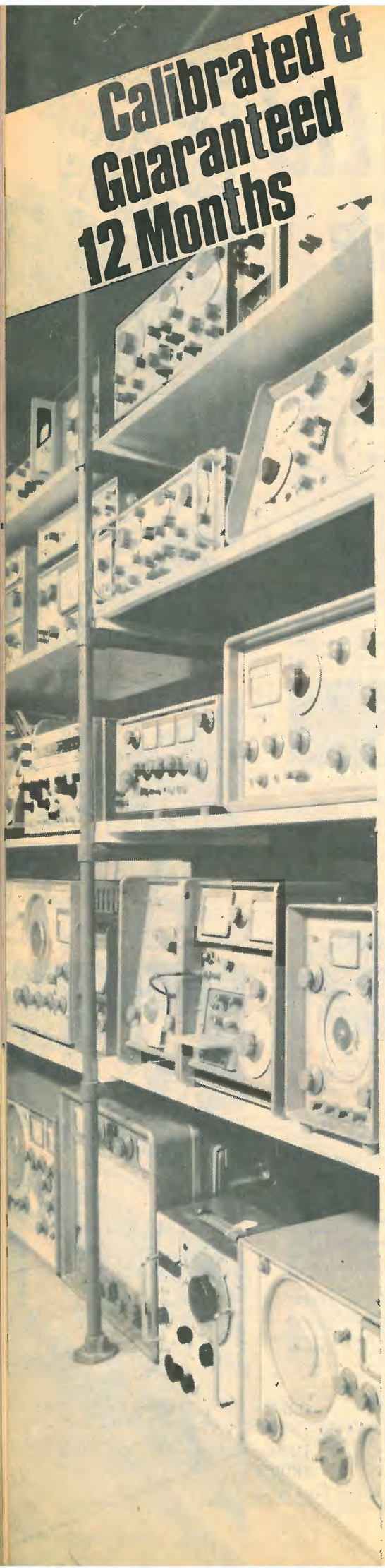

Electronic

49-53 Pancras Road, London NW1 2QB
Tel: 01-837 7781

Digital Voltmeters & Multimeters

ADVANCE

DRM6 True R.M.S. DVM 4½ digit, scale 1999. 10mV-1KV 10μV resolution. Frequency range DC-1MHz . . **£295.00**

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**

SOLARTRON

7040 D.M.M. 4½ digit c/w Battery Pack **£265.00**

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**

WAVETEK

755 Programmable Digital Phase Meter 40Hz-2MHz. 0-360 . . . . . **£750.00**

Miscellaneous R.F. Accessories

HEWLETT PACKARD

1100A Delay Line **£75.00**
8431A Pass Band Filter 2-4GHz. 50 Ohms **£75.00**
8436A Pass Band Filter 8-12.4GHz. 50 Ohms **£75.00**
8732A Pin Modulator 1.8-4.5GHz 50 Ohms **£100.00**
8734B Pin Modulator 7.0-12.4GHz 50 Ohms **£100.00**

ROHDE & SCHWARZ

ZDP Reflectometer 300-4,200MHz 50 Ohms **£70.00**
ZPW Directional Coupler 380-1000MHz 50 Ohms **£75.00**

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, DC 75MHz. 1825 Time base and Delay Generator, UNUSED CONDITION — BARGAIN **£1,600.00**

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**
PM3230 Dual Beam Scope DC-10MHz 20mV/div, TV frame and Sync separator **£155.00**

SOLARTRON

CD 1400 Dual Trace Oscilloscope with 2 off CX 1441 and 1 off CS 14481 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 DC125MHz. 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**
7A22 Differential Plug In Unit. D.C-1MHz 10μV-10V/div. Selectable upper and lower — 3dB joints DC offset. 100,000:1 cmrr. SUPERB VALUE **£450.00**
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**
575 Transistor Curve Tracer **£400.00**
556 Dual Beam Scope (Mainframe) DC-50MHz dependent on choice of Plug-ins **£325.00**
555 Dual Beam Scope (Mainframe) DC-33MHz wide choice of Plug-ins **£300.00**

TELEQUIPMENT

D67A Dual Trace Portable Oscilloscope. DC-25MHz. 10mV-50V/div. Full delayed Sweep **£450.00**

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**

A copy of our trading conditions is available upon request

Carriage and packing charge extra on all items unless otherwise stated

Please note: All instruments offered are secondhand and tested and guaranteed 12 months unless otherwise stated

Hours of business: 9a.m.-5p.m. Mon.-Fri. Closed lunch 1-2p.m.

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Brokers Ltd

The Test Equipment People

Calibrated & Guaranteed 12 Months

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

PM5704 TTL Pulse Generator with P.S.U. 0.1Hz-10MHz. TTL O/P will drive up to 30 gates **£250.00**

PM5715 Pulse Generator Similar spec. to PM5712 but with variable rise and fall times **£575.00**

PM5770 Pulse Generator 1Hz-100MHz Variable delay, width, rise and fall time. Single or double pulse, base line offset **£790.00**

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**

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**

Recorders

ADVANCE

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**

HOUSTON INSTRUMENTS

6520 YT Recorder **£450.00**

PHILIPS

PM8110 price now to read .. **£250.00**

PM8110 Mini Single Channel Chart Recorder Sensitivity 10mV-10V full span. Chart width 12cm. Chartspeed 5 and 20mm/min **£300.00**

RECORD

3" Paper Width Recorder with 500 μA sensitivity FS. Left-hand zero. 1 and 6 per hour chart speed **£75.00**

YOKAGAWA

3047 Two Channel Chart Recorder Scan width 250mm. Sensitivity 0.5mV-100V. Speeds 60cm/min to 2cm/hr. **£530.00**

Signal Sources

ADVANCE

H1E LF Sine/Square Oscillator 15Hz-50kHz. Sine Square **£75.00**

J2E L.F. Oscillator 15Hz-50kHz **£90.00**

J3 L.F. Oscillator 10Hz-100kHz **£150.00**

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**

608E A.M. Signal Generator 10-480MHz **£675.00**

MARCONI INSTRUMENTS

TF.801D/1 AM Signal Generator 10kHz-470Mhz **£400.00**

TF.995A/5 AM/FM Signal Generator 1.5MHz-220MHz **£380.00**

TF995B/2 AM/FM Signal Generator 200KHz-220MHz **£675.00**

TF1060 AM Signal Generator 450-1250Mhz. From **£400.00**

TF1101 R-C Oscillator 20Hz-200kHz. 1mV-20V into 600 Ohms. Metered O/P **£125.00**

TF1370A R-C Oscillator 10Hz-10MHz **£245.00**

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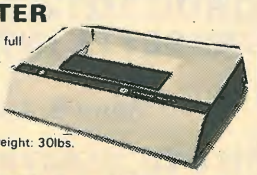

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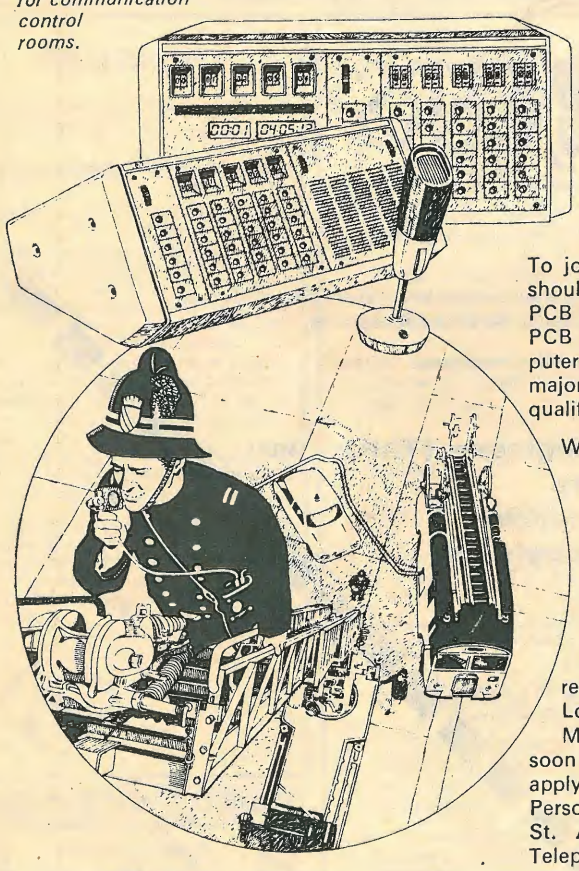

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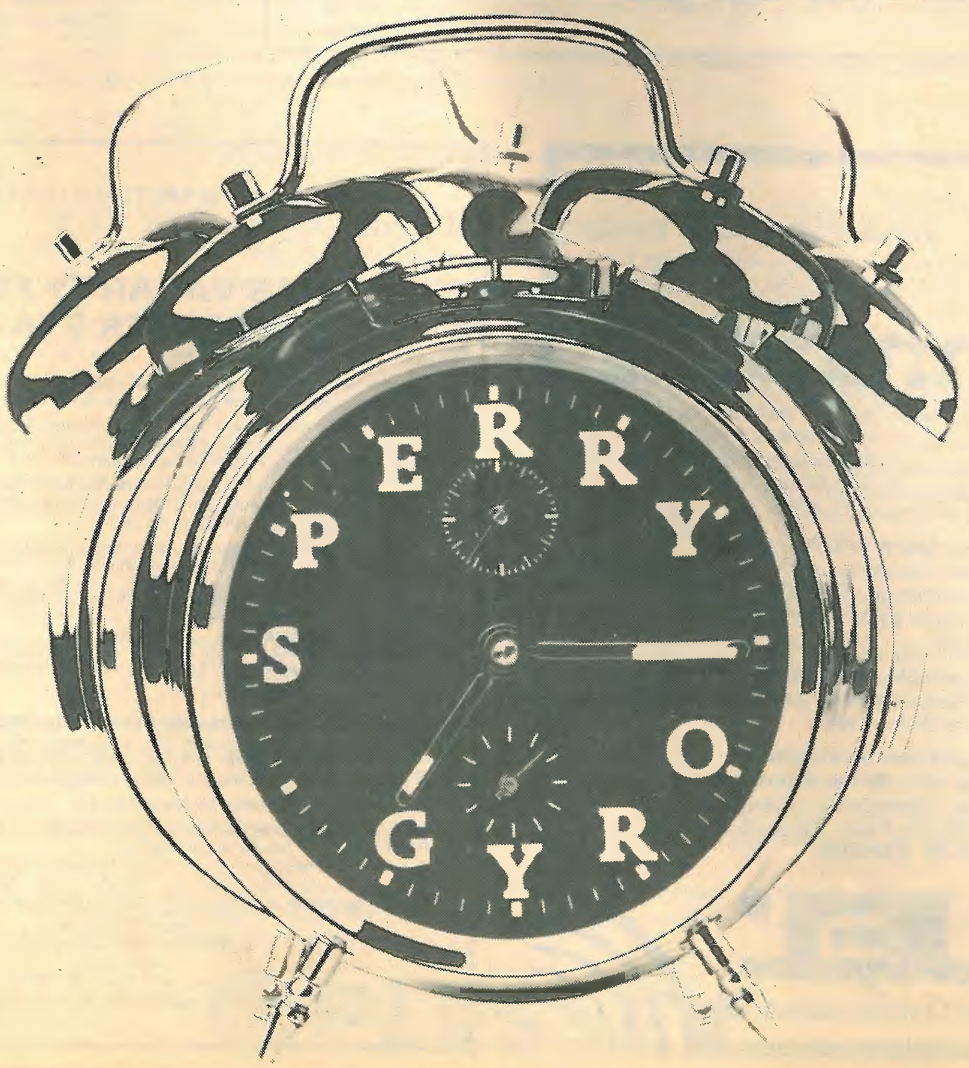
We know how it is. After all, we see the problem from both sides. For example, we know that reasons for changing vary greatly – advancement, or further experience (or even money!) is perhaps only available elsewhere, or, regrettably there may be an intractable personal problem. But often it is difficult to pinpoint a single cause; several factors probably interact. Whatever your situation, Sperry Gyroscope may be able to help.

We believe that we have something special to offer: a friendly, supportive and highly creative environment; small working groups backed by large company resources; a diversity of products and technology which is probably unrivalled in an organisation of our size, centred on control systems and involving precision mechanical, electronic and software engineering. To back up all that we have an attractive benefits and relocation package.

If you feel it is time for a change to a successful and understanding company, contact Sperry Gyroscope now. You can either send us brief details or, for further information, write to or phone Don Manning our Engineering Recruitment Officer.

Sperry Gyroscope, Downshire Way, Bracknell, Berks. RG12 1QL. Bracknell (0344) 3222.

SPERRY GYROSCOPE
DIVISION OF SPERRY RAND LIMITED



8807

ENGINEERING TRAINING for the BBC

The BBC requires lecturers for its Engineering Training Department.

The Department trains staff for operational, technician and engineering work both on recruitment and thereafter throughout their careers. The posts concerned deal with technician and engineer training for television, radio, transmitters and communications, a degree of specialisation being normal within the field.

The Department is situated in the country at Evesham in Worcestershire and is very well equipped. Welfare and Club facilities are excellent.

We are looking for engineers, male or female, who have some relevant practical experience, either in broadcasting or in a closely related field. They must have the ability to present ideas clearly and sympathetically to a wide range of students. Given these qualities and the right potential, we will provide whatever additional training is necessary.

If you are qualified to degree level or equivalent, in a relevant topic area and would like to know more then write to **Mr. J.H. Brooks, Head of Training Section (Engineering), Engineering Training Department, Wood Norton, Evesham, Worcestershire, Telephone Evesham 41112, Ext. 224.**

BBC

RADIO ENGINEER HAITI

required to work as technical adviser to the Haitian Radio School team working on a new adult literacy scheme. Responsibility for the maintenance and repair of the radio station equipment and the training of Haitian counterparts.

A British Volunteer Programme post, language training provided.

For further information write with details of curriculum vitae to CIIR Oversees Volunteers, 1 Cambridge Terrace, London NW1 4JL.

(8779)

NATIONAL AUDIO VISUAL AIDS CENTRE

AV TECHNICIAN

required for laboratory evaluation of audio visual aid equipment. Experience with one or more of the following types of equipment necessary; audio recorders, vhf radio receivers, cine projectors, still projectors, video recorders, tv receivers, mini-computers. Send résumé of education qualifications, previous experience and two referees. Salary negotiable from £3600. Write Head Technical Information Service, NAVAC, 254 Belsize Road, London NW6 4BY.

(8837)

ROYAL MARSDEN HOSPITAL, Fulham Road, SW3. Medical Physics Technician — Grade IV, £3,423-£4,488, required in the Physics/Radiotherapy Workshop group to repair and maintain a 10MeV Linear Accelerator, three cobalt units and two X-ray units. The appointed person will also be required to assist with the installation and testing of radiotherapy equipment. Applicants should have an interest in mechanical/electrical servicing, and hold HNC or similar qualification in engineering or electronics and have at least 3 years' technical experience to obtain salary on scale. Application forms and job descriptions from Personnel Department, tel. 352 8171 Ext. 447.

(8842

Test Technicians

Ultra Electronic Communications, part of the international Dowty Group are world leaders in sonar buoy design and manufacture advanced railway and train location networks, sophisticated aircraft communication systems and search and rescue beacons.

Our production department requires additional male or female Testers with experience of radio or analogue circuits and test equipment. Candidates should have several years of practical experience in this area with or without qualifications.

Salaries will be negotiable and accompanied by a wide range of attractive large company benefits, including a very generous relocation package.

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.**

(8800)

UEL Electronic Communications Ltd

NATIONAL MARITIME INSTITUTE

FELTHAM, MIDDLESEX

HAS VACANCY FOR COMPUTER STAFF

If you are interested in Computing and preferably have had some experience in writing programs, we would like to hear from you.

The National Maritime Institute carries out investigations into the performance of ships and offshore structures using towing tanks, water tunnels, manoeuvring tanks and wind tunnels.

Computers are used extensively to analyse experimental data and to carry out theoretical computations. Microprocessors, minicomputers and mainframes are used on-line and via terminals.

If you would like to know more about these vacancies on our Feltham and Teddington sites, please write or telephone.

Age: At lease 16 on 31 December of the current year.

Minimum Qualifications:
GCE (Ordinary Level) Grade A, B, C or CSE Grade 1 or equivalent in 4 subjects including English Language and a Scientific or a Mathematical subject.

Commencing Salary (including Outer London Weighting)
£2050 at age 14, £3006 over 21, rising by annual increments to £3578. There are excellent career prospects with promotion to higher grades and opportunities for part-time day release for further study.

Staff restaurant, sports and social sections.

5-day week of 41 hours (including lunchbreaks).
PART-TIME staff would be considered.
4 weeks' paid holiday plus 9½ days public and privilege holidays.

For further details or terms of employment and application forms apply to:

Personnel Section
National Maritime Institute
Faggs Road
Feltham, Middlesex TW14 0LQ
For technical details telephone 01-977 0933 Extension 5070

(8772)

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.

Development and Evaluation of Digital Equipment

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

(8821)

We are one of the World's leading establishments in Motor Vehicle Research – Further growth combined with an impressive capital investment programme has led to openings in two vital areas:

ELECTRONICS ENGINEERS

The Association has an on-going investment in sophisticated and advanced electronic equipment, which is playing an increasingly important part in all aspects of Motor Vehicle Research.
Engineers are required to be responsible for the performance and calibration on a wide range of essential equipment. Applicants should be qualified to degree or equivalent level and have at least two years experience in the use of electronic measuring, control, communications and computing equipment, preferably gained in a research function.

TECHNICIANS (INSTRUMENTATION)

To work closely with the above Engineers and play an important part in the efficiency and smooth running of new and existing electronic equipment. We would like to hear from qualified technicians who are fully familiar with electronics and preferably have a knowledge of both analogue and digital integrated circuits.

MIRA OFFERS

The opportunity to work in a stimulating and professional environment. A wide variety of challenging projects. Exceptional career prospects. The chance to use your ability and initiative where it will be appreciated. Good salaries, attractive fringe benefits and job security.

If you would like to know more about any of the above positions please contact, Ray Cray or alternatively, write with career details to,
The Personnel Manager,
Motor Industry Research Association,
Watling Street,
Nuneaton,
Warwickshire
CV10 0TU.
Telephone:
Nuneaton (0682) 68541.

(8761)

BRUNEL UNIVERSITY
DEPARTMENT OF EDUCATION

GRADE 3 AUDIO/VISUAL LABORATORY TECHNICIAN

We are looking for a technician (male or female) to be responsible, under the Chief Technician, for the day-to-day running of a combined Physics/Chemistry laboratory and also an Audio/Visual Teaching Laboratory, including first-line maintenance. This involves working in close co-operation with both the academic and other technical staff as well as post-graduate students.
The ideal candidate will probably have either O.N.C. or City and Guilds (or equivalent), and 3-5 years' relevant experience. A knowledge of Nuffield Physics would be an advantage.
Day release may be given to study for higher qualifications.
21 days' annual leave plus one week at both Christmas and Easter. There iare good luncheon, sports and social facilities at hand. Salary within the scale £2,688-£3,060 (under review) plus £275 London Weighting.

Write for application form to the Assistant Secretary (Establishment), Brunel University, Uxbridge, Middlesex UB8 3PH, or telephone Uxbridge 37188, extension 49.

(8801)

UNIVERSITY OF NOTTINGHAM
DEPARTMENT OF PHYSICS

SENIOR EXPERIMENTAL OFFICER IN GENERAL ELECTRONICS DESIGN

Applications are invited for a Senior Experimental Officer in Physics. Candidates should have an honours degree in Electrical or Electronic Engineering and at least two years of industrial experience.
The successful applicant will be expected to assist in the design and commission of analogue, digital and microprocessor based electronics in both the teaching and research areas of the department.
There will be opportunity to work in close collaboration with a number of research teams on a wide variety of problems including the introduction of microcomputers for both control and data processing.
Salary will be in the range £3883-£6555 (interim scales), depending on age and experience.
Further particulars and forms of application returnable not later than 10th January from the Staff Appointments Officer, University of Nottingham, University Park, Nottingham NG7 2RD. Ref. No. 646. (8813)

COLOUR TELEVISION ENGINEER

Exciting opportunities exist in a small company for a qualified person with working knowledge of Bush, Ferguson and Decca televisions. Salary from £3500 per annum with fringe benefits. Challenging prospects for the right person.

Apply: **G. B. Griffiths**

TELFURB TV LTD.
51-53 High Street, Wheetley, Oxon
Tel. 086 773849

(8825)

ITN

SENIOR ENGINEER VTR

SALARY £6,499 P.A.

Independant Television News Ltd. has a vacancy for a Senior Engineer in the ITN Facilities Centre in Central London.
Applicants should have several years' experience of broadcast VTR Operations including editing and maintenance.
The work covers a wide variety of programmes including news, commercials and feature materials.
Contributory pension scheme and free life insurance.
Please telephone the personnel office on 01-637 3144 for an application form quoting Reference No. 83305.
Closing date: 31st December.

(8805)

ELECTRICAL/ELECTRONICS ENGINEERS FOR A CAREER IN TECHNICAL SALES

Acheson Industries (Europe) Ltd, international leaders in specialist lubricants and surface coatings, require enthusiastic people to join their expanding sales team.

We require field engineers located in the Midlands and Home Counties to assist us in meeting an increasing demand for our established range of conductive and lubricating coatings. Applicants should be aged 25-35 and have relevant qualifications or experience in an Electrical or Electronic Industry. Previous marketing and selling experience is not essential but applicants should be self-motivated, willing to learn and able to communicate at all levels.

Starting salary negotiable, £4,500 minimum, Company car, modern pension scheme and other staff benefits.

Please write in confidence, giving personal details to Mr. Alan Bate, Acheson Colloids Company, Division of Acheson Industries (Europe) Ltd., Prince Rock, Plymouth, PL4 0SP.

Acheson

(8767)

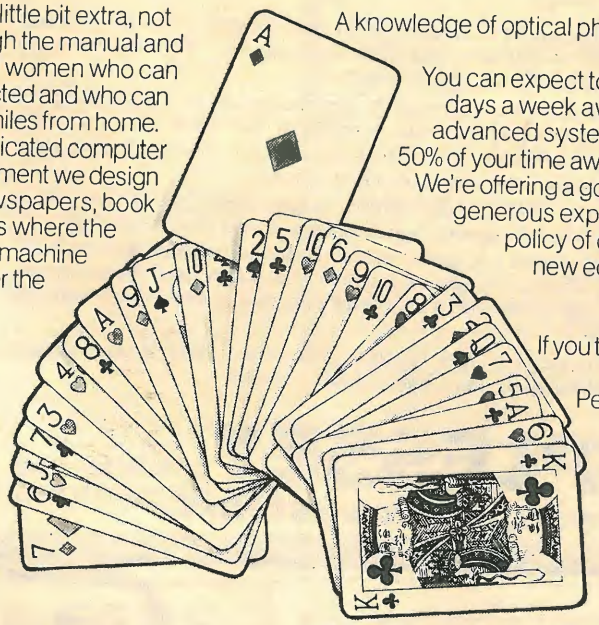
ELECTRONICS FIELD SERVICE ENGINEERS

It's the only pack of cards you'll need

Field Service Engineers with that little bit extra, not types who can only shuffle through the manual and replace faulty cards, but men and women who can think logically, look for the unexpected and who can diagnose and repair a fault many miles from home.

As world leaders in sophisticated computer controlled photo typesetting equipment we design and manufacture systems for newspapers, book publishers and typesetting studios where the pressures are often high. And if the machine goes down it's you who has to lower the temperature.

So you should be tactful, diplomatic and have presence, in addition to relevant field experience and a qualification to ONC or HNC level.



A knowledge of optical physics and a general mechanical aptitude would be useful.

You can expect to travel widely, initially perhaps 2 days a week away but as you progress to more advanced systems you could be spending up to 50% of your time away, almost anywhere in the world.

We're offering a good salary, a Cortina 1600 Saloon, 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.

If you think you can meet this challenge get in touch with David Hilton, Personnel Manager, Linotype-Paul Ltd., Kingsbury Road, London NW9 8UT. Tel: 01-205 0123

Linotype-Paul 1974 (8765)

Opportunities in Telecommunications with Shell

MANCHESTER

Shell UK has a large Private Telecommunications Network for the transmission of telephone, telegraph, facsimile and computer data; we need high calibre staff to complete current and future projects.

TELECOMMUNICATIONS ENGINEER

To participate in the further planning and development of both the Shell UK Private Network and of associated communication services, covering such activities as analysis of present systems, consideration of more effective alternatives, recommendation of improvements and implementation of approved changes.

Responsibilities will in the main cover computer and other data communication services and there will be some involvement in document and/or voice communication services. The incumbent will report to a Senior Telecommunications Engineer/Analyst.

A formal qualification to degree level in one branch of light electrical engineering, including some specialisation in computing or communications engineering subjects supported by extensive experience in planning and implementing Computer Communications Systems, is essential for this position. Demonstrable knowledge of Data Communications and Computing Equipment Systems, Microprocessor techniques as applied to Data Communications and Software Techniques of Hand Shaking and Communication Protocols would be of considerable advantage.

Male/female applicants please write or telephone for an application form to: Marjorie Mooney
Shell U.K. Information and Computing Services
Rowlandsway, Wythenshawe, MANCHESTER M22 5SB. Tel. 061-499 4454

SENIOR NETWORK CONTROL ENGINEER

To co-ordinate the activities and supervise the Network Control staff, handle non-technical staff liaison and deputise from time to time for the Head of Telecommunications Network Control.

A detailed knowledge of modern Data Communications equipment and techniques is essential with particular emphasis on fault diagnosis. An understanding of computer systems (hardware and software) and modern telephone networks using stored programme controlled exchanges is also required. The applicant would also need to demonstrate very high technical standards, and have proven supervisory experience.

A formal qualification to at least HNC Electrical/Electronic Engineering with "O" level English Language is a pre-requisite for this appointment. A degree would be preferred. In addition a minimum of two years' experience in a similar post and five years' experience in the Computing Industry is required.

We offer excellent prospects for the future together with a competitive salary commensurate with the positions plus the usual fringe benefits you would expect from a large organisation.
Substantial relocation expenses will also be paid where applicable.

(8780) **Shell**

Microwave Test Engineers

Plessey Radar is a leader in the design, development and manufacture of ground/shipborne radars for a variety of military and civil applications. We are currently involved in an exciting programme of long term projects.

We are looking for engineers to carry out test and design evaluation on a wide range of active and passive radar system components, sub-assemblies, antennas etc., spanning the frequency range 100 MHz to 18 GHz. Successful candidates will work as members of small teams in a dynamic, production orientated environment.

Ideally, you will have a Degree or HND/HNC with some experience in this specialised field, although this should not deter those with lesser qualifications from applying. Competitive salaries will be negotiated and generous relocation allowances are available to assist transfer to the Isle of Wight. We are pleasantly located in a rural environment near Cowes. The area offers a wide selection of inexpensive housing, superb recreational amenities and easy commuting.

Please write with brief details or ring Jim Handley, Resources and Remuneration Manager, on (0983 82) 4141. Plessey Radar, Cowes, Isle of Wight.

PLESSEY
electronic systems

(8760)

CAPITAL APPOINTMENTS LTD.

FREE JOBS LIST
for
FIELD SERVICE ENGINEERS, BASIC SALARIES TO £5,000 + CAR

(8781)

30 Windmill Street, London, W1
01-637 5551

NORTHERN COUNTIES RADIO SCHOOL LTD.

RADAR LECTURER REQUIRED

Qualifications: DOT Cert. and PMG/MRGC Cert.

Apply: The Principal
NCRS Ltd.
91 Lancaster Road
Preston PR1 2QJ

(8774)

VIDEO OPERATOR

required by Research Recordings Video Hire Department to deliver and operate video recorders, monitors and cameras. A knowledge of London, an ability to liaise with clients and being prepared to work long hours are essential.

Starting salary £3,250 + Vehicle + Overtime.

Ring Ron Kirk 286-2263

(8819)

PROJECT ENGINEERS

Based at Teddington Studios

THE JOB:
To join a team of Project Engineers engaged in providing new facilities for this expanding company. Thames Television's Engineering Department has a proven record of innovation and excellence in this field.

EXPERIENCE:
Experience in planning and executing Television Systems is essential for a senior post. For junior posts experience in TV equipment design, project work in related fields or operation experience may be acceptable.

A good theoretical grounding in Electronics with particular reference to professional Broadcast Engineering is necessary. Equally important are personality and drive combined with a logical and enquiring mind.

CONDITIONS:
Salary dependent upon experience will be up to £7200 (Supervisory Engineer Grade), 21 days holiday, pension scheme, subsidised restaurant and social club.

For application form please telephone or write to Mike Allen, Staff Relations Officer, Thames Television, Teddington, 01-977 3252.

THAMES

(8768)

Calibration Engineers

Electronic Instruments

Wouldn't you like to work in a well equipped laboratory that's got the best in modern equipment, including instrument manufacturer's testing aids?

Wouldn't you also like to work for a company renowned for advanced technological innovations that demand the use of the most modern instruments available?

Ferranti are looking for Engineers whose aim is quality, to be responsible for calibration, maintenance and repair of the wide variety of instruments used within our Development Laboratories.

If you have an HNC/ONC or C. & G. in electronics together with the experience and enthusiasm to tackle the job, Ferranti can offer you a good salary (opportunities for overtime if you want it), a productivity bonus scheme, flexible working hours and other benefits associated with a large and successful company.

You have nothing to lose, and probably a great deal to gain by talking to us. So why not telephone or write quoting ref. no. D/859/W W to:

The Personnel Department,
Ferranti Computer Systems Limited, Western Road,
Bracknell, Berkshire. Telephone: 0344 3232 ext. 471

FERRANTI
Selling technology

1974

(8758)

MANAGEMENT & EXECUTIVE SELECTION

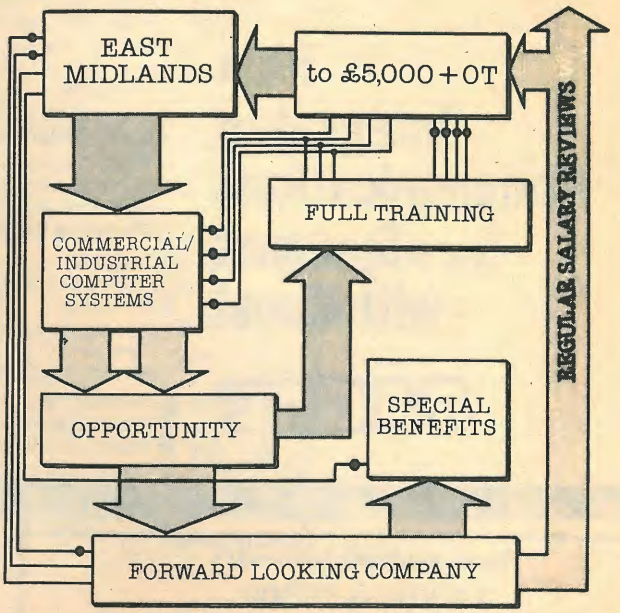
telephone 01-637 9611

REPAIR and RETURN TECHNICIAN

SALARY: To £5000 + O.T.
AREA: Hinckley
EXPERIENCE REQUIRED: A good electronics/electro mechnical background, ideally with HNC or TI qualification. Computer systems experience is preferred, but all applications will be considered.
OPPORTUNITY: The U.K. Division of this multi-million dollar American company is small but established, and with sales at an unprecedented high, they expect to double in size within five years. Thus career progression is virtually guaranteed.
TRAINING: Full training will be provided both initially and on a regular basis.
FORWARD-LOOKING COMPANY: The company manufacture powerful mini and micro computers for industrial/commercial use. Their success has resulted in over 18,000 systems installed world-wide. Always at the forefront of technological advances, their activities are constantly highlighted in the International and Trade Press.
SPECIAL BENEFITS: Free BUPA, Free Life Assurance, Contributory Pension Scheme (5% of salary) 20 days' Holiday p.a.

For positive career advancement, contact Tony McGrath

Suite 201/6, Albany House, 324 Regent Street, London W1R 5AA 01-637 9611 **MANAGEMENT & EXECUTIVE SELECTION**



SALES ENGINEERS

SURREY, MANCHESTER/CHESTER

Join one of the fastest growing Digital Multimeter companies in Britain.

Previous selling experience is not essential.

Applicants should have a knowledge of digital instrumentation and a strong desire to be successful in marketing.

An excellent salary package is offered together with normal company benefits. A company car will be provided.

Apply in writing to.

KEITHLEY

Roy Quaife
1 Boulton Road
Reading
Berks (8775)

We are a privately owned company holding franchises for leading makers of video and audio equipment.

We need an

EXPERIENCED ENGINEER

Located at our Southampton branch to be responsible for the operation of our Service Department, including work at the bench, carrying out repairs on site, installation, warranties and providing a 'technical service to our sales staff'. The successful applicant will also be expected to develop the service aspect of our business.

If you have a knowledge of Sony, National, J.V.C., Hitachi, Sansui or like equipment we would like to hear from you.

Please apply in writing giving details of age, experience and qualifications to:

Mr. T. J. Holdoway, Chairman/Managing Director

VIDEO SOUTH LTD.

101 Eden Vale Road, Westbury, Wiltshire (8808)

PRODUCTION/ MANUFACTURING ENGINEER

- Responsible to the Operations Director to provide support for manufacturing materials control, Product Test, Q/C and Engineering.
- Experience: Min. HNC/C & G full tech. with several years within the precision electro/mechanical industry. Previous electronics experience is desirable.

SENIOR TEST ENGINEER

- Responsible to our Disc Product Test Manager to test, debug and repair our high technology range of Disc products and become involved in improving product design and Quality Assurance procedures.
- Experience: Formal electronics training (HNC or equivalent) with experience of Digital/Analogue and/or computer systems electronics is desirable.

SENIOR SERVICE ENGINEER

- Responsible to the Customer Engineering Manager for in-house and field repairs and installations.
- Experience: Formal electronics training (HNC or equivalent). Digital/Analogue and/or computer systems electronics experience desirable. Enthusiasm more importance than previous experience.
- Must enjoy European travel.

CIRCUIT DESIGN ENGINEER

- Responsible to the Engineering manager to work on advanced disc systems incorporating high technology servo and data channel electronics.
- Experience: HNC/HND with several years relevant experience. Knowledge of the latest discrete and integrated component technology is essential.

★ If you would like to find out more about any of the above positions or other electronic/mechanical positions not advertised.

★ If you want to join a fast expanding company manufacturing advanced computer Disc Drives and Drum memories.

★ If you want to be **more** than a small cog in a big wheel.

Phone Mrs. Amery on **Leatherhead 76221** (and reverse the charges!)

VERMONT RESEARCH LIMITED

CLEEVE ROAD, LEATHERHEAD, SURREY

Telephone: Leatherhead 76221

(8840)

Communicate with Racal

Plan Integrated Communications Systems with Racal

RACAL

Racal Communications Systems Limited have vacancies for engineers in their SYSTEM & INSTALLATION PLANNING DEPARTMENT. The Department is responsible for the design of a wide range of radio systems from small networks to multi-million pound turnkey projects

The work is challenging and stimulating, entailing contact with potential customers and direct liaison with our own Marketing and Design staffs.

The equipment involved in these projects includes a complete range of local and remotely controlled MF HF VHF radio equipment, antennas, terminal and ancillary units, radio relay and power sources, which can be installed in static or transportable environments. The work also includes propagation analysis and L.O.S. calculations.

Senior Planning Engineers

To take total responsibility for planning and presenting responsive and cost effective communication systems in a highly competitive field. We are looking for engineers with experience in this field, who wish to extend their responsibility and experience.

Planning Engineers

To work on large projects with senior staff or on smaller projects with minimum supervision Technical or operational experience in radio communications is a basic requirement for these posts.

Conditions of employment are attractive and include five weeks annual holiday and membership of an excellent Pension and Life Assurance Scheme. Relocation assistance will be available in appropriate cases.

Please apply to:
The Personnel Manager, Racal Communications Systems Limited.
Western Road, Bracknell, Berks. Tel: Bracknell 3244, Ext. 149.
These vacancies are available for men and women.

8759

Automotive Industry
£4000 to £5000

Lumenition, an expanding company engaged in the automotive electronic ignition and fuel injection field wish to appoint an engineer to their research and development staff. The company forms part of the successful Autocar Equipment Limited group. Lumenition automotive ignition systems are sold to customers throughout the United Kingdom and in countries overseas.

The appointee will be part of an engineering team which is dedicated to the development of new, advanced systems. He or she will have an engineering degree or HNC level qualification ideally with two or three years' experience in analog or digital systems and opto-electronics.

Starting salary is negotiable around £4000 to £5000.

Please write to the General Manager stating age, current salary and how you meet the requirements.

Lumenition®

Lumenition Limited
77/85 Newington Causeway, London S.E.1 (8814)

SENIOR DEVELOPMENT AND TEST ENGINEERS

A leading company in the phototypesetting industry requires engineers who feel capable of working on a brand new range of minicomputer based V.D.U. terminal equipment, incorporating the latest in MS1 and LS1 techniques in real time applications. The development position involves a new project from specification stage through to production. The product will be microprocessor (Z80) based and experience in this field, particularly on the software side, is essential. The right candidate for the systems test position will be qualified to at least HNC level and/or have considerable experience in digital electronics with knowledge of 74 Series T.T.L. A background in the word processing or printing industry would be advantageous. The position would involve some U.K. and European travel to handle system installations and back-up service for our overseas agents.

The company provides 4 weeks' holiday and pension scheme. Salaries negotiable.

Phone for application form to: **Miss Bux, Datek Systems Limited, 849 Harrow Road, Wembley, Middlesex. Tel: 01-904 0061.**

(8822)

Laboratory Technicians

Sony Broadcast Limited is a subsidiary of the Sony Corporation of Tokyo, concerned with the manufacture and sales of the finest range of professional Broadcast Equipment available today.

Our policy is that the product delivered to the customer should be of the highest quality.

We are currently seeking the following personnel to join our expanding engineering facilities at Basingstoke.

LABORATORY TECHNICIANS

Technician: Development Laboratory

The successful applicant will have a working knowledge of analogue and digital electronics, which will be applied to the construction and testing of prototype circuits under the supervision of the designers. Accurate and professional standards of work will be required. Previous experience in television is not essential, however, the postholder can expect to learn more about this rapidly advancing field of technology.

Technician: Quality Assurance

The Sony reputation for ultimate performance and reliability is maintained by rigorous pre-dispatch testing of equipment before delivery to the customer. Practical experience with television systems and equipment will be an advantage for this post. This successful applicant will be working with state-of-the-art cameras, VTRs and associated equipment.

Starting salaries will be in the range £2,700 – £3,600 dependent on qualifications and experience.

If you feel that you have the background, and are motivated by the challenge of contributing to the growth of a dynamic new company, please write, giving details of your education, experience and current position to:

Personnel Manager

SONY Broadcast

Sony Broadcast Ltd.
City Wall House
Basing View, Basingstoke
Hampshire UK RG21 2LA

Development Engineers/ Systems Programmers

Your career could really take off here in Kidsgrove, N. Staffs

£3600-£7200

We're at the forefront of computer technology, we're successful and we're growing fast. This continuing expansion means that we now need more Engineers and Programmers to work on the design of the following developments:

- Input/Output Controllers
- Communication System Controllers
- Intelligent Communication Terminals

The work involves:

- Logic design
- Network Systems Programming
- Intelligent Terminal Programming
- Microprocessor applications
- Programming of I/O Controllers

You may already be experienced or a recent graduate in electronics, computer science or other science discipline. We want to see you to tell you more.

Kidsgrove is situated in the pleasant rural setting of North Staffordshire. A wide variety of housing is available and we'll help you move.

Find out more, fix a date with the 'decision takers', ring Herrick Thwaite on Stoke-on-Trent (0782) 29681 ext 3531 or write to him at ICL, Westfields, West Avenue, Kidsgrove, Stoke-on-Trent ST7 1TL. Please quote reference WW1098.

These positions are open to both men and women.

International Computers

think computers – think ICL

ICL

8788

FOREIGN AND COMMONWEALTH OFFICE
COMMUNICATIONS DIVISION
has vacancies for

RADIO TECHNICIANS

at CROWBOROUGH, SUSSEX

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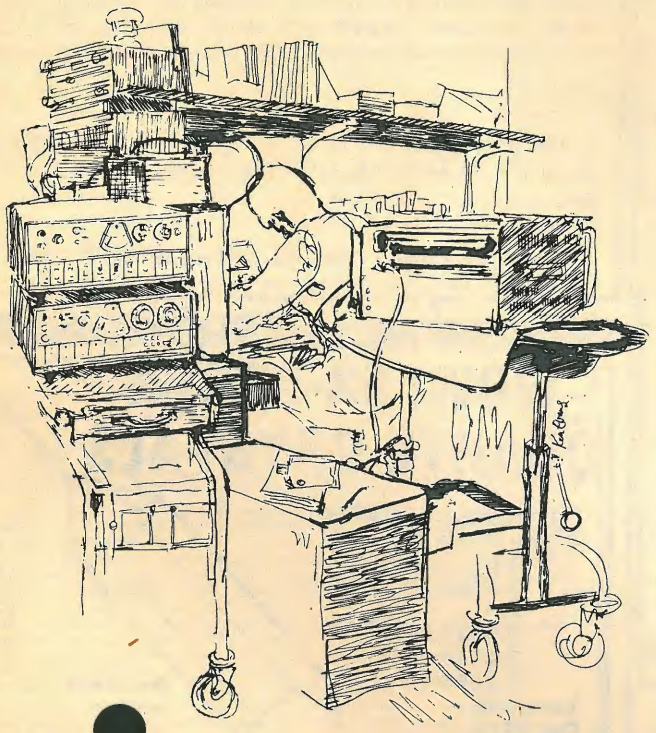

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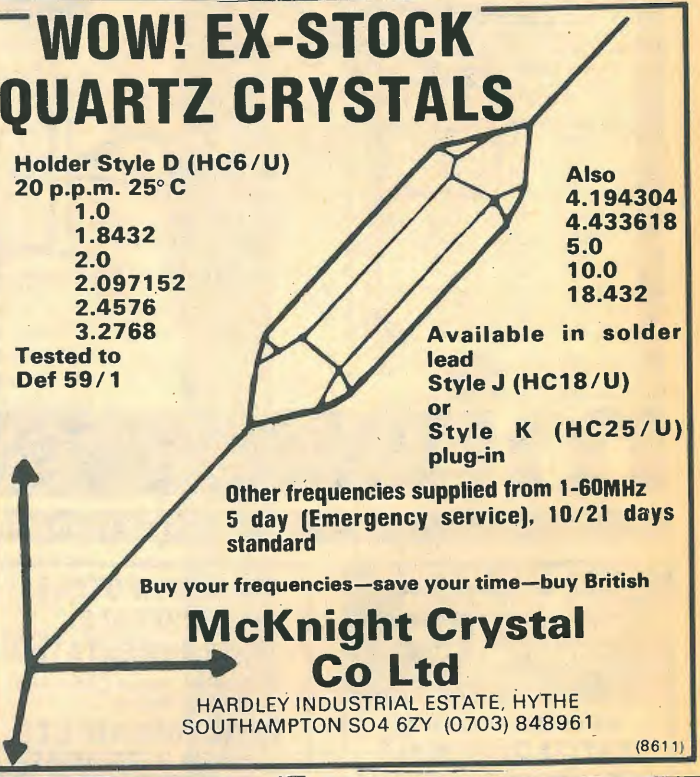

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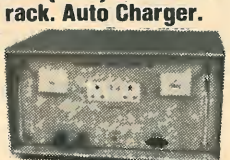

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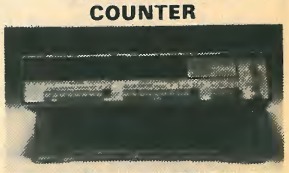

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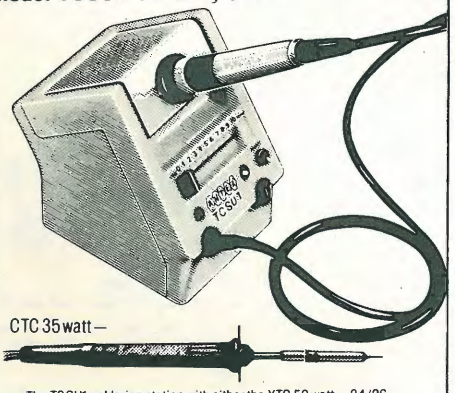
ANTEX

Mayflower House, Armada Way, Plymouth, Devon Tel: 0752 67377/8 Telex: 45296

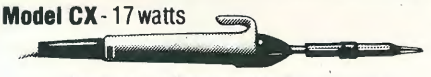
Model TCSU1 Soldering Station



CTC 35 watt—

The TCSU1 soldering station with either the XTC 50 watt—24/26 volt soldering iron or the CTC 35 watt—soldering iron for pin point precision and exceptionally fast recovery time. We have put at least twice as much power into irons which are already well known for good recovery time. The temperature control stops them from over-heating; the "fail-safe" electronic circuit provides protection even if the thermocouple fails. TCSU1 soldering station **£38.10** XTC and CTC irons **£14.85** inclusive of VAT and P.&P.

Model CX - 17 watts

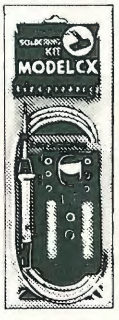


. . . a miniature iron with the element enclosed first in a ceramic shaft, then in a stainless steel. Virtually leak-free. Only 7½" long. Fitted with a 3/32" bit. **£4.37** inclusive of VAT and P.&P. Range of 5 other bits available from ¼" down to 3/64"

Model X25 - 25 watts

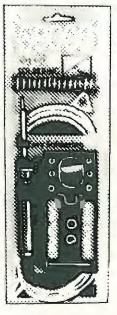
A general purpose iron also with a ceramic and steel shaft to give you toughness combined with near-perfect insulation. Fitted with 1/8" bit and priced at **£4.37** inclusive of VAT and P.&P. Range of 4 other bits available.

Model SK3 Kit



Contains both the model CX230 soldering iron and the stand ST3. Priced at **£6.21** inclusive of VAT and P.&P. It makes an excellent present for the radio amateur, modelmaker or hobbyist.

Model SK4 Kit



With the model X25/240 general purpose iron and the ST3 stand, this kit is a must for every toolkit in the home. Priced at **£6.21** inclusive of VAT and P.&P.

Model SK1 Kit

This kit contains a 15 watt miniature soldering iron, complete with 2 spare bits, a coil of solder, a heat sink and a booklet, 'How to solder'. Priced at **£6.48** inclusive of VAT and P.&P

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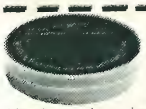

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'Arax' Use in conjunction with 'Arax' Multicore solder for general metal fabrication.

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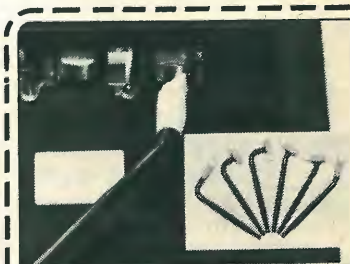

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