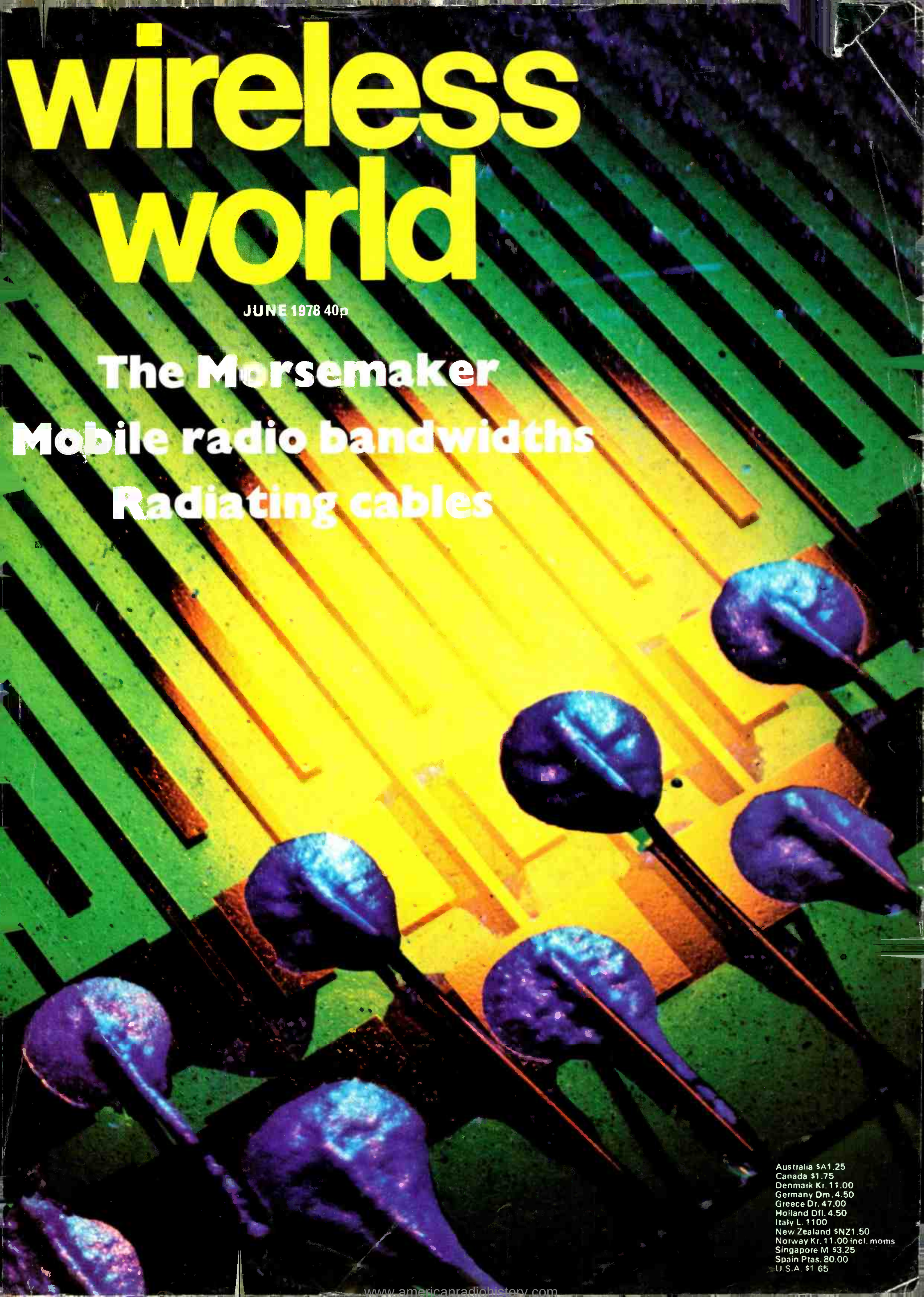
wireless world

JUNE 1978 40p

The Morsemaker

Mobile radio bandwidths

Radiating cables



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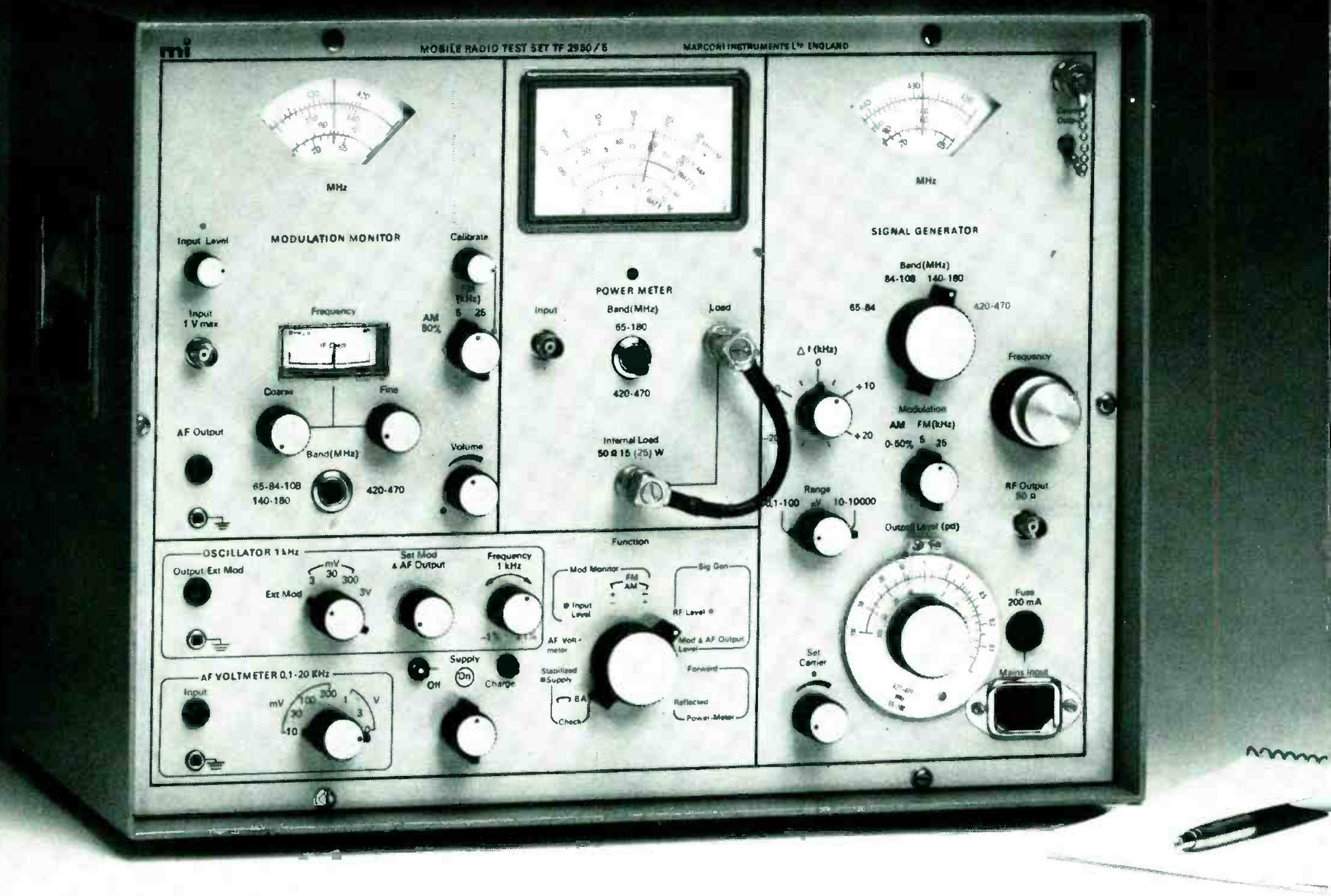
The better value box for mobile radio servicing.



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

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

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

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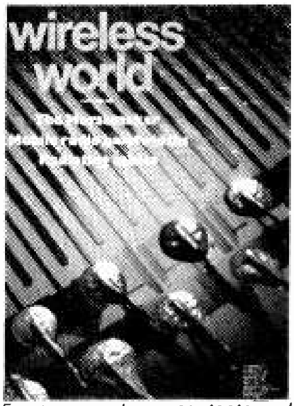

Front cover shows contacts and electrode arrangement of a birefringent electro-optic ceramic display made by SEL. Photo by Manfred P. Kage made available by SEL, Stuttgart.

IN OUR NEXT ISSUE

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The paperless revolution. **Latest developments in the use of electronics to store, process, transmit and display information, and the effect they could have on our lives.**
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wireless world

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* 0.2% Basic accuracy
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* **Four**-digit display for D and Q
* Microprocessor-directed ranging
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* Series or parallel measurement mode selection
* Built-in Kelvin test fixture tests radial and axial lead components

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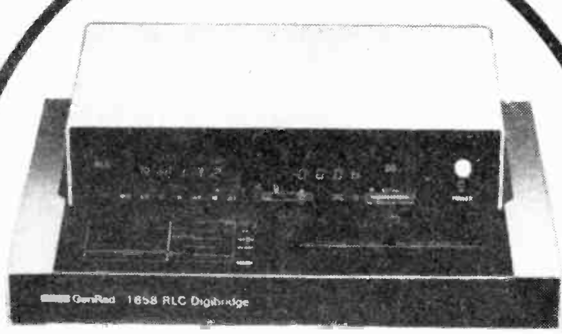

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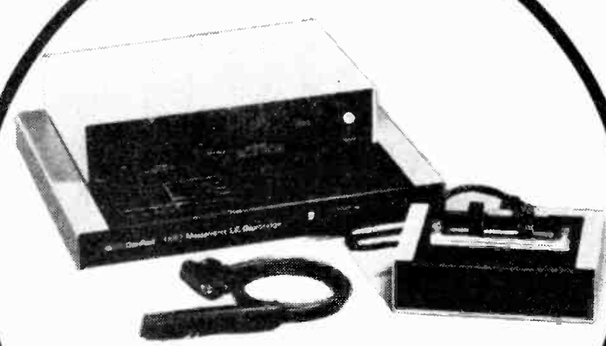

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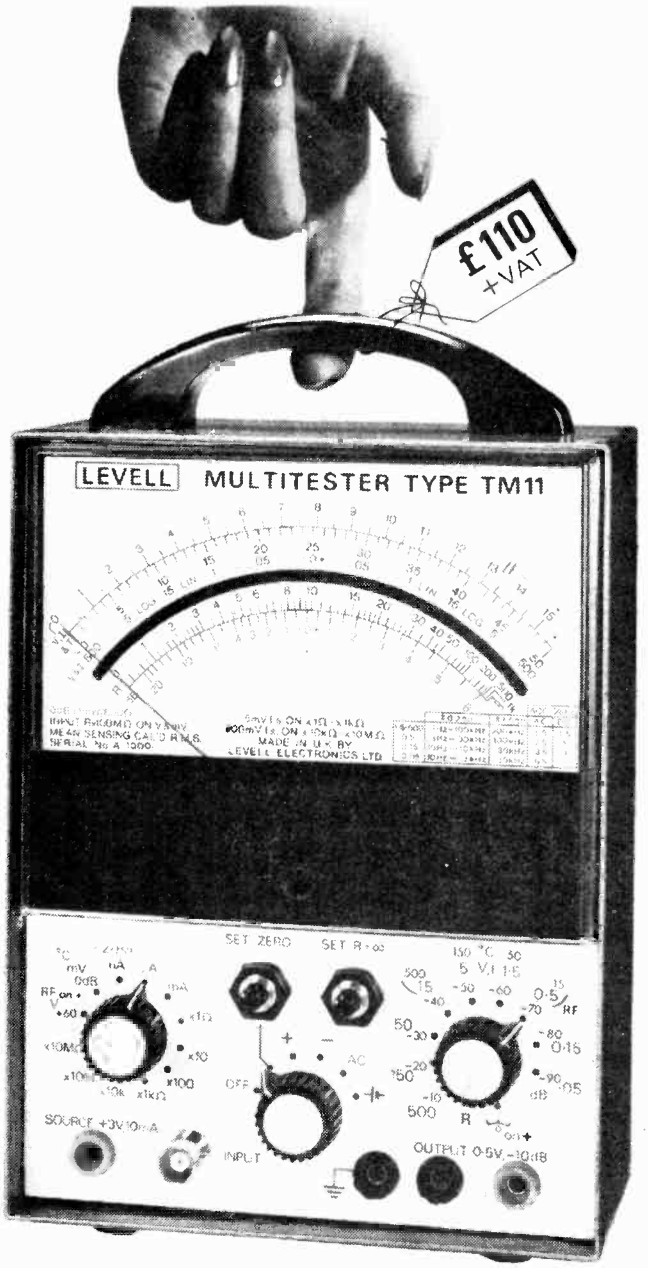

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The instrument operates from a 9 volt battery, life 1000 hrs., or, AC mains when optional Power Supply Unit is fitted. Size is 240mm x 150mm x 80mm. Weight is 1.75 kg. Meter scale length is 140mm. Leather case is available at £13 + VAT.

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Get started with the best MPU KITS available ex-stock

A.M.D. 2900 KIT

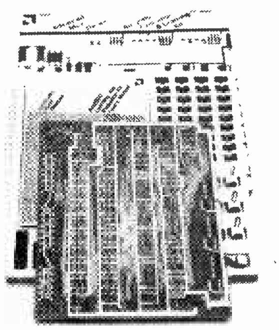
Advanced Micro Devices has designed an educational tool, the Am2900 Evaluation and Learning Kit, to be used by the design engineer learning microprogramming.

The kit consists of one Am2901 Bipolar Microprocessor, one Am2909 Bipolar Microprogram Sequencer, and several memories, registers, and multiplexers organized in a typical CPU (Central Processing Unit) structure.

This kit is NOT a four-bit computer.

All components required in the assembly of the Am2900 Evaluation and Learning Kit are supplied in the kit package. The only item that need be supplied by the user of the kit is a +5V power supply capable of delivering approximately 2 amperes of current. The assembly diagram and assembly instructions in this book show the location of each of the components on the printed circuit board.

Price: £202.30
(add £16.18 V.A.T.)



MOTOROLA MEK6800D2 KIT

MEK6800D2 provides an expandable kit that is ideal for those who wish to develop systems using the M6800 microprocessor, but who do not want to invest in expensive terminals.

The kit includes a hexadecimal keyboard and display, 384 byte of RAM, 16 I/O lines, an ACIA, an audio cassette interface and 1K byte monitor with step-by-step and trace features, all built around the MC6800 MPU.

Featuring

* 24 Key Keyboard
* 7 Segment Display
* Cassette Interface
* EROM Expandable
* RAM Expandable
* Wire Wrap Capability
* Parallel and Serial Interface Capability
* Single 5 Volt Supply Required
* Layout on Boards
* Documentation

Price: £175.88
(add £14.07 V.A.T.)

T.I. MICRO 99-16

(ASSEMBLED BOARD ONLY)

Micro 99 is a microprocessor PCB system which is designed to fulfill the dual roles of OEM microcomputer board and a low cost, limited resource prototyping system for Texas Instruments microprocessors. The first board in the system is the Micro 99-16 CPU board which consists of a TMS9900, static RAM, PROM, 15 levels of interrupt, 16 I/Os, TTY and RS232 interface.

Memory

RAM 256 x 16 bit words of STATIC RAM (TMS4042-2NL).

PROM sockets for 1536 x 16 bit words of FUSIBLE LINK PROM (SN74S472) or TIBUG monitor included.

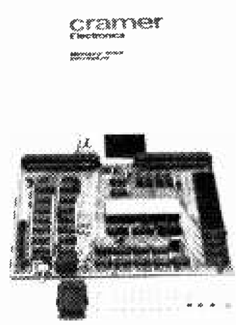
Power Supplies

+ 12 volts ± 0.6v – 100mA
+ 5 volts ± 0.25v – 2.0A
– 5 volts ± 0.25v – 5mA

PCB

Double Euro-card-dimensions 233.3mm x 160mm

Price: £340.00
(add £27 20 V.A.T.)



ZILOG Z80 KIT

The Z80-EBC kit (kontron) is a combined development system for evaluating the third generation Z80 microprocessor.

It comes as a complete kit with a 5 slot mothercard and requires only a 5V power supply. The Z80-EBC boasts a cassette interface, along with a hexadecimal keyboard and six, seven segment L.E.D.S. The ZPROG monitor gives the user control via the keyboard from where he may dump, load alter and run his programs.

Optional boards (PROM, RAM, and I/O) give the user expansion capability for a total system at a competitive price.

Featuring

* 27 Key Keyboard
* 7 Segment Display
* Cassette Interface
* EROM Expandable
* RAM Expandable
* Parallel and Serial Interface Capability

Price: £215.00
(add £17.20 V.A.T.)

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WW—078 FOR FURTHER DETAILS

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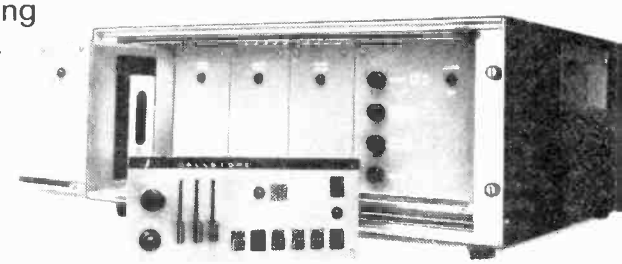
All these facilities, and more, are available in the Racal-Thermionic 'Callstore' cassette recorder/reproducer. Actuated either by incoming audio signals or by local or remote control, Callstore uses four cassette transports, each giving up to four separate channels, including a search control track which is cued at the beginning of each message.

For details write to:

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

RACAL



Callstore, from Racal-Thermionic, answers all the questions.

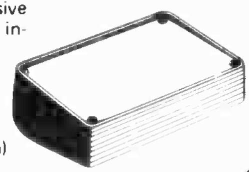
WW—012 FOR FURTHER DETAILS

BIMCONSOLES
BIMBOXES
BIMBOARDS
BIMDRILLS
BIMDICATORS

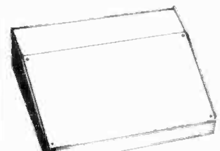
MINI DESK BIMCONSOLES

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

BIM1005 (161x96x58mm) £2.12*
BIM1006 (215x130x75mm) £2.94*



LOW PROFILE BIMCONSOLES

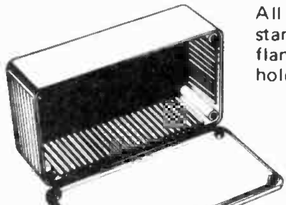


1mm Grey Aluminium panel sits recessed into front of console base, which is moulded in Orange, Blue, Black or Grey ABS and sits on 4 self adhesive rubber feet. Incorporating guides for holding 1.5mm thick pcb, the base also has stand-off bosses for supporting small sub-assemblies etc. and ventilation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

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

ABS & DIECAST BIMBOXES

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



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

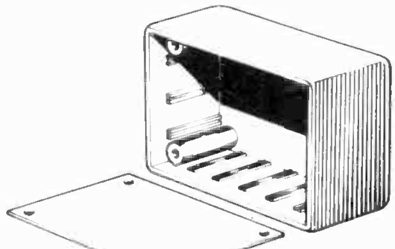
	ABS		Diecast	Hammertone	Natural
(100x50x25mm)	BIM2002/12	£0.95*	BIM5002/12	£1.20*	£0.97*
(112x62x31mm)	BIM2003/13	£1.05*	BIM5003/13	£1.50*	£1.20*
(120x65x40mm)	BIM2004/14	£1.15*	BIM5004/14	£1.86*	£1.49*
(150x80x50mm)	BIM2005/15	£1.30*	BIM5005/15	£2.38*	£1.91*
(190x110x60mm)	BIM2006/16	£2.04*	BIM5006/16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

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

MULTI-PURPOSE BIMBOXES

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

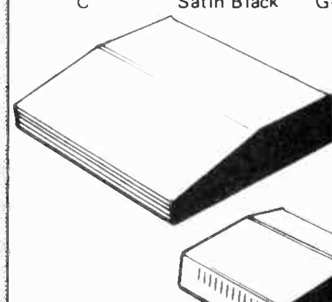
BIM 4003 (85x56x28.5mm) £1.24*
BIM 4004 (111x71x41.5mm) £1.56*
BIM 4005 (161x96x52.5mm) £2.08*



ALL METAL BIMCONSOLES

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

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



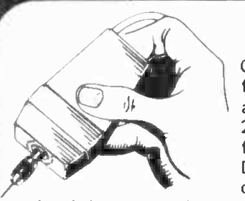
15° Sloping Panel

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

30° Sloping Panel

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

MAINS BIMDRILL

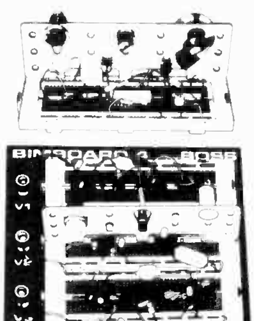


Operates directly from 220-240Vac and supplied with 2 metres long cable fitted with 2 pin DIN plug. Will drill brass, steel and aluminium as well as pcb's etc. Has integral biased-off switch and accepts tools with 1,2 and 3.2mm dia shanks £9.72*
Accessory Kit including 1mm, 2mm, .125" twist drills, 5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

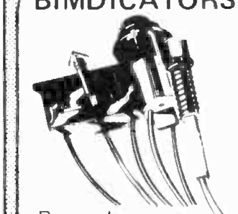
DIL COMPATIBLE BIMBOARDS

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

Bimboard 1 £ 9.72* Bimboard 2 £22.68*
Bimboard 3 £32.40* Bimboard 4 £42.12*



BIMDICATORS



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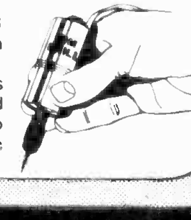
Major Bimdrill with 3 collets up to 3mm capacity £12.96*
Mains to 12 Volts adaptor, lathe, stand and accessory kits also available, details on request.



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Just clip it over your IC.
It instantly and accurately shows both static and dynamic logic states, on a bright, 16-LED display.
It finds its own power.
It cuts out guesswork, saves time, and eliminates the risk of short-circuits.
LM-1 is suitable for all dual-in-line logic ICs; DTL, TTL, HTL, CMOS; up to 16 pins.
LED on = logic state 1 (high), LED off = logic state 0 (low), and each LED is clearly numbered 1 to 16 in the conventional IC pattern.

Try the LM-1 and you won't know how you ever managed without it!

Brief specification

Input Threshold	2V ± 0.2 volts.
Input Impedance	100,000 Ohms
Input Voltage Range	4 volts minimum 15 volts maximum across any two or more input leads
Maximum Current Drain	200 mA @ 10 volts
Maximum Input Frequency*	10,000 Hz 50% duty cycle
Operating Temperature Range	0°C to 50°C
Weight	3 ounces (85 grams)
Maximum Dimensions	4.0 x 2.0 x 1.8" 102 x 51 x 45 mm

*LM-1 will respond to signals up to 0.1 MHz when the input signal swing exceeds the threshold voltage by more than 0.5 volts.

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Design, breadboarding, testing and checking new logic systems.
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The new, comprehensive JVC ¾" video cassette range

See-and believe

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

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

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

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

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

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

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

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

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To get the optimum results from any U-format equipment use Fuji Beridox tape. *Provably* superior to conventional CrO_2 tape, it's now available from every Bell & Howell dealer.

Beridox ¾"(19mm) video cassettes

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KCA-15 (15 min. playing time)
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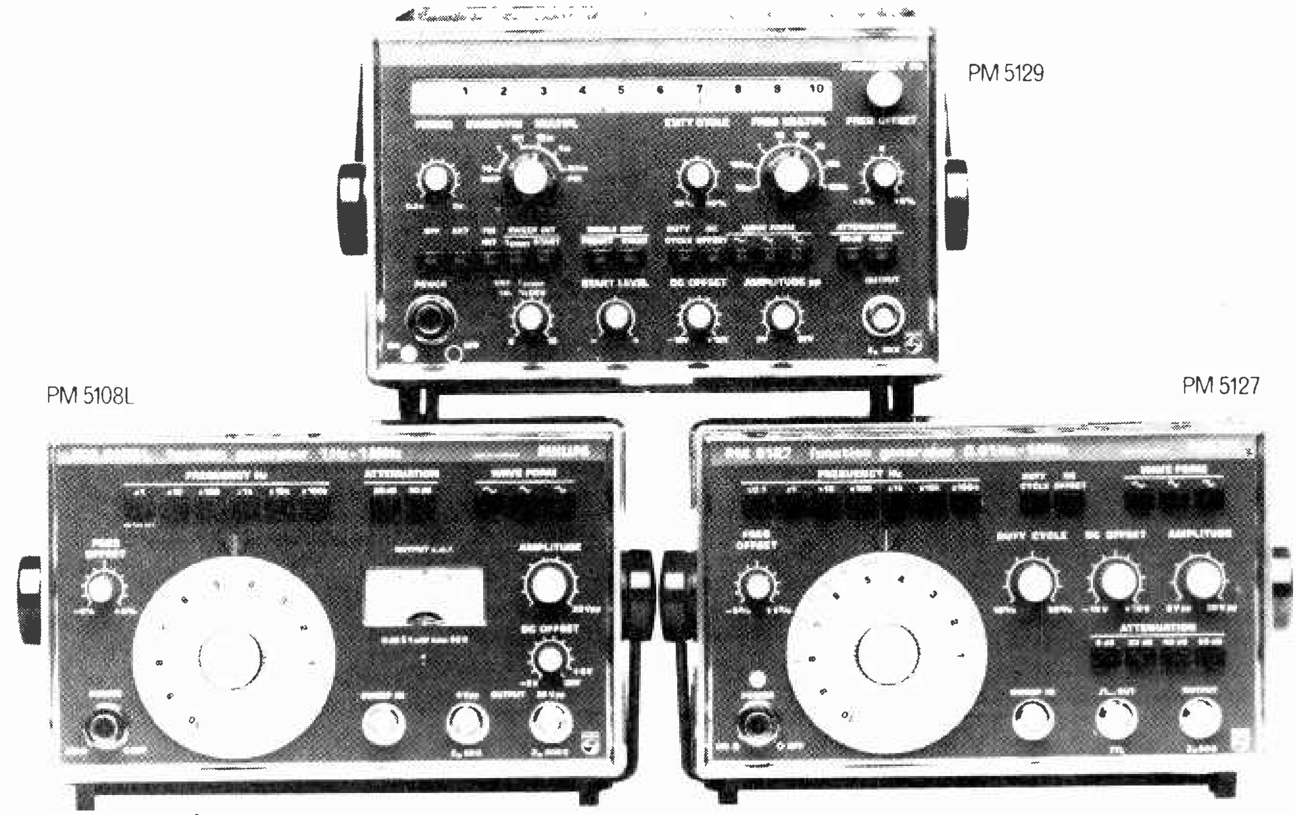
WW2

GEC SEMICONDUCTORS

WW—016 FOR FURTHER DETAILS

Philips covers the low frequency range



The compact PM 5127 function generator covers .01Hz to 1MHz in seven ranges with a facility for frequency offset. Waveforms available are sine, triangular and square, with adjustable duty cycle if required.

The comprehensive PM 5129 function generator incorporates an internal sweep generator. Single shot with variable start and stop level is included. In the burst mode a burst of pulses or a single pulse with variable width and frequency can be produced. Frequency range: 1mHz to 1MHz.

The general purpose PM 5108L function generator has such useful features as an output level meter, variable frequency offset, two simultaneous outputs (50Ω and 600Ω), 20 volts output and stepped and variable attenuators

The table below shows the scope of Philips' LF coverage, while the scale of its test and measuring activity is indicated at the foot of the page.

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Low Frequency Instruments Survey

Classification	Type nr	Frequency range Hz (0.001 0.01 0.1 1 10 100 1k 10k 100k 1M 10M)	Output V (0 10 20 30 40)	Waveforms: sine	Waveforms: square	Waveforms: triangle	Variable duty cycle	DC offset	Output characteristics: 600 Ω	Output characteristics: 50Ω	Output characteristics: TTL	Sweep: Ext	Sweep: Int	Sweep: FM	Sweep: AM	Meter
RC oscillators	PM 5106	▬	▬	●	●					10Ω						
	PM 5107	▬	▬	●	●				●		●					
Function generators	PM 5108	▬	▬	●	●	●		●	●		●	●		●		●
	PM 5108L	▬	▬	●	●	●		●	●	●		●		●		
	PM 5127	▬	▬	●	●	●	●	●		●	●	●		●		
	PM 5129	▬	▬	●	●	●	●	●		●	●	●	●	●		
	PM 5167★	▬	▬	●	●	●		●		●		●		●		
Digital generators	PM 5141	▬	▬	●	●				●		●					
Sweep generators	PM 5165	▬	▬	●	●	●		●		●		●	●	●		
Amplifier converter	PM 5171	▬		●	●				●		●					

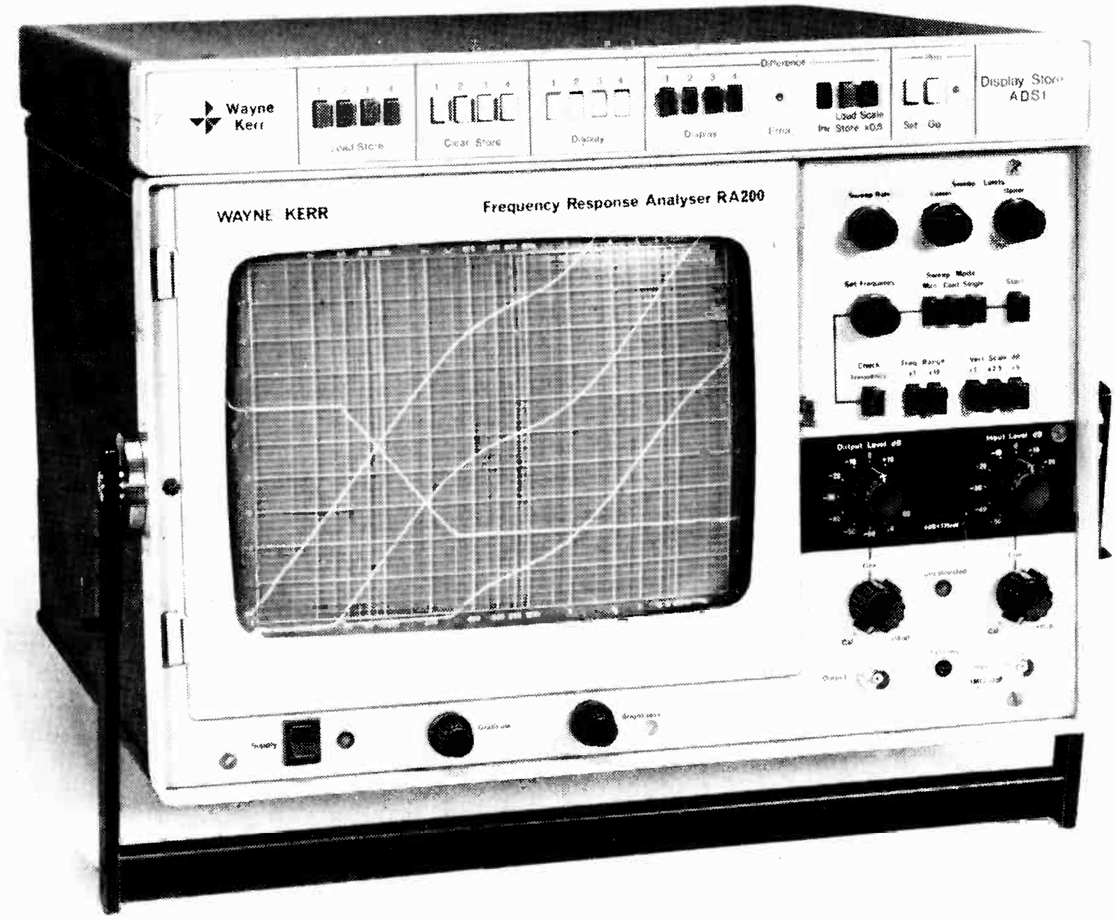
★output waveforms also include pulse and ramp

Test & Measuring Instruments

PHILIPS

RA200/ADS1

Frequency response analysis with a difference



The Wayne Kerr RA200/ADS1 is undoubtedly unique. It gives fast, accurate frequency response measurements for any audio system – displaying up to five different curves as gain/frequency plots on a long-persistance CRT. The basic unit, the RA200, performs all the detector and sweep functions, requires no synchronisation, and will adjust automatically to the incoming frequency.

Four Channel Digital Store

The matching display store, the ADS1, is a fully compatible digital storage unit powered by the RA200, and can give continual updating of each curve stored to ensure fast, precise readouts. It incorporates rechargeable batteries to permit stored data to be retained for up to two weeks when the unit is switched off.

The RA200/ADS1

This complete unit provides facilities for displaying the difference between any two stored curves, or comparison of any new input with a stored reference curve. Minor variations from a desired characteristic can be readily amplified, and departures from a linear response clearly shown as deviations from a straight line by use of the store 'invert'. Slow-acting pen recorders can also be driven by the unit.

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

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Unitronics SA, Torre de Madrid, Princesa 1, Piso 12 Oficina 9, Madrid 8, Spain. Tel: 242 5204.

Scandia Metric AB, Fack 171 19, Solna 1, Banvaktsvagen 20, Sweden. Tel: (08) 820 410.

Please send me further information on the Wayne Kerr RA200/ADS1.

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WW/6/78

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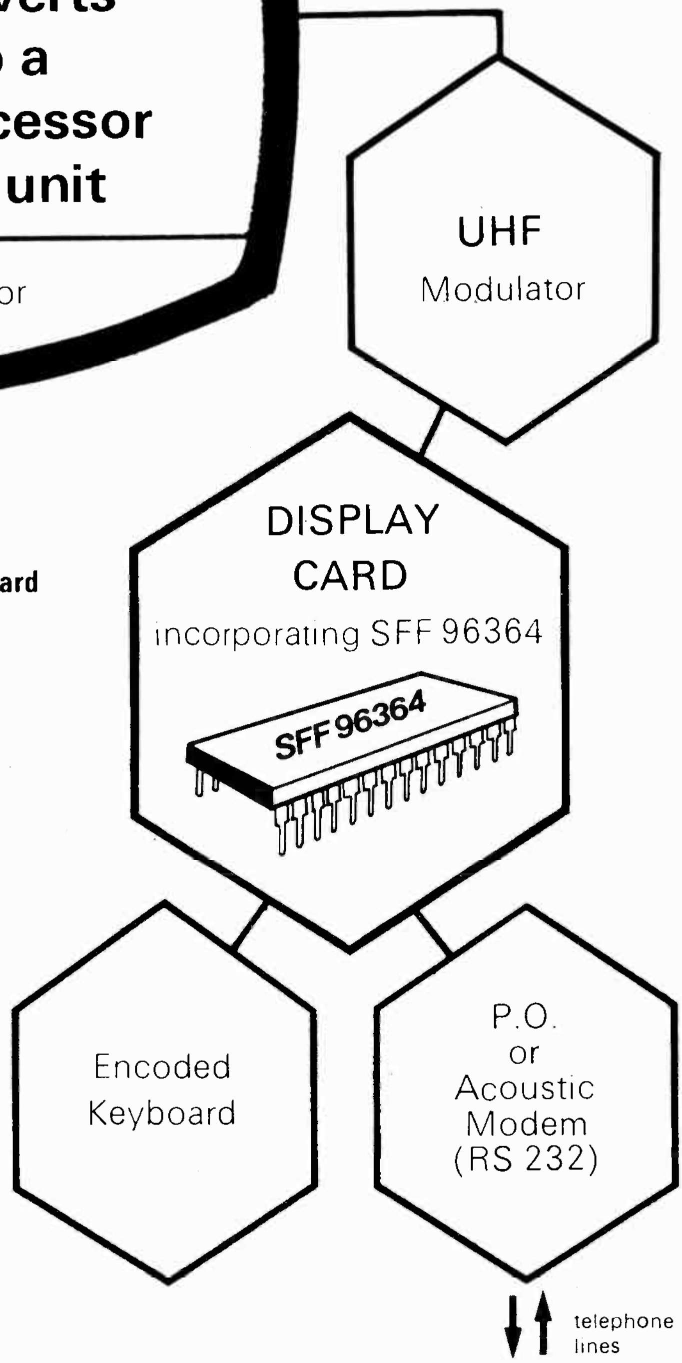

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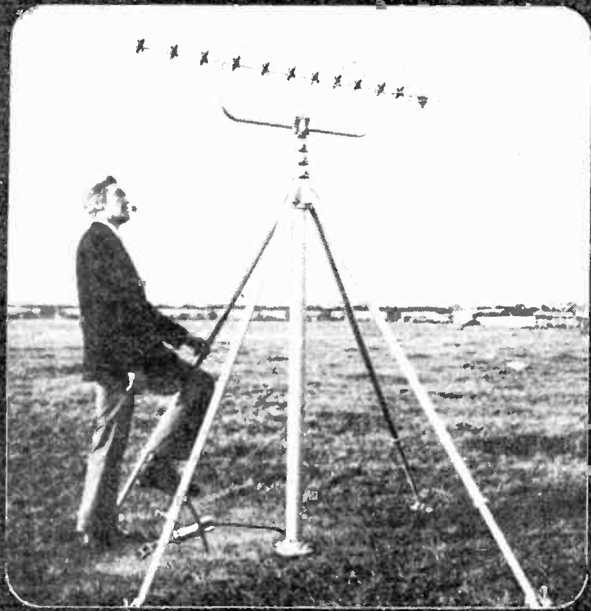

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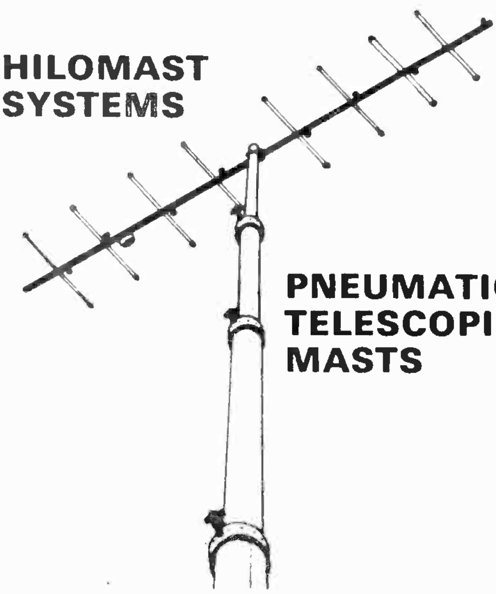

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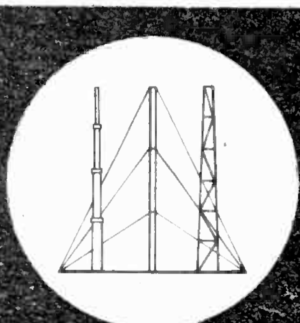

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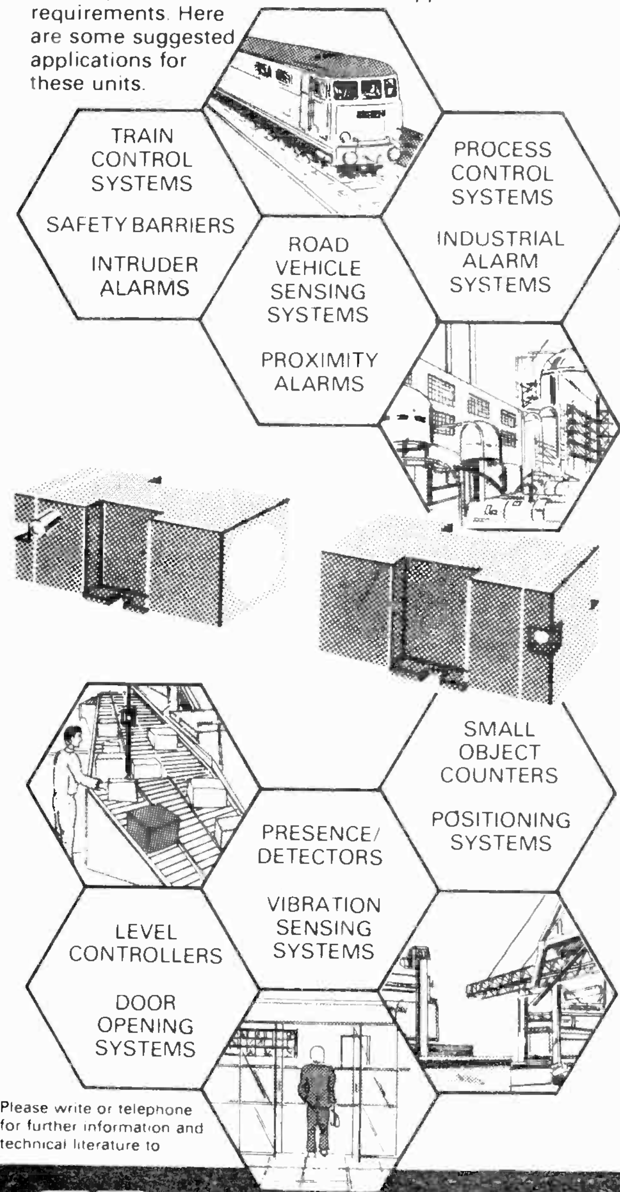

Please write or telephone for further information and technical literature to

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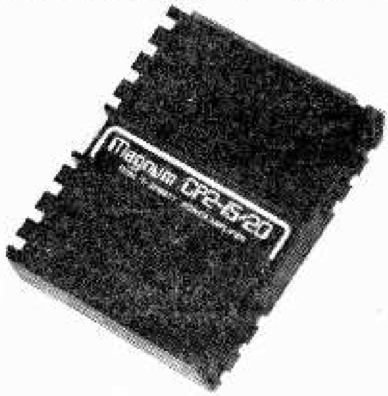

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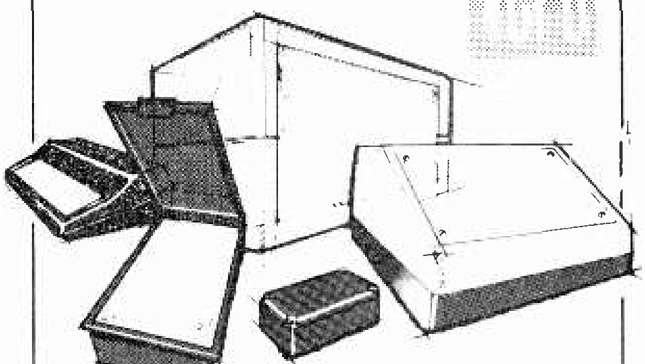

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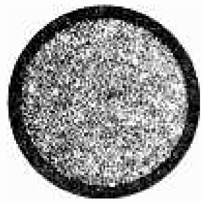

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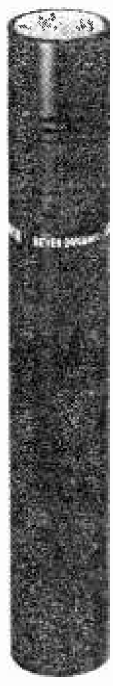

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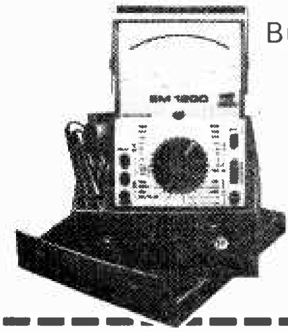

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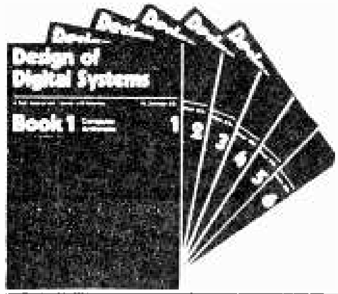

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WW6

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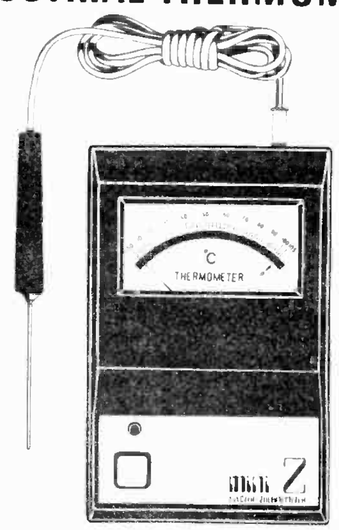

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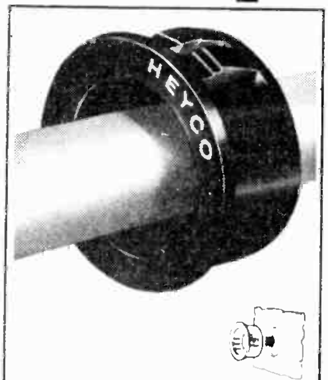

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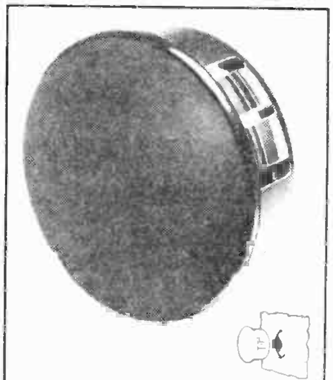

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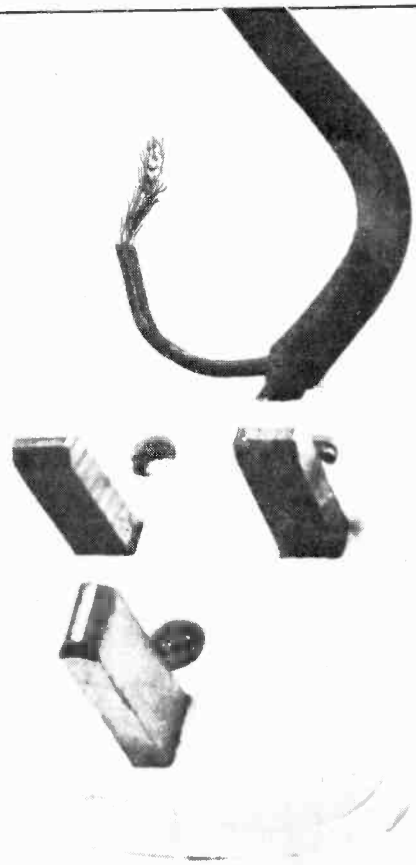

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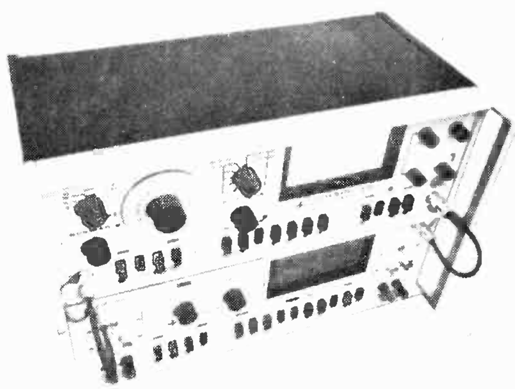

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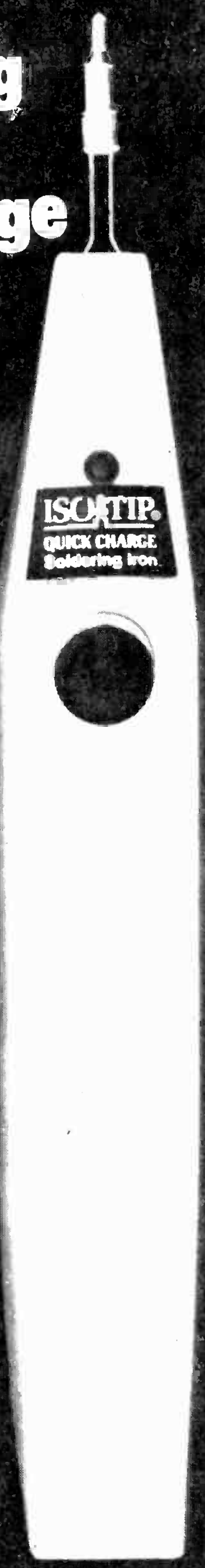

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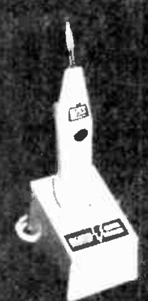

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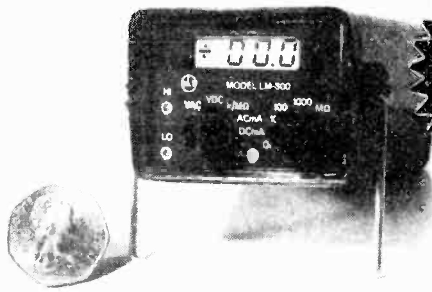

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wireless world

The spectrum and society

While the Home Office's judgements on the assignment of radio frequencies remain "classified" there is little chance of the public getting to know what the issues are and how they affect them and forming any opinions on the matter. Maybe the man in the street doesn't really care. Satisfied with his one vote, he is content to leave such matters to parliament and the technocrats that advise it. But the opinions of those people who really do care, the socially responsible, are in fact badly needed for a task that can be accomplished from no other source of information — the assessment of social values. For more than a decade it has been recognized that the present "law of the jungle" method of carving up frequency space only between those who are powerful enough to make vociferous claims for it is not good enough in civilized societies — and that is what those who use the spectrum most intensively claim to be. It has also been recognized that very little is known about the effects of spectrum decisions on interests other than those of the claimants and on such important issues as energy, pollution and poverty. In 1970 a telecommunications panel of the US National Academy of Engineering declared: "The allocation of any national resource must finally be made in what is deemed to be in the public interest by those responsible for its management. As the physical resources are exhausted, the social and economic considerations will become paramount and the limited resources must be allocated with greater attention to these factors."

Social factors of course are qualitative issues that deeply concern the community — about health, housing, education, amenities, racial harmony and so on — and are evident in its pattern of organization. They are often influenced by myths, religions or political ideologies. In some countries the social criteria are imposed arbitrarily by a totalitarian government, but elsewhere they seem to be derived from innate personal values (e.g. the idea of good) with no empirical basis. As such, social factors are extremely difficult to pin down and introduce into practical affairs, although they are in fact the criteria of many political decisions. Economic factors, on the other hand, being essentially matters of quantity, are comparatively easy to handle.

If portions of the spectrum are to be assigned fairly in accordance with social needs, and not merely in response to the emotional appeals of pressure groups, some objective method of measuring these needs, comparing them and establishing priorities will have to be found. And this is where the co-operation of an informed public is essential. The aim of such an objective method would be a rationalization of different types of service. It would be possible to establish, for example, that *x*MHz of bandwidth for a given time of television broadcasting in central Birmingham was equivalent to *y*MHz of bandwidth for a given time of mobile radio operation in the suburbs of London. Such precision may never be attained in practice, but this is the ideal towards which recent studies have been directed.

Some progress in this kind of investigation has been made in the USA, where of course the work of the spectrum managers is open for all to see and the public can take an interest in it. The British public should also be made aware of what the electromagnetic spectrum means to them, because it is only through the free expression of opinions on social issues which are affected by this resource that researchers can obtain the objective assessments they need.

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Current dumping — does it really work?

Theory and practice

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

This article endorses the soundness of the current dumping principle, though querying whether it should be called feedforward error correction in the feedback loop. In several respects the distortion reduction appears due to a passive bridge balance. It shows that dumper β-variation results in distortion, fortunately very low, which cannot be balanced out in present circuits. Readers are challenged to produce a circuit which nulls out such current distortion as well.

Measurements, in part 2, show that the amplifier performs very well, and analyses of the distortion oscillograms and wave analyser measurements show that, qualitatively, much of this data can be understood. We both heartily agree that the current dumping principle as embodied in the Quad 405 amplifier has significantly advanced the state of the art in class B power amplifier design.

A FLURRY OF EXCITEMENT and controversy has occurred since the article on the current dumping amplifier by P. J. Walker[1]. A class B audio amplifier capable of low crossover distortion, with no quiescent current, seems too good to be true! We have followed the letters to the editor with great interest, and noted that the situation seems to be a stalemate as regards the conventional-feedback versus feedforward argument. Each of us has changed his mind regarding the operation of the amplifier several times. It was in this framework that we decided a more careful analysis was necessary. We present first a view of the theory as we see it, and later on deal with some corroborating measurements made on a Quad 405 amplifier.*

Early letters have been adequately handled by Mr Walker[2], and we feel there is value in the equivalent circuit of Peter Baxandall[3]. But we fail to see how the independence of output impedance under two limiting conditions (dumpers on with infinte mutual conductance, off with zero gain) can imply distortionless behaviour.

There seems to be an advantage in the circuit, but it is precisely in the region of output transistor turn-on that such arguments are inapplicable. Accordingly, we were sceptical of the results, not having really taken the pains to work out all the details presented in Mr Walker's article and the letters. Referring to Fig. (d) of Mr Baxandall's letter, we were led to conclude that the distortion voltage created by the dumpers must somehow find its way out of the otherwise linear components. Mr Olsson's letter[3] also requires an answer.

Simplified analysis

An illuminating but incomplete analysis of the amplifier is possible. The effect of the dumpers can be looked on as a distortion voltage applied between the input and output of the dumper stage. In Fig. 1 assume for now that A has zero output impedance and has infinite gain (both conditions are related later). Labelling v_1, v_2, e_0, v_s, i_3 and i_4 as in Fig. 1

$$\frac{v_1}{Z_1}+\frac{v_2}{Z_2}+\frac{v_s}{R_s}=0,$$

and summing i_3 and i_4 for the total current

$$\frac{v_2-e_0}{Z_3}+\frac{v_1-e_0}{Z_4}=\frac{e_0}{Z_L}.$$

These two equations are easily solved for e_0 in terms of v_s and either one of v_1 or v_2 (we give both for didactic reasons):

$$e_0\left(\frac{1}{Z_L}+\frac{1}{Z_3}+\frac{1}{Z_4}\right)=-\frac{Z_2}{Z_3R_s}v_s+v_1\left(\frac{1}{Z_4}-\frac{Z_2}{Z_1Z_3}\right),$$

or

$$e_0\left(\frac{1}{Z_L}+\frac{1}{Z_3}+\frac{1}{Z_4}\right)=-\frac{Z_1}{Z_4R_s}v_s+v_2\left(\frac{1}{Z_3}-\frac{Z_1}{Z_2Z_4}\right). \qquad (1)$$

Either equation shows that e_0 will not depend on v_1 or v_2, which have distortion, if $Z_1Z_3=Z_2Z_4$, just the Walker balance condition. Under this condition the output e_0 depends only on v_s (with the same coefficient now) and not on the distortion voltage $v=v_2-v_1$.

If the gain A is made finite, a balance condition will still follow (messy algebra) as long as the amplifier A has zero output impedance, so that the dumper input current can be ignored**. This has been discussed by Bennett and Walker[2].

Another slant on a simplified analysis is to consider the output of the class A amplifier to be a true current source, with infinite output impedance. Then the equivalent circuit can be redrawn as in Fig. 2, with the dumpers again approximated by a voltage source, which admittedly is not very realistic with the current source approximation.

The class A amplifier has been characterised by a transconductance G_m with the output connected to the point v_2. To avoid getting dumper voltage distortion (v) into the output, any signal due to v at the inverting input of the class A amplifier should be zero. This requires $Z_1Z_3=Z_2Z_4$ independent of the value of G_m, because the criterion is simply a passive balance of the bridge. It

*As a result of the widespred advertising campagin for the Quad 405, we have heard it referred to as the "currently dumped amplifier." (We trust that the Acoustical Manufacturing Co. will forgive us for this levity.)

**For finite gain A, the dumper distortion v cannot be balanced to zero if the bridge is destroyed by shorting Z_4 in the circuit of Fig. 1. This fact also follows from our more general analysis below.

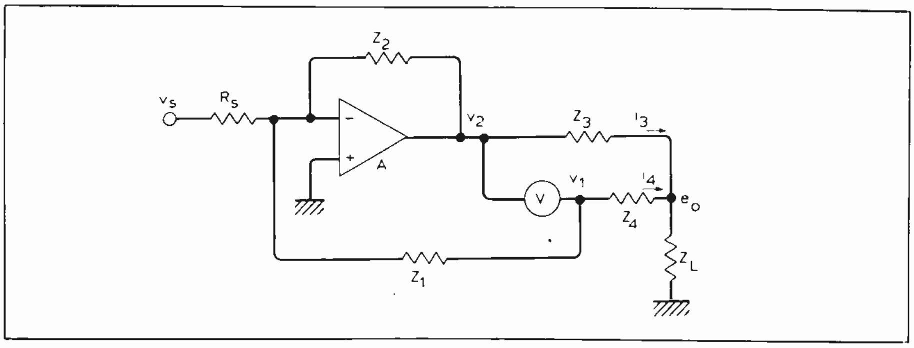

Fig. 1. *Simplified equivalent circuit of the current dumping principle considering only dumper voltage distortion.*

might be considered passive feedforward error correction in the amplifier with judicious feedback applied.

Naturally the effect of the dumpers is to amplify current, and then such a simple analysis is not warranted. Passive balance is lost and a more general analysis is necessary to establish if a balance condition still exists.

Balance condition

If the balance condition $B=0$ can be achieved (see boxed item) the output e_o will contain no dumper distortion contributions. The condition $B=0$ is the counterpart of the Walker balance condition $Z_1Z_3=Z_2Z_4$ which followed from setting the coefficient of v_2 equal to zero in our earlier equation (1). This condition is analysed next in some detail as it really contains all the information we have been seeking.

Firstly, returning to a remark made earlier ** suppose that Z_4 is omitted (i.e. short-circuited), thus destroying the bridge. Solving the equation $B=0$ for G_m in this case $G_m =$

$$-\frac{\beta\{(Z_1+Z_2+Z_3)R_s+Z_1(Z_2+Z_3)\}+Z_1Z_3}{(\beta+1)Z_1Z_3R_s}$$

which is negative†. For d.c. stability, we must assume G_m to be positive so that the overall feedback around the amplifier be *negative* feedback. Thus no bridge balance condition is possible when $Z_4=0$.

Secondly the possibility of achieving bridge balance *does* exist in the general case. Rearranging the equation $B=0$,

$$Z_2Z_4-Z_1Z_3 = \frac{\beta\{(Z_1+Z_2+Z_3+Z_4)R_s+Z_1(Z_2+Z_3)\}}{(\beta+1)G_mR_s+1} \quad \ldots(3)$$

Provided $Z_2Z_4>Z_1Z_3$ and assuming these impedances to be real for the moment, balance can be achieved for finite transconductance G_m *as long as* β *can be assumed to be constant.* In fact, equation (3) gives the value of G_m re-

†Unless explicitly stated otherwise, we assume that Z_1, Z_2, Z_3, Z_4 are real.

More detailed analysis

The Quad 405 contains a class A amplifier which has a current output. Referring to Fig. 4 of Peter Walker's article[1], the collector of Tr_7 is the output of this amplifier. The resistor R_{30} is not a significant load as it is "bootstrapped away" by C_{10}. Other connections to this point are the dumper bases, Z_2 and Z_3. Capacitors C_9 and C_{11}, presumably to prevent r.f. instability, are ignored. Hence in an improved modelling circuit we consider the class A amplifier to have a current output and a traconductance G_m from input (emitter of Tr_2) to output (collector of Tr_7). Capacitor C_8 (Z_2) does not really connect to the same point as $R_{20\text{-}21}$ (Z_1), something about which more will be said later. Consider now the circuit shown in Fig. 3, ignoring Z_0 for the moment.

Dumper current gain is set at $\beta+1$, but of course $\beta+1$ will change from about 20 when Tr_9 conducts to about 2000 when Tr_8 and Tr_{10} conduct.

The defining equations and their meaning are all given below.

- Setting amplifier input current to zero:

$$\frac{v_s-v_i}{R_s}+\frac{v_2-v_i}{Z_2}+\frac{v_1-v_i}{Z_1}=0$$

- Setting class A output current equal to $-G_m v_i$:

$$-G_m v_i = \frac{v_2-v_i}{Z_2}+\frac{v_2-e_o}{Z_3}+i_b$$

- If dumper output current is properly accounted for:

$$(\beta+1)i_b = \frac{v_1-e_o}{Z_4}+\frac{v_1-v_i}{Z_1}$$

- Using the currents in Z_3 and Z_4 to calculate e_o:

$$\frac{v_2-e_o}{Z_3}+\frac{v_1 e_o}{Z_4}=\frac{e_o}{Z_L}$$

Here there are six variables (v_s, v_i, v_1, v_2, i_b, e_o) and four equations, so three of our variables can be eliminated. Choosing to calculate e_o as a function of only v_s and i_b and manipulating gives

$$[(Z_1+Z_2+Z_3+Z_4)(Z_L+R_s+Z_LR_sG_m)+(Z_1+Z_4)(Z_2+Z_3+Z_3R_SG_m)]e_0$$
$$=[(\beta+1)\{(Z_1+Z_2+Z_3+Z_4)R_s+Z_1(Z_2+Z_3)-(Z_2Z_4-Z_1Z_3)R_sG_m\}$$
$$-\{(Z_1+Z_2+Z_3+Z_4)R_s+(Z_1+Z_4)Z_2\}]Z_Li_b$$
$$+[(Z_1+Z_2+Z_3+Z_4)-(Z_1+Z_4)Z_2G_m]Z_Lv_s \quad \ldots(2)$$

which we write as

$$Ae_o = BZ_Li_b + CZ_Lv_s$$

where the coefficients A, B and C are represented by the expressions in square brackets ††.

These equations are all linear, and it is good to pause awhile to ponder whether the distortion has been properly considered. The voltage across the dumpers V_2-V_1 will control i_b for the output $(\beta+1)i_b$ in a complex way related to the turn-on curve of the dumpers. In choosing to eliminate v_1 and v_2, the distortion must appear in our equations as a distorted i_b which is not a copy of e_o or v_s. We deliberately chose to eliminate v_1 and v_2 from our equations so that all the dumper distortion contributions to e_o occur in the single term BZ_Li_b. Now e_o can still be made rigorously proportional to v_s, if the large bracket B multiplying i_b can be set equal to zero for all signals. (The parameter β occurs *only* in the coefficient B in equation 2). The balance condition for the new equivalent circuit of Fig. 3 is thus $B=O$.

†This is essentially a d.c. analysis of the circuit, and as such will remain valid only for frequencies low enough that time delay effects through the class A amplifier and bridge components can be ignored.

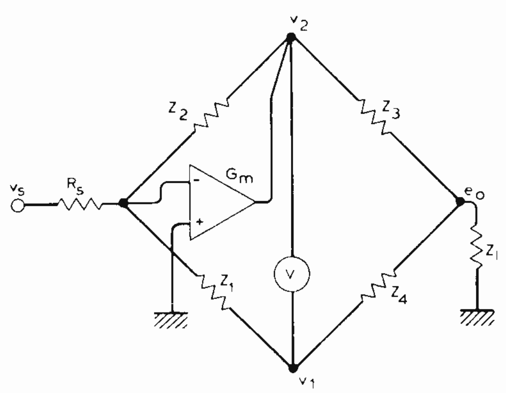

Fig. 2. *Simplified equivalent circuit showing that passive bridge balance can remove dumper voltage distortion.*

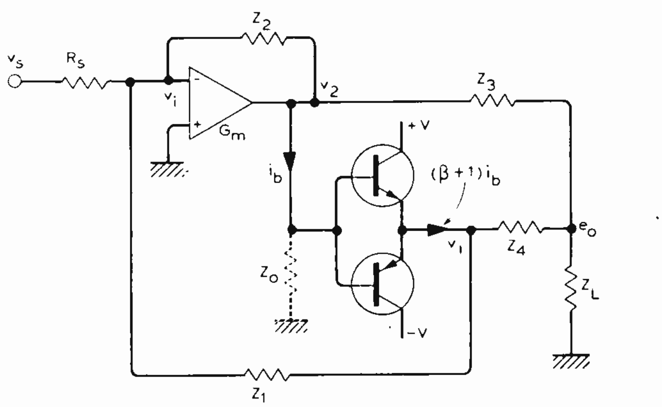

Fig. 3. *Equivalent circuit for more complete analysis, see box.*

quired for perfect bridge balance, and hence complete independence of the output from dumper distortion. A vital requirement that this be completely achievable in practice is that β be constant. (The extent to which non-constancy of β contributes to the presence of dumper distortion in the output is examined later.)

Thirdly, from equation (3), if G_m tends to infinity then the balance condition reduces to precisely the Walker condition $Z_2Z_4=Z_1Z_3$ which appeared in the simple analysis of Fig. 1. So for large transconductance in the class A stage, the balance condition is precisely that obtained before. Moreover, Z_2 and Z_4 can be respectively capacitive and inductive without affecting our argument

Fourthly, we can now answer the claims by Olsson and others that the (non-linear) dumper input current i_b prevents the attainment of perfect bridge balance in the case of finite G_m. The analysis of Fig. 3 shows that no matter how non-linear i_b may be, if β is constant perfect balance can be achieved with finite G_m. Lest Fig. 3 is thought unrealistic, in that in practice a perfect current source is not available for the class A amplifier, we have made a more complete analysis. Taking into account the shunting effect of a load Z_o shown broken in Fig. 3 across this stage in any practical case, and we find that it has absolutely no effect upon the balance condition $B=0$. The only effect of Z_o in equation (2) is to add further terms to the coefficient A of e_o, but it does not change the other coefficients. As a perfect current generator shunted by Z_o is equivalent to a voltage source with a finite output impedance, by including Z_o in Fig. 3 we have shown that balance *is achievable even with an imperfect class A stage*, provided β is constant and assuming Z_2 and Z_4 to be real.

Next, we must answer the question which we have thus far begged: To what extent will variations of β in the dumper stage (which certainly are present to considerable extent in the Quad 405 circuit, and at least to a certain extent in any realizable class B output stage) contribute to dumper distortion appearing in e_o through the incomplete cancellation of the term BZ_Li_b? From the balance equation (3) provided β does not fall too low and provided G_m is large, the effect of changing β will be small.

To quantify this conclusion, return to equation (2). Assume that β varies from say β_{min} to β_{max} as the dumpers operate. The dumper output current βi_b, denoted by I_D can be assumed to be constant to a first order approximation and independent of β in the operation of the circuit. If Δe_o represents the peak-to-peak distortion in the output signal e_o due to changing β in the dumpers, then

$$\Delta e_0 \approx \frac{\{(Z_1+Z_2+Z_3+Z_4)R_s + (Z_1+Z_4)Z_2\}\left(\frac{1}{\beta_{min}+1} - \frac{1}{\beta_{max}+1}\right)Z_LI_D}{(Z_1+Z_2+Z_3+Z_4)(Z_L+R_s+Z_LR_sG_m) + (Z_1+Z_4)(Z_2+Z_3+Z_3R_sG_m)}$$

This formula can be further approximated assuming (as in the Quad 405) that the bulk of the load current is furnished by the dumpers, so that $I_D = e_o/Z_L$, and that Z_2 and G_m dominates the terms on the right-hand side. Then

$$\frac{\Delta e_0}{e_0} \approx \frac{(Z_1+R_s)\left(\frac{1}{\beta_{min}+1} - \frac{1}{\beta_{max}+1}\right)}{G_mZ_LR_s}. \qquad \ldots(4)$$

This distortion has the shape of a half-wave-rectified sine wave. That due to changing dumper current gain can be reduced to insignificance by making β_{min} and G_m adequately large. This component of distortion then is being reduced by conventional feedback on account of the appearance of G_m in the denominator of equation (4). This distortion percentage is independent of the output signal provided it is large enough to cause both dumpers to operate and is also frequency-independent. We comment later on the possibility of removing such distortion entirely.

In the Quad 405, where approximately Z_1 is 500Ω, R_s 180Ω (R_{16} in the circuit diagram, Fig. 4 or ref. 1) Z_L 8Ω, β_{min} 20, and G_m 50,000A/V, the distortion expected due to changing β is of the order of 10μV peak or about 132dB below full output and hence negligible.

Further interesting conclusions can be drawn from equation 2. For instance, it can be shown rigorously that for large G_m, the output impedance of the amplifier is that of Z_3 and Z_4 in parallel. The voltage gain of the amplifier equivalent circuit e_o/v_s can also be shown to be approximately $-R_1/R_s$.

More interesting, perhaps, is an estimate of the effect of bridge unbalance on the output distortion. Returning to equation (2) to calculate the effect, Δe_o, on e_o of a change ΔZ_i of any *one* of the bridge impedances Z_1, Z_2, Z_3 or Z_4 (assuming Z_2, G_m large), and considering that the dumper notch distortion ($\Delta V \approx 1.5V$) results in a peak-to-peak fluctuation ΔI_D in I_D of approximately $1.5/R_3$ amps then

$$\Delta e_0 \approx \frac{1.5Z_1}{Z_2}\cdot\frac{\Delta Z_i}{Z_i}.$$

The dumper distortion voltage approximates a square wave of amplitude 1.5 volts, whose transition time is determined by the signal frequency and amplitude, the dumpers and Z_4. Our formula for bridge error shows that if $Z_2=1/j\omega C$, then the distortion seen from bridge unbalance will be the time derivative of this, which would appear as sharp spikes whose amplitude depends directly on the speed of the transition.

Further thoughts

Recapitulating on the operation and analysis of the current dumping amplifier, the dumpers produce a distortion voltage which is completely removed by a balance condition which approximates to $Z_1Z_3=Z_2Z_4$, and which becomes progressively less dependent on the gain G_m of the class A amplifier as it is made large. A second kind of distortion is the asymmetry of the dumper current gain, and any non-linearity of this gain with signal. This current distortion cannot be balanced out, and its effects vary as $1/G_m$, so they are reduced by conventional feedback. In the Quad 405 amplifier this distortion appears to be low but perhaps not negligible.

In electronics, the concept of duality allows a voltage source to be transformed to a current source and vice versa. We feel it is possible that a bridge configuration exists such that the current distortion can be nulled as well as the voltage distortion. It may be possible to superimpose the two bridges with one class A amplifier. We have devised several theoretical methods for removing current distortion entirely, maintaining the normal bridge components, by applying positive current feedback to the class A amplifier to give it zero output impedance. The value of β then disappears from the analysis. However, the amount of feedback required depends on G_m. We feel a better solution is possible and challenge the readers of this journal to produce one.

Results of measurements will appear in part 2.

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2. Letters to the editor. *Wireless World* vol. 82, April 1976, pp. 54-55.
3. Letters to the editor. *Wireless World* vol. 82, July 1976, pp. 60-62.

BOOKS RECEIVED

Small Craft Radar by John French. Although this publication is primarily of interest to small craft users, anyone, technically qualified or not, who is interested in radar will find the book interesting. The first two chapters cover the evolution of small radars and their principle. Operation and interpretation are then described with the help of numerous radar display photographs. Final chapters discuss the practical use of radars, their installation, and fault finding. Price £4.50 hardback, pp.207. Stanford Maritime Ltd, 12 Long Acre, London WC2E 9LP.

Cable television by John E. Cunningham is a practical guide aimed at engineers and technicians who want a working knowledge of c.t. systems. The book is an American publication. Price £8.35 paperback. pp.352. Prentice Hall International, 66 Wood Lane End, Hemel Hempstead, Herts.

World of Amateur Radio

Pity the newcomer?

Comments from the Papakura Radio Club of New Zealand reprinted recently in *Break-in* show a concern with a problem for newcomers that is far from parochial. Only a decade ago, it suggests, newcomers could buy surplus military equipment and get on the air with c.w. or a.m. phone quickly, easily and economically – "even 17-year-old school-leavers" – and were made welcome. Before long, interference, receiver noise and weak signal reports would become annoying and the new amateur would often build, buy or modify equipment "learning as he did so". This process would continue until the amateur achieved an "adequate" station.

Then, the report continues, came the 1970s and good, reasonably-priced, off-the-shelf, Japanese s.s.b. equipment and "who could afford not to buy?" So now, it believes, "we have sold the amateur fraternity down the drain. The dealers may eat, drink and be merry for they have us over a barrel; they have created a need, a "status" that only commercial s.s.b. rigs fulfil. So now they (or the manufacturers or the currency rates) load the price on – over $1,000 New Zealand for a transceiver, what school leaver can afford that? What family-man can? What hope have they of getting on the air? And if they were to do so with a.m. who would work them? Why do perfectly good but valve-type ex-taxi v.h.f. radios get laughed off the table at junk sales? What have we done to our hobby? At age 32 I am one of the youngest (active) amateurs in our club," the writer concludes.

Is this an exaggerated, unduly pessimistic viewpoint that ignores the second-hand equipment market and the simpler c.w./n.b.f.m. rigs and the considerable enthusiasm for direct-conversion receivers and low-power transmitters? Possibly, but very few amateurs in the UK or elsewhere would not recognise the problems described by the New Zealand club.

Examination woes

In a recent Amateur Radio Operator's Certificate examination in South Africa only one-third of the 242 candidates were successful, 66.9% failing. The PMG comments: "we gain the impression that candidates come ill-prepared and unable to answer the questions in the manner expected . . . very few attempted the calculations which were very simple and could have earned them good marks in relatively short time. The descriptive questions were answered rudimentarily and important points missed . . . candidates apparently do not read the questions carefully and do not answer what the examiner really requires . . . time is wasted by the examiners in an effort to decipher ambiguous handwriting." One or more candidates received a total mark of 0 per cent; the highest was 80.6 per cent. The precentages of passes varied significantly at different centres, ranging from only 18% in Cape Town, 27% in Pretoria to 32% in Durban and 40% in Johannesburg. The copy of the examination paper reprinted in "Radio-ZS" shows that the standard required is high — and that Part 1 of the paper on regulations is in Afrikaans, with Part 2 (technical) in English.

Up and down the bands

Following the successes in South America, 144MHz transequatorial-mode contacts have been reported between Australia and Japan. Australian amateurs have also recently claimed two "world records" for u.h.f. contacts: between VK6KZ and VK3ZBJ on 432MHz during January, a distance of 2460km; and between VK5QR and VK6WG on 2.3GHz during February, a distance of 1185km.

European amateurs have been re-examining the opportunities for "moonbounce" (earth-moon-earth) working on 144MHz, despite the rigorous requirements for high-gain aerials. Douglas Parker, G4DZU has received signals from the West Coat of the USA and from Sweden using a 56-element array based on four 14-element Parabeam arrays. Dr Pieire Aubry, HB9XM, has had good moonbounce contacts with West Coast Americans W6PO and W7FN using a very large array providing about 21-22dB gain. Harwell & District Amateur Radio Society recently experimented with a 680ft rhombic aerial intended for 144MHz moonbounce operation.

Vaughan Henderson, ZL2TGH has reported that the VHF Coordination Committee of the New Zealand society has expressed concern at the "massive interference caused by scanning transceivers when transmitting with the equipment switched to the scan mode." The committee would like to see this type of transceiver modified so that they are incapable of transmitting in this way. One possibility, it is suggested, is to ground the scan pulse generator output from the press-to-talk switch.

Radical changes introduced by FCC in American amateur callsign practices seem bound to blur the traditional "call-district" identification. Amateurs will be permitted to retain their callsigns when moving to a different call area. Other changes include, for new stations, call prefixes in the KH1/KH9 series for various US territories in the Pacific; KP1/KP4 in the Caribbean. The "N" prefix will be used for three-letter callsigns issued to general and technician classes.

It is hoped soon to extend the r.t.t.y. teleprinter news bulletins (GB2ATG) to include transmissions on 14MHz to provide coverage in Australia, New Zealand and North America. Two or three transmission periods on Sundays may be introduced, possibly at 0800, 1500 and 1600 GMT. Arthur Gee, G2UK, has become President of the British Amateur Radio Teleprinter Group.

In brief

A blind amateur, Ted John, G3SEJ, of Wallasey who lost his sight while serving with the Royal Navy in World War II and now works for the Merseyside Police, has received the Wally Waldrop Silver Cup Award of St Dunstan's Amateur Radio Society in recognition of his services to war-blinded radio amateurs. The Society, with about 30 members, meets regularly at Ian Fraser House near Brighton where an amateur station is permanently installed. Many St Dunstaners are now reaching retirement age and St Dunstan's state that "radio work has proved to be an ideal occupation and means of communication with friends at home and abroad." . . . The RSGB has reported that a large amount of Japanese amateur-type 144-148MHz equipment is in use in the Middle East for defence purposes and is suggesting that amateurs may be asked not to buy equipment made by the firms concerned in view of the threat this poses to amateur frequencies. . . . The ITU callsign series J2A-J2Z has been allotted to the Republic of Djibouti. . . . The Norwegian beacon LA4UHF is now operational on 432.89MHz. . . . Headquarters of the Royal Signals Amateur Radio Society has moved back to Catterick Camp in North Yorkshire from the School of Signals, Blandford, Dorset. . . . The Edgware society is holding a 40-year celebration dinner on May 20. . . . The UK FM Group London is proposing that the GB2RS news bulletins should be broadcast over the GB3LO London Repeater on Sunday mornings.

PAT HAWKER, G3VA

Radiating cables

by R. Johannessen, B.Sc., M.I.E.E., Standard Telecommunication Laboratories Ltd

During the past ten years radiating cables have found increased use in a number of applications. Many aspects of their performance can be specified simply, once they have been derived either empirically or from theory. For the communications engineer with a problem either of coverage or of frequency spectrum conservation, the article sets out where radiating cables may be useful and the aspects to which he needs to pay particular attention.

IN MOST MOBILE RADIO applications the base station aerial and the base station electronics are physically separated, so that the best possible coverage from the aerial is combined with easy access to the transceiver equipment. The link between the two is generally a coaxial cable, such as the UR67 and it is usually assumed that all energy transmitted from the base station goes to the transmitting aerial, no energy being transmitted from the coaxial cable. It is also assumed that the energy received by the base station has been picked up by the aerial, not by the coaxial cable itself. These assumptions are sufficiently valid where the mobile is some distance away from the cable, but are unacceptable if the propagation path between mobile and base station aerial is obstructed. If the obstruction is considerable and the mobile is only a few metres away from the cable, then the coupling between the mobile and cable could exceed the coupling between the aerials. In a radiating cable* system the cable is designed to couple with the surroundings and there are at least three ways in which this may be achieved: the outer conductor is made as a solid continuous sheet, but with a part missing in the form of a long slot, the edges of which run parallel to the cable axis; the outer conductor is constructed as a braid, woven loosely; or the outer conductor is constructed as a long sheet covering the entire cable circumference but with a series of holes or slots punched in the sheet.

Path loss components

In designing a communication system in which the base station aerial has been replaced by a radiating cable, the path loss between base and mobile can be conveniently split up into three components.

*sometimes called "leaky feeders".

Coupling. This is the difference in dB between the power entering the radiating cable and the power picked up by a tuned dipole located some 2 to 5 metres from the cable's axis and close to the transmitter end. Due to the variations in the received power (see 'standing waves' below) the coupling tends to be the mean difference as the dipole is moved about in the region of the location indicated. Different sources quote coupling at different ranges, hence the 2-5 metres bracket. Cree and Giles tested eight different cables and give the measured coupling[1] in the region 50-110dB, depending upon cable type, carrier frequency and mounting method. The cable manufacturer will usually specify the coupling for his own cable, though care should be taken in interpreting the conditions under which that coupling is valid. In general, as the frequency is increased the coupling loosens, giving a weaker received signal. The results of Cree and Giles indicate a change of 6dB per octave over the range 42MHz-460MHz. Similar tests at STL over the range 69MHz-156MHz have given 4.8dB per octave, and tests on one particular cable at low and medium frequencies gave a relationship suggesting 3.5dB per frequency octave in the region 155kHz-790kHz with a very good fit to this curve, as shown in Fig. 1. Harms *et al*[2] studied the effect on cable coupling as the method of cable mounting is altered. Based on two different cable types (one with five small slots per inch of cable, and the other a 64° slot running along the cable axis) the path loss relative to a cable suspended one metre above ground was found to increase by the following amounts:

cable laid on grass	4dB
cable laid on concrete	6dB
cable located in stone drain	7dB
cable buried in soil inside a 3-inch plastic pipe	14dB
cable buried in soil with protecting pipe (moisture dependent)	13-22dB

Tests have shown that as the degree of moisture in the ground increases, the coupling loss drops. A number of tests have been carried out to establish the rate at which the coupling loss increases as the radial range is increased. Typical values for v.h.f. are 5dB/distance doubling for ranges 3 metres to 15 metres, increasing to some 10dB/distance doubling for 60 to 100 metres. At l.f./m.f. the rate of decay is greater, typical values being 8.5dB/distance doubling around 5 metres, increasing to 20.2dB/distance doubling around 10 metres. In all cases there is a fair spread between configurations, as shown in Fig. 2, the curves being based on some 63 v.h.f. combinations of cable type, mounting method, range and frequency.

Insertion loss. The definition and characteristics are as for standard coaxial cables. For radiating cables there is a wide choice, with typical values from 20 to 50dB/km at 100MHz. In general, the loss increases as the diameter is reduced, and cost is reduced. The loss increases with frequency at a rate which is similar to typical conventional cables such as the UR67. With some radiating cables the loss increases significantly when the cable is laid directly on a conducting or lossy surface such as concrete or iron. This is particularly so with some of the cables where the outer conductor is removed for more than 1/3 of the surface.

Standing waves. If the path loss is measured between a radiating cable and a mobile aerial which is moving in a direction parallel to the cable axis, a number of variations will be observed. Neighbouring path loss maxima are separated by a distance which is generally just under the free-space wavelength and the difference between such a maximum and the next minimum may be of the order of 30dB. The loss maxima are, however, very narrow and a small movement of the aerial will reduce the loss substantially. These standing waves are repeatable and can be found in different degrees with any frequency and on many sites. The author has studied many different cables but has never found a cable which is completely without them, although Yoshida suggests[3] that with a particular cable design this phenomenon may be removed. It is the presence of the standing waves which makes it imperative to average the coupling over some distance, as suggested above.

Modulation effects

The deep minima of signal level will give rise to an amplitude modulation which can be very noticeable in a moving a.m. receiver. It is sometimes assumed that this modulation effect can be completely bypassed by using f.m. transceivers and operating the receiver in the limiting condition. Recent work at STL has investigated the r.f. phase variation experienced by a receiver moving parallel to a cable energized at 105MHz. Figure 4 shows the result of some of this work, indicating large excursions from a linear phase relationship the average deviation being around 115°/metre. With a receiver moving at a speed of 150km/hour, this yields a modulation with a deviation of 0.013kHz. If the transceivers operate with a maximum deviation of ±2.5kHz this small f.m. noise still imposes an upper bound on the achievable s/n ratio. It is an improvement on the a.m. case, but may nevertheless prove unacceptable for some tone signalling applications where the broadening of the tone spectrum might introduce errors.

Applications

Propagation conditions in many tunnels are such that reliable v.h.f. or u.h.f. propagation is difficult to achieve with conventional base station dipoles or Yagi arrays. A much better result can be expected with a properly designed radiating cable system connected to the base station transceiver and laid along the tunnel wall or roof. Such systems have been successfully designed in many cities. Breitenbach[4] refers to the use of cables for the S-Bahn in Munich and for the U-Bahn at Hanover. Martin and Webster[5] describe work done for coal mines in Britain, and Yoshiyasu *et al*[6] describe test results from railways in Japan using radiating cables. Above ground a number of other applications exist. Harms and Martin[7] show that the UK Transport and Road Research Laboratory have been considering the feasibility of using radiating cables as a means of achieving a well-controlled radiation field for transmitting information from the roadside to drivers.

Johannessen and Blair[8] show how cables installed in a building can achieve a good coverage inside the building with minimum frequency spectrum occupancy. In this building a freely radiating antenna was considered as an alternative, but it was found that a conventional aerial located on the roof and giving the same coverage inside the building would pollute the spectrum well outside the required geographical coverage area, by an amount which was in the region of 50-70dB stronger than in the radiating cable case. Deane has shown[9] the remarkable feature of radiating cables, which is the rapid decay in signal beyond the cable end — one of the reasons for using the cables where pollution must be minimized. The cases quoted above substantiate the argument that a radiating cable can be used to advantage where it is known that the movements of the mobiles enable the cable always to be positioned within some 20-100 metres of them.

Power loss calculation

By way of an example of the kind of calculation necessary for an installation, consider a building with two floors and a ground floor layout as shown in Fig. 3. It is proposed to use a radiating cable with coupling at 3m of 80dB and insertion loss 50dB/km at 450MHz. The receiver is assumed to need —132dBW from an aerial which has a loss of 8dB relative to a dipole. Reasonable coverage should be achieved by locating the base station in the security area and locating a radiating cable in the ceiling of the ground floor with one arm towards each of the extremes of the building. In the factory area the cable is looped to overcome the extensive shadowing likely to exist with large machinery and extra shelving. Maximum distance from the cable becomes 25 metres, giving a coupling of around 100dB. Maximum cable length will be 150 metres, with an insertion loss of 0.15 × 50 = 8dB. From Fig. 1 of reference 8 is obtained a one-sigma variation of 6dB which must be increased to 12dB to give 95% probability of coverage. This factor is realistic, since extensive tests indicated that the distribution approximates closely to a normal distribution at least up to the 95% values. Allowing for a 3dB loss where the transmitter power is split into the two cable paths, we get a transmitter requirement of —132dBW + 8 + 80 + 6 + 6 + 8 + 8 + 12 + 3 = —1dBW, which is well within what a standard base station transmitter provides. A 10 watt transmission provides some margin for internal obstructions.

Measurement

Before measuring the performance of a radiating cable it is important to ensure that the transmitter connected to the cable is properly screened, so that the path between the transmitter and receiver is not bypassed. If it is bypassed, then the results will not allow extrapolation to other site conditions. It may be found convenient to derive the statistically best fitting straight line to a plot of received signal level against distance from the transmitting end of the cable, since the intercept of this line conveniently yields the coupling, and the slope approximates to the insertion loss. The paper in reference 2 indicates the weakness of this approach and outlines a more accurate method, using the probability distribution, which also includes an allowance for the standing waves.

Installation

Some cable manufacturers provide special connectors, since the cable dimension is likely to be different from standard coaxial cables. Where connectors are not available, small diecast

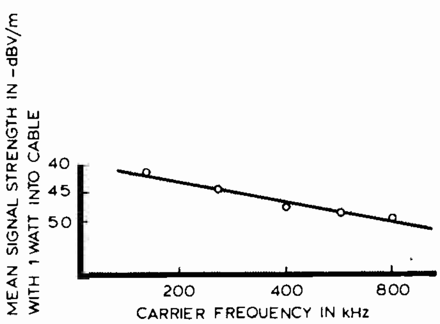

Fig. 1. Variation of coupling with frequency in the l.f./m.f. region.

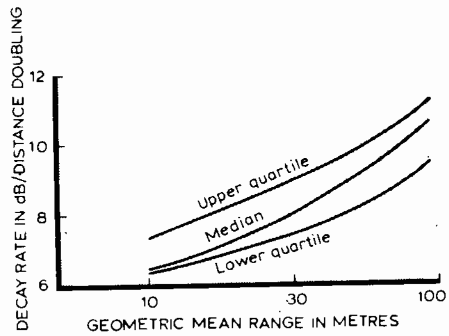

Fig. 2. Changes in decay rate as the mean radial distance is increased.

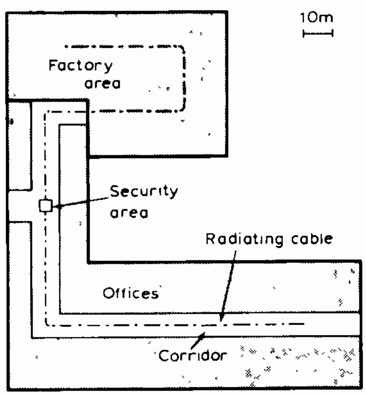

Fig. 3. Example of layout of radiating cable in a building with mixed contents.

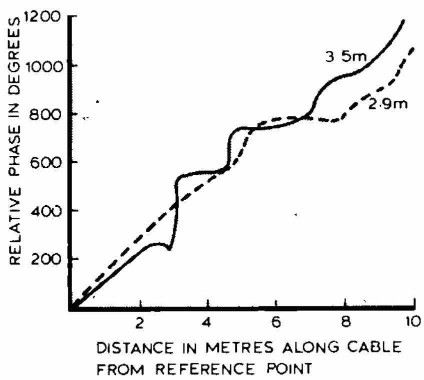

Fig. 4. Phase variation along a radiating cable.

boxes have been used. The end of the cable away from the base station may be terminated in a resistor to keep down standing waves on the cable itself. In some cases it is useful to connect the end of the cable to an aerial via a suitable attenuator if, for instance, a small yard or area outside the building is to be included in the coverage area. Many buildings will have an artificial ceiling to hide service ducts for feed cables to electric lights and gas pipes, heating pipes, etc., which can often be used for the radiating cables. If, after installation, it is found that a part of the building has too low a field strength, it will often be sufficient to break the radiating cable at the nearest point, form a T-junction and lay another arm of the cable into the area with the weak signal. A simple form of T is a hybrid, made up of standard cable with the same Z_0 as the radiating cable and three arms at 0.15 and one at 0.65 times the cable wavelength.

Cable costs

Cable cost is highly dependent on insertion loss, and from some cable manufacturers the radiating cable sells at about the same price as a coaxial feed cable of similar insertion loss. 1978 prices quoted for cables with a loss in the bracket 20—40dB/km at 100MHz are generally in the range £500-£2500 for one kilometre length.

The author

Mr Johannessen graduated from the University of St Andrews in 1962. For three years he worked with the Radio Division of Standard Telephones and Cables developing navigational aids for aviation. This was followed by a period at ICL, where he was particularly concerned with the efficient interfacing between computers and their peripherals. From 1969 he has been with Standard Telecommunication Laboratories where he is a principal research engineer. Recent responsibilities have included the study of more efficient use of communication and navigation systems, the development of low cost navigational aids and the evaluation of radiating cables for applications where spectrum conservation is of particular importance.

Much of the information presented in this paper forms part of a study carried out by STL for the Transport and Road Research Laboratory and is published by permission of the Director. The author also acknowledges the cooperation from many colleagues both at TRRL and STL have taken part in the work relating to this paper.

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CHIP MAKERS GO UP-MARKET

SEMICONDUCTOR MANUFACTURERS have learnt their lesson from the collapse of the digital watch market over the past two years. Fairchild's latest annual report, just published, for 1977 shows that the company made a loss of $25 million on consumer products. National Semiconductor's last annual report, for the year to the end of March 1977, showed a similar picture, digital watches causing a fall in corporate profits to only $10 million on sales of nearly $300 million.

This may be an example of the effects of miniaturisation. The more devices are produced the cheaper they become, but the more have to be sold to bring in the same return. It's a fact of economics that the chip makers will have to learn to deal with.

National's new factory, just opened in Greenock, outside Glasgow, has been built with the intention of better serving the European market which is, they estimate, going to become extremely important in the near future. By 1979, when it comes fully on stream, National will have spent more than $10 million on it. The markets they will be going for are telecommunications, which they believe has only been beld back temporarily by economic circumstances and which is about to benefit from the need for a new generation of equipment, and the top end of the consumer market, including video recording. They estimate that the needs of the European consumer are, in equipment such as hi-fi and colour tv, many years ahead of those of his counterpart in the United States, and National want to be ready to pounce when the market improves. They are now making the M1011 Dolby noise reduction chip and expect to produce 300,000 of them a month by October, though most of them will go to Japan.

All eyes in hi-fi now seem turned to the upper end of the market. A recent new product launch by ITT made it clear that they are about to abandon the cheaper, mass market end with which they have been connected and go for the better-heeled customer. Renewed interest in home video recording, with launches of the Video Home Recorder from JVC and the Betamax from Sony following one another in quick succession, indicates that consumer product makers want to make products with a higher unit price that will sell to those less affected by changes in economic conditions. Allied with that, the benefits of North Sea oil, though perhaps less than had once been thought, will make the European market more attractive.

The colour tv market will become particularly important to National. European makers, they say, "incorporate up to ten times more value in integrated circuits that their US counterparts," because more digital functions are being put on the set. The Germans, for example, are interested in microprocessor control of tv sets to plan up to a week's viewing, and the display of time in one corner of the screen.

National also expect the European data processing industry to provide them with a lot of business from companies of all sizes.

National European marketing director Tom Reynolds told *Wireless World*, however, that the only market segment they did not expect much from is the military and communications market. "It's growing, but it's far slower, and we don't see that changing. The avionics sector may grow but it still has a boundary on how much it can grow."

National estimate that the European market and the Japanese market are about equal for semiconductor chips, but regard the market in Japan as closed: "We've broken a few fingernails trying to get into that market," said European general manager Charles Arkebauer. Both Japan and Europe are currently about half the size of the American market and growing at 12% a year.

What is extraordinary about the National plant at Greenock is that it produced the first known 4in linear bipolar wafer in the world last December, only eight months after a fire which completely destroyed the wafer fabrication area. The fire cost them $30 to $40 million in sales last year. The capacity of the plant will, when it is fully equipped and manned next year, reach 30,000 to 40,000 wafers a month, amounting to between 40 and 50 million chips a month. One advantage of the increase in wafer size is that the yield, the number of chips per slice, increases because the number of wasted chips around the periphery of the slice becomes a smaller proportion of the total. National intend to introduce 5in wafer production once the present investment programme has been completed but with each size increase above 4in the advantages become smaller.

There is no mask production at Greenock. "That would mean another massive investment, and there are excellent mask-making resources in the UK already," said Tom Reynolds. The Greenock plant already represented 30 or 40% of National investment programme. The chips made in Greenock will be shipped out to various assembly plants around the world. □

NEWS OF THE MONTH

Microwave landing — the decision

THE ALL WEATHER Operations Divisional meeting, held by the International Civil Aviation Organization in Montreal to decide on the microwave landing system to be used world-wide from the 1980s has recommended the international adoption of the Australian-American system — the time-referenced scanning beam. The British-developed Doppler system was voted out by 39 votes to 24, with eight abstentions. Voting was by means of a secret ballot — a French suggestion to reduce the possibilities of "horse-trading."

A statement issued by the British Civil Aviation Authority who had proposed the Plessey Doppler system, reads "The UK delegation is naturally disappointed that the ... meeting did not select Doppler m.l.s., since it believes that this is the better and more mature system." It points out that the delegates had to plough through about 2000 papers of highly technical matter in a very short time — a task not easy for those who had not been directly involved with m.l.s. The statement goes on to say that a good deal of work remains to be done before m.l.s. can be used to full advantage and concludes "The delegation congratulates the USA and Australia, the joint proposers of the TRSB/Interscan system and wishes them every success in its continuing development."

This rather waspish valediction is explained by the feeling, held by the CAA and Plessey (and some Americans), that TRSB is not yet a complete system. The original proposal and relevant costing submitted to ICAO entailed the use of a Compact aerial (a "thinned," lower-cost type). Most testing has, however, been carried out using a "fully-filled" array and the results given to ICAO have been obtained using this aerial. Several other types, the AMSCAN, developed by Texas Instruments, a Rotman lens and Compact were all developed to reduce the cost of TRSB, but only the expensive fully-filled phased array seems capable of effective landing guidance.

In view of the fact that interest has, in the last few years, been almost exclusively concentrated on TRSB/Interscan and Doppler, it is surprising that the German DLS (D.m.e.-based Landing System) began to rally considerable support during the meeting. Its advantages are its relatively low cost, its simplicity and its use of a smaller spectrum allocation than the US/Australian/British systems, and it attracted a great deal of support from the smaller countries, some of which have not yet been able to install the much older instrument landing system (i.l.s.).

It is, therefore, even more surprising that towards the end of the ICAO meeting the Germans withdrew their proposal, issuing a joint paper with the Americans and Australians supporting TRSB. A Plessey spokesman told *WW* that a hybrid TRSB/DLS system will be discussed, and it seems possible that those countries who voted for TRSB will have supported a system other than the one for which they voted.

Commercial considerations must now be examined, since it has often been said that, whichever system was adopted, manufacturers anywhere could make the equipment. But no indication of the royalties payable has been expressed by the Americans. They are on record as saying that, since the original Doppler patents are American, they could impose large royalties, but would waive them if Doppler were chosen. There would be no royalties payable on TRSB, they have said. So it would appear that they cannot now change their minds and ask for royalties on a non-patented system, and Plessey expect to make TRSB equipment freely, without licence problems. They already use the electronically-scanned beam in the AR3D three-dimensional radar. Prospects therefore look reasonably good for Plessey.

Electrets may reduce chances to hide radiation risks

A MATCHBOX-SIZED warning device may make those living and working in areas where there is a risk of radioactive contamination less reliant on official, possibly self-interested, reports of contamination levels.

The equipment which measures radioactive dosage has, until now, been too expensive and cumbersome for the man in the street to use. Now the French Laboratoire d'Electricité Genérale de l'ecole Superieure de Physique at de Chimie Industrielles in Paris has developed and licensed a cheap device which will provide a pocket alarm once a given radiation dose has been exceeded.

There are two main types of radiation measurement device. One measures the equivalent doses received over a period by people in or near irradiated areas. These dosimeters may use photographic films sensitive to X, gamma and beta radiation which are developed at regular intervals, radio-flourescent glasses whose flourescent emissions are proportional to the absrobed ultra-violet dose, and stylodosimeters with ionisation chambers, which are electrometers whose charge decreases as a function of the irradiation dose. The first two cannot be read directly by the user and accidents may be detected only after a time. The third device provide instant readings but they are fragile, expensive and, if the electrometer is accidentally discharged, unreliable.

The second type of device, called flow-meters, give an instantaneous measurement of the radiation intensity, and can trigger an alarm once a set threshold has been reached. The Geiger counter is an early example. They are expensive and bulky so tend to be used only for checking and decontamination.

The device developed by the LEGde l'ESPCI measures the dose absorbed but is also able to trigger an alarm if the dose threshold is reached. The principle is that the external field around an electret (a permanently polarised dielectric material) decreases in the presence of ionising radiations. This is because they alter the conductivity of the electret, and the electret attracts surrounding ions.

The electret is sandwiched between two electrically-connected electrodes. The electret is bonded to one of them but insulated from the other by a layer of air into which any radiation ions may enter. Initially the electret attracts the electrode to which it is not connected, and a restoring force is applied by a spring. But as ions enter the air gap the attractive force lessens and the spring moves the electrode away from the electret, setting off the alarm.

The absorbed dose may be measured by applying a voltage between the two electrodes cancelling the electret field, the value of voltage needed to move the electrode away from the electret being related to the absorbed dose. The device's sensitivity depends on the initial charge of the electret, the strength of the spring and the thickness of the air gap. The triggering threshold may be adjusted between 1 and 40 Rem (Rontgen equivalent man). The device does not use any energy from its three nickel cadmium rechargeable cells as long as the sound and vision alarms are not triggered. The device will sell for less than $20, according to LEG de l'ESPCI.

The ESPCI belongs to the City of Paris, and the Laboratory of less than a dozen people who developed the device is one of ten within the School. Initially they had been doing basic research on the properties of dielectrics and, in 1972, they noticed what they thought was a new effect, the electret effect. It turned out to be fairly well-known, but Bell Labs, who discovered it in 1962, thought so little of it that they didn't patent it.

The first industrial devices to use the effect were microphones, where the high quality of capacitor microphones was desirable but the inconvenient polarising power supplies they required were not. Electret microphone production has risen to 1000 million units in about five years, and is likely to increase if postal and telephone authorities begin to use them in telephone handsets.

The nuclear debate is as active in France as in Britain, and it is bound to take a new turn if methods of measuring radiation become so easily and cheaply available to workers and environmental lobbyists. What the device cannot do, however, is decide what radiation dosage these groups should accept before the alarm is triggered. The levels that we were told were safe ten years ago are now being treated with some scepticism and a great deal of anxiety. □

Engineering education may be the political battleground of the '80s

ANY RECOMMENDATIONS the Finniston inquiry makes for the education of engineers will not be implemented if they do not meet the collective approval of the engineering professors at Britain's universities.

Although the Engineering Professors' Conference, which represents Britain's 500 professors of engineering in 55 universities, is unlikely to state this quite so baldly in its evidence to the Finniston Committee of inquiry into the engineering profession, the 120 professors who attended the annual meeting of the conference at King's College, London, in early April seemed united on the needs of engineering as well as on the need to present to Finniston a unanimous view.

The conference, which met in closed session for most of its three days, heard some tough talking, but the degree of willingness to abandon cherished viewpoints was, according to some of those present, remarkable for a group of men not usually noted for either reticence or the ability to compromise. Most of the arguments appeared to be about means, not ends, and if true this means that Finniston is likely to receive a submission from the elite of the science teaching profession that will burn a hole in his desk.

The chairman of the Conference committee, Professor Chisholm of Salford University, seemed pleased with the way the meeting had gone, though he was unwilling to say what proposals they would put to Finniston until they had approved a final draft and submitted it to the inquiry, probably in mid-May.

Nevertheless it appears that the evidence is likely to contain a proposal for increasing the length of engineering degree courses from three years to four. The extra year should be aimed especially at more able students. The degree should be retained as the qualification for entry to the engineering profession. There should be greater contact between industry and the universities. Students should start periods of industrial training earlier in their courses than they now do, and university departments should be more willing to offer their skills and facilities to industry.

Students should have a trial period of industrial training before their degrees, and this should come early in the course, preferably between leaving school and going to university, and certainly before starting their third year. The experience would be valuable, say the professors, in teaching students the way industry is "organised, or disorganised," the way the trade unions operate and so on. It is difficult, they say, to teach engineering design to students who have never seen anything manufactured.

The conference is aware that there are not enough training places in industry for the students that want them, and they say that university departments will have to make a greater effort to persuade firms, particularly the smaller and middle-sized companies, that it would be in their interest to provide the places. The trade unions should also realise that the students undergoing training must be allowed to try their hands at tasks normally done by others. The government, in their turn, must provide the money to make the four year courses both possible and worthwhile.

But the professors have laid greatest stress on their own part in the impoving of engineering education standards, which they see as the key to the rejuvenation of British industry and the economy. As well as acknowledging the extra work involved in greater contact with industry, the professors call for a halt to the freezing of university posts. Additional staff will be needed with considerable industrial experience, they say, and industrial experience should be accorded greater importance as a qualification for senior lectureships and even chairs in engineering than it now is. At the moment there is too much emphasis on research and published papers as qualifications for university posts. Higher pay would be needed to attract the talent the universities wanted.

The submission is also going to contain some strongly-worded proposals on secondary education. For example, Denis Healey's budget proposals for increased spending on the training of mathematics teachers is unlikely to go far enough for the professors, who think that maths teaching, as well as that of science and modern languages, is of the first importance if engineering is to benefit. In addition, they support the Standing Conference for University Entrance in proposing a common core syllabus in sixth form mathematics. They see no advantage in the proposed introduction of N and F level exams, and say that A level should be retained as the basis for entrance to university. Schools should have closer links with local industry, the universities and professional institutions to give a more informed picture of industry than pupils seem currently to absorb. There should be no common system of examinations at 16 plus.

More broadly, the professors were anxious to stress that they were keen to increase the quality of engineers, not necessarily the quantity. They identify three classes of engineers: the high fliers, with "real creative or management potential", who would benefit from the degree's extra year; the average engineer "with sound knowledge of engineering practice and responsible experience" whose education so far has been too acedemic; and the technician, who would not need a degree, but would provide vital, highly-skilled support for the other two. More technicians need to be trained, they say.

The meeting was addressed by Sir Kenneth Berrill, head of the Government "think tank," at one of the closed sessions. He told the meeting that the problems of industry in general and education in particular were so complex that no ready solutions could easily be found. But he urged that the professors arm themselves with a closely-argued case to put forward to both Finniston and, in the debate that would follow it, the Government. It appears that his off-the-record remarks revealed a rather gloomy future for the British economy.

The responsibility for implementing Finniston will belong to the Government of the day. Those proposals affecting education will be the responsibility of the Minister for Education and Science, whoever that will be. There's little doubt that the professors have got the bit between their teeth. In the four years since the Engineering Professors' Conference succeeded an earlier 20-year old body it has grown from what one committee member described as "a social club" to a fairly militant, active and determined pressure group.

How effective they will be remains to be seen. One is reminded of the 1947 battle over the introduction of the health service, especially when delegates seem so self-conscious about their lack of standing compared with that of the medical profession — in a single hour medicine or branches of it were mentioned half a dozen times.

In the late '40s, of course, the doctors lost. But there are important differences. Firstly the doctors had wanted to avoid change which, as they saw it, would erode status they had already attained. The professors want to institute changes which will bring them, and hence they believe engineering, a status it currently lacks. Secondly, the education ministry has never been the source and inspiration of much political ambition. The DES is something of a backwater for an aspiring Prime Minister. But even in the event that the Prime Minister of the day were to break with precedent and appoint as Secretary for Education the best of the talent available to him there seems no-one on either front bench who matches even remotely the ability of an Aneurin Bevan. The Professors' chances of getting their way look good. □

Renewed attack on Hitachi

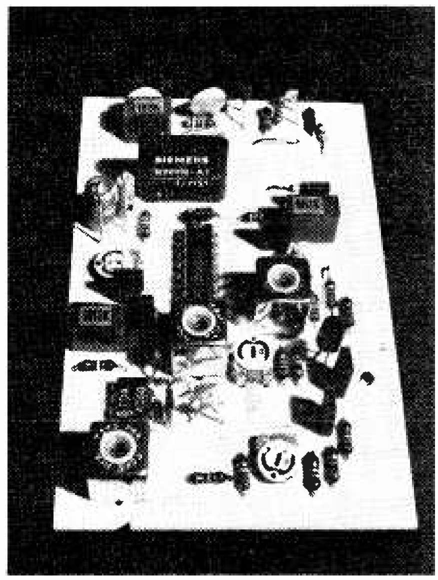
The electronic components working party of the National Economic Development Council has produced a report saying that, had Hitachi's application proved successful, 5,000 jobs would have been lost in the UK electronics industry.

Largely repeating arguments put forward before Hitachi were forced to withdraw their application, the working party, whose members include Jack Akerman of Mullard and five representatives of trade unions, including the chairman, said that the plan would have added capacity to an industry which already had too much.

Particular attention is drawn to "Hitachi's operating methods." Hitachi would not keep promises to buy a certain proportion of British made components for its tv sets, and there were no sanctions which could be applied if the company did not keep its promises. The company would have pleaded "technological problems" in reverting to its normal sources of supply.

The party calls for greater management skills and greater capital investment to halt the rise in imports and increase exports. Imports must be reduced by 5 per cent a year, producing a trade surplus in the industry of £270m by 1980. The current deficit is £170m. Imports must be reduced to a quarter of the UK market. British output would need to double.Because of over-capacity this implies somewhat less than double the capital investment. □

New signs of activity in the s.a.w. market



A television picture i.f. stage using a Siemens B39936 surface acoustic wave filter, at top left of the board.

THE PARIS Electronics Components Show in April was the scene of some furious lobbying by the makers of surface acoustic wave (s.a.w.) devices. GTE, for example, seemed anxious to make it known that they were ahead in s.a.w. technology, while Plessey were stressing their ability to produce reliably in quantity. Others in the ring include Philips/Mullard, Siemens and Plessey.

S.a.w. filters for use in tv sets are now cheap enough to compete with conventional LC filters. That is why most tv makers have started or are about to start using them in tv i.f. strips. Rank say they now use them in teletext decoders but, from July, they will be phasing Mullard and Plessey s.a.ws into all their sets. Decca say they have just produced a circuit design and will be using them well within a year. Thorn are not using them yet but hope to start production within a month or so using Plessey devices.

GEC say they are unlikely to put them into any of their sets this year, though they are looking at various designs. New receivers will have provision for s.a.w, but they are waiting for newer devices to arrive which do not present such a great reflection problem. They are interested in the GTE devices, though they will have to wait for one that is suitable for use in British sets. The devices, say GEC, would be best suited to use in teletex decoders through their present decoders do not use them.

There have been a number of reasons for the expense until now: the low yields achieved from each batch of devices; the expense of the material used; and the cost of the equipment needed to produce the circuits. Now yields have improved, cheaper material is used and the equipment cost can be written off.

Suppliers admit privately that the s.a.w. market has not so far lived up to the hopes expressed for it when devices first began to appear a couple of years ago. Demand may be as low as half capacity, less in some cases. Plessey announced the delivery of their millionth chip, to GTE subsidiary Saba, in Paris, but clearly they had expected to have sold the millionth device some time before that. Plessey, who independent sources agree seem to be up at the front of the field, began deliveries at the beginning of May, 1977.

There seems no clear reason why there should be a sudden rush for s.a.w. other than what one source described as a bandwagon effect. Once one maker begins to use them, as they have on the Continent, the others follow. The price is now competitive and there is the additional advantage that the sets do not need alignment either before despatch or, vitally important for our traditionally rental market, after they leave the factory.

Teletext is one reason for the change. It requires more stable circuitry, with better phase response, which would be difficult to achieve using conventional i.f. strips. One reason for all the activity in Paris may have been that the German Bildschirmtext service may begin before the autumn. Many eyes were on Siemens, who might be expected to have an advantage in the German market, but it appears that their market will be fairly local, whereas Plessey and the rest will have their eyes on the world market, with all the complexity of different standards that that involves. Siemens were content to announce that they were now making their s.a.w. devices on lithium niobate, which the others are already using.

In general, four types of material are used: quartz, zinc oxide, bismuth germanium oxide, and lithiam niobate. The first is used where temperature stability is of over-riding importance, bismuth germanium oxide offers a delay of around 6μs/cm, about twice that for other materials, and this makes it useful where the wavelength at the lower frequencies used would otherwise increase the size of the chip. Lithium niobate, however, has a much greater coupling co-efficient than the others, around 5% compared with 1% or less.

Siemens originally intended to use a ceramic material with piezo-electric properties as the substrate for the comb-like filter structures. "However, the high cost of manufacture and low constancy of this material were not in keeping with the low price level demanded for television sets. $LiNbO_3$ single crystals, in contrast, open the way to economical batch production with optimum filter characteristics and the highest possible frequency accuracy."

In addition the devices have not been easy to design into a tv set. The insertion loss of a conventional LC filter is around 5dB, while that for an s.a.w. filter is at least 10dB greater. For that reason they have to be supplied with a preamplifier to supply the right level and preserve the signal-to-noise ratio, but the higher the gain of the preamplifier the more likely it will be that breakthrough will occur from the tuner's input to its output, diminishing the sharpness of the traps at either side of the fundamental frequency of the filter. The output impedance of the tuners is also complex, with a modules which may vary with frequency from 30 to 40 ohms at angles of ±75° or so. This has made them difficult to match into the following i.f. i.c, causing reflections.

Plessey, besides offering s.a.w. filters to suit NTSC and British and European PAL systems, have produced a new preamplifier, the SL1430, for their s.a.w. devices. It requires only an external capacitor, they say, and its balanced differential output couples straight into the s.a.w. filter, which then goes into the video i.f. i.c. input.

All the makers now stress that the techniques now in use make available devices which are consistent in performance in large quantities. GTE are also stressing the importance of making the devices to CCIR PAL standards.

There seems no reason why s.a.w. devices should be confined to tv sets.

The military market for s.a.w. is well ahead of the consumer market. Cost is less of an object than performance, and s.a.w. is used, for example, in the British Airborne Early Warning System (AWACS) and other projects.

One outcome of the slow start has been that rival makers have been talking earnestly to one another when selling the idea of the technology to the outside, buying, world, but are prepared to cut one anothers' throats now that orders can be landed. And once the customers start to get on the bandwagon we may expect to see further rapid improvements in their performance. The next stage will be to combine the preamplifier and i.f. stages in a single package. □

MAVIS—assistance for the handicapped

At a recent colloquium on home television data systems, Julia Howlett of the National Physical Laboratory described MAVIS, which is a microprocessor/television set combination intended as an extremely versatile teletext display and aid for motor-handicapped people.

A Zilog Z80 micro, with 16k r.a.m. and 14K p.r.o.m. for short-term and programme storage, a bubble memory for bulk storage and a cassette facility, is contained in a small unit attached to a domestic television receiver.

The applications of the system are such that severely handicapped children and adults who are able to do hardly anything for themselves are able to play, draw, write, calculate, control peripheral equipment, operate toys, control fires, lights, etc., using a puff/suck tube, pedal, joystick or one of several arrangements of keys or switches.

The system is essentially a word processor with additional commands for the control of external equipment (fires, lights, etc). In its application as a controller, a command can be "typed" on the screen, using any of the methods of input, and the word "command" selected from a matrix of available instructions, whereupon the desired action will be carried out.

Work is currently being carried out on the simulation of speech and many suggestions have emerged from demonstrations already given for further application, not only for the handicapped, but as a straightforward information system for domestic use.

MAVIS is the result of cooperation between the NPL and Loughborough University of Technology. Ferranti Ltd at Moston are currently building the second proptotype.

FCC produces ideas for better spectrum use

LABORATORY AND field test results show that the existing mobile radio bands could hold seven to ten times more channels using technology that exists today, according to a study commissioned by the FCC. News of the still unfinished study, by Dr Bruce Lusignan of Stanford University, came in a report, "Spectrum-efficient technology for voice communications" by Raymond M. Wilmotte, plans and policy co-ordinator of the FCC's task force (See WW News, February '77, p.41). Lusignan's study was undertaken to see whether the existing US mobile radio bands could be used more effectively to allow greater traffic.

These test results have now given the force sufficient confidence to brief the Commission about a spectrum-efficient technology and its implications. The spectrum-efficient technology referred to is a narrow-band system which uses s.s.b. rather than f.m. It employs an amplitude compandor and a newly-developed frequency compandor, which enable voice signals to be transmitted using a channel bandwidth of 2.5kHz, instead of the 15 to 30kHz currently required. Although the cost is estimated to be up to $90 more per system than current f.m. systems, the signal quality is just about the same as that using current f.m. systems, and under high-interference conditions it is usable where the f.m. systems, and under high-interference conditions it is usable where the f.m. signal is unintelligible.

As a result, using the narrow band technology exclusively, the number of land mobile channels possible below 470MHz could increase from 1,586 to 12,390 and the channels above 800MHz could increase from 600 to 6,000. By interlacing the narrow band channels with the existing channels, these numbers could increase to 3,434 and 2,400 respectively. The 470 to 512MHz band was not included because of the relatively small areas available for use by land mobile services.

Currently, 56MHz is allocated for land mobile radio use, and if narrow band technology is used exclusively, the existing land mobile radio service could be accommodated in 6MHz, thus freeing 50MHz (not including the 800MHz domestic public land mobile or general reserves).

Wilmotte's reasons for the non-appearance of this technology until now is that market forces have required manufacturers to place a much higher emphasis on cost per unit than on spectrum efficiency and that, for the last two decades, attention and money for research has been largely focused on digital rather than analogue techniques. For these reasons, the task force focused its attention on anlalogue techniques.

According to Wilmotte, in introducing a new technology into the national communications system, the FCC will be entering areas in which it is relatively inexperienced. A procedure could be established by reserving spectrum space for each service, to be used exclusively by new technology having specified spectrum-saving characteristics. This space would be gradually filled by the new users, switching from operations using current, less efficient technology. The space vacated by the less efficient technology would then be available in which to introduce even more efficient spectrum-saving technology.□

Sony close on Matsushita's heels in home video

Though Sony's Betamax was announced three years ago — six months before its VHS competition — its UK debut followed that of Matsushita's VHS by weeks. Obviously concerned at the timing of JVC's UK introduction of VHS at the end of February, Sony brought forward its "launch" (though not apparently its deliveries) from later in the year, staging a very professional show that was led by Sony chairman Akio Morita.

Betamax actually had a one year lead in the market, but Akira Hirada of Matsushita's overseas operations division told journalists some eight months ago that they were "catching up fast in Japan and especially in the U.S." claiming a 40 to 50 per cent for VHS. By 1980 JVC recently said they expect VHS to have 65 per cent of the U.S. MARKET. Sony say they have already sold 500,000 Betamix units in the U.S.A. and Japan. (At the Berlin radio exhibition they quoted a figure of 300,000, which indicates a selling rate of around 25,000 per month.)

At the VHS launch at the end of February JVC put the UK market at 250,000 machines by 1980 and said that they expect the UK to absorb 100,000 units (all makes) in the next 12 months. Others are less optimistic. Marketing executive Joe Clarkin of 3M reckons that is "a little excessive" and at a recent press visit to 3M's tape manufacturing plant at Gorseinon estimated 15,000 VHS units will be in the UK by the year end. Peter Hutchings, director of the recording materials division at 3M, told *Wireless World* that while he saw a steady increase in video tape sales, that was in the educational market, and that current domestic sales are insignificant "and will stay so until the (recorder) price drops to around £500." Perhaps this will come sooner rather than later. Either way, 3M expects to have Betamax cassettes available – they are already a licensee in the US – when the machines arrive in June and is currently negotiating with Matsushita over VHS cassette manufacturing.

Main point of difference between these long-play machines and their predecessors is higher recording density, leading to longer playing time and lower tape consumption. At around £13 to £14 recommended retail for a three-hour cassette, tape cost works out at 7p per minute (if the tape is used once). It is in response to this situation that Philips dramatically cut the price of their cassettes in the UK — their N1700 plays for 2½ hours, earlier models one hour – so much that other tape makers say they can't make it at that price *and* make a profit: "margins are trimmed to dangerous levels," Peter Hutchings recently told journalists. The machines themselves are similarly priced, the Sony SL8000UB at £750 "expected" retail and the

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News in brief

Scenic Sounds of London are now selling the Transamp LZ differential input-output amplifier module for recording console microphone input circuitry and medical and industrial use. Noise figure can be less than 1dB, say Transamp. Price say Scenic Sounds is £20.

The Recording Industry of America (RIAA) have suggested a new playback curve which reduces disc rumble. The present RIAA curve exaggerates rumble by lifting the bass, some 20dB at 20Hz. The new curve rolls off below 30Hz with a relative level of reference to 1kHz of —0.2dB at 2Hz.

Voyager 2, launched last summer to fly past Jupiter in 1979, has developed a fault in its radio receivers. One of the two receivers may have failed and the other may have difficulty receiving commands from earth. The craft switches receivers if a command is not received from Earth for seven days. Engineers are trying to study telemetry from Voyager 2 (there are no transmission problems) to simulate conditions and rectify the fault. By mid-April the two Voyagers were about 300 million miles from Earth.

The ESA Meteosat 1 has been transmitting meteorological data daily since the end of March to the European space operations centre at Darmstadt from the French naval vessel Henri Poincaré. Every three hours the ship's position, wind and sea temperatures, and other information is sent via satellite from special equipment which future ships may carry as standard.

The replacement for OTS 1, destroyed last year (WW News Nov. '77 p.53, Jan. '78 p.35) may now be launched on or after May 4. It has already been delayed because of technical problems with the Japanese communications satellite which had been due to precede it, and because of that old favourite, faulty cable connectors.

The Soviet Union launched its 1000th Cosmos satellite on March 31. Cosmos 1000 will supply navigational information, constantly sending out signals of fixed frequency to allow ships accurately to determine their position when weather conditions make this impossible using coastal and global ground systems, or the stars. The initial period of revolution is 104.9 minutes, apogee 1,024 km, perigee 978 km, and orbit inclination 83 .

According to Tass Correspondent Nikolai Zheleznov, writing in *Soviet News*, "In establishing the co-ordinates, use is made of the Doppler effect. The frequency of the signals changes because of the speed of the satellite. Using this data an electronic navigator can produce navigational information in a convenient form — geographical co-ordinates and precise astronomical time."

The principle appears to be similar to that of the Transit satellites used in the US Navy's navigation satellite system (WW Feb. 1975, pp.52-57). Such satellites should make possible a large degree of automatic navigation.

Mr Ken Jolly, who retired as director of the British Radio Equipment Manufacturers' Association and the Radio Industry Council on March 31, has been succeeded by Mr Oliver Sutton CBE.

The Morsemaker

A digital instrument for producing random Morse signals

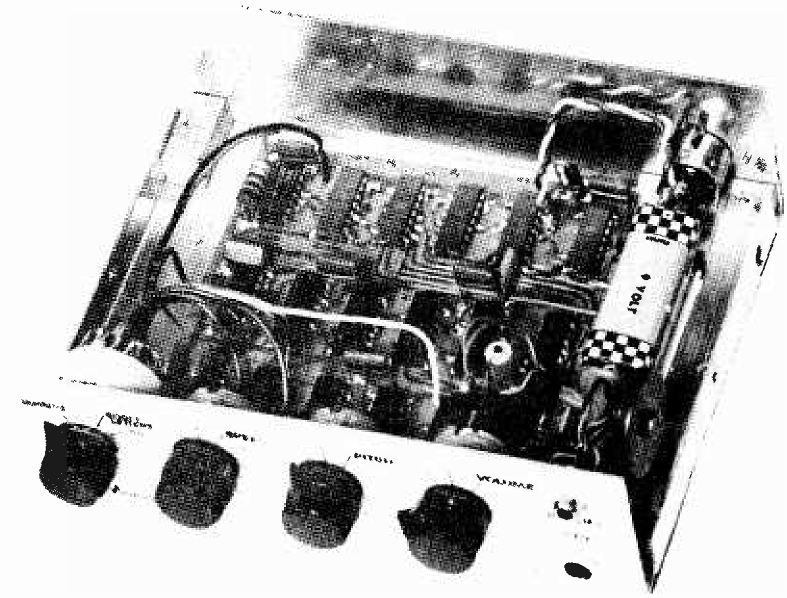
by **Murray Ward,** B.Sc., M.Sc. Ed.

This unit uses c.m.o.s. i.cs powered from a 9V battery to produce a continuous and random string of Morse numbers or letters. Because the speed can be varied over a wide range, the instrument enables anyone learning Morse to practise at their own pace. A rotary switch selects numbers, short letters only, or any letter. Other controls are for pitch and volume. A key jack is also provided so that the instrument can function as an audio oscillator for sending practice.

MORSE characters can be generated digitally with one clock pulse by making use of the time relations in the code. A dot is one unit of time, a dash is three units, the space between dots and dashes within a character is one unit and the space between characters is three units.

For numbers, the Morsemaker takes advantage of two characteristics. Each number contains five elements, and within each number there is at most one changeover from dots to dashes or vice-versa. Numbers are produced by selecting at random the first element, either a dot or dash, and one changeover point after the first, second, third or fourth element, or no changeover for numbers 5 and 0. The number is then ended after the fifth element.

For letters a different strategy has to be used because they vary in length from one element to four, and most of them change over from dots to dashes more than once. Therefore, letters are generated by selecting at random the first element, the changeover points, and the end of the letter after the first, second, third or fourth element. In this way all of the possible combinations of two elements taken 1, 2, 3, or 4 at a time are produced. Because only 26 combinations are required, the four extra groups have to be eliminated. A block diagram of the Morsemaker is shown in Fig. 1. The complete instrument only uses NOR gates and D type flip-flops as shown in Fig. 2. A tone oscillator, which is formed by two NOR gates, provides the audio output and also a means of



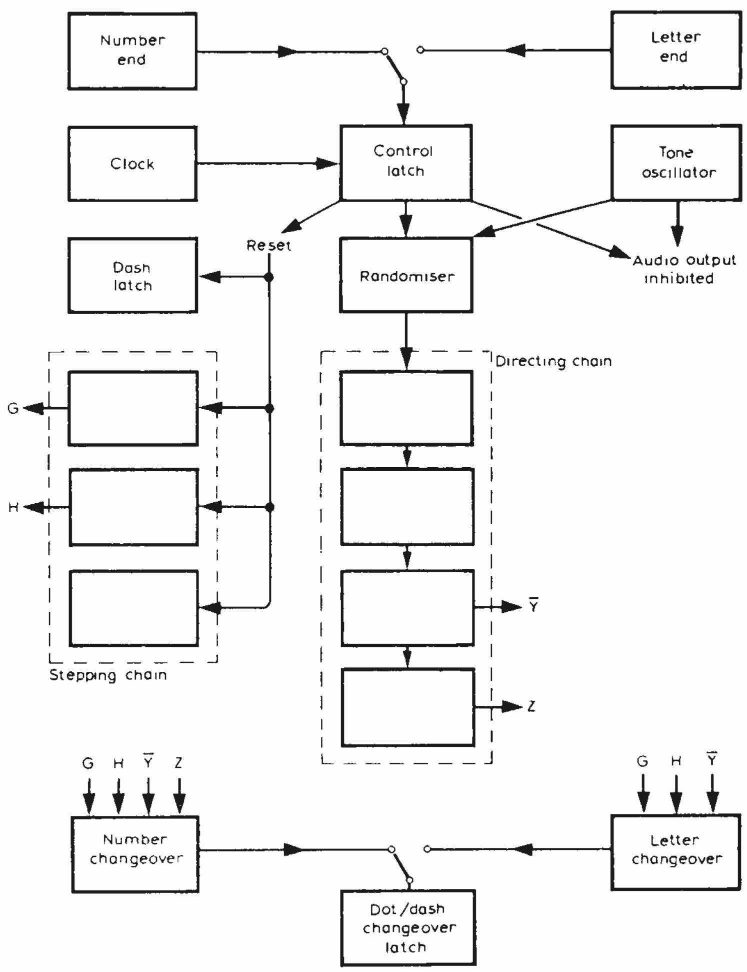


Fig. 1. *Block diagram of the Morsemaker. All of the circuit operations are carried out by NOR-gates and D-type flip-flops.*

"randomising" the sequence of characters. A similar circuit with a longer time constant forms the clock which operates at the dot frequency. In the randomising circuit a diode modifies the duty cycle of the oscillator by altering the charge and discharge time of the capacitor. This ensures that the string of characters is random.

The dash latch uses a D type flip-flop arranged to divide by two. The Q output is recombined with the clock pulses through an OR gate to fill the gap between alternate dots as shown in Fig. 3. This produces dashes that are 3 dots long and separated by the length of a dot. Any voltage spikes on the output of the latch are removed by a 10n capacity.

If clock pulses feeding the NOR gate are prevented from reaching the flip-flop, a string of dots is produced. This happens when both inputs to gate 4001/2b are low which in turn is dependent on the state of the dot/dash changeover latch. Therefore, the initial state of 4013/1a determines whether the character to be generated begins with a dash or a dot.

The output of the dash-latch is connected to a stepping chain composed of three divide-by-two flip-flops whose outputs form a six step binary count as each element in a character is produced. At the beginning of each character these flip-flops, together with the dash-latch, are reset so that outputs G, H, and K are high. In practice it is not necessary to use all of the 3 digits in the binary output, see table 1. For example, in step 6 which is used to signal the end of a number $\overline{G}\,\overline{H}\,\overline{K}$ is never reached, so H can be left out and step 6 defined by $\overline{G}\,\overline{K}$. Similarly, step 5 is used to end the longest letters and to effect the dot/dash changeover for the numbers 4 and 9. Steps 1 to 4 all contain K so $\overline{K}$ on its own will define step 5.

A second chain of four flip-flops forms the directing chain which determines the particular number or letter to be generated. Unlike the stepping chain whose state changes as a character is being generated, this one changes only

Table 1 Boolean control expressions

Stepping chain

	full version	short version	
1	G H K	[G H]	reset position
2	$\overline{G}$ H K	[$\overline{G}$ H]	
3	G $\overline{H}$ K	[G $\overline{H}$]	
4	$\overline{G}$ $\overline{H}$ K	[$\overline{G}$ $\overline{H}$]	
5	G H $\overline{K}$	[$\overline{K}$]	
6	$\overline{G}$ H $\overline{K}$	[$\overline{G}$ $\overline{H}$]	

End of number

[$\overline{G}$ $\overline{K}$]

End of letter

$X\,Y\,Z\,[\overline{G}\,H] + \overline{X}\,Y\,Z\,[G\,\overline{H}] + \overline{Y}\,Z\,[\overline{G}\,\overline{H}] + [\overline{K}]$

$= (X\,[\overline{G}\,H] + \overline{X}\,[G\,\overline{H}]\,)\,Y\,Z + \overline{Y}\,Z\,[\overline{G}\,\overline{H}] + [\overline{K}]$

Dot/dash changeover

number

$(Y\,Z\,[\overline{G}\,H] + \overline{Y}\,Z\,[G\,\overline{H}] + Y\,\overline{Z}\,[\overline{G}\,\overline{H}] + \overline{Y}\,\overline{Z}\,[\overline{K}]\,)\,\overline{W}\,X$

letter

$W\,[\overline{G}\,H] + X\,[G\,\overline{H}] + Y\,[\overline{G}\,\overline{H}])$

Blocked letter combinations

$(\overline{V}\,W\,X\,Y + \overline{V}\,\overline{W}\,X\,\overline{Y} + V\,\overline{W}\,\overline{X})\,[G\,H]$

The square brackets have been included to make the stepping expressions easier to pick out; they have no mathematical significance.

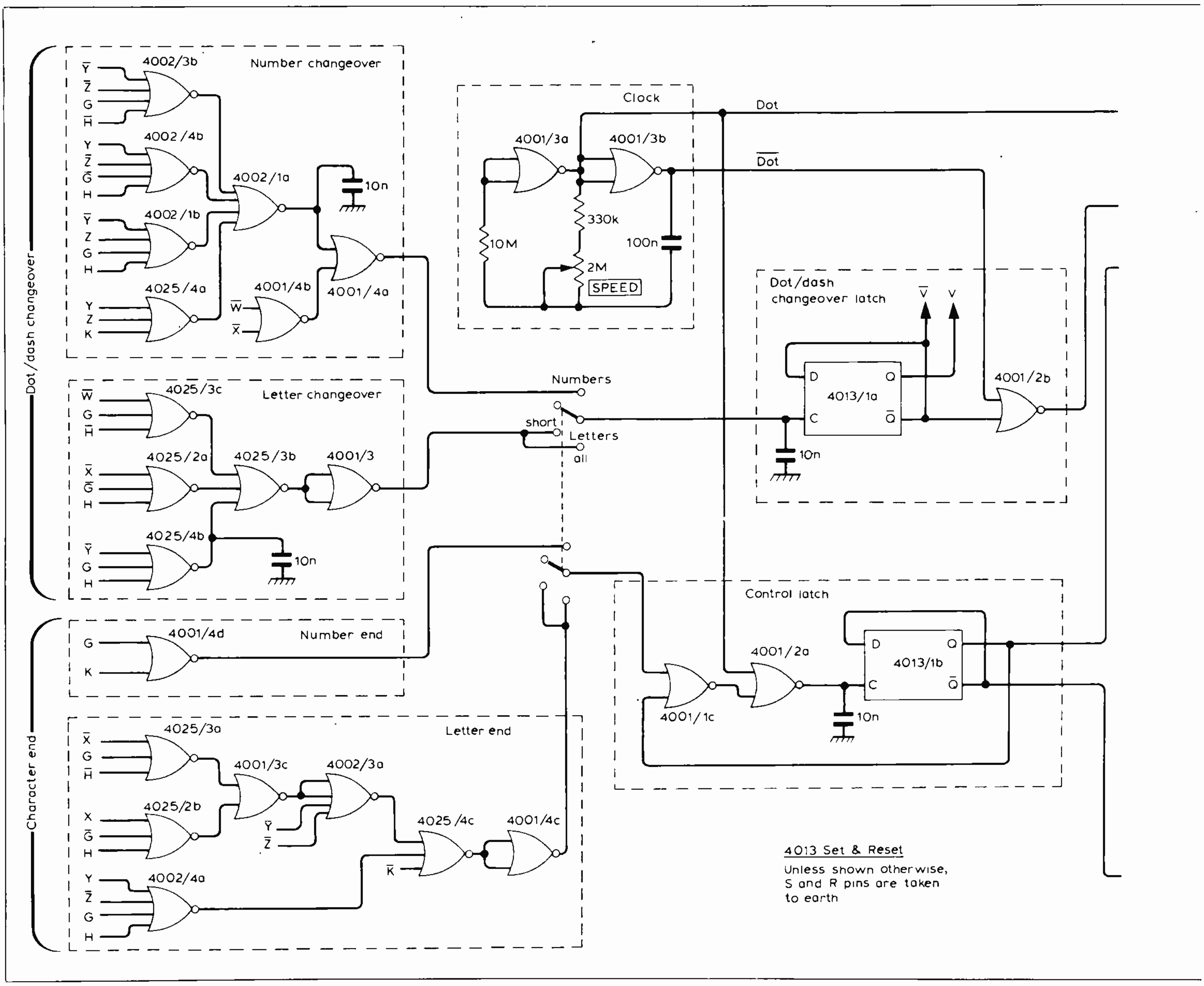


Fig. 2. *Complete circuit of the Morse-maker.*

between characters and its state is "randomised" by a burst from the tone oscillator.

Production of characters

Table 2 shows the Boolean expressions for Morse characters. Number 2, which in Morse code is . . — — —, starts with a dot so at the beginning V must be low. At step 3 there is a changeover from dots to dashes, brought about by $\overline{Y}$ Z from the directing chain together with G $\overline{H}$ from the stepping chain.

Other numbers are produced in a similar way, except for 5 and 0 where W X prevents any changeover. The outputs of W and X can be combined in four ways, W X $\overline{W}$ X W $\overline{X}$ $\overline{WX}$, so there is a 1 in 4 chance of a 5 or 0 in a long string of numbers. This is higher than the 1 in 5 needed for equal probability of all numbers, but in practice it is not noticeable. There is no particular reason for using WX as any one of the four combinations would serve equally well.

In the case of letters, for example X, the V output from the dot/dash changeover latch is high. Because X starts with a dash the change step from dash to dot is brought about by W [$\overline{G}$ H].

This produces a pulse at the C input of the changeover latch which changes state, and prevents dot pulses from the clock reaching the dash-latch. In this instance only two dots are produced because at step 4 the expression Y [G H] re-activates the changeover from dots to dashes. The letter X ends at step 5 with the term $\overline{K}$.

Between characters

Several things happen in the period between one character coming to an end and the next starting as shown in the block diagram. While a number or letter is being produced the Q output of the control-latch is low. At the rotary switch that selects either numbers or letters, the character-end signal is a positive pulse. When this reaches the control-latch via two gates the latch changes state and four operations follow. One input of 4001/1c goes low to prevent any further pulses reaching the latch from the character-end circuits. The centre input of 4025/2c goes high to silence any audio output. The dash-latch and the latches in the stepping chain are reset. A burst of tone enters the directing chain via the "randomiser." This burst continues until the next pulse reaches the control-latch via 4001/2a, resetting it to the Q high state ready for the next character to begin. There are short breaks in the tone supplied to the directing chain due to the diode in the "randomiser" oscillator. This prevents any possibility of the Morse-maker getting into a groove and repeating the same sequence of character. All of these operations take place on a period equal to three dots between the end of one character and the beginning of the next.

During this period the state of the changeover-latch is also made random so that the next character may begin with a dot or a dash. When the control-latch resets the stepping-chain, G and H go high. At various times during the "randomising" of the directing-chain, $\overline{Y}$ and Z are high and pulses reach the changeover-latch.

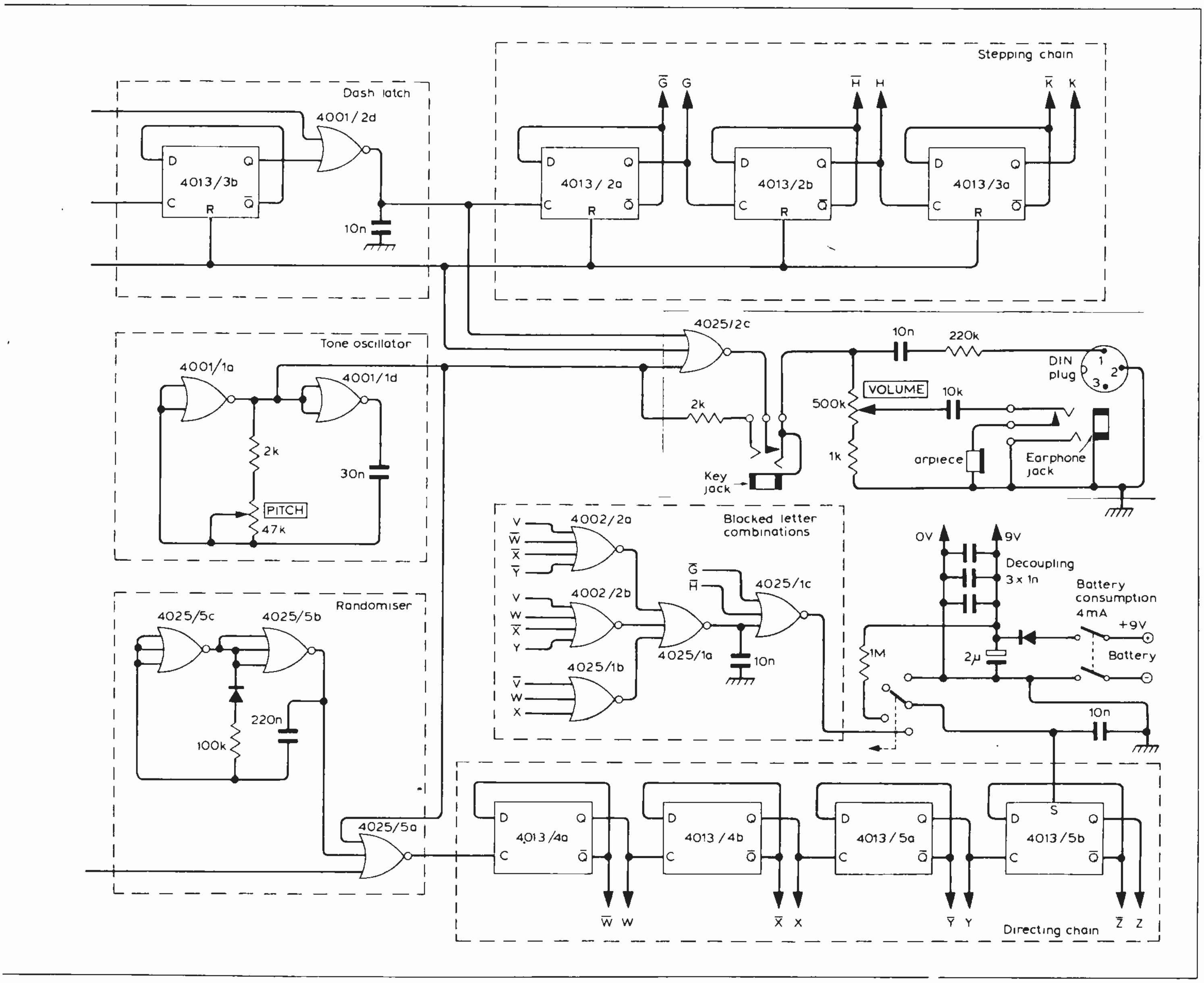


Table 2 Boolean expressions for Morse characters

Morse character numbers		Boolean expression: dot/dash changeover	Boolean expression: end of character
1 . — — — —	6 —	$Y Z [\overline{G} H]$	
2 . . — — —	7 — — . . .	$\overline{Y} Z [G \overline{H}]$	
3 . . . — —	8 — — — . .	$Y \overline{Z} [\overline{G} \overline{H}]$	$[\overline{G} \overline{K}]$
4 . . . . —	9 — — — — .	$\overline{Y} \overline{Z} [\overline{K}]$	
5	0 — — — — —	$\overline{W} \overline{X}$ inhibits changeover	
Morse character letters			
1 element			
E .	T —		$X Y Z [\overline{G} H]$
2 elements			
A . —	N — .	W	$\overline{X} Y Z [G \overline{H}]$
I . .	M — —	$\overline{W}$	
3 elements			
R . — .	K — . —	$W X$	
U . . —	G — — .	$\overline{W} X$	$\overline{Y} Z [\overline{G} \overline{H}]$
W . — —	D — . .	$W \overline{X}$	
S . . .	O — — —	$\overline{W} \overline{X}$	
4 elements			
(blocked) . — . —	C — . — .	$W X Y$	
F . . — .	Q — — . —	$\overline{W} X Y$	
P . — — .	X — . . —	$W \overline{X} Y$	
V . . . —	(blocked) — — — .	$\overline{W} \overline{X} Y$	$[\overline{K}]$
L . — . .	Y — . — —	$W X \overline{Y}$	
(blocked) . . — —	Z — — . .	$\overline{W} X \overline{Y}$	
J . — — —	B — . . .	$W \overline{X} \overline{Y}$	
H	(blocked) — — — —	$\overline{W} \overline{X} \overline{Y}$	
First element			
$\overline{V}$	V		

From table 2 it can be seen that the expressions controlling the ends of letters are $X Y Z[\overline{G} H]$, $\overline{X} Y Z[G \overline{H}]$, and $\overline{Y} Z[\overline{G} \overline{H}]$ for letters containing one, two and three elements respectively. Each of these contains the term Z. For letters of four elements Z is low. This enables the Morsemaker to output only short letters by preventing Z from going low. To do this the set input of flip-flop 4013/3b is taken to +9V via a 1MΩ resistor.

There are four combinations of dots and dashes that are not used in Morse code for English. All of these consist of four elements. If one of them is generated by the randomising process, it is detected at step 1 and converted to a short letter by changing $\overline{Z}$ to Z.

As noted previously, the numbers 5 and 0 occur slightly more often than is required. There are some similar variations for letters. The proportions of 1, 2, 3 and 4 element letters is determined by the respective end-of-character expressions from the directing-chain. Letters consisting of just one element, E and T, are generated more frequently than the others. Furthermore, the blocked letter combinations are converted to E, U, O and M. In practice, however, this is not obtrusive.

Conclusion

The Morsemaker has been designed to supplement rather than replace other sources of Morse code, such as cassettes, discs and RSGB slow Morse transmissions. The device is useful for two reasons — it is always available, so a few moments' practice can be taken at any time, and its speed is continuously variable so, together with the short-words-only mode, the unit has an effective "difficulty control."

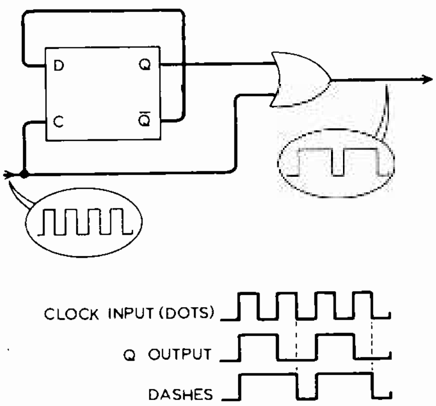


Fig. 3. *Producing a dash from three dots.*

The author
Murray Ward graduated from Southampton University in 1953 and taught for 15 years in schools. After completing an M.Sc in educational research at the University of Surrey, he worked on curriculum evaluation for the Schools Council. At present he is employed by the National Foundation for Educational Research and monitors the standards of mathematics in schools for the Assessment of Performance Unit of the DES. He holds the amateur radio callsign G3KZB.

Acknowledgement

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Printed circuit board

A double-sided p.c.b. for the Morsemaker will be available for £3.85 inclusive from M. R. Sagin, at 23 Keyes Road, London N.W.2.

Mobile radio bandwidths

The case for 12.5kHz channels and a way of dealing with data

by W. M. Pannell, Pye Telecommunications Ltd

The article begins by showing the disadvantages of widening an existing bandwidth to accommodate new techniques which could easily change over the next decade or so. Many of the arguments advocating the use of wider band f.m. techniques are concerned with environments not typical of the UK and other countries, and include theories based on ideal situations. Similarly, arguments against the narrow band a.m. equipment used in the UK are often conditioned by tests in different environments. The article concludes by proposing a common channel bandwidth unit, a single unit which on its own is suitable for speech transmission but which can be used for high speed data by employing two or more adjacent units.

The systematic reduction of mobile radio channel bandwidths has been pursued vigorously in the United Kingdom over a number of years, resulting in a reduction of channel spacing — by successive factors of two — from 100kHz in the 1950s to the channel spacing of 12½kHz currently in use in the v.h.f. bands. During the same period, amplitude modulation has been the predominant mode of operation, although more recently, the use of frequency (phase) modulation in the v.h.f. bands has been increasing. This trend has possibly been influenced by the exclusive use of f.m. in the u.h.f. bands which use, at the present, 25kHz channelling.

During the same period, bandwidths in the USA have also been steadily reduced, but have tended to stop short of those adopted by the UK. The difference in policy can be attributed to the almost exclusive use of f.m. in the USA, although the use of single frequency simplex may also have influenced the decision. Currently in use in the USA are v.h.f. bandwidths of 20kHz below 50MHz and 30kHz above. U.h.f. channels are now based on 25kHz increments.

As the channel spacings have become smaller, the adverse effects of such reductions on the performance of systems employing frequency modulation have been seen to increase, while with a.m. the reduction in the performance involving some parameters has been considerably less. It could be broadly stated, that, with frequency modulation, it is the channel bandwidth rather than the "state of the art" limitation, which restricts the performance, whereas with a.m. the reverse tends to be true. It is for these reasons that in the UK, with the predominantly a.m. market, the trend has been towards narrower channels, while the USA, and the other countries which use f.m. almost without exception, halted the channel splitting process when a measurable loss of performance using the f.m. mode became obvious.

There are, of course, some disadvantages or restrictions incurred by reducing bandwidths with both modulation modes, but certain of these can be overcome by improved techniques and by observing basic rules when planning systems.

One restriction made increasingly obvious by the introduction of narrower channels — f.m. or a.m. — is that of sideband radiation, on which the limits necessary to achieve adequate protection in the adjacent channel become much tighter as bandwidth decreases. Consequently, while normal speech can be accommodated with little difficulty, the transmission of high speed digital intelligence, with its attendant larger sideband spectrum, introduces limiting factors. Thus we now have a situation where, with *high speed* digital techniques, it may be necessary *at the moment* to increase channel bandwidths rather than to retain the existing spacings.

Arguments have also been advanced that even with speech modulation the wider bandwidth f.m. systems exhibit considerable advantages over narrow band systems, either a.m. or f.m.[1], while it has been stated elsewhere that the use of less than 25kHz is a backward step[2]. It may be concluded from these reports therefore that such opinion considers that mobile radio would appear to benefit from the use of a common channel bandwidth suitable for data and speech, and that the bandwidth should be of the order of 25kHz.

Against a common 25kHz channel plan

At this point it is as well to consider the implications of using, in the UK and many other countries, a common channel bandwidth plan for both speech and data and to examine why the arguments advanced for a minimum of 25kHz channelling do not necessarily apply in the real world.

First of all, it is as well to remember that the existing 12½kHz channel bandwidth in the v.h.f. band has been in actual use for a considerable period of time. A paper was read by P.A. Webster[3] at an IEE convention in 1966 on the subject of 12½kHz operation and subsequently such equipments were being manufactured and operated well before 1970. Thus experience of such a band-

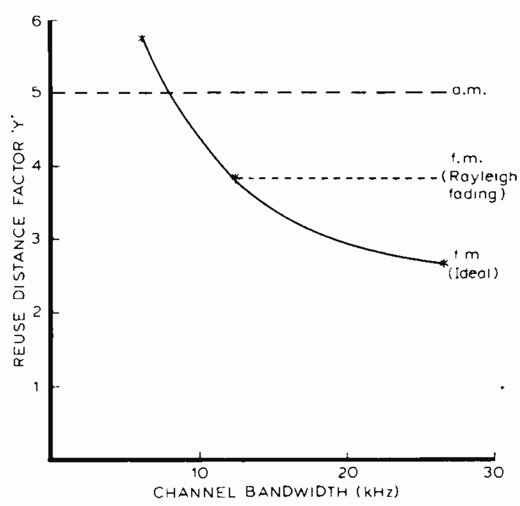


Fig 1. Re-use factor as a function of channel bandwidth, for two-frequency operation. For areas of equal coverage fixed-site to fixed-site distance equals operational distance XY; alternatively Y-1 times larger operational distance plus smaller operational distance when areas are unequal. (Assumptions made: 12dB/octave of distance signal reduction; plane earth propagation; operational distance is range achieving 20dB s/n ratio in mobile from base, alternatively 20dB s/n ratio in fixed receiver from mobile on perimeter; 3dB maximum degradation of s/n)

width in the UK extends over nearly 10 years and its success cannot surely be open to question.

On the other hand references still quoted in support of wider bandwidths include a theoretical paper by Buesing in 1970[1], previously written for FCC Docket 15398 (1965), both of these dates being prior to work in the UK which proved the feasibility of narrow channel systems.

Briefly therefore, the UK has the experience of 12½kHz operation in the v.h.f. bands — both a.m. and f.m. — while the USA, apart from tests at 15kHz in the vastly different single frequency environment of the USA, have not ventured below 20kHz and in the main, consider 30kHz as the preferred bandwidth.

In addition, the use of f.m. has been universal in the USA and — possibly of greater significance — the experience of the USA has been coloured in the v.h.f. bands by the predominant use of single frequency simplex.

Capture effect and its advantages is the theme of many an argument supporting the use of f.m. and while it is agreed that substance for such an argument exists with the use of the wider bandwidths operating under certain ideal conditions, some of the gains derived by using 25kHz channelling can be disputed, particularly in a mobile environment.

Undoubtedly if ideal conditions — no fading — exist, then the capture effect obtained with 25kHz channelling when compared with narrower channel spacings could result in the theoretical (two frequency) re-use factors postulated by Magnuski[4] and made possible by the improved protection ratio. However, the real world is not ideal and the presence of fading introduced over the circuit by various causes can reduce, or even eliminate, the so-called capture effect. Gans and Yeh[5] state: "although co-channel interference without fading could be markedly reduced by increasing the modulation index, it remains approximately constant with index, for indices greater than unity when fading is present".

Summarising this statement, it means that with a 2.5kHz audio bandwidth, any greater deviation than 2.5kHz — the deviation associated with a 12½kHz system — will not benefit the co-channel performance of the system under fading conditions.

Fig. 1 has been plotted to show the relative two frequency re-use distances based on the paper by Magnuski[4] It shows the constant re-use distance over plane earth which can be attributed to the use of a.m. operating in the two frequency mode: the improvement in re-use distance with bandwidth is shown for the *ideal non-fading f.m. conditions* also in the two frequency mode; whilst the dotted curve illustrates the effect of Rayleigh fading on the effective re-use distance as the capture effect is lost. It can be seen therefore that if fading is included, the re-use distances, based on the level of co-channel interference suggested by Magnuski, are not so appreciably different for a.m. and f.m. over the range of bandwidths shown.

It must be emphasised that the re-use distances shown in Fig.1 are based on two-frequency simplex operation. If we consider single frequency operation, the re-use distance must be related to the levels of signal between the fixed sites and consequently a different expression must be considered.

For example, in two frequency operation the level of unwanted signal (f.m. or a.m.) must be XdB down at the input of a mobile receiver located on the perimeter of the distant area, relative to the level of wanted signal into that receiver from its own fixed station. The required value of XdB determines the re-use distance, which, in turn, for two similar areas, can be expressed as *n* times the operational radius of either area (fixed to mobile). See Fig. 2.

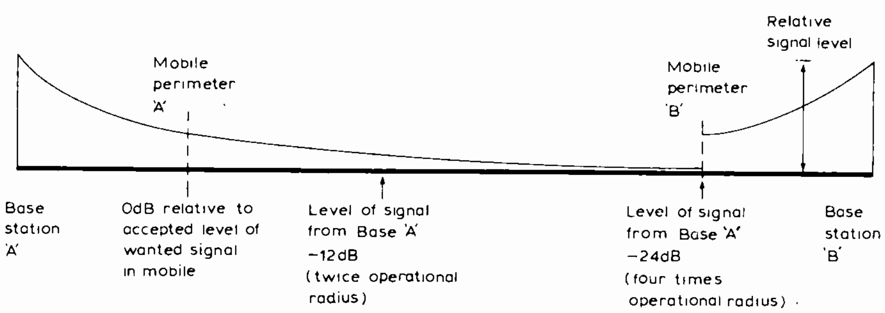


Fig 2. Re-use distance for two-frequency operation (a.m. case, after Magnuski, reference 4). Notes: 1. Re-use distance = 5 times operational radius for similar areas of coverage. Alternatively for dissimilar areas, re-use factor = 4 times operational radius of larger area plus operational radius of smaller area. 2. Propagation loss based on 12dB per doubling of distance over plane earth. Example shown over flat earth for clarity only. 3. Example shows level of signal 'A' at perimeter of 'B'. Reverse also applies but is omitted for clarity.

In the single frequency case we must consider the fixed receivers, their antennae being correspondingly higher than in the mobile case. Let us imagine therefore that the mobile antenna is elevated to a height equal to that used at the distant fixed station. The "operational" range is naturally extended from that obtained with the mobile antenna at vehicle height, and "C", shown in Fig.3 suggests a point where the same wanted signal level as received at the perimeter of area "A" in the mobile situation might be obtained.

Based on the average level of signal attenuation over plane earth following a "12dB per doubling of distance" law, the point where the signal level (now unwanted) should equal the noise level into the receiver at base station B will be at 4 times the "operational" distance (A to C). At this point the unwanted signal will therefore be 24dB below the wanted signal from a mobile on perimeter B and thus the signal-to-noise ratio at base B receiver will be 21dB, i.e. a degradation of 3dB relative to the s/n ratio without the interfering unwanted signal (a.m. case assumed).

As an example, if we take a typical situation involving fixed a.m. equipments with antennae at 100 feet and mobile units operating with antennae heights of 5 feet, it can be shown that over plane earth the "operational" radius will approximate to 17 miles. Thus, with the two-frequency re-use factor of 5, as shown in Fig.1, the distance between two fixed stations with similar coverage should be of the order of 5 × 17 miles (85 miles).

If we now raise the antenna of a mobile to 100 feet from the original 5 feet, the "operational" radius will increase to 28 miles and, applying the factor of 4 previously discussed, we arrive at an equivalent fixed-to-fixed station re-use spacing of 112 miles.

Thus, in the example given, it can be seen that by using the single frequency mode the fixed-station to fixed-station re-use distance must be increased to 112 miles from the two-frequency re-use distance of 85 miles.

Reducing the re-use factor, however, for example by considering the *ideal* f.m. 25kHz case (Fig.1) decreases the difference between re-use distances for the single and two-frequency modes, and in fact at the re-use factor of 2.68, as given by Magnuski, the two modes show similar spacings at the antenna heights quoted above. However, increasing the antenna heights will again restore a spacing difference between single and two-frequency operation.

Where such a difference exists, the greater distance needed in the single frequency case must be implemented and this naturally improves the fixed-to-mobile performance. If not implemented then fixed-to-fixed interference must necessarily be of a higher order, and the degradation of the mobile signal into the base receiver will consequently be greater.

The implication of the need to increase re-use distance when single frequency operation is employed is therefore obvious from the above.

Continuing, although capture under *ideal* conditions can permit a shorter re-use distance between co-channel users to be considered, the protection afforded by such capture is only present when a wanted signal is transmitting and its level relative to any unwanted signal is in excess of any protection ratio achieved by the capture effect.

When the wanted signal is not available then unwanted signals will be heard unless tone squelch is fitted. Thus the satisfactory use of the smaller re-use distance is based in the *ideal* case on the fitting of tone squelch to *all* systems.

Under fading conditions, when capture is virtually non-existent, unwanted signals will be heard when the squelch is opened by a wanted signal unless the re-use distances are extended to approximately those of a.m. Capture can also introduce other unwanted hazards in the communication circuit and there is, for example, a conflict between channel loading, in terms of busy hour occupancy, and capture effect.

Let us assume full capture is possible. As channel loading increases, and in particular in cases where coverage is required of, say, a town in which the greater proportion of mobiles operate, and surrounding rural districts where the number of mobiles may be low, the probability of a mobile on the perimeter of the coverage obtaining access falls sharply with traffic loading[6]. For example, if it is assumed that mobiles awaiting access exceed one, then, if capture effect is present, the nearer mobile will always tend to gain access, and with signals having a difference considerably in excess of the 9dB postulated by Magnuski[4] the likelihood of a weak station obtaining access is poor. A.m. will not suffer so markedly in this respect and weaker signals will have a better chance of accessing the channel.

Obviously as and when fading of the stronger signal occurs and capture becomes relatively non-existent, then the ability of a distant mobile to access the channel will improve. The effect of fading on such a circuit therefore will be to introduce an element of uncertainty into the ability to access the channel, an uncertainty which will worsen as channel loading increases.

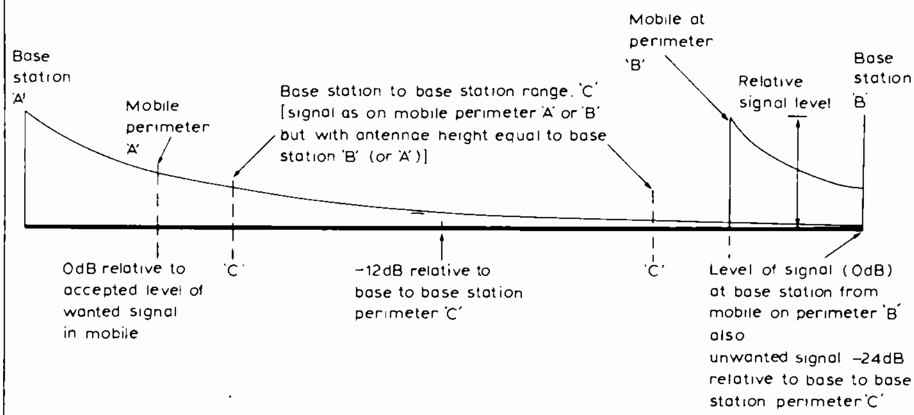


Fig 3. Re-use distance for single frequency simplex (a.m. case, after Magnuski). Notes: 1. Re-use distance = 4 times base to base range 'C'. Range is where signal level equals that required on perimeter 'A' (or 'B') for mobile case, but with antenna height at 'C' equal to base station 'B'. 2. Propagation loss based on 12dB per doubling of distance over plane earth. Example shown over flat earth for clarity only. 3. Example shows level of signal 'A' at perimeter of 'B'. Also level from mobile (at perimeter 'B') into base 'B' receiver. Reverse also applies but is omitted for clarity. 4. Example also shows base-to-base range 'C' for signal level equal to mobile requirement at perimeter of either area. 5. Solution to any situation. 'A' to 'B' must equal or exceed re-use distance for two-frequency condition.

Re-use in practice

The ideal degree of re-use as postulated by Magnuski[4] is shown as a function of bandwidth in the graph Fig. 1. The dotted curve on the same graph indicates the limitation which is imposed on f.m. under fading conditions.

However, *even if the greater deviation of 25kHz channels could always be accompanied by the ideal non-fading situation*, and a higher protection ratio would therefore be made possible, the degree of re-use would, nevertheless, be much reduced from that indicated theoretically where the theoretical model assumes plane earth, uniform propagation and an infinite usable area. Regardless of the mode or bandwidth the reasons are:

- The need for channels is not uniform in space: the areas of high demand being very bunched.
- In countries having the general geographical configuration of the UK, many of the re-use areas would fall in the sea.
- In London, the degree of re-use would be extremely limited — only small coverage systems falling into the desired category — and this limitation could tend to restrict any possible gains using 25kHz f.m. even under *ideal* conditions.
- Propagation anomalies lead to irregularly shaped service areas and cause the actual packing of re-use areas to be less than theoretical.

It is therefore considered that 25kHz f.m. systems, operating with a normal degree of fading and located in areas having average geographical hazards, irregularly spaced areas of usage and with varying degrees of packing density, cannot take full advantage of the gains argued by the US sources, and the resultant gains postulated by them are unlikely therefore to be achieved with any marked degree of consistency.

Existing re-use parameters in the UK – for both a.m. and f.m. – have been determined, on the other hand, over many years of experience and have been developed bearing the foregoing shortcomings in mind.

Intermodulation potential

Buesing[1] indicates the order of increase in intermodulation products which will occur as the number of channels increase with decreasing channel spacing. Undoubtedly doubling the number of channels by halving the bandwidth will increase the number of third order products by a factor of some seven to eight times. Is this likely to be a major problem, however?

If one considers, say, 10 adjacent channels on a single site, then, as an approximation, there will be some 470 third order 2- and 3-signal products possible, although less than half will fall on-channel. Obviously this is a problem which, to eliminate, requires suitable planning and technical safeguards.

Doubling the number of adjacent channels on that site (by halving the channel bandwidth) would increase the third order products from 470 to some 3760, resulting in a formidable array of on-channel products to eliminate.

However, would such a situation be allowed to arise in a correctly planned environment? In practice, channels would be chosen from the *total* spectrum available and suitable well-known intermodulation precautions observed. Certainly off-channel radiated products would be reduced to a low level as a matter of course, whilst planning procedures would ensure that in the immediate vicinity where receiver overload could generate i.m. products, other systems were not allocated critical frequencies. It is submitted therefore that, far from increasing the intermodulation interference potential, the ability to be able to choose from twice the number of channels would often enable freedom from interference to be practised with greater effect.

It is further submitted that this ability would be enhanced still further by our use of two-frequency operation in the UK as undoubtedly the single frequency environment encountered in some countries is often a major contributor to the high level of spectrum pollution, involving intermodulation, existing in the urban complexes of those countries.

Impulsive noise

The impulsive interference aspect of any argument often tends to be subjective. While the degree of interference worsens by some 3dB on each occasion the channel bandwidth is halved, there are conflicting views as to the actual degrees of annoyance value, in particular, where the equipments and systems involved are "tailored" to minimise this annoyance value.

Where the range extremes tend to be in electrically quiet rural areas, most interference present will only be high in high signal areas and thus the effect upon reception will be much less than if the reverse is true. Here the systems parameters dictate the result.

If the equipments are optimized to reduce the effects of impulsive interference, e.g. adequate noise limiting, tailored audio/loudspeaker responses, attention to phase response and filter ringing susceptibility in receivers, the actual effect upon the listener will be much less than if such points are not considered.

It is suggested that, although theoretically 25kHz f.m. systems, when correctly tuned, should be less affected by impulsive noise compared with narrower band systems, the different character of the noise pulse under aural conditions often makes the difference much less obvious. For equal orders of frequency stability, any frequency drift will worsen the interference effects with f.m. to a greater extent than with a.m.

Effect of bandwidth on effective range

The reduction in effective range as the bandwidth is reduced is necessarily affected by the type of modulation, degree of impulsive noise present and the minimum acceptable signal. Fig. 4 shows the effect of introducing such variations into the calculation. Variations in the parameters are likely to be as follows: (a) at threshold, there could be up to a 3dB gain in s/n in f.m. systems each time the bandwidth is halved; (b) impulsive interference will worsen at the rate of approximately 3dB each time the bandwidth is halved; and (c) signal/noise will drop by up to 6dB in the f.m. case each time the deviation (bandwidth) is halved. Calculations have been based, however, on 5dB which has been obtained in practical tests[7].

It must be highlighted at this point that the result shown in Fig. 4 must be interpreted in relation to the type of system used, and indications are that confusion often exists concerning the two quite different levels of signal required from mobile telephone service and private mobile radio. In practice, the tendency will be for private mobile radio levels to approach threshold at the service area perimeter and thus, for the present argument, the curves at threshold only should be considered.

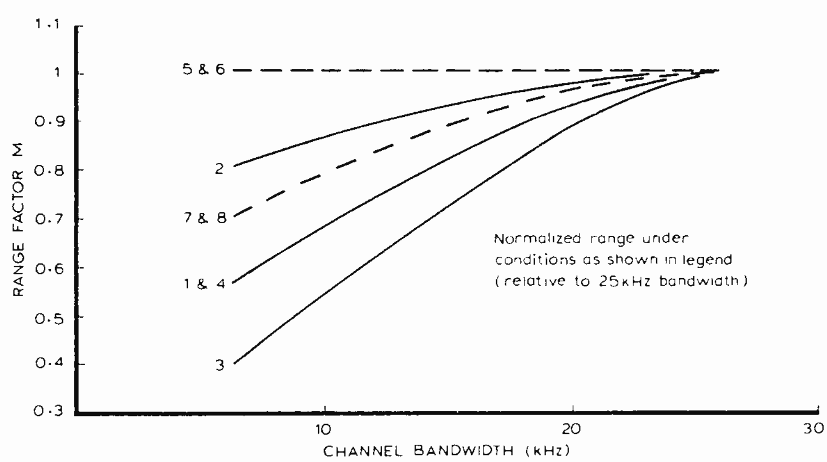


Fig 4. Effect of bandwidth on range (based on reference 7). Curve 1, f.m. above threshold. No impulsive interference (−5dB per halving of bandwidth). 2, f.m. at threshold, no impulsive interference (−5 + 3dB = −2dB per halving of bandwidth). 3, f.m. above threshold, impulsive interference (−5 −3dB = 8dB per halving of bandwidth). 4, f.m. at threshold. Impulsive interference (−5 + 3−3dB = −5dB per halving of bandwidth). 5, a.m. above threshold, no impulsive interference (0dB per halving of bandwidth). 6, a.m. at threshold. No impulsive interference (0dB per halving of bandwidth). 7, a.m. above threshold. Impulsive interference (−3dB per halving of bandwidth). 8, a.m. at threshold. Impulsive interference (−3dB per halving of bandwidth).

In addition, the general results shown in Fig. 4 are, as is emphasised, theoretical, and in practice the results will be modified by a number of other factors, for example, geographical considerations, equipment and system design, degree of mandatory impulsive noise suppression, acoustic considerations. However, locating the base station so that the coverage perimeter is generally in an electrically quiet, rural type environment tends to allow curves 2 and 6 to apply. Similarly, the implementation of suitable laws against the generation of excessive electrical noise will also favour results towards curves 2 and 6. Suitable suppression circuits and/or tailoring of the acoustic parameters — loudspeaker, listening environment — will reduce the actual effect of impulsive interference insofar as it affects the listener, and again the trend will be towards curves 2 and 6.

It is, therefore, strongly advanced that, although Fig. 4 indicates quite appreciable losses of range under certain "above threshold" conditions, these conditions are not necessarily so important in private mobile radio use. The curves tend to show that, at extreme range, a.m. will exhibit some advantages relative to f.m. and is possibly a point in favour of its use in private mobile radio.

Data transmission

Let us now consider mobile radio as a means of carrying data traffic.

First of all, we have the simpler data systems. In this category we can include conventional tone methods, on-off, sequential, f.s.k., d.p.s.k. etc, where the rate is relatively slow – effectively less than 1200bit/s. There is no difficulty in accommodating these systems in the normal radio audio pass band and, together, with the sideband radiation, such intelligence can be handled by a 12½kHz system with little difficulty. Bit rates, in any case, will be limited by the characteristics of any normal telephone line feeding a radio system, and unless special grades of line are used the top limit handled would appear to be around 1200bit/s. Thus any system configuration employed for data transmission could well be affected by its associated land line.

Indications are, however, that 12½kHz channels will readily support up to 4800bit/s and it is submitted that this speed is more than adequate for normal data needs.

A 25kHz channel, on the other hand, can support >9600bit/s, which is (i) not practical when fed by a normal telephone line owing to the limitations of that line; the use of radio links as a substitute for telephone lines in order to increase the bit rate is contrary to

continued on page 65

LETTERS TO THE EDITOR

CIRCUIT ACTION AND PROGRAMME SIGNALS

High fidelity enthusiasts claim to have heard differences in the performance of wide-range amplifiers. In recent issues Mr Peter Baxandall and Mr James Moir have tried to show that the claims are ill-founded; but mathematical physics suggests that this may not always bo so.

If a potential difference $V = E\,e^{j\omega t}$ be applied across a capacitance C, then the current flowing at time $t = C\,dV/dt$

$$\text{is } VC\left\{\frac{1}{E}\frac{dE}{dt}+j(\omega+t\frac{d\omega}{dt})\right\}$$

and so the capacitance's complex impedance

$$Z = \frac{1}{\left\{C\left(\frac{1}{E}\frac{dE}{dt}+j(\omega+t\frac{d\omega}{dt})\right)\right\}}$$

Hence, if the amplitude is small but rising rapidly, or if the frequency has a high rate of variation, then Z may differ considerably from $1/j\omega C$ – a formula often used in the design of RC circuits for amplifiers and measuring instruments.

The complex impedance of an inductance contains somewhat similar terms with further complications arising from the non-linear relationship between current and associated magnetic flux.

I tried to take account of all this recently when designing variable high-pass and low-pass filters with a slope of some 40 dB per octave and a plateau variation within + 0.5 dB; but the mathematics became impossible; and although I achieved my objectives, I came to realise how little is known about the *actual* behaviour of electric circuits.

Variations from steady-state values depend upon programme material in ways that defy exact analysis. It has not yet been proved mathematically or otherwise that their effect upon the performance of wide-range amplifiers must always be inaudible. Until it has, the possibilities remain that the high fidelity enthusiasts are right in their claims, that distorted sound from gramophone records and loudspeakers has characteristics that reveal this effect to a sensitive ear, and that specifications which appear to be unnecessary tend to cause its decline.

Peter Hannam
Colne
Lancs

DIGITAL ELECTRONICS THEORY

In reply to Mr Forcer (May Letters) my analysis of the digital electronics industry indeed contains "many sweeping statements" which at first glance do appear to be "unjustified". However, having spent over seven years in digital electronics it does not need much awareness on my part to see that the majority of engineers are incompetent at putting together fast logic. The industry is littered with complex computer systems that crash regularly, service engineers not knowing the reasons why. Too many students and engineers do not have a coherent set of design techniques to apply in their work.

In an attempt to rectify this catastrophic, myopic, situation I am working with two colleagues under the title of CAM Consultants and we regularly give seminars on digital techniques and we have written the first volume of a book on the subject to be published in May 1978.

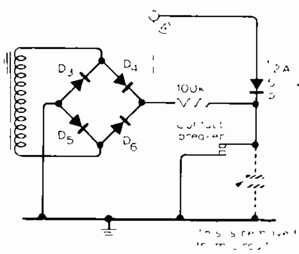
The proof of the pudding is always in the eating and I ask Mr Forcer to name projects or systems which do not suffer from catastrophic failures from time to time. I must repeat that engineers today use analogue techniques (taught by the colleges) to solve digital problems, and thus they cannot solve them in a scientific fashion. For example, no company I have ever visited knows how to lay out a p.c.b. for high-speed logic applications. Because of this systems suffer from data dependent faults which one can only see by the failure of the system itself.

Finally, I would like to see any Post Office course notes on mains filters and power supply decoupling. Also I would be interested in hearing from other engineers who (mis)believe that digital electronics is based upon an adequate set of scientific principles and mathematical techniques, which lead to efficient reliable digital systems. If they exist show me!

Malcolm F. Davidson
CAM Consultants
South Mimms
Herts

LONG RUNNING C-D IGNITION

I thought you might be interested to know that I have been operating R. M. Marston's capacitor-discharge ignition system (January 1970 issue) for eight years. It has been installed in a Ford Cortina, two Humber Sceptres, one Ford Capri, one Triumph Dolomite and now in a Citroen GS, and in that period I have done about 200,000 miles, which means that the 2N3525 thyristor must have fired about 1500,000,000 times. The system has worked faultlessly and no component has been changed.



In the early days I did have trouble with the contact breaker becoming dirty and to some extent it still tended to become pitted. I decided to disconnect the distributor capacitor as I believed the instantaneous heavy current when it becomes short circuited was the cause. I soon found, however, that the contact breaker became much worse from the point of view of failure through dirty contacts. I decided, therefore, to adopt the old trick, very common in telephony, of wetting the contacts. On a negative earth system this was very easily achieved by the accompanying circuit.

Referring to Fig. 5 in the 1970 article, a diode is connected in series with the wire from the contact breaker and 400V d.c. is connected to the contact breaker via a 100kΩ resistor.

Since doing this modification the contact breakers on all cars were never changed, cleaned or adjusted. Each car averaged about 30,000 miles. The plugs on all cars were not changed. The only maintenance was that at about 15,000 miles the plug gaps were reset to 0.30in purely to prevent overstress on the coils.

Incidentally, I have a switch for reverting back to the old system and, of course, it reconnects the capacitor, but I have never had to use it except in the early days before I carried out the above contact wetting.

S. S. Joseph
Felixstowe
Suffolk

BREATHALYSER SUBSTITUTE

With reference to the first item by "Mixer" in your April issue – the breathalyser substitute. There may be people "who can knock back four or five doubles without turning a hair", but it wouldn't matter if the alcohol did have that peculiar effect. What does seriously matter is that it makes the drinkers quite sure they can drive better than ever, whereas the reverse is the case – a very dangerous state to be in. An investigation of motorists leaving pubs showed that even those who were clearly unfit to drive were quite sure of their capability.

But use of a reaction-time meter is a very interesting idea and worth looking into. Alcohol as a major cause of road accidents is already well established; probably greater than all the other causes "Mixer" mentioned put together, though I admit that reliable figures on some of them would be difficult to obtain. Bad temper is certainly conducive to bad driving, but persons who display it are those who react too quickly! Old age is a doubtful starter. I am 76, and my wife and I have both been driving for 54 years. My driving has steadily become safer during that period. During the last 20 years I've had no police criticism, nor have I as much as dented our own or any other car, and rarely have to brake hard, though when the need arose one soporific afternoon, owing to a farm vehicle unpredictably turning across our path, I reacted swiftly and effectively; while a child owes her life to similarly quick reaction by my wife. By contrast, the young and inexperienced would have no difficulty with a reaction test, but apart from drinkers are perhaps the most dangerous class of drivers, as the insurance premiums testify. A combination of alcohol and youth is the worst of all, evidenced by the multiple fatal accidents so often following weddings and other parties.

One other weakness of the reaction-time criterion is that being pulled up by the police, like the prospect of hanging, "concentrates the mind wonderfully".

A combination of both tests might be effective, provided evidence could be produced of clear correlation between reaction time and liability to drive dangerously. Experience, observation and anticipation may largely or even more than compensate for some slowing of measured reaction.

M. G. Scroggie
Bexhill
Sussex

I.C. SOCKETS

Mr B. R. Smith in his letter in the March issue argued the case for i.c. sockets to fit 0.15in strip boards. I suggest that it might be possible to adapt sockets having wire wrapping pins (such as Vero Miniwrap sockets) by bending the pins to fit the 0.15in matrix. These pins can be quite neatly formed as necessary.

B. P. Castle, G4DYF
Sevenoaks, Kent

SPECTRA OF TONE BURSTS

Mr Coleman, in your October 1977 letters, tells us again that tone burst signals have amplitude spectra of different shapes if the carrier phase or framing is varied, and that the phase spectra are also changed, "in a non-linear fashion," He avers that he is correct, questions my grasp of basic principles and suggests that I ask one of my (brighter!) students to "check the calculations." What better way of answering him than by testing his own advice?

Accordingly, one of my undergraduates has been considering the matter, and has now given me his results. His view, like my own, is that Mr Coleman's claim makes up in theoretical precision for what it lacks in practical significance. I think the student will go far, but let me now explain.

Suppose a carrier, $\cos(\omega_c t + h)$, is modulated by a pulse function, $P(t)$. Then the spectral amplitude density, $C(\omega)$, of the function $P(t).\cos(\omega_c t + h)$ will be

$$C(\omega) = \int_{-\infty}^{\infty} P(t).\cos(\omega_c t + h).e^{-i\omega t}\,dt.,$$

giving precisely,

$$C(\omega) = \frac{e^{ih}P(\omega-\omega_c) + e^{-ih}P(\omega+\omega_c)}{2}$$

where $P(\omega)$ is the Fourier Transform of $P(t)$.

Hence the spectral density of the modulated pulse is the result of two curves, and is not symmetrical about ω_c. In theory, both the amplitude and argument of $C(\omega)$ will depend upon h, the point which Coleman, without qualification, considers it important to make.

Now $P(\omega-\omega_c)$ has a predominant maximum at ω_c whereas $P(\omega+\omega_c)$ does not, and if $\omega_c \gg 0$, this latter term has even a negligible value. This is so for a variety of forms of $P(t)$ e.g. rectangular (as for the tone burst), triangular, parabolic or sinusoidal, or even a "wavy" function. When there are several cycles in each pulse (or when the period of the carrier is much shorter than the period of repetition, for a periodic function) the spectral density of the modulated carrier becomes very similar in form to the spectral density of its envelope, a fact known and exploited by communications engineers over more than 30 years past.

$f(t)=u(t).\sin(\omega_c t+h) = \Sigma C_n\cos(n\omega_o t-\theta_n)$						
n	$h=0°$ (of f_c)		$h=10°$		$h=20°$	
	C_n	$\theta°_n$	C_n	$\theta°_n$	C_n	$\theta_n°$
1 (f_o)	.039	0	.039	−.618	.038	−1.26
3	.041	0	.041	−1.86	.040	−3.79
7	.049	0	.049	−4.35	.048	−8.82
9	.058	0	.058	−5.55	.057	−11.28
11	.075	0	.075	−6.81	.074	−13.80
15	.328	0	.328	−9.36	.327	−18.76
16 (f_c)	.500	+90	.500	+80.04	.500	+70 01
17	.308	0	.308	−10.61	.309	−21.21
19	.097	0	.097	−11.86	.098	−23.62
21	.055	0	.055	−13.12	.056	−26.01
25	.027	0	.027	−15.62	.028	−30.70
33	.012	0	.012	−20.62	.013	−39.70
37	.009	0	.009	−23.14	.010	−44.06
43	.006	0	.006	−26.92	.007	−50.30
45	.005	0	.005	−28.18	.006	−52.31

Mathematically, with the above provisions,

$$C(\omega) = \frac{e^{ih}P(\omega-\omega_c)}{2},$$

which shows that $C(\omega)$ is essentially unaffected in amplitude by a change in h whilst the phase shift produced is almost exactly proportional to h. This was the point taken for granted in my letters of December 1976 and July 1977.

It is, of course, important to demonstrate (as Coleman did not) the practical value of this result, and this my undergraduate has done. With the help of our digital computer, he obtained the amplitude and phase spectra of a periodic, 1kHz sine-wave burst, of unit height, with onset angles (h) 0°, 10° and 20° on for 8 complete cycles and off for the same interval. The fundamental spectral line is therefore at 62.5 Hz and the carrier (f_c) is the 16th harmonic, though all other terms are odd harmonics (due to half-wave symmetry) with a spacing of 125 Hz.

To save space I have not listed, in the accompanying table, all the results obtained, but those shown are entirely representative of the whole spectrum. They confirm that the effect of changing h (by the amounts I used in my earlier work) on the amplitude spectrum is inconsiderable, whilst the phase spectra show essentially linear shifts to within a few tenths of a degree, or much less for most harmonics.

For example, the listing for $h = 10°$ shows an additional 1.25° linear shift with increasing frequency for each neighbouring harmonic, i.e. $(2 \times 1/16 \times 10)°$.

Note that these results are not invalidated if the off interval is increased so as to make each burst distinct. Mr Coleman would seem to have learned something here, for in answer to James Moir, in your September 1976 letters, he claimed, again without qualification, that "no feature of a periodic waveform observed in (a normally lively) room can be a transient."

The trouble with Mr Coleman is that his arguments are either false or dead, and his naive concept of correctness is in keeping with the tone and content of all his earlier correspondence. We are not surprised, or advised, by his empty praise for the techniques of others, or by his impertinent warnings. An educationalist, however, does not reject those who do not understand, so I am always ready to answer him. Several of my students are just waiting to be called now, as I write.

Roger C. Driscoll
The Polytechnic of North London
London N7

RECEIVING AFRTS TV IN GERMANY

The American Forces Radio and Television Service (AFRTS) in the Federal Republic of Germany is well known for its chain of radio transmitters. Less well known is the fact that it has a large number of low power television transmitters, broadcasting English language programmes from 1200 to 2400 hours each weekday, and 0900 to 0100 h at weekends. Programme quality in general is fairly high and many English speaking persons living in Germany have converted standard television sets to receive these programmes. The main differences between AFRTS and German television standards are: NTSC is used for colour encoding instead of PAL; scanning frequencies are based on 60Hz instead of 50Hz; different number of lines per picture (less than 625); and different spacing between sound/vision carriers (4.5 MHz instead of 5.5MHz).

Most people install a small converter to deal with the last problem; this costs between Dm20-45 (about £5-12). The 60Hz frequency and number-of-lines per picture differences may be dealt with by adjusting the vertical hold control. NTSC colour is compatible with monochrome tv sets, and most people accept the fact that they will only receive AFRTS programmes in monochrome. (Or buy a NTSC receiver!). The main financial cost, therefore, is that of the sound/vision carrier spacing. However, on most tv sets this is unnecessary. Sony, Hitachi, and Sanyo all accept the following modification:

Between the sound i.f. detector and the sound i.f. i.c. stage is an adjustable transformer. If this is bridged on the detector i.f. side by a 150pF trimmer and switch in series (see Fig. 1), AFRTS sound may be received when the 150pF capacitor is in circuit by adjusting this trimmer and the transformer core. Normal (German) sound may be received by switching the capacitor out of circuit. Some tweaking of both capacitor and transformer will be necessary to find optimum points for both systems but the

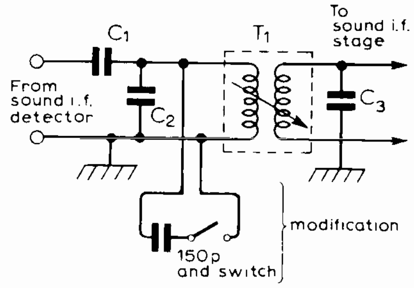


Fig. 1

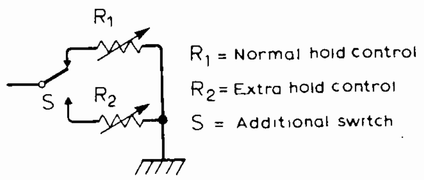


Fig. 2

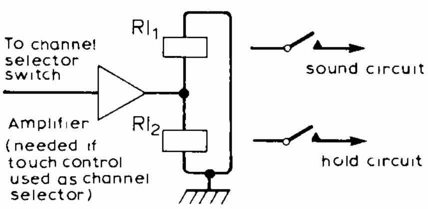


Fig. 3

final result (at least on my Sanyo) is better than that achieved with a converter unit.

If one doesn't want to have to adjust the vertical hold control when switching back and forth from AFRTS to German standards, an extra trimmer pot can be inserted in parallel with the normal hold control and switched as required, (see Fig. 2). It is not recommended to have both hold control and sound control on the same switch as one then hears the sync/line pulses on sound. However, two relays could be used instead of switches and driven from the channel selector switch as shown in Fig. 3.

The end result of the conversion is that one has German first, second, and as many of the local (third) programme as are in the region, plus English language AFRTS. Almost as good as being able to receive BBC1 and 2!

Robin A. Flood
Eastbourne
Sussex

AUDIO EQUIPMENT REVIEWS

A certain amount of attention has been paid in your pages of late to matters concerning reviewing in general and *Hi-Fi Choice* in particular, so an "official" comment from ourselves is perhaps overdue. The "British hi-fi scene drama" in the February issue is largely of your own making, and your sensationalist writing has merely succeeded in fomenting and fueling a very minor controversy. Certain of the parties mentioned in the report felt that they had been misrepresented, and this has had the no doubt desired effect of stimulating both correspondence and the "curiously bitter storm . . . raging in the hi-fi teacup." There has always been argument and debate within hi-fi circles and certainly equipment reviewing is one of the more sensitive areas; but to imply a conspiratorial boycott is a little far-fetched. Manufacturers and distributors have refused to submit equipment for a *Hi-Fi Choice* book in the past, and it then becomes an editorial matter to decide to what extent the absence of such equipment will reduce the value of the publication to its purchaser. If the product concerned is widely available, popular, and heavily promoted, we would not be doing our duty to our readership if we did not obtain samples by other means for inclusion.

However, the responsibility of a magazine is twofold, and the need to ensure fairness towards a manufacturer is equally important. The reviewer is best able to achieve a fair review of a product if he is aware of what the designer is trying to achieve. If he can discuss points arising from his investigations without fear of reprisal, the whole project is likely to benefit. All manufacturers and distributors submitting equipment are consulted as a matter of course if we feel we may have received a faulty sample, and the opportunity to inspect galleys to correct errors of fact is also made available. (This naturally does not imply that value judgements based on criteria qualified within the book are susceptible to change at a manufacturer's behest.) Unfortunately, it is obviously not normally possible to extend these courtesies to a manufacturer who has declined to submit his product, and although extra care is taken to ensure that the review is fair and representative, things are inevitably made more difficult.

I do not propose to dwell at any length on the vituperative points raised in Mr Cooke's letter in your April issue; suffice it to say that I regard them as the inevitable result of inadequate communication. I will, however, take issue on the matter of our name, which he criticises strongly on philosophical grounds. I can only speak for myself and the future editorial policy of the magazine, but my interpretation of our name and function is that we should try to provide comprehensive and comparable data on a significant proportion of the available products in whatever category we are examining, to enable the reader to make his own choice according to his particular needs. Despite many years of international standards bodies, this is something that manufacturers have singularly failed to achieve. Any attempt by an individual to compare simple performance specifications of several audio products is doomed to failure because of the lack of standardisation in manufacturers' supplied data. As far as possible *Choice* will use "standard" measurements, as this will at least help in its own small way towards wider acceptance of such standards. But I don't believe that anyone would seriously suggest that such "objective" testing on its own is all that is necessary to enable the consumer to formulate his own choice. The reviewer must assemble data and provide an interpretation for the lay reader. He must also place himself in the position of the conumer and examine the product in relation to its intended use, which may involve developing new test methods or setting up controlled listening panels.

By the time this letter is printed the *Loudspeaker* book should have appeared, and I hope that interested parties will endeavour to form their own judgements and criticisms of the project. Although far from perfect, I do believe that we have succeeded in undertaking a daunting task at least as well as, and in many ways considerably better than, our contemporaries. One unfortunate result of the *Hi-Fi Choice* format is its inability to publish manufacturers' feedback in the wake of publication, so it might be in the best interests of the industry as a whole if *Wireless World*, who are largely responsible for starting this controversy in the first place, could make space available for frank and open discussion of the results of the project.

Paul Messenger
Editor, Hi-Fi Choice
London, W1

PENNY-PINCHING IN AUDIO AMPLIFIERS

After following the running battle on types and relative importances of amplifier distortions, we have decided to release our own findings on this matter. Assuming that the source is of such characteristics as to avoid those problems caused purely by gross mismatching, we have found that the much-discussed differences in sound fall into two simple categories: frequency response deviations, and penny-pinching. The first is the easiest to visualise and test, although surprisingly small variations in response can cause a significant difference in the perceived sound — and not always where one might expect. A slightly "fat" bass is often mistaken for muffled treble, and weak bass for clarity.

The penny-pinching is the more insidious, however. One well-known American amplifier of 200 watts per channel has filter capacitors more appropriate to a 30 watt per channel amplifier. The power supply, as a result, is significantly modulated by the varying load placed upon it by the signal. If the input stages are in perfect balance, it has little effect; but if there is a mismatch in any of four long-tailed pairs, the sound becomes purest mud. Many other amplifiers appear to have had their driver and output transistors selected purely on the basis of peak voltage and current into a resistive load, and a cost book. Nobody seems to notice (or care) that the load won't be a resistor, that the current gain of the transistor is not what the tidy little number in the catalogue says (except under those conditions) but varies wildly with collector current, or that the drivers and pre-drivers have to handle fairly high current themselves if they are to drive the output devices well enough to supply the heavy peak currents often needed. The worst offenders have cut down on these devices to such a point that their 250 watt per channel amplifier, when connected to a speaker, clips at only 70% of the peak voltage developed by the Quad 303 bench amplifier. This test was conducted again with the current limiting disconnected and with another amplifier from the same firm, with identical results.

Other pinchpenny dodges include aluminium electrolytics whose impedance rises dramatically with frequency, cheap speaker switches that make better diode detectors than switches, crude output meters that merely put a series diode and the meter coil across the output, fuseholders and wire grippers that neither hold nor grip, and a special award to the miser who ordered 3-amp mains switches — for a 350 watt per channel amplifier. The distortions introduced defy all description!

Pre-amps and speaker cables are under test and evaluation by this group now, and initial results are surprising. The cable that was supposed to "clear up transients' made the amplifiers ring severely on high slew-rate input signals. Impressive sound, but unreal. Back to the bench and listening room to sort this out further.

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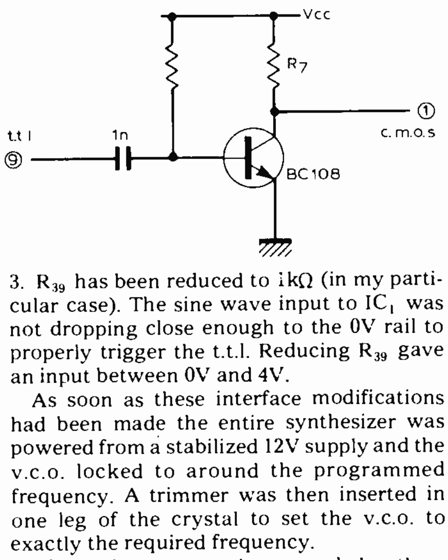
F.M. TRANSCEIVER SYNTHESIZER

I have recently completed construction of the synthesizer portion of T. D. Forrester's f.m. transceiver (November and December 1977) which works very well now that the following modifications have been incorporated.

1. The v.c.o. was found to oscillate at a minimum frequency of 30MHz (i.e. 0V on D_{17}, L_1 slug fully in) with 10 turns on L_1. Turns have been increased to 20 and D_{18} removed.

2. The 4059 was not being clocked by the 74LS74, even at 15V. Experiment showed that the 4059 required a pulse input of at least 70% V_{cc} before it would clock, which could not be directly supplied by the t.t.l. The accompanying buffer circuit was therefore introduced between the t.t.l. output and the 4059 input.



3. R_{39} has been reduced to 1kΩ (in my particular case). The sine wave input to IC_1 was not dropping close enough to the 0V rail to properly trigger the t.t.l. Reducing R_{39} gave an input between 0V and 4V.

As soon as these interface modifications had been made the entire synthesizer was powered from a stabilized 12V supply and the v.c.o. locked to around the programmed frequency. A trimmer was then inserted in one leg of the crystal to set the v.c.o. to exactly the required frequency.

I hope these suggestions may help others constructing this project and would be interested to hear of other modifications. Also, thanks to G4DPM who assisted with the above work.

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LOUDSPEAKER POLARITIES

Referring to "Mixer's" mention in Sidebands (January issue) of the Sheffield record sleeve, the inexplicable note suggesting reversal of polarities of *both* playback speakers may have a sound reason running directly along the lines of "Mixer's" thinking. In my research into fidelity and imaging of stereo systems I have noted audible differences between normal and reversed polarity. It seems that for impulsive sounds the ear *prefers* a negative pressure impulse. This has been noted by Madsen and Hansen[1], and perhaps is the basis for Sheffield's note, although polarity in multi-way speakers is often not constant. So "Mixer" is half right, but the idea is to have the speakers suck when the drum goes bang.

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Reference

1. "On aural phase detection," by Villy Hansen and Erik Rorbaek Madsen, J. *Audio Eng. Soc*, vol. 22, No. 1 (1974).

"*Mixer*" *replies:* Well, I must say it's very nice to be told that one is even half-right, sometimes. But, if the reason for Sheffield's sleeve note is to be discovered, maybe they should be asked – it does save such a lot of theorizing.

BIRDS' GEOMAGNETIC SENSE

What an interesting contribution Professor Dawson and Dr Dawson have made towards the resolution of the mechanism of birds' geomagnetic sense (February Letters). Let me review some evidence for the "electrodynamic" model.

As M. Bookman (M.I.T.) has pointed out, the literature contains no evidence for avian geomagnetic sensing in the "wings restrained" configuration. There is evidence for absence of this sense when birds are tested with wings fixed[1]. Yet, there is good evidence for the sense in the "wings free" condition[2]. Hence a connection between wing movement and geomagnetic sense is likely.

Out of respect for the researchers who have taken pains to present the case for this avian orienting ability, using rigorous experimental technique and statistical tests for high probability (and for at least one who lost his life in the work), may I urge the verification of the Emperor Penguins' sense by experiment. I would be most interested to find the effect of a "strait-jacket" on the orientation of experimental subjects. The penguin apparently uses vigorous flipper movements during his characteristic "tobogganing" mode of cross-country movement.

Now, a response to the serious objection that physiological "noise" would mask the required signal. If we describe the logic element of biological systems (in computer jargon) as a wide fan-in, low-level analogue integrating gate with "inhibit" and "assert" inputs, sometimes with, sometimes without, a pulsed, regenerative, digital, variable repetition rate transmission line driver; then system design considerations demand that the low-level analogue element be shielded from the effects both of adjacent transmission lines and of actuator noise. For, if this were not the case, the system would be dangerously unstable. Hence the nervous system seems to have the properties required to handle low-level signals in the presence of high-level noise.

In the standard demonstration of nerve action-potential transmission speed in the human arm, A. M. Brown (Open University) used a 200V, 50μs pulse in shocking electrodes spaced about 1cm apart, applied to the wrist, following S. Rose's method. This skin potential gradient of $20kV.m^{-1}$ indicates the effectiveness of the shielding.

In the context of flying birds, R. H. J. Brown (Cambridge) has suggested that after the high-energy take-off phase of flight the wing up-stroke may be largely passive (private communication). This would reduce the amount of masking noise, which is of course in "common mode" between the wings (or using the alternative jargon, is bilaterally symmetrical) in contrast to the electrodynamic signal which is unidirectional across the wings at any given time.

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References

1. M. E. Meyer and D. R. Lambe. *Psychon. Sci.* 1966, vol. 5 (9), pp. 349-350.
2. W. Wiltschko and R. Wiltschko. *Science*, 1976, pp. 62-64.

PROGRAMMING MICROCOMPUTERS

If I may take the liberty of commenting on Mr Pittman's thorough and systematic approach to programming (March issue), I hope it will encourage potential programmers if I say that one soon learns to dispense with flow diagrams, for all but the trickiest operations. Also I take an essentially optimistic view of errors. The machinery will discover some of them. But with problems involving real data, if the programme produces correct answers on the first five runs, there is a good chance it will continue that way. If it doesn't, then one can then start to test for likely errors in likely places.

As for the hardware, like W. Trapman writing in January Letters, I too have long nursed the hope that the naked microprocessor and its adjuncts will go away, and only return when properly dressed. The articles by Mr Pittman and Dr Shelton show only too clearly how primitive it all is compared with even a £5 pocket calculator.

However, one can take heart from the development of computers over the last fifteen years. Since I first wrote occasional blocks of machine code for a Ferranti Sirius (1000 words of storage, nine accumulators and less than 100 instructions) there have appeared with bewildering rapidity bigger stores, faster processors, more powerful languages, sophisticated operating systems, interactive facilities, remote terminals — the list is endless. All these are intended to be user beneficial, though users contest this vociferously when something goes wrong. Somewhere of course there still lurk expert programmers composing important software in machine code and assembly languages, but the user himself can be thankful that computers *did* go away and get properly dressed. It surely won't be very long before the microprocessor also matures.

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Interconnection of logic elements

The transmission line, t.t.l. and tri-state devices

by **I. Catt,* M. F. Davidson* & D. S. Walton†**, *CAM Consultants † Icthus Instruments Limited

This article outlines the concepts required when designing a complex logic system and describes the fundamental principles of connection between basic logic gates.

A digital system is composed of logic gates and interconnections between them. To ensure correct functioning of the system it is important to consider a model of this connection. The simplest case is a logic gate driving another single gate with no fanout as shown in Fig. 1. It is impossible to consider the interconnection without a ground or V_{cc} return path, and when this is present there is a distributed capacitance and inductance which forms a transmission line.

Properties of a transmission line

To characterise a transmission line a step propagating along a two-wire line is considered as shown in Fig. 2. Using Faraday's law of $V = d\phi/dt$ around loop abcd, L is defined as the inductance per unit length of the wire pair so $L = \phi/i$. In time t, the step will advance a distance s so that $s/t = c$ and the change of flux will be $\phi = L\,s\,i$. Substitution into Faraday's law gives the voltage applied to the line to overcome back e.m.f; $V_{AD} = L\,i\,ds/dt = L\,i\,c$. From $Q = VC$, $i = vCc$ where C is the capacitance per unit length of the wire pair, so $c = \pm 1/\sqrt{LC}$ and $v/i = Z_0 = \sqrt{L/C}$. Therefore, a step may propagate in either direction.

The two parameters which characterise a transmission line are the velocity of propagation c, and the impedance Z_0 which relates the voltage difference across the line to the current in the line. Thus, $v = iZ_0$ where Z_0 is a property of the geometry, and medium, μ and ϵ, in which the wires are embedded.

To use the formulae for Z_0 and c it is necessary to calculate L and C for any geometry that may be used. In general it is impossible to solve analytically for L and C and so other methods are used. Values for most practical cases are in the literature. It is common to represent a lossless transmission line as the model shown in Fig. 3 which allows the equations of step propagation to be derived. This method has little to recommend it especially as it appears to lead to a spurious high frequency cut-off. There is, of course, no high frequency cut-off inherent in any transmission line geometry and the only factor which can cause this is a frequency dependent behaviour of the dielectric. If the dielectric is vacuum, there is no frequency dependence and no cut-off.

The sinewave concept can be very misleading in digital electronics and it is invalid to think of a single step as being composed of a superposition of sinewaves. The diagram in Fig. 4 shows a step which is propagating along a transmission line with velocity c ($c = 1/\sqrt{\mu\epsilon}$), the velocity of light in the medium surrounding the conductors. A true sinewave signal is infinite in both time and distance, i.e. it can only exist in an infinitely long transmission line, and any practical situation is an approximation to this ideal. Because the step is travelling at the velocity of light there can be no energy or information ahead of it and there can be no effect at any point P in front of the step. This consideration alone is sufficient to demonstrate that such a step cannot be analysed into a superposition of sine-

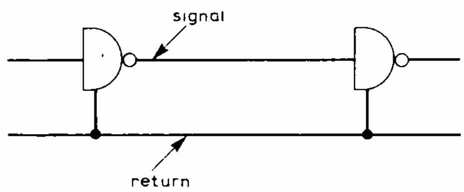
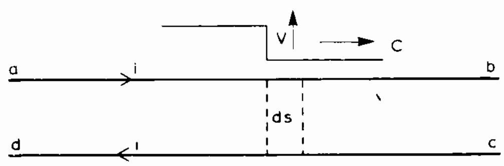


Fig 1. *Simple example of a logic gate driving another gate.*

Fig 2. *A step propagating along a two-wire line.*



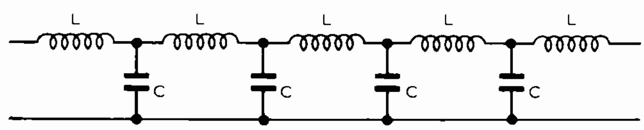
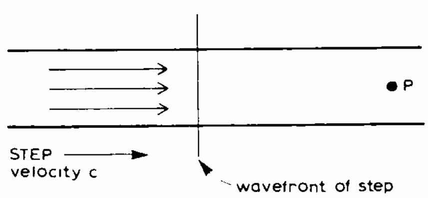


Fig 3. *Model of a lossless transmission line.*

Fig 4. *A simple step should not be considered as a superposition of sinewaves.*



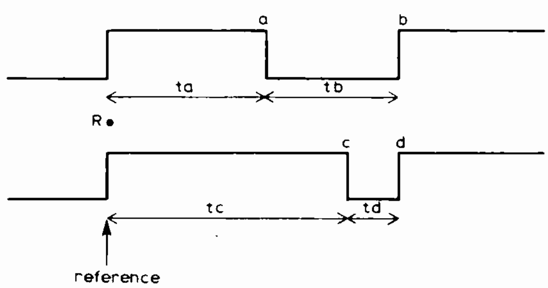


Fig 5. *Two digital signals, illustrating edges as separate events in time.*

waves because these sinewaves would have to exist both ahead of and behind the step. Also, if the transmission lines were cut before the step arrived at P, any effect which was already at P would have to vanish instantaneously, again impossible. Mathematics indicate that if we superpose many sinewaves of appropriate amplitudes and phase relationships we would obtain a step waveform. This is undeniably true but its converse, that we can analyse a step into a superposition of sinewaves, does not follow logically and is in fact not true. The sinewave is responsible for much confusion particularly in the discussion of factors affecting the choice of capacitors for logic decoupling. It is important to remember that a step is a shock wave, formed by a transverse electromagnetic wave front travelling at the speed of light, and all digital signals are combinations of either positive or negative going edges. Any observer can only see the signal as it passes him on the transmission line.

The important parameter of the two digital signals in Fig. 5 is the time delay between the edges. Each edge a, b, c or d must be considered as a separate event in time which is completely unconnected with any other transition. A logic gate connot predict the arrival of any edge until the shock wave actually arrives. It then responds to the amplitude of the signal and by the time the next shock wave arrives it has settled down to the steady state condition.

Transistor transistor logic

Before discussing t.t.l. circuits it is worth considering the evolutionary process which lead up to them. In early d.t.l., transistors were only capable of sustaining a 1mA collector current which resulted in the circuit arrangement shown in Fig. 6 where a 10kΩ resistor was used in the collector. One problem with this circuit is its inability to drive stray capacitance. Consider the output waveform in Fig. 7 which is obtained when a pulse is applied to the input. The transistor switches on and the stray capacitance is discharged through the saturated transistor to produce a rapid falling edge. When the transistor switches off it cannot supply current so the stray capacitance charges through the 10kΩ resistor to produce an exponential rise which corresponds to a time constant of RC. Therefore, this type of gate is not very good at driving long signal lines. In practice the load is not strictly capacitive, but is a transmission line with a characteristic impedance of around 100Ω. However, in this case because R is much greater than 100Ω it makes very little difference and the slow edge masks any transmission line effects.

Logic designers attempted to circumvent this problem by using a "push-pull" output stage to give rapid transitions in both directions as shown in Fig. 8. Here the output is driven by a "phase splitter" so that while the top transistor is on the bottom one is off and vice versa, but in practice there is an overlap of a few ns. This causes a low impedance across the supply rails which produces a current spike. This type of output was used in the unpopular 73 series of logic. The final step in the evolution of t.t.l. was the insertion of a series limiting resistor in the collector of the upper transistor.

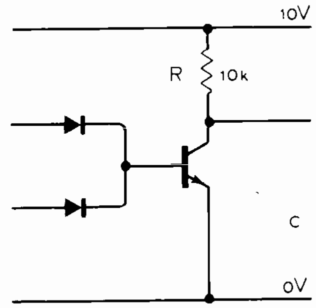


Fig 6. *Early form of logic, diode-transistor logic.*

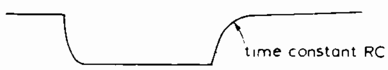


Fig 7. *Output waveform from d.t.l. in Fig 6.*

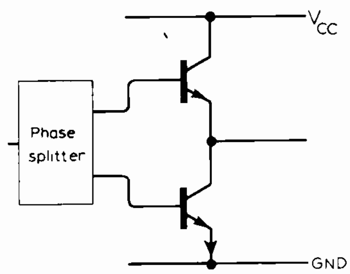


Fig 8. *Push-pull output stage to give rapid transitions.*

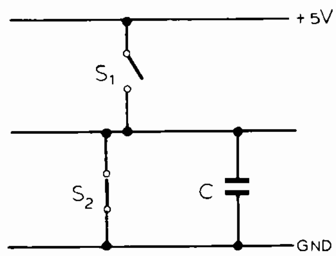


Fig 9. *Basis of t.t.l. circuit required to drive a capacitive load.*

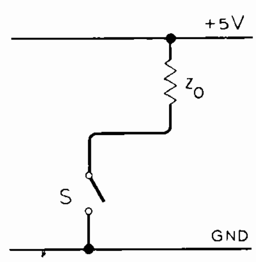


Fig 10. *Only one switch required for a resistive load.*

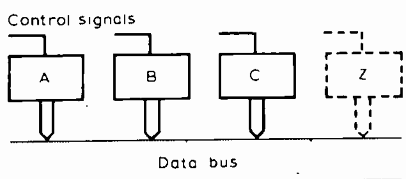


Fig 11. *Tri-state devices connected to a bus.*

Unfortunately, during the evolution of t.t.l the way impedance levels and device speeds have changed has not been considered fully. While d.t.l. worked initially with a 10kΩ output impedance we now have t.t.l. devices with an internal pull-up resistor of around 100Ω. This means that the transmission line behaviour cannot now be ignored. In fact, when the connection to a t.t.l. device is considered as a transmission line the upper transistor in the output is redundant and serves no useful purpose. A capacitive load requires a circuit as shown in Fig. 9 because, to produce a voltage across the capacitor, a charge must be fed into it via S_1. Discharge of the capacitor must take place through S_2. As already mentioned, a t.t.l. gate must drive a transmission line with an impedance of about 100Ω. The current and voltage are related by $V = iZ_0$ where V is the voltage applied to the line and i is the resulting current. In this case the load is essentially resistive and only one switch is required as shown in Fig. 10. When S is closed the output is low and when it is open the output is high. If the interconnection is terminated with a resistor $R = Z_0$, effects due to stray capacitance and inductance will not affect the output rise or fall times. Therefore, under certain conditions the t.t.l. "push-pull" configuration is unnecessary and an open collector gate will suffice.

Tri-state devices

Common data-bus structures are widely used in mini computer systems but because conventional t.t.l. cannot be wire-ORed it cannot be used. To overcome this limitation tri-state devices have been produced and are rapidly becoming standard components for bus drivers and memory outputs. A tri-state device has an additional control input which determines whether or not the device is enabled. When enabled, its outputs are in the high or low states as normal. When disabled, its outputs assume the high-impedance or off state and the device behaves almost as though its outputs are disconnected from the package pins. In this system only the device which is driving the bus is enabled, so active pull-up is achieved with the benefits of wire ORing. However, even with these apparent advantages it must be considered whether tri-state t.t.l. is necessary and desirable.

With regard to its necessity, the answer is definitely no. Any function which is possible with tri-state devices can be implemented more simply with open-collector t.t.l. Tri-state is an unfortunate development caused by a misunderstanding of the requirements for transmission line driving. The answer is also no for desirability because it has a failure mode which can lead to the progressive collapse of all the tri-state devices driving a bus. For example, in Fig. 11 if device A becomes enabled at the wrong time due to a fault in the circuitry it could place all lows on a bus to which another device is quite legitimately outputting all highs. This leads to catastrophic power dissipation in the good device and the process can then repeat until all of the devices are destroyed. For the Ti 74365 hex bus-driver, power dissipation in this failure mode can be calculated as follows. The output short-circuit current is specified as 40-130mA so the power dissipation per gate for a 15V rail will be between 0.2 and 0.65W, and the total dissipation for a package of six gates will be 1.2 to 3.9W. The quiescent power dissipation of 0.3 to 0.4W per package means that the total worst case figure is 4.3W. This is about ten times the rated dissipation of a d.i.p. and will destroy the device. □

This article is based on material from a book "Digital Electronic Design", by the above authors, published by C.A.M. Publishing, 17 King Harry Lane, St Albans, Herts, price £8.00 including postage.

LITERATURE RECEIVED

"Modern Instrumentation Tape Recording" booklet available free from SE Labs (EMI) Ltd, Spur Road, Feltham, Middlesex TW14 OTD WW401

Power devices from RCA and specimen circuits for many applications described in booklet 2M1169 from RCA Ltd, Solid State-Europe, Sunbury-on-Thames, Middx TW16 7HW WW402

Trimmer capacitors described in six Voltronics leaflets, free from ITT Components Group. Capacitor Product Group, Brixham Road, Paignton, Devon T24 7BE .. WW403

Video filters, including new range for use with d-a or a-d converters, is published by Matthey Electronics, William Clowes Street, Burslem, Stoke-on-Trent ST6 3AT WW404

"Electronic Components Buyers' Guide" is published by the Electronic Components Industry Federation. Free from ECIF, Liberty House, Regent Street, London W1R 5EE. WW405

Alarm systems applications and equipment descriptions in catalogue from Highland Electronics Ltd, Highland House, 8 Old Steine, Brighton, East Sussex BN1 1EJ WW406

Components catalogue from Jack Evans Distribution is now available from JED at 244 Bath Road, Hayes, Middx UB3 5AX WW407

Remote computing facilities provided by EMI's PIX for users of IBM360/370 and 3030 are simply described in a brochure, obtainable from Data Comms, Division, EMI Technology, North Feltham Trading Estate, Feltham, Middx WW408

Time interval measurement is the subject of three application notes from Hewlett-Packard, in which time calibration, the 5359A synthesizer and 3570A counter are described. AN 191-1/2/3. Hewlett Packard Ltd, King Street Lane, Winnersh, Wokingham, Berks RG11 5AR WW409

Instrument repair and calibration — the business of IEC Ltd—is described and illustrated in a brochure, obtainable from Instrument House, 212 Ilderton Road, London SE15 1NT WW410

Tools, for electronics and electrical work, are listed in a catalogue produced by Toolrange, Upton Road, Reading RG3 4JA ... WW411

Altair microcomputer systems are described by Compelec in their new brochure. Copies from Compelec Electronics Ltd, 107 Kilburn Square, London N.W.6 .... WW412

Infra-red emitters and injection lasers from RCA are featured in the OPT-113C product guide, available from RCA Solid State-Europe, Sunbury, Middx WW413

Mobile radio bandwidths *continued*

frequency conservation; and (ii) unnecessary except for digital speech, which in turn should be justified on its own merits; it is not a reason for making all channels broad and thus wasting spectrum.

Any trends in technique which are likely to be developed in the future and which may enable higher bit rates to be achieved within the limitations of a normal speech band, line and radio, are not within the scope of this article. The rate of progress over the past two decades, however indicates a real possibility that before the 1999 World Administrative Radio Conference we could well be in possession of techniques which could require a totally different approach to frequency planning. Is it therefore wise at this stage to put all our eggs in one basket and use a common, and probably wider bandwidth, for high speed data or speech?

Such a move not only reduces channel availability within the spectrum, it implies the exclusive use of frequency modulation and tone squelch. Furthermore it implies a period of chaos whilst the various existing systems and users are "sorted out."

Use of the split channel technique — 25kHz equipment allocated on a 12½kHz channel basis but relying upon geographical separation — would tend to restore the channel availability insofar as *quantity* is concerned, but in practice, owing to the geographical separation requirement, could result in but a small increase in availability — particularly in the type of urban area associated with the United Kingdom.

Alternative data/speech possibility

Let us now consider the inevitable. Speech systems will be with us for a long time and will tend to predominate for some time. The use of data technique will, however, increase. Existing "state of the art" high speed data techniques, where justified, will require a minimum of 25kHz channel width to accommodate the sidebands etc associated with existing techniques.

The solution proposed for this situation is quite simple, it merely advocates remaining with 12½kHz channel allocations and using the channels in the same manner for speech as at present. The channels would also be suitable for the simpler data transmission systems of 1200bit/s and up to 4800bit/s if suitable lines are used.

Above this speed, *where high speed is justified* two or more adjacent 12½kHz channels would be allocated, possibly from a discrete section of the spectrum to simplify sideband cut-off problems. Such a wide band system could be required for digital speech.

As and when techniques improve, it would be a simple matter to insert conventional narrow band users into vacated 12½kHz slots, thus making full use of the available spectrum.

It may well be that technical changes involving, for instance, 6¼kHz operation for speech, would enable further channel allocations to be made available in the future. In this case the allocation of channel units would be in 6¼kHz multiples with data possibly requiring up to three or four such units.

By such a technique we are not penalizing the small user requiring speech communication only, neither are we limiting the data user to bandwidths which could be restrictive.

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2. Home Office sifts WARC evidence, *Wireless World*, October, 1977
3. Mobile radiotelephone equipment for very narrow channels, P. A. Webster, V.h.f. and u.h.f. Mobile Communication Systems and Equipment, I.E.E. conference paper, January 1966.
4. Improving spectrum utilization in mobile radio communication, Henry Magnuski, 26th Annual Conference I.E.E.E. Vehicular Tech. Group, Washington D.C., March 1976.
5. Microwave Mobile Communications, edited by Wm. Jakes Jnr.
6. Spectrum engineering — the key to progress, the Joint Technical Advisory Committee 1968.
7. Report on tests to determine the feasibility of 12.5kHz channel spacing for the public radiotelephone service, British Post Office, POTHQ/TD6 4.2, 2nd August, 1976.

CIRCUIT IDEAS

Modifying the K.B.6 ASCII encoded keyboard

This keyboard does not have a lower case character output and fails to provide the parity bit required for some applications. Although it is quite easy to sense the seven bits of the ASCII output, the TMS 5000 NC encoder chip provides the parity bit on pin 6 which can be hard-wired to the redundant segment 2 on the outlet.

Cut the track leading from switch "P" to the plated-through hole near pin 20 of the TMS 5000 r.o.m., close to the switch. Trace the track from pin 22 of the r.o.m. to the contacts of the ";+" switch, and hard-wire this to the disconnected contact of the "P" switch. Lower case characters will now be obtained by simultaneously pressing the "shift" and "ctrl" keys together with the requisite character key. The keyboard however contains sufficient hardware to implement a separate lower case key, and the redundant "here is" key may be used for this purpose. Wire the non-earthy side of the "here is" key to pins 4 and 5 of the 7400 marked ×4, and connect a 5.6kΩ resistor from these pins to pin 14 of the 7486 marked ×5. Connect a wire from pin 6 of the 7400 to pin 4 of the 7486. Finally, cut the connection between pin 4 of the 7486 and the ground line on the key side of the printed circuit board. The consequential loss of the "@" character and the "NUL" ASCII output from the "P" as previously connected, can be made good by borrowing another redundant key and wiring it into the r.o.m. lines which previously yielded the "P" and "@" characters.

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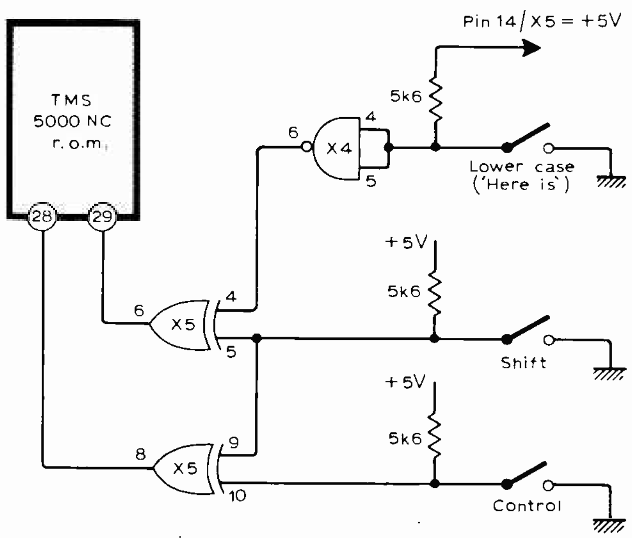
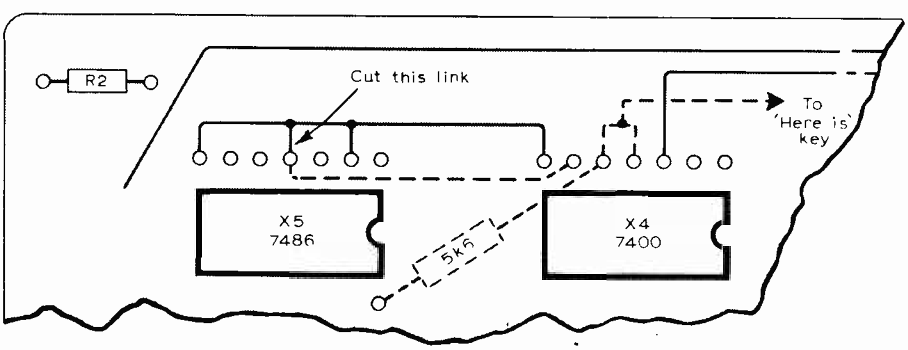
Fortis Green,
London.



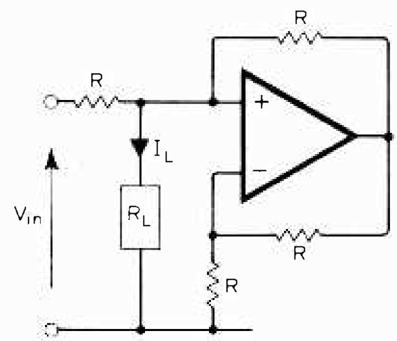
Pin 28	Pin 29	Output
0	0	Lower case
0	1	Upper case
1	1	Control
1	0	Shift

TRUTH TABLE



Earth referenced V-to-I

The circuit idea for Earth referenced V-to-I which appeared in *Wireless World* December 1977, required one op-amp and three transistors. This simpler circuit uses one op-amp to produce a current source referenced to ground.



It can be shown that the load current $I_L = V_{in}/R$. If R_L is replaced by a capacitor, a ground referenced integrator is formed and the resulting voltage ramp may be taken via a buffer stage across C or alternatively from the output of the o-amp. For the last mentioned connection, the output ramp is modified to become

$$V_o = \frac{2}{CR} V_{in}\,dt.$$

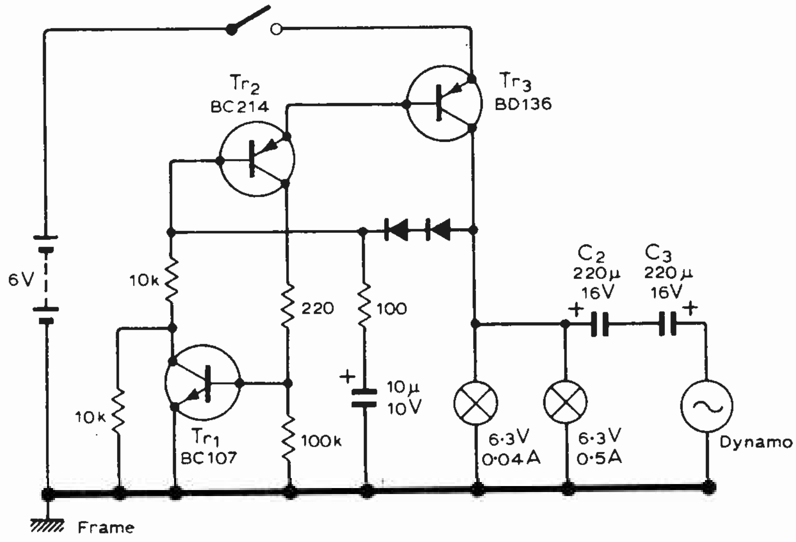
The maximum load resistance that may be used is $\leq V_{OH}/2I_L$ where V_{OH} is the peak output or the op-amp before saturation commences.

M. Applebaum,
Chubb Alarms Manufacturing,
Middx.

Standby battery for dynamo lighting

An a.c. bicycle dynamo can be provided with standby battery power by using the circuit shown. The battery supplies current via Tr_3 which should have an h_{fe} of greater than 40 and a V_{CEsat} below 100mV at 0.5A collector current. The circuit is activated when the peak dynamo output falls below the battery voltage. The 100µF isolating capacitor, C_2/C_3, provides power factor correction for the dynamo by cancelling its internal inductive reactance. The correction covers a large speed range because the internal inductance falls with increasing dynamo speed. This raises the typical output of a bicycle dynamo, around 4.5V r.m.s., to about 5.5V r.m.s. The optimum value of C_2/C_3 should be found by experimentation.

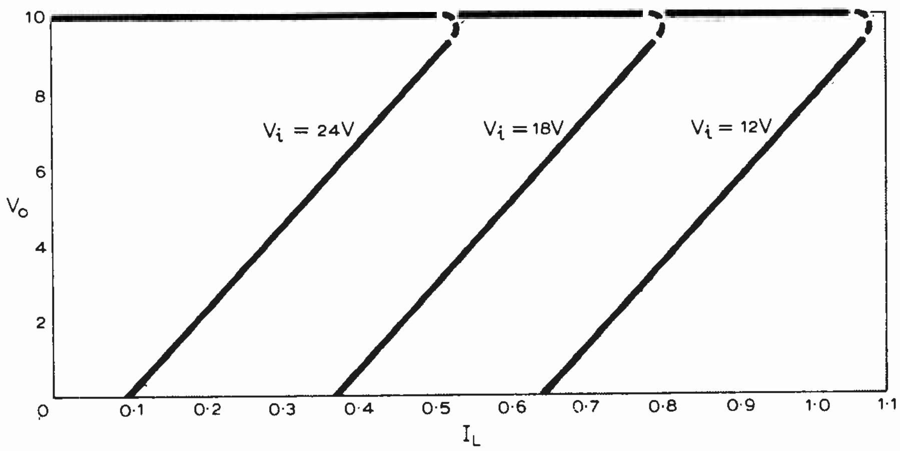
Brian J. Pollard,
Coventry.



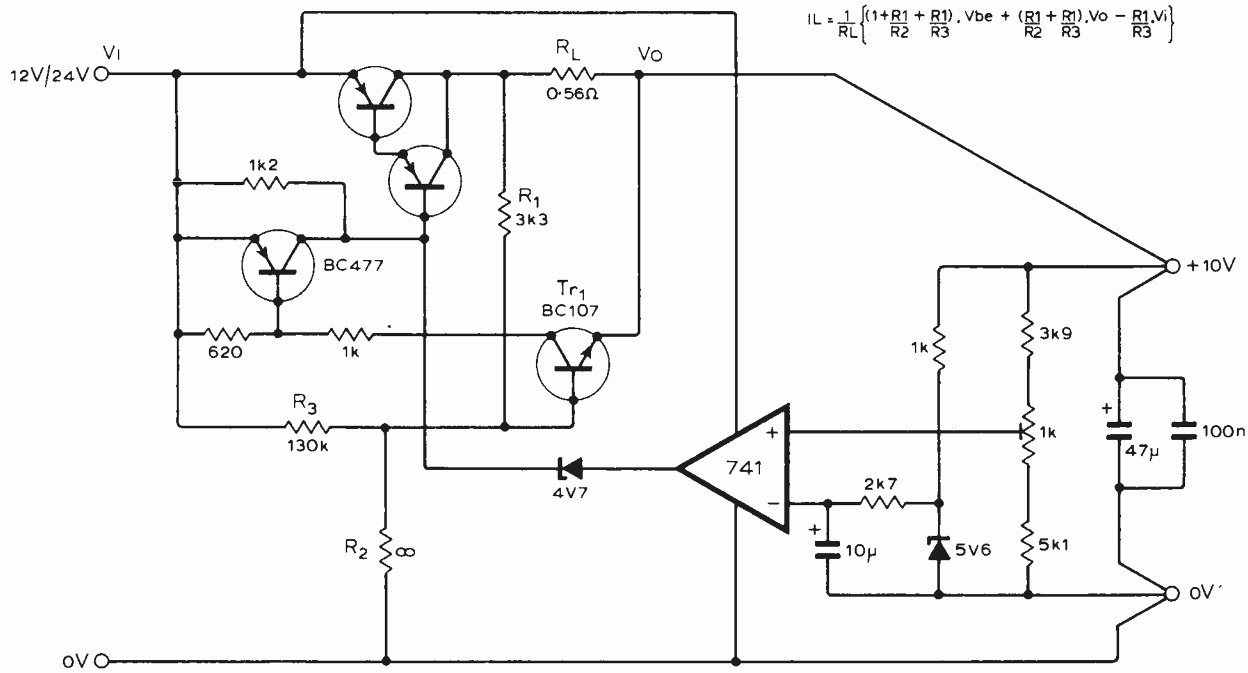
Fold-back current limiter

This design has been found useful when supplying series regulated circuits from a wide range of input voltages. By choosing suitable values for the current limiting components, R_1, R_2, R_3 and R_L, fold-back current limiting characteristics can be achieved that will protect the series regulating transistor from over dissipation when V_i-V_o is high, and allow higher values of load current to flow when V_i - V_o is low. Current limiting takes place when Tr_1 conducts. With the values shown and the V_{be} of Tr_1 assumed to be 0.65 volts, the current limiting characteristics will be similar to those in the graph.

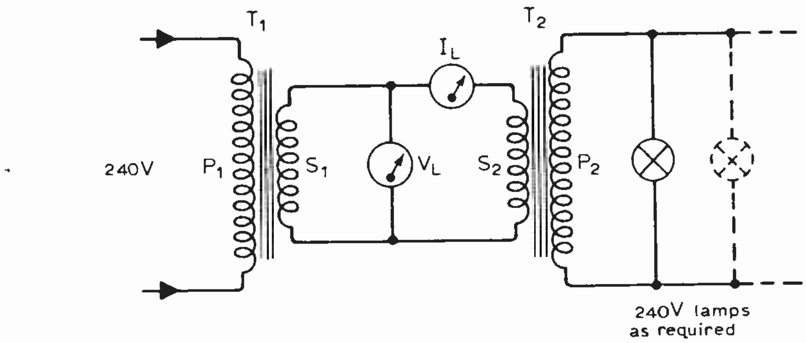
A. J. Ewins,
North Harrow,
Middx.



$$I_L = \frac{1}{R_L}\left\{\left(1+\frac{R1}{R2}+\frac{R1}{R3}\right).V_{be} + \left(\frac{R1}{R2}+\frac{R1}{R3}\right).V_o - \frac{R1.V_i}{R3}\right\}$$



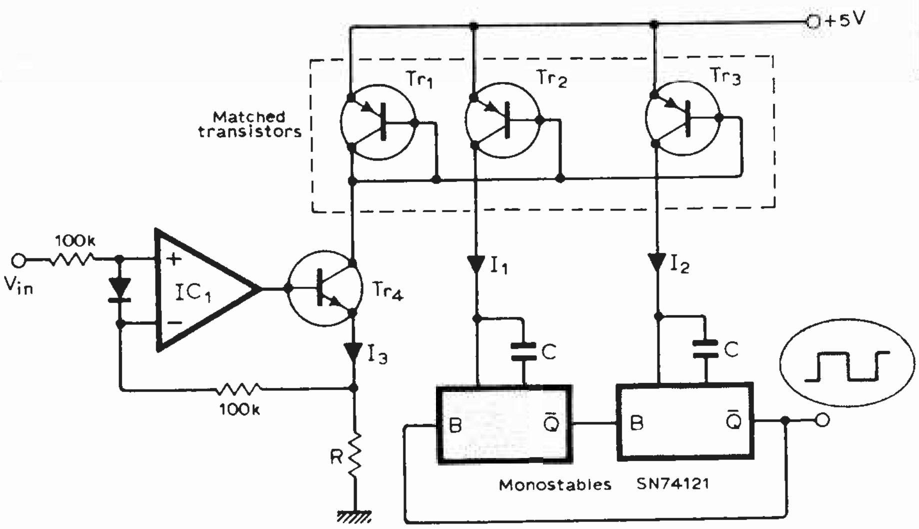
High a.c. loads



A shortage of high-current loads presented a problem when it was necessary to soak-test two identical mains transformers. The test conditions were satisfied by using a reflected load technique with the two transformers back-to-back as shown. Readily available 240V domestic lamps provided highly suitable loads. With a little care and adaptation this principle can be applied to dissimilar transformers. Also, suitable resistors can be used in conjunction with the lamps for fine load trimming.

Geoffrey T. Edwards,
Woodley,
Reading.

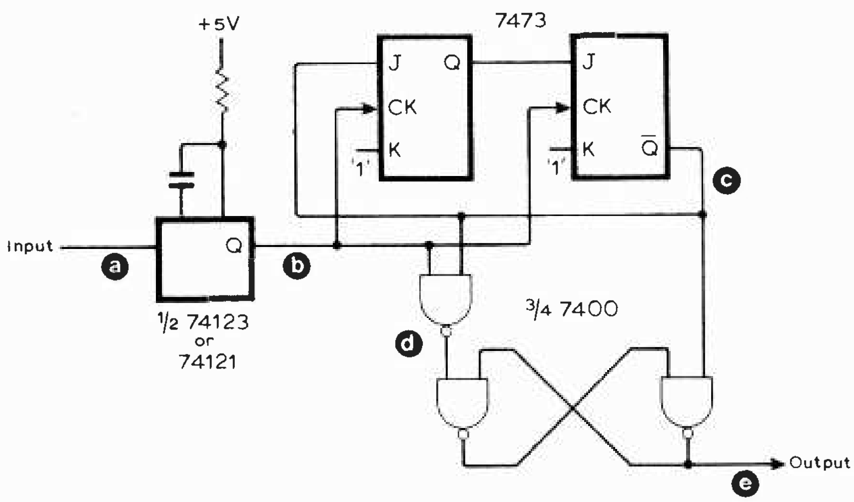
Linear v.c.o. operates from 5V

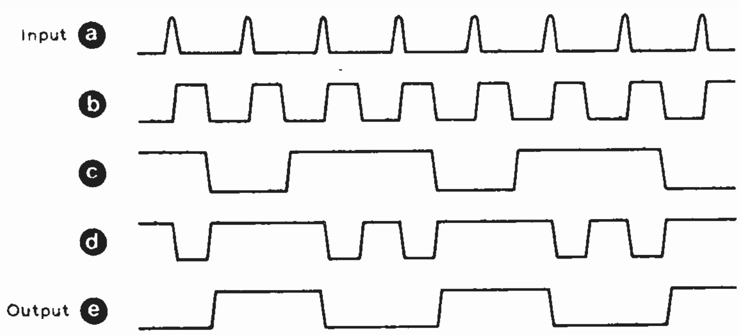


When designing hybrid analogue/digital systems, it is often necessary to use a voltage controlled oscillator operating from a 5V supply rail. This circuit uses a standard current differencing amplifier IC_1 together with t.t.l. monostables to achieve this. The amplifier is biased as a voltage follower so that a current V_{in}/R flows through Tr_1. Because Tr_2, Tr_3 and Tr_4 are connected in a current mirror configuration, equal currents I_1 and I_2 are injected into the monostables. The monostables, which are connected back to back, oscillate at a frequency defined by the current in Tr_1. Care should be taken in choosing the current defining resistor R because thermal considerations limit the current to 2.5mA. The centre frequency may be chosen by $f_c = 1/(4CR)$ for $V_{in} = 2.5V$. Nonlinearities in the emitter base junction of Tr_1 are removed by feedback. In practice the main deviations in V-to-F occur because of a mismatch between the current mirror transistors. This mismatch is most significent at currents above 1mA.

Kirit Patel,
London Business School.

Divide by three





This circuit uses only three t.t.l. i.cs to divide an input signal by three and provide an equal mark-to-space ratio output. The monostable is adjusted to produce an equal mark-to-space ratio from any input signal.

D. J. Eaton,
St. Leonards on Sea,
E. Sussex.

Loudspeaker system design

Three-enclosure system with active delay and crossovers — part 2

by **Siegfried Linkwitz** Dipl. Ing.

This is not the "ultimate loudspeaker", but in the first part of this article in the May issue Mr Linkwitz says that "the recording is the next weak link in the chain." The equalized system incorporates electronic crossovers and delay compensation. Part one describes the enclosure design and this article gives sufficient information for the experienced constructor to duplicate or to adapt the electronic design to other needs.

THIS SPEAKER DESIGN project was started with the idea of mounting the boxes flush with the surrounding wall. Positioning the box in front of a wall causes a severe dip in amplitude response when the distance from the front of the box to the wall equals a quarter wavelength. For a typical 300mm enclosure depth the dip occurs around 250Hz, Fig. 2 (ref. 7).

If one imagines the walls near the speakers to be made of mirrors then one can easily visualize the images of the box in these mirrors. At frequencies where the radiation from the box is omnidirectional, each of these images can be thought of as a separate sound source, whose output will add or subtract from the original source, depending upon how far the image source is removed in terms of wavelengths. For a half wavelength distance to the image source, corresponding to a quarter wavelength distance from the speaker to the mirror, the output from the real and the imagined source will cancel each other.

This description of virtual sound sources is valid provided that the speaker is radiating sound towards the walls and that the walls, floors and ceiling act as acoustically reflecting surfaces, i.e. mirrors. Mounting the boxes flush with the reflecting surface eliminates the virtual image behind the speaker and produces a smooth frequency response. The completed system with flush mounted boxes performed very satisfactorily. In particular it gave a good sense of depth perspective for some stereo material.

It was discovered later that by moving the speaker out into the room and at least 0.5-1m away from walls and floor, a significant improvement in sound perspective was obtainable, see photograph in part 1. On approprate program material it now became quite easy to pinpont the location of individual instruments both laterally and in their distance behind the speaker plane. It might be said that the whole sound stage moved into focus.

Furthermore, tape hiss and record surface noise became spatially separated from the musical material. The noise originated definitely at the speaker boxes while the musical instruments assumed their own space between and behind the boxes. In this sense the noise and ticks from a record surface are comparable to tne coughing and shuffling of people at a live concert where one can concentrate on the performance and not be side-tracked by unrelated acoustical events[8].

It is not clear why the placement only a relatively short distance away from the walls should give such a marked improvement, particularly in light of the just-mentioned frequency response interferences from virtual images. It might be that the ear-brain combination performs a time domain analysis and is able to allocate the wall reflections which occur 4 to 6ms later than the direct sound to the characteristic of the listening room and to the program material.

Mounting of the speakers away from the walls was accomplished by hanging them from the ceiling with a nylon monofilament. Electrical connections run from the back of the enclosure to the wall behind it and also serve to keep the speaker aiming forward. The small hanging units might be appropriately called satellites to the woofer box. The woofer itself is located halfway between the satellites, which are 2.5m apart.

The listening room is 5×8×4m (w×l×h), with the speakers in front of the narrow walls and the typical listening positions 5 to 6m away from the satellites.

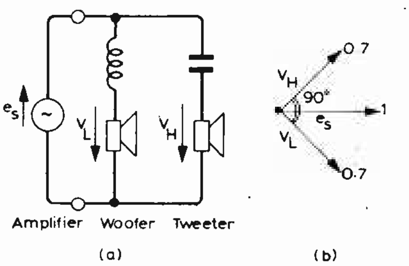


Fig. 7. *Schematic network with 6dB per octave slopes and voltage phasor diagram at the crossover frequency.*

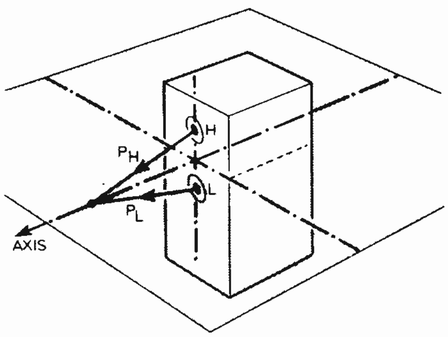


Fig. 8. *Plane of points are equidistant from the high frequency and low frequency drivers. The sum of the sound pressures is proportional to the sum of the electrical drive signals only in this plane.*

Crossover design

The simplest crossover network is the —6dB per octave slope filter of Fig. 7. Assuming idealized components, the current from the generator will split in such a way that the vector sum of the voltages across the low and high frequency driver terminals is equal to the source voltage at all frequencies $\mathbf{V}_L \hat{+} \mathbf{V}_H = \mathbf{e}_S$.

Correspondingly the vector sum of the sound pressures p_L and p_H generated by the drivers will be directly proportional to the generator voltage $\mathbf{p}_L \hat{+} \mathbf{p}_H = k\mathbf{e}_s$ and independent of frequency, provided that the distance from the listener to each of the drivers is identical. The B110 and T27 drivers though are a wavelength apart, which means that equidistance is obtained only for a plane in space, Fig. 8. For points outside this plane the sum of the two driver outputs will vary with frequency.

Furthermore, because the two drive voltages already have a 90° phase difference the summation will be different for symmetrical points above and below the plane of equidistance. In the crossover frequency region where both drivers contribute equally the system will radiate its maximum pressure at a 14-degree angle below the plane, Fig. 9. This simple dividing network has a wide range of overlap between the two drivers and therefore a tilted radiation pattern over at least two octaves.

A seemingly attractive feature of this network is its complete lack of phase distortion for points which are equidistant from H and L, Fig. 8. At these points perfect square-wave reproduction is achievable under free-field conditions or in an anechoic chamber. In a living room the increased radiation towards the floor and the reduced radiation upwards will produce a coloration in sound due to the frequency-selective change of the reverberant field. The ear is more sensitive to the amplitude response than to phase shift. Therefore this filter and related designs with even greater than 90° phase difference between the drive signals and correspondingly greater off-axis intensity peaks are not used for the satellite system[9].

A 24dB per octave slope filter was chosen which has no off-axis peaks in the radiation pattern[10], Fig. 9. The steep filter cut-off narrows the overlap region where the B110 and T27 interact. The T27 has its fundamental resonance at 1.4 kHz and the highpass provides 27dB of attenuation at this frequency. At 5kHz where the B110 exhibits a cone resonance the filter has reduced the drive voltage by 18dB, Fig. 10. A 6 or even 12dB per octave filter would have insufficient attenuation to minimize exciting these resonances. The 18dB per octave filter was not considered because it tilts the polar pattern.

All these filters, with the exception of the 6dB per octave network, have a frequency-dependent phase shift and consequently some phase distortion. Only a network of linearly increasing phase shift with increasing frequency will have no phase distortion. The slope of the phase curve is constant in this case. Any deviation from the constant slope indicates that some amount of phase distortion is present. The question arises how much slope variation can be tolerated before it becomes audible and not merely visible on an oscilloscope. The slope of the phase curve, usually referred to as envelope delay or group delay, has been plotted for typically used Butterworth crossover networks and the new network function[10], Fig. 11. Merely changing the polarity to one of the drivers drastically changes the group delay for the summed driver outputs as in the case of the first and third-order Butterworth crossovers. Their on-axis amplitude response is unchanged, unless the drivers are separated some distance from each other. Then the polar pattern will tilt either up or down with the change in driver polarity.

To investigate the audibility of phase distortion an all-pass network was built which duplicates the group delay of the new second and fourth-order crossover networks (12 and 24dB per octave curves in Fig. 11). Listening with headphones to stereo and mono program material, no audible difference could be detected with either one of the all-pass networks switched in or out. Therefore it seemed safe to use the fourth-order filter with its sharp cut-off behaviour which minimizes the overlap between drivers.

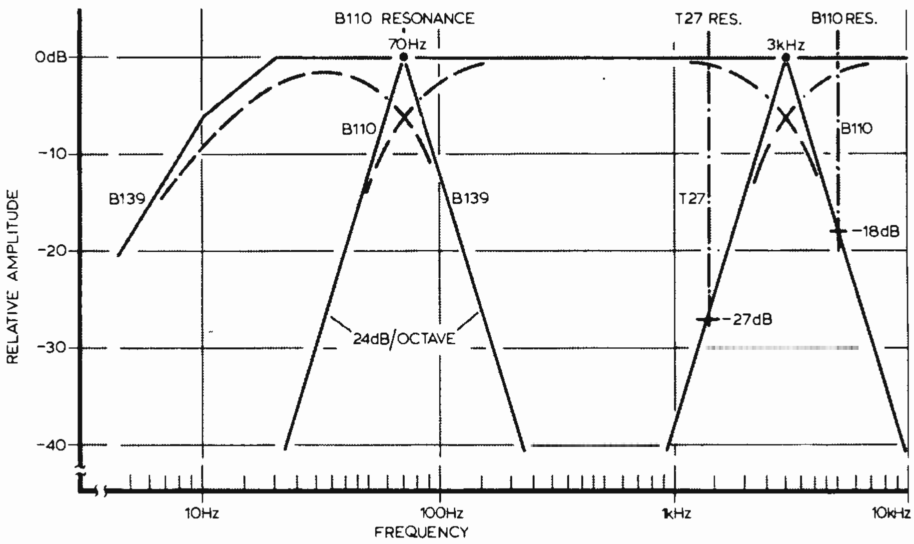


Fig. 10. *Schematic response for crossover points and driver resonances.*

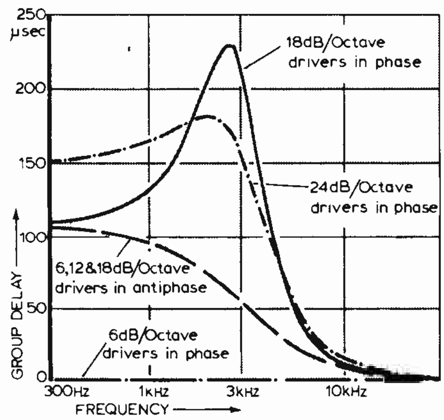


Fig. 11. *Group delay frequency response of a speaker system due to a 3kHz crossover between midrange and tweeter with conventional first and third-order Butterworth networks, and with second and fourth-order cascaded Butterworth sections (ref. 10).*

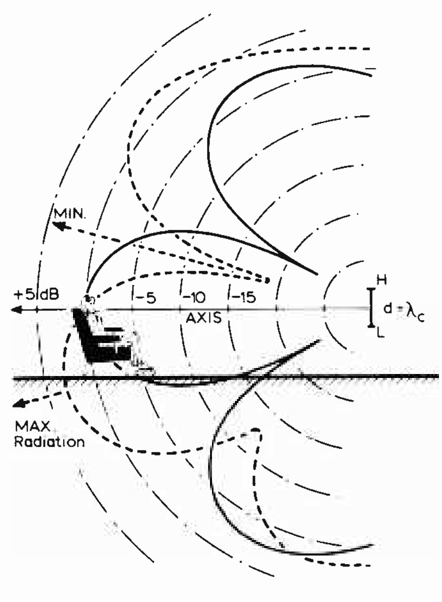


Fig. 9. *Radiation of a 6dB per octave crossover network at the cross-over frequency (3dB peak occurs below the plane of equidistance for non-coincident drivers) and the symmetrical pattern of a 24dB per octave crossover network at the crossover frequency (ref. 10).*

Crossover and equalizer circuits

The crossover networks and equalizers consists of a variety of active filter circuits. The overall block diagram of Fig. 12 gives an indication of the system complexity. Design formulas are presented for each functional block so that the experienced constructor should be able to duplicate the circuits of Fig. 13 or adapt the design to particular needs.

3kHz crossover networks

The fourth-order high and low-pass filters are made up from cascaded second-order Butterworth sections, Fig. 14. The outputs V_H and V_L are in phase with each other at all frequencies and the voltage sum is equal to V_{IN}. At the crossover frequency f_c, therefore, the output from each filter will be $V_{IN}/2$ or 6dB down, which is different from the typical 3dB crossover point for filters where V_H and V_L are in phase quadrature[10].

Delay compensation

The B110 and T27 drivers do not radiate from the same acoustical plane even though they are mounted on the same

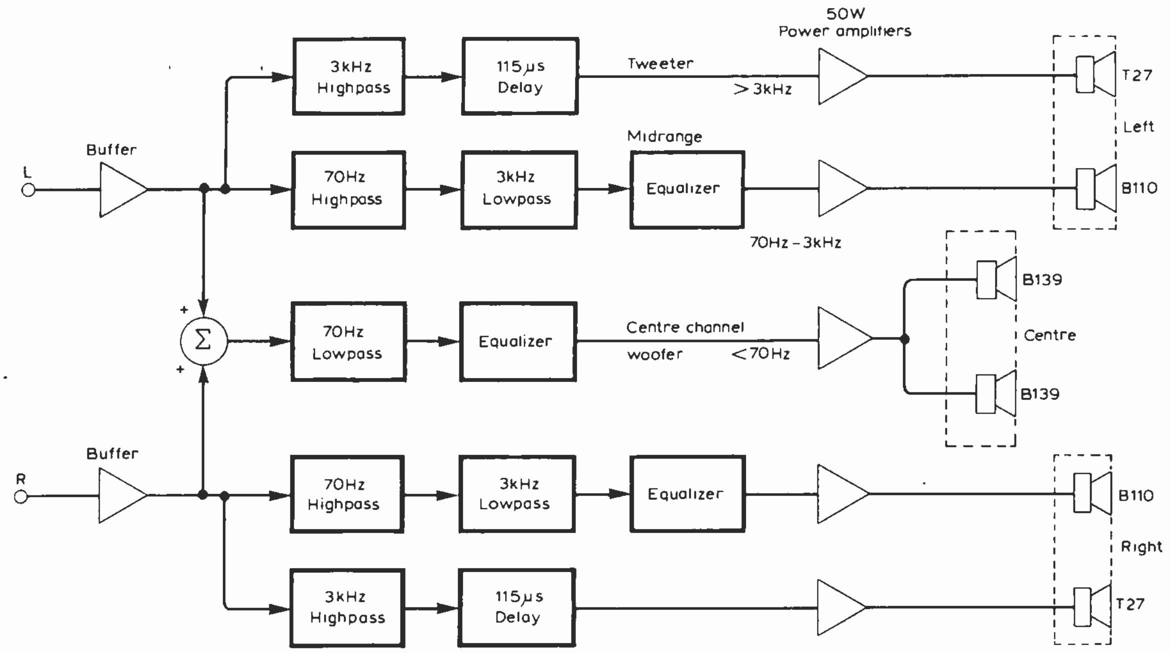
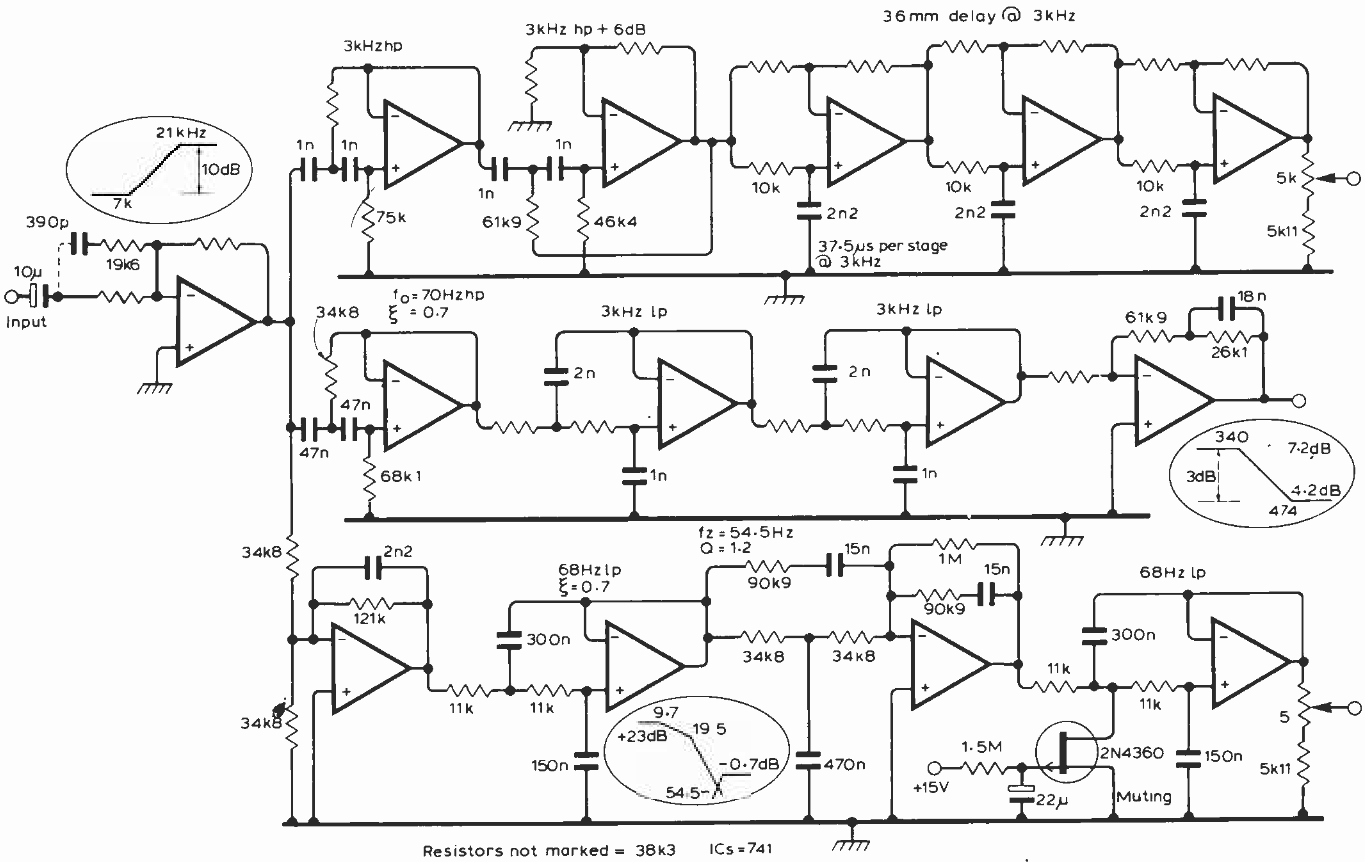


Fig. 12. *System block diagram. Design formulas for each functional block are given to allow adaptation of the circuits of Fig. 13.*

Fig. 13. *Circuit diagram of crossover networks and equalizers incoroporating delay compensation. Broken lines show optional h.f. boost components.*



baffle. The electrical signals arrive at each voice coil at the same time but because the T27 voice coil is located in front of the B110 voice coil the sound pressure wave generated by the T27 will be advanced relative to the B110. The 40mm driver off-set may seem insignificant unless it is related to the 144mm wavelength of a 3kHz tone where it corresponds to a 100° phase difference between the two driver outputs.

The effect of driver off-set on the on-axis frequency response can be quite significant, particularly if both drivers contribute almost equally over a wide frequency range, Fig. 15. The frequency region of overlap is significantly narrower for higher-order filters because of their steeper cut-off.

The driver offset can be compensated for by adding electrical delay to the tweeter drive signal, or by mounting the tweeter in a different plane. Mechanically moving the tweeter back is feasible provided care is taken to avoid sharp cabinet edges and their associated scattering of sound. For electrical delay an all-pass network has been used, Fig. 16. Its delay varies with frequency from $\tau = 2RC$ at low frequencies, approaching zero delay at very high frequencies. To reduce the frequency dependency in the crossover region of around f_c the component values should be chosen such that $RC \leqslant 1/20f_c$. Several delay stages are cascaded to obtain the required total delay. This delay has to be determined experimentally, but the spatial driver offset gives a reasonable starting point.

70Hz crossover network

The transition between the woofer and the satellite uses 24dB per octave slope filters similar to the 3kHz crossover. A transition frequency of 70Hz was chosen because the B110 output is 3dB down at this frequency due to the small internal volume of the satellite enclosures. The output continues falling off at a 12dB per octave rate below this frequency with approximately second-order Butterworth response shape. Therefore the driver in the closed box can be used as one half section of the required high-pass filter. The other half is implemented with an active second-order Butterworth filter section — the first stage in the centre channel of Fig. 13. The low-pass filter for the B139 is again the two amplifier fourth-order network design — the second and fourth stages of the lower channel in Fig. 13.

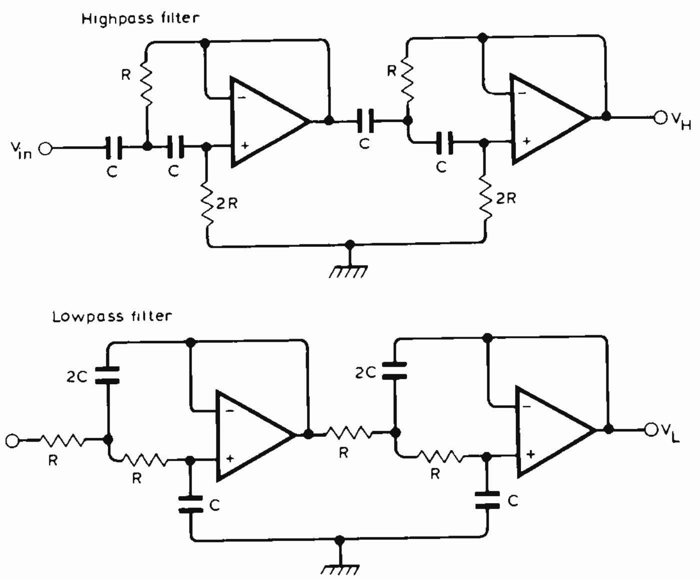
Woofer equalization

The response of the woofer does not extend sufficiently far down in frequency. The fall-off in acoustic output will therefore be compensated with a properly increasing drive signal. Over the frequency range where the driver acts like a rigid piston its frequency response when mounted in a closed box (ref. 11) is

$$F_w = \frac{\left(\frac{f}{f_0}\right)^2}{\sqrt{\left[\left(\frac{f}{f_0}\right)^2 - 1\right]^2 + \left(\frac{1}{Q_0}\frac{f}{f_0}\right)^2}}$$

This is a high-pass function with a corner frequency near the closed box resonance f_0 and some peaking depending on Q_0, Fig. 17. The two parameters f_0 and Q_0 can be conveniently determined from the frequency response of the driving point impedance[11] of the speaker system, Fig. 18. If the system is driven from a generator with an internal impedance much larger than R_{max}, then the terminal voltage becomes proportional to the system impedance and Q_0, f_0 can be determined from the voltage response as in Fig. 19.

For the two B139 woofers in their closed box, the resonance occurs at 54Hz with a Q_0 of 1.2. The response can now be compensated with a network which exactly complements the woofer roll-off and extends it to a lower cut-off frequency, Fig. 20. This design approach can be used to equalize other speaker systems if careful attention is given to



$$f_c = \frac{1}{2\pi\sqrt{2}\,RC}$$

Fig. 14. *Fourth-order 24dB per octave crossover filter sections are made up from cascaded second-order sections in both high and low-pass forms.*

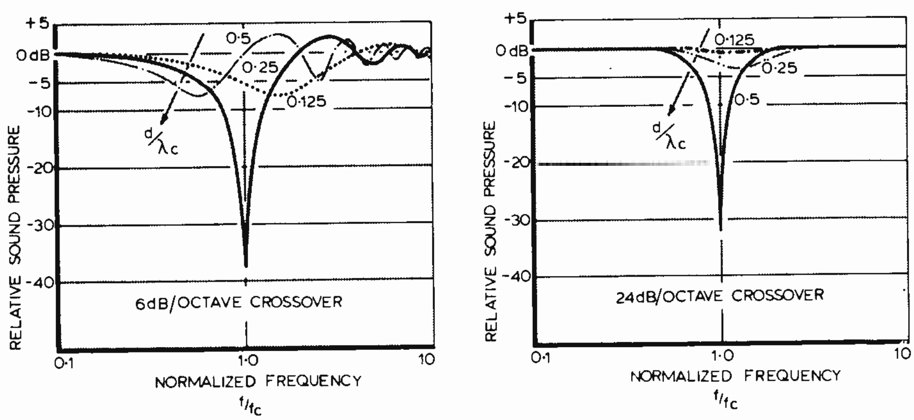
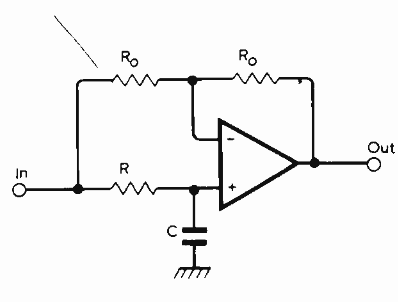


Fig. 15. *On-axis response when the tweeter is positioned acoustically in front of the midrange by d/λ_c with 6dB per octave crossover, and 24dB per octave crossover.*



$$\text{Delay } \tau = \frac{2RC}{1 + (2\pi fRC)^2}$$

Fig. 16. *Several all-pass phase shift networks are cascaded to obtain the required delay compensation.*

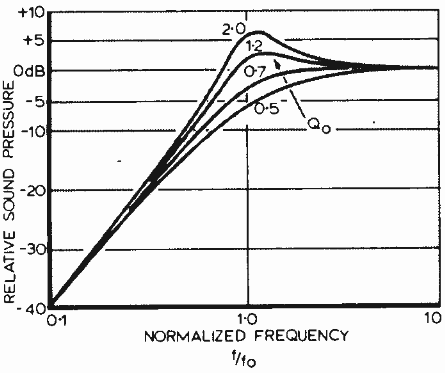


Fig. 17. *Fall-off in response of a rigid piston in a closed box (ref. 11). Box resonance f_o and Q are determined as in Figs. 18 and 19.*

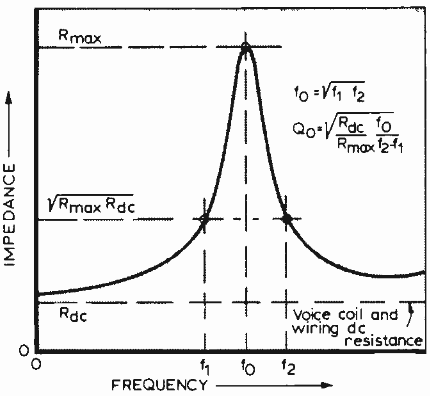


Fig. 18. *Schematic response of the woofer driving point impedance measured as in Fig. 19 from which f_o and Q_o of Fig. 17 are derived (ref. 11).*

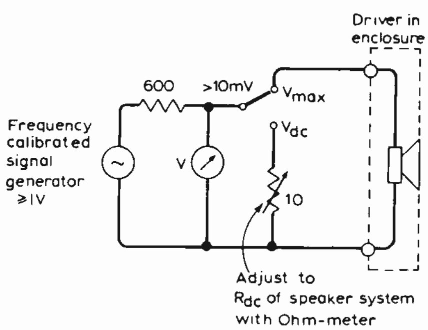


Fig. 19. *Measurement setup for Fig. 18 to determine R_{DC}/R_{MAX} from V_{DC}/V_{MAX} and the frequencies f_1 and f_2 from $V = \sqrt{V_{MAX} \times V_{DC}}$*

the cone excursion capability and the power amplifier output voltage swing limitations. Both increase by a factor of four when the cut-off frequency is lowered by an octave.

For the playback of records much of the linear excursion range of the woofer is used to reproduce the large amplitudes of record rumble. This wastes driver linearity. Fortunately the left and right-channel vertical rumble outputs from the pickup are out of phase and therefore cancel when the left and right channels are summed for a center channel woofer, as in this design. Separate left and right channel woofers can easily be tied together electrically to eliminate the unnecessary movement of air at subsonic frequencies from one speaker box to the other[12].

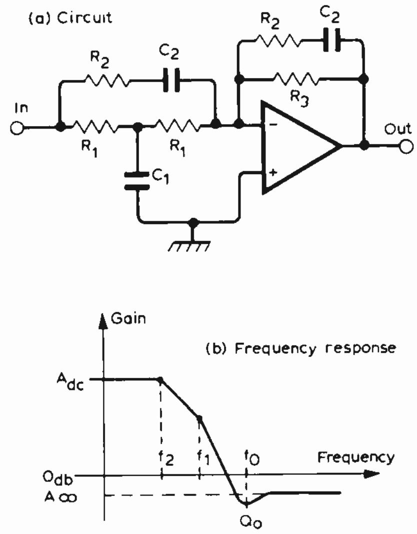
The corrected response of the woofer can be verified by placing a microphone about 1cm away from the cone to determine the near-field sound pressure which for a uniformly moving piston is proportional to the far-field sound pressure[13].

System equalization

As active networks are already used for the crossover filters it seems attractive to also use them to equalize the complete speaker system for a flat amplitude response at the preferred listening location. A microphone at that position will pick up the direct sound coming from the speakers and a large number of reflections from various objects and the walls of the room. The microphone cannot distinguish between the different sources. The microphone output voltage which corresponds to the direct sound from the speakers will be masked by the voltage due to the reverberant sound field. The ear-brain combination seems to be taking its clues for locating the details of the stereo image from the direct sound even when the reverberant sound energy is much larger than the direct sound. This might explain why attempts to equalize for a flat response at the listening location gave unsatisfactory results.

The response at one metre from the speaker measured in the room appears to be a better starting point for equalization. But even for this location a completely flat response does not seem to give the most natural-sounding reproduction. Some form of shelving or sloping response seems necessary[14].

In this design a 3dB low-frequency boost is applied to the B110 signal to obtain flat acoustic output over its range (last stage in the centre channel of Fig. 13). The T27 is allowed to follow its own gradual roll-off, but if a flat high-end response seems desirable then the simple network shown with broken



(c) Design formulas

$$f_o = \frac{1}{2\pi R_1 \sqrt{C_1 C_2}}$$

$$Q_o = \frac{1}{2\xi} = \frac{R_1}{2R_1 + R_2}\sqrt{\frac{C_1}{C_2}}$$

$$\frac{R_2}{R_1} = \frac{1}{Q_o}\sqrt{\frac{C_1}{C_2}} - 2 \qquad A_{dc} = \frac{R_3}{2R_1}$$

$$f_1 = \frac{1}{\pi R_1 C_1} \qquad A_\infty = \frac{R_3}{R_2 + R_3} < 1$$

$$f_2 = \frac{1}{2\pi (R_2 + R_3) C_2} \qquad \frac{A_{dc}}{A_\infty} = \frac{R_2 + R_3}{2R_1}$$

Fig. 20. *Network extends the woofer low frequency response to f_1 by providing exact compensation for Q_o and f_o with schematic amplitude response, and design formulas.*

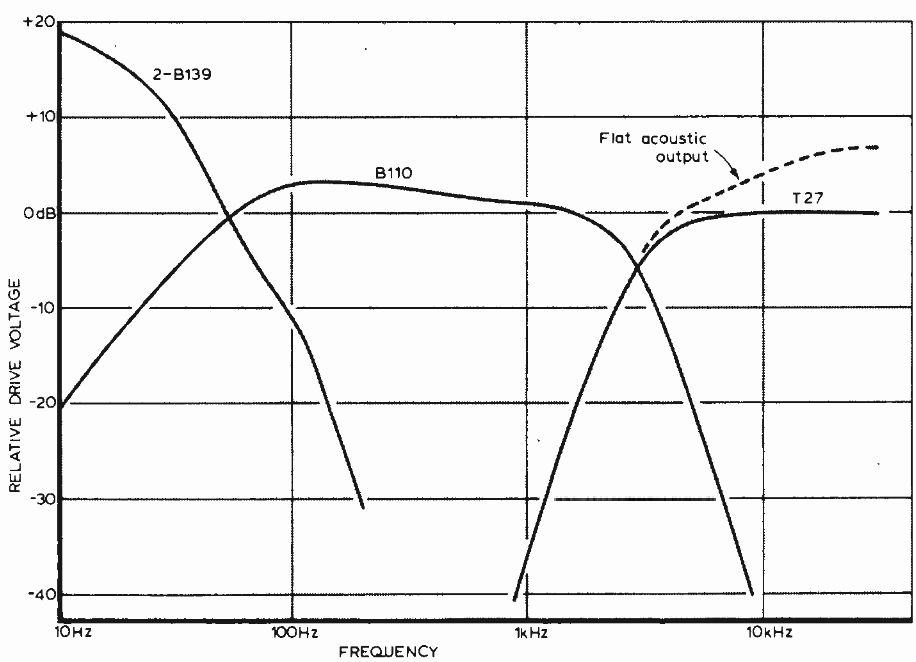


Fig. 21. *Measured voltages at the driver terminals of the complete system. A flat response does not seem to give natural-sounding reproduction.*

lines at the input stage will give the necessary high-frequency boost.

An analogy might help to describe the subjective impression of a properly designed and equalized system by comparing it to the colour photograph of a familiar scene. A fair sound system might correspond to an out-of-focus picture, possibly with the wrong reds and blue or an overall colour tint. Comparing two such systems to each other is like looking at two blurry pictures of reality, where one might prefer one over the other because of its colour balance but there is no question of either being a realistic reproduction. A high accuracy sound system corresponds to a photograph which is focused and without unnatural emphasis on any colour. When a high standard of reproduction is being approached it becomes possible to hear clearly areas of slight imperfection like in a picture which is not exactly focussed or has just a slight colour tint. For the high-frequency equalization of the speakers this means that too much output shifts the sound image out of focus. The image depth becomes blurred because the high frequency overtones seem to be less distant than the virtual sources which generated them.

The chosen speaker equalization appears to match the greatest variety of program material. A properly functioning treble control in the preamplifier is needed though to correct for differences in recordings. The final response of the drive voltages for the three speaker units, Fig. 21, could have been generated or approximated with passive networks. The practical implementation might prove to be difficult though and no attempt has been made to design a passive crossover/equalizer. The design flexibility of active networks far outweighs the possible cost saving of passive networks when only a single system is being built.

Conclusion

It is hoped that some of the design techniques and ideas expressed here will stimulate a more rational design of loudspeaker systems. Certainly the drivers will be continuously improved for reduced spurious resonances but even more so the enclosure design, materials and shapes will need further study and development[15]. Nevertheless it is possible to design a highly satisfactory system even with today's standard components.

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Siegfried Linkwitz became interested in sound reproduction as a hobby, recognizing the many dualities between the propagation of microwave and acoustic fields. "A 1GHz electrical wave and a 1kHz acoustical wave have about the same wavelength." After modifying and equalizing several commercial loudspeakers, he set about designing his own system — out of frustration with available units.

He is program manager for a high performance microwave spectrum analyzer with Hewlett-Packard, and he's been involved with the design of signal generators, a vector-voltmeter (8450A) and was project leader for a spectrum analyzer (8554L). Joined Hewlett-Packard Company in California as a development engineer for r.f. test equipment following graduation in 1961 from Darmstadt University.

System X speed-up

An Integrated Systems Development (ISDD) has been set up by the Post Office to accelerate the development of System X, the electronic exchange equipment "that will revolutionise the nation's phone system." *(Wireless World, passim).* The department is to be headed by Mr John Martin, who has worked on electronic exchange equipment for 15 years, and on System X for four.

In a statement the BPO said they intended to place contracts for the first production exchanges before the end of the year. The first exchanges would come into service by the early 80s. The new department is an offshoot of the TSSD (Technical Systems Strategy Department), set up in 1974 which, under Roy Harris, has been responsible for the overall design of the system. ISDD will liaise with Plessey, GEC and STC, who are developing System X with the PO, and other Post Office departments.

The Carter Committee on the running of the Post Office criticised the slow development of System X, which it feared would arrive too late to be competitive in world markets.

The Post Office revealed some of the ideas underlying System X at the Communications 78 exhibition and conference at Birmingham.

System X will use integrated digital transmission and switching, stored programme control and common channel signalling. The devices used would be based on low power Schottky t.t.l., c.m.o.s. and n.m.o.s. □

IERE hits out at "degree obsession"

"The national obsession with education to 'degree standard' has deprived the traditional technician engineer training pattern (ONC/HNC) of both its status and much of its best raw material; this, coupled with the inflexibility of CEI's qualification rules and procedures which has robbed the technician engineer of the facility to proceed by practical achievement to chartered engineer status, has divided the electronic engineering profession into a rigid two-class structure to the detriment of the profession and of the national interest."

This broadside was delivered in the IERE's evidence to the Finniston Committee on the future of the engineering profession. In other respects, however, the IERE seems to agree with the views of the Engineering Professor's Conference that degree courses should be longer and that there should be more co-operation with industry. The IERE recommends that there should be an extensive publicity campaign aimed at raising degree course entry standards to restore the status of ONC, HNC, HND and TEC courses and the associated work levels, to stimulate recruitment and to boost the morale of "this vital element of the engineering workforce."

This, as we said in our September, 1977 leading article, is more like it. □

Nabbed by satellite

American GEC has demonstrated a system for preventing drugs being smuggled over remote parts of the Mexican-US border which uses mobile radio and a geostationary satellite.

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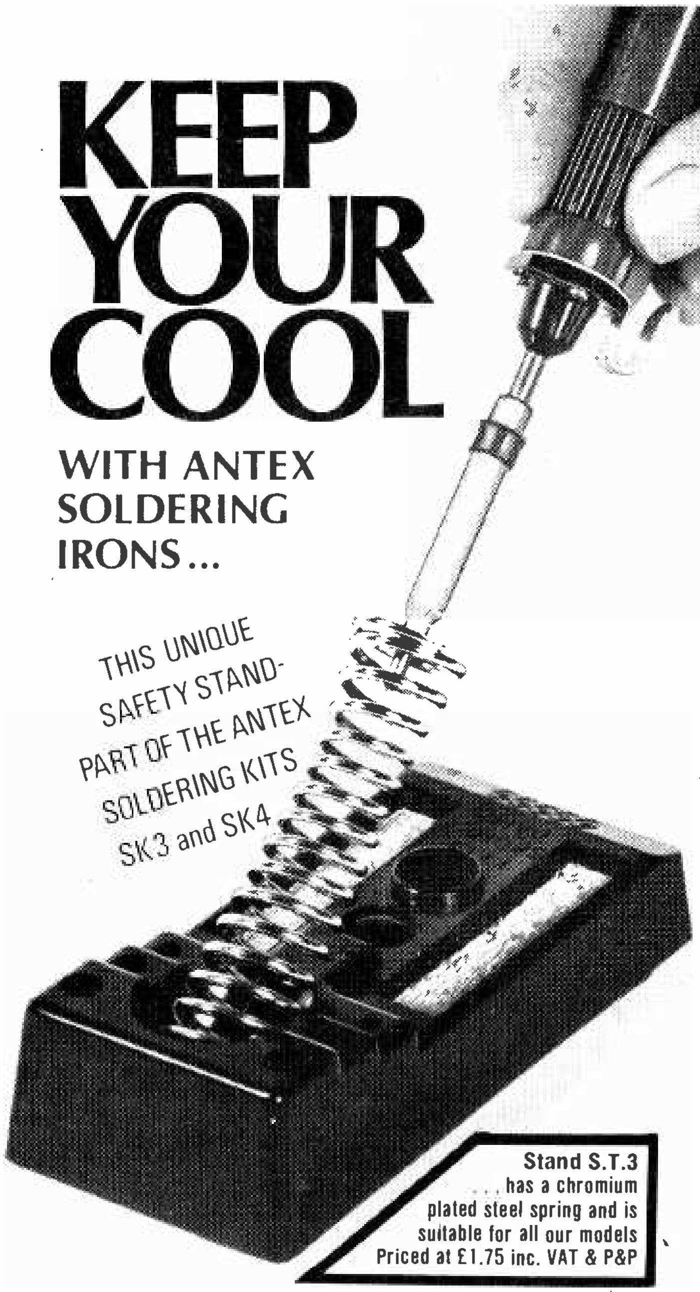

With the new Antex soldering stand you have the assurance that with the iron tucked neatly into the strong angled spring coil you have maximum safety when preparing or waiting for the iron to heat. Moulded into this stand is provision for six alternative bits, and two small sponges for cleaning bits.

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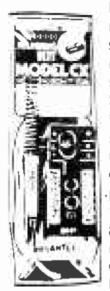
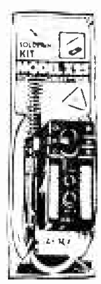


Contains both the model CX soldering iron and the stand S T . 3 Priced at £5 62 it makes an excellent present for the radio amateur, model-maker or hobbyist

Model SK4 KIT



With the model X25 general purpose iron and the S T 3 stand and its B E A B safety label, this kit is a must for every tool kit in the home **£5.62** inc VAT & P&P

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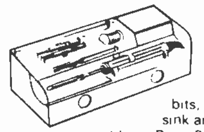
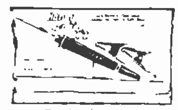


This kit contains a 15-watt minature soldering iron, complete with 2 spare bits, a coil of solder, a heat sink and a booklet, 'How to solder' Price £6 18 inc VAT & P&P

Model MLX KIT



The soldering iron in this kit can be operated from any ordinary car battery It is fitted with 15 feet flexible cable and battery clips Packed in a strong plastic envelope it can be left in a car, a boat or a caravan ready for soldering in the field Price £4 59 inc VAT & P&P

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Optimising Viewdata

Determining the maximum number of simultaneous users of the system

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

For the Viewdata information retrieval system to operate economically it has to deal with as many simultaneous users as possible. This article explains how the characteristics of the computer (April and May issues), and in particular the moving-head disc store, place a limit on this number, and how simulation studies have been made to establish the maximum rate of user requests the disc store can satisfy.

IN AN EARLIER article it was mentioned that one of the criteria used for the selection of a computer and its associated software for Viewdata was its ability to support as many simultaneous users as possible in order to reduce the cost per user per unit time. Two approaches were considered. In the first, the computer would poll and service the users in turn, any spare time remaining being used for "housekeeping" duties or to support interactive services not related to information retrieval, e.g. calculations and messages. This scheme introduced the complications of interleaving a polling algorithm, involving many unnecessary computer enquiries, with random scheduling. The alternative approach uses a wholly interrupt-based mechanism, with a fast hardware micro-programme, for all work. Also, in order to facilitate the information retrieval process, a direct correlation was established between the numbered prompt and the physical address of the data required on the random access storage medium.

In order to assess the capability of the Viewdata computer to support a number of simultaneous users, assumptions were made regarding the number of requests per minute a user was likely to make in the information retrieval mode and the size of the data page in terms of the number of characters which a computer response might involve. For the purpose of the study a cycle time of 12 seconds was selected, 2 seconds of which were accounted for by the maximum response time of the computer which was initially imposed as a desirable constraint. The size of the data page was settled at 960 characters maximum to ensure compatibility with teletext.

With these premises a study was carried out to find out which features of the computer place a limit on the number of simultaneous users. Three features were considered: c.p.u. power; amount of internal store; and disc store access. The result of the study is illustrated in Fig. 1. This shows that, as the number of simultaneous users increases, the cost per port is reduced until a limit is reached at about 200 users when the internal store limit of the GEC 4080 computer is reached and precludes further increases. This is because each user requires about 1 kbyte of buffer storage in the main memory.

If one assumes that the internal store limit is overcome in some way, it is possible to increase the number of simultaneous users and at the same time reduce the cost per port. In the GEC 4082 the maximum internal store is 1 Mbyte. The next limit to be reached is that of disc throughput, at about 700 users, given that the whole data bank is stored on a single disc. The amount of c.p.u. mill-time per user is only about 1ms, thus placing the c.p.u. limit well beyond 700 users if they are all engaged in information retrieval.

There are a number of ways which may be used to overcome the core limit and the disc limit, but one has to keep in mind a further limitation which so far has not been introduced explicitly, i.e. that of the network. Clearly a computer centre with a 1400-line telephone capability (assuming working and standby equipment are used to support users) is a major centre and it may well be questioned whether it is desirable to go much beyond this point. The internal storage limit of the computer used may be easily overcome by taking the users' buffers outside the main frame and

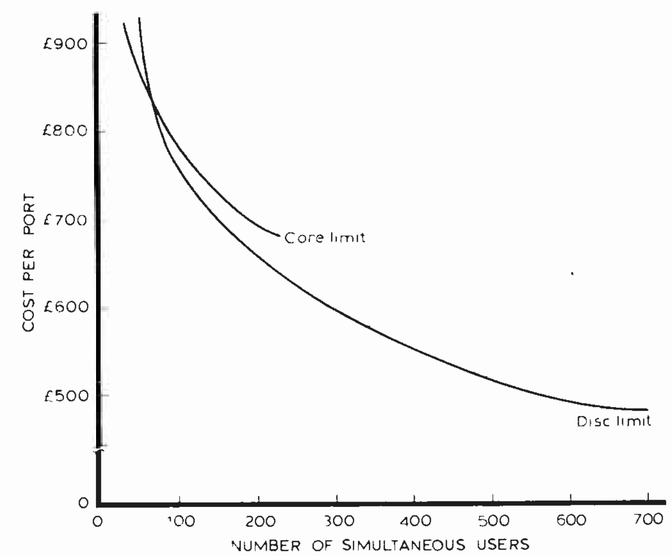

Fig. 1. Graph of cost per port plotted against number of simultaneous users.

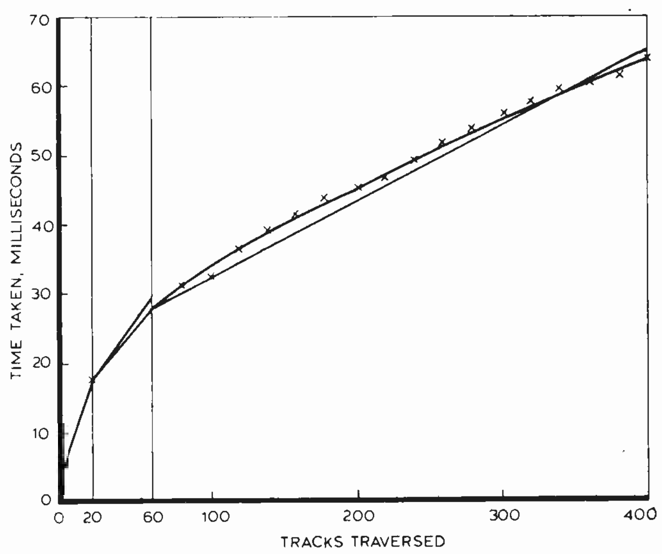

Fig. 2. Seek time of moving head disc.

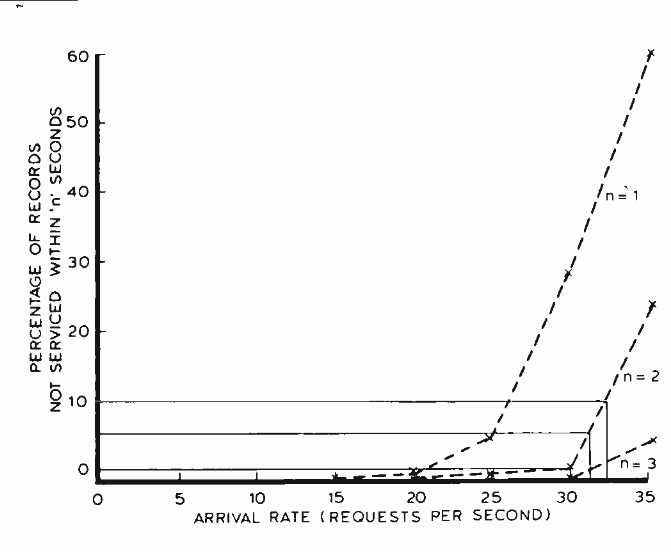

Fig. 3. The "sawtooth" method for disc optimisation.

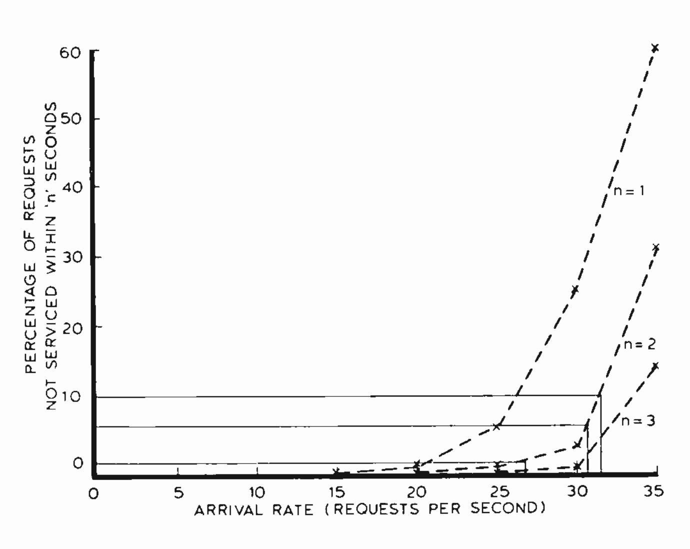

Fig. 4. The "triangular" method for disc optimisation.

using the direct memory access channel of the machine to transfer data frames at high speed from internal memory direct to line buffers. Indeed this may be more economic than increasing internal memory.

We have seen above that the major item of equipment placing a limit on the number of simultaneous users is likely to be the moving-head disc, once the limit imposed by the main frame memory is removed as indicated above. Taking average values for the parameters of the disc currently tested as: 12.5ms average latency; 6.0ms for the transfer of 1kbyte page from disc to internal memory; and 33.0ms average seek time (see April issue for definition of these terms); we find that the average access time is about 52.2ms, thus giving a rate of acceptance of requests of 19 per second.

The rate at which users are likely to make requests is clearly highly variable and statistics will have to be taken on a sampling basis, at least in the initial stages of the current trials of Viewdata, and possibly subsequently at regular intervals, to ascertain the distribution of user response times and establish long-term trends. Nevertheless it is possible to derive some figure on which to build a number of likely scenarios.

Given that the transmission rate from computer to terminal is at 120 characters per second (1200 bit/s) a full page requires about 8 seconds to be transmitted. The time taken by the user to read a full page and to respond with a further request depends obviously on the reader, but a good average time is about 30 seconds. Thus the build-up of one scenario is as follows:

Transmission time	8s
Reading and response time, say	30s
Maximum user waiting time	2s
	——
Total	40s

The time to transmit a 1-character response from terminal to computer (133ms), the time to return the first character at 1200 bit/s (9ms) and the c.p.u. processing time (1ms) have been neglected.

A count of a number of typical data pages and lead-in pages on Viewdata has shown that on the average the page content is about 500 characters. Thus the average cycle time for the average user is probably about 20 seconds. The initial system design process has tended to err on the conservative side and has assumed an average cycle time of about 12 seconds, thus allowing 10 seconds for disc retrieval for all the users connected to the computer at any one time. In fact this time could be between 10 and 18 seconds. Given these assumptions it would appear that a Viewdata computer using a single moving-head disc with the specification mentioned above would be able to service between 190 and 350 users within the stipulated maximum response time of 2 seconds.

While the use of average disc access time gives a rough approximation to the maximum rate of requests the moving-head disc can satisfy, it is necessary to do a computer simulation to establish the disc capability with a higher degree of accuracy, under different assumptions than complete randomness of disc searches. Accordingly a model of disc access time versus number of tracks traversed, obtained from the manufacturers, was approximated to by a number of straight line segments giving the relationship in an explicit form. The form of the model (which relates to the seek time) is shown in Fig. 2. It shows the seek time as a function of the number of tracks to be traversed and reflects the design of the head movement servomechanism which provides a measure of anticipation in feeding head movement acceleration according to the total track number to be traversed.

The disc latency (the delay incurred while the reading head waits until the sector required rotates to a position where it may be read) is also simulated randomly in steps of 1/6 of a disc revolution, each complete revolution taking 24ms in the model studied. The arrival of requests is assumed to take place at random times, each request specifying a track number in the range 1 to 400 and a fraame number within the track in the range 1 to 12, also selected randomly. Two disc retrieval strategies were simulated. In the first, the "sawtooth" method, it is assumed that the moving-head traverses the disc from the centre to the periphery. As each request arrives it is placed in an ordered list of increasing track numbers. The first request to be satisfied having a track number higher than the track numbers 2, 15, 25, 72 arrives while the head is moving towards track number 17, requests 25 and 72 are placed in the lists of next requests, while requests 2 and 15 are held to await the next traverse of the head. This continuous update of the request-ordered lists implies that the head satisfies requests at progressively higher track numbers as it sweeps across the disc surface. When the head reaches the last track, track number 400, it returns to track 0 and repeats the procedure, no attempt being made to satisfy requests on the return journey.

In the "triangular sweep" method, which was also simulated, the head satisfies requests both on the outward journey and on the return journey according to the same method.

The results of the disc simulation are shown in Figs. 3 and 4. The performance criterion selected to compare the two methods is defined as: N = arrival rate of requests 99% of which are satisfied within 2 seconds of arrival. It may be seen from these figures that the sawtooth method is capable of coping adequately with an arrival rate of 30 requests per second, while the triangular method can only manage about 26 requests per second. It is interesting to note that the triangular method gives better mean service times than the sawtooth method at all arrival rates up to 30 per second. Clearly the performance criterion is important in selecting the optimum search strategy.

Assuming that the sawtooth disc search algorithm is chosen, we see that the system performance is now upgraded to a capability of 30 requests per second. Thus a Viewdata system using this strategy is capable of supporting a simultaneous user population of between 300 and 540 depending on the user response time.

The current Viewdata system uses improved double density discs, capable of storing about 70Mbytes per disc drive, distributed on five surfaces, each surface containing 823 tracks. There are 34 sectors per track and 512 data bytes per sector. The average cylinder seek, latency, and transfer times are also improved to 27.5ms, 8.3ms and 2ms respectively, giving an improvement in total average access time from 52.5ms to 38ms.

A new disc simulation is now in progress to assess the maximum request arrival rate that may be satisfied by this disc, within 2 seconds. However, on the basis of the average values quoted above it is anticipated that arrival rates of approximately $30 \times 52.5/38 = 40$ per second may be satisfied. This is equivalent to supporting 400 to 720 simultaneous users.

Conclusion

This series of articles (February-May 1977, April-June 1978) has described in some detail the various aspects of the Post Office's Viewdata system, including the terminal, the computer and the associated software, the network and communications system and most importantly the way the whole system has been designed as an entity to meet the needs of a potentially huge user population.

As already reported in *Wireless World* the Viewdata market trial is due to begin in the middle of 1978, and soon that sector of the public which will be invited to participate and represent the silent majority will be able to make its views known and, it is hoped, confirm the enthusiasm of the professional and business communities for this new and potentially immeasurably powerful and beneficial medium. The full public service will start early in 1979

Acknowledgements

The author wishes to thank the Director of Research, PO Research Centre, Martlesham, for permission to publish this series of papers and the Director of Marketing, GEC Computers Ltd, for permission to publish information on the GEC4080. Thanks are also due to the members of the Viewdata research development teams who have all contributed to make this design a success. Particular thanks are due to the helpful advice of Mr S. Crammond, who has been primarily responsible for the design of the terminal, and to Mr G. Turner, who has been responsible for the design of the Viewdata software (jointly with Mr W. Izatt, until about the end of 1975).

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Sony close on Matsushita's heels in home video

Continued from p48

JVC HR3300 EK £710 recommended retail, exclusive of V.A.T.

Sony's three-hour European-standard Betamax, first previewed at last year's Berlin exhibition as a two-hour version (Toshiba, Sanyo also announced models) began life as a one-hour NTSC machine three years ago. The decreased running costs – then one third if the Sony U-matic cassettes – was achieved mainly as a result of eliminating guard bands between tracks on the helically-scanned tape and also by improving the U-wrap tape transport mechanism, particularly the tape guides. The better mechanism meant that both tape thickness and track width could be reduced. Increasing coercivity of the (chromium dioxide) tape from 500 to 600 oersteds improved the h.f. characteristics of the tape.

At high frequencies azimuth loss is relatively high and Sony engineers found that tilting the two heads +7 and -7° respectively gave enough loss between adjacent tracks to reduce crosstalk sufficiently, at the frequency of the f.m. luminance carrier anyway. (Crosstalk is at least 30dB down at 4MHz for a 15° error.) Crosstalk reduction at the lower frequency of the chrominance carrier relies on reversing the colour phase polarity on alternate lines and only on alternate tracks. On playback the video signal is added to, or subtracted from, a one-line delayed version of itself, this cancelling crosstalk from the adjacent tracks.

Then JVC, a Matsushita subsidiary, launched the two-hour VHS parallel-loading or "M" format in 1976, developed with the assistance of its parent. Sony were forced to extend their playing time for Betamax, especially in view of the televised sports events and films that last over an hour. This they did by halving tape speed and reducing video head width from 60 to 40μm (NTSC).

To keep things easily interchangeable, tracks were "overwritten" using a 40μm head, the tracks overlapping by 10μm to give a 30μm track width. In this case, when standard-format normal-speed tape is played on a long-play machine the long-play head traces the standard track with a good interchangeability allowance, and with a signal drop of 2 or 3dB. There is also a small reduction with playing a standard format tape made on a long/normal-play machine, some recording zone remaining unused. A recording made with a long-play head but at normal speed can be played back by a normal play machine, gaps remaining between tracks.

Of course the same technique can apply to VHS and indeed last year Matsushita introduced a four-hour version, perhaps more in a game of marketing one-upmanship than in response to a real need.

For the new PAL versions of Betamax and VHS, playing time, tape speed and track width are different from the earlier versions. A European-system prototype from Matsushita (and Hitachi) at the Berlin show advertised a 33.4mm/s tape speed – the same as the NTSC version – giving a playing time of two hours. But speeds and widths were changed for both formats.

Last October JVC, on behalf of Matsushita, Mitsubishi, Hitachi, Akai and Sharp announced agreement on the new VHS format with a 23.39mm/s tape speed, giving three hours playing time with their E180 cassette, and a track width of 49μm. Betamax now has a 33μm track width, a tape speed of 18.7mm/s and a maximum playing time of 3¼ hours with the new thinner L750 tape (750 feet).

VHS uses an azimuthal slant of ±6° to reduce h.f. crosstalk, while phase coding with successive 90° shifts for each line on alternate tracks is adopted for i.f. crosstalk. Then on playback a two-line delay is used to bring about crosstalk cancellation, instead of the one-line delay of Betamax. Pre-emphasis improves signal-to-noise ratio which, by itself, could run into trouble when limiting in the presence of large-amplitude low-frequency components by losing h.f. detail. To avoid this JVC band-split and limit the h.f. portion separately from the l.f. component, which is then added back prior to further limiting.

Thorn Hire VHS. Home video recorders are to be available on a rental basis from Thorn in the UK. Announcing this at the May trade radio shows are Thorn Consumer Electronics whose VHS rental will be £18 a month (a figure which could make sense with frequent use, but which might prove excessive after the novelty has worn off).

Also marketing VHS are Akai (already in the UK), General Electric, GTE-Sylvania, Hitachi, Mitsubishi, Normende, Saba, Sharp, Thomson-Brandt, as well as the Matsushita brands. Behind Beta format are Aiwa, NEC, Pioneer, Zenith, Sanyo, Toshiba, the last two reportedly dropping their V-cord machines for Betacord models.

Also at the May radio shows, Grundig are expected to announce a four-hour version of the Philips VCR system. □

Logic design — 13

Flags and flag sorters

by B. Holdsworth* and D. Zissos† *Chelsea College, University of London

†Dept. of Computing Science, University of Calgary, Canada.

When a student in a classroom environment wishes to ask a question, he raises his hand, and waits for the teacher to ask him to speak. On being told to go ahead, the student lowers his hand and proceeds to ask his question. Similarly when a device wishes to communicate with another device in the same system, it raises a flag in order to attract attention.

A SIMPLE communication system is shown in Fig. 1 where f represents a flag signal, which is, in this case, equivalent to the student raising his hand in the classroom. If and when the called device is able to communicate with the calling device, it sends back, as in the case of the teacher, a 'go-ahead' signal. The calling device then clears its flag and the two devices communicate.

A typical example of the use of flags occurs when a peripheral device such as a paper tape reader is ready to transfer data to another device, such as the c.p.u. of a digital computer. Firstly, it makes the data available for transfer and secondly, it generates a signal — the flag — to inform the c.p.u. that the data is available for transfer.

If device 2 in Fig. 1 is dealing with a situation during which it must not be interrupted, the flag of device 1 is *disabled*, that is, it is prevented from being raised. When the restriction is removed, the circuit is enabled. In the classroom analogy this corresponds to the teacher first not allowing his students to interrupt him to ask him a question and then at some later time removing this restriction.

Summarising, a flag is a signal generated and used by a device to inform some other device that it wishes to communicate with it. A disable signal prevents the flag from being raised and an enable signal allows it to be raised. A clear signal turns the flag off without disabling it.

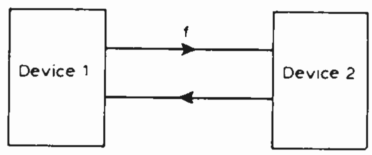


Fig. 1. Two communicating devices, with a flag signal.

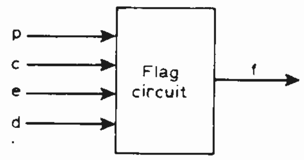


Fig. 2. Elements of a flag circuit.

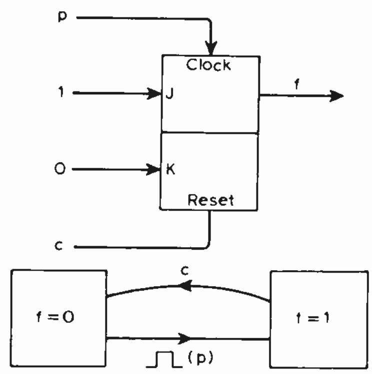


Fig. 3. Simplest flag circuit (a) and its state diagram (b).

Flag circuits

The block diagram of a flag circuit with turn-on, clear, enable, and disable facilities is shown in Fig. 2. A signal on terminal *e* enables the circuit, whereas a signal on terminal *d* disables the circuit. Clearly, the two signals must not be applied simultaneously. When the circuit is enabled, a signal on terminal *p* generates a flag, which is cleared by a signal on terminal c. When the circuit is disabled, the presence of signal *p* does not turn the flag on. If enable and disable facilities are not needed, terminals *e* and *d* are omitted.

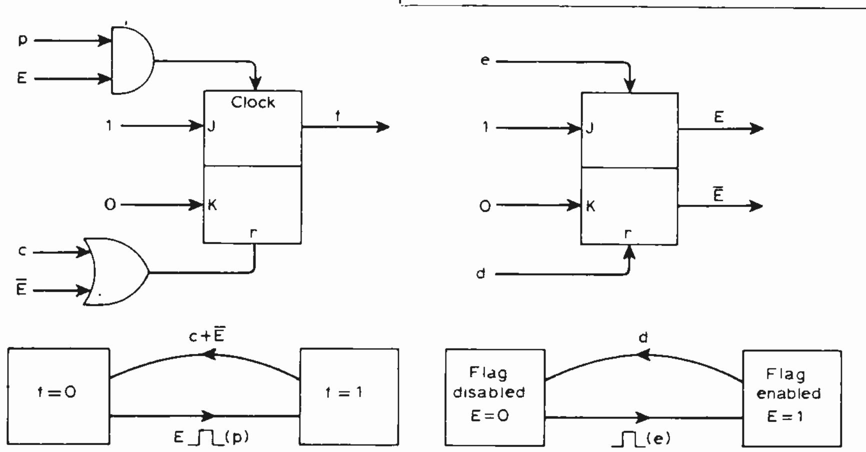
Flag circuit 1. The simplest circuit consists of a single JK flip-flop, which uses signal *p* as its clock pulse and signal c as the reset signal, as shown in Fig. 3(a). Since J = 1 and K = 0 a pulse on terminal *p* will set the flip-flop, whilst a signal c on the reset terminal resets the flip-flop unconditionally. The state diagram for this circuit is shown in Fig. 3(b).

Flag circuit 2. The flag circuit in Fig. 4 is basically the same as circuit 1, with the addition of a second flip-flop, the function of which is to enable and disable the flag flip-flop. If the second or E flip-flop is set, the circuit reduces functionally to that in Fig. 3. When E = 0 the flag flip-flop is unconditionally reset and cannot be turned on. The E flip-flop is set by the enable pulse on its clock line and reset by a disable signal *d* on its unconditional reset terminal *r*.

Flag circuit 3. Alternatively a flag circuit can be described by the two state diagrams shown in Figs. 5(a) and 5(b). From the state diagrams, the following equations are obtained.

turn-on set of E = e,
turn-off set of E = d,
hence $E = e + E\bar{d}$.
Turn-on set of A = BE,
turn-off set of A = $\bar{p}\bar{c}\bar{B}$,
hence $A = BE + A\,\overline{\bar{p}\bar{c}\bar{B}}$,
$= BE + A\,(p + c + B)$.

Fig. 4. Circuit 2, with an additional flip-flop to enable or disable the flag. State diagrams are at (b).



Turn-on set of B $= p\overline{A}$,
turn-off set of B $= \overline{A}c$,
hence B $= p\overline{A} + B\,\overline{A}\overline{c}$,
$= pA + B(\overline{A} + \overline{c})$.
$f = AB$.

Diagrams corresponding to these equations are shown in Fig. 5(c).

Identification of flags

In a computer system, each of the peripherals can communicate directly with the computer. As explained earlier, every device generates its own flag when it needs to communicate with the central equipment. These flags are ORed to generate a master flag: when the central device is a computer or a microprocessor the master flag is called an interrupt request because it is used to request the computer or the microprocessor to interrupt its current activity and service the peripheral's needs. The master flag or the interrupt request simply informs the central device that one of the peripherals in the system wishes to communicate with it. It is the function of the called device to identify which of the peripherals wishes to communicate with it.

There exists two basic methods for identifying flags – the polling method and the vectored method.

Polling method. In this method, also known as the rest and skip method, the central device, when it receives an interrupt, sequences through the peripherals looking for the individual device that needs servicing, as illustrated in Fig. 6. When it finds such a device, it stops sequencing and calls the corresponding service routine, at the end of which the polling of the devices continues until they have all been polled. At this point the main programme is resumed.

The flow chart of a polling routine for n devices is shown in Fig. 6(b). The counter in the flow chart is an internal counter in the central device. In this system no hardware assistance is provided for determining which device is requesting service. Whilst this method saves in hardware cost, considerable processor time is used in test loops and system performance is degraded.

Vectored method. In this method, the presence of a flag is automatically detected and identified by means of a circuit known as a flag sorter. The basic arrangement of the system incorporating the flag sorter is shown in Fig. 7.

Flag sorters

A flag sorter (alternatively called a priority encoder) is defined as a device that automatically detects the presence of a signal at its input and identifies it, producing an interrupt signal I, and the identity of the signal being automatically generated on address lines A and B. The interrupt signal I is the OR function of all the input signals,

$$I = f_0 + f_1 + f_2 + f_3$$

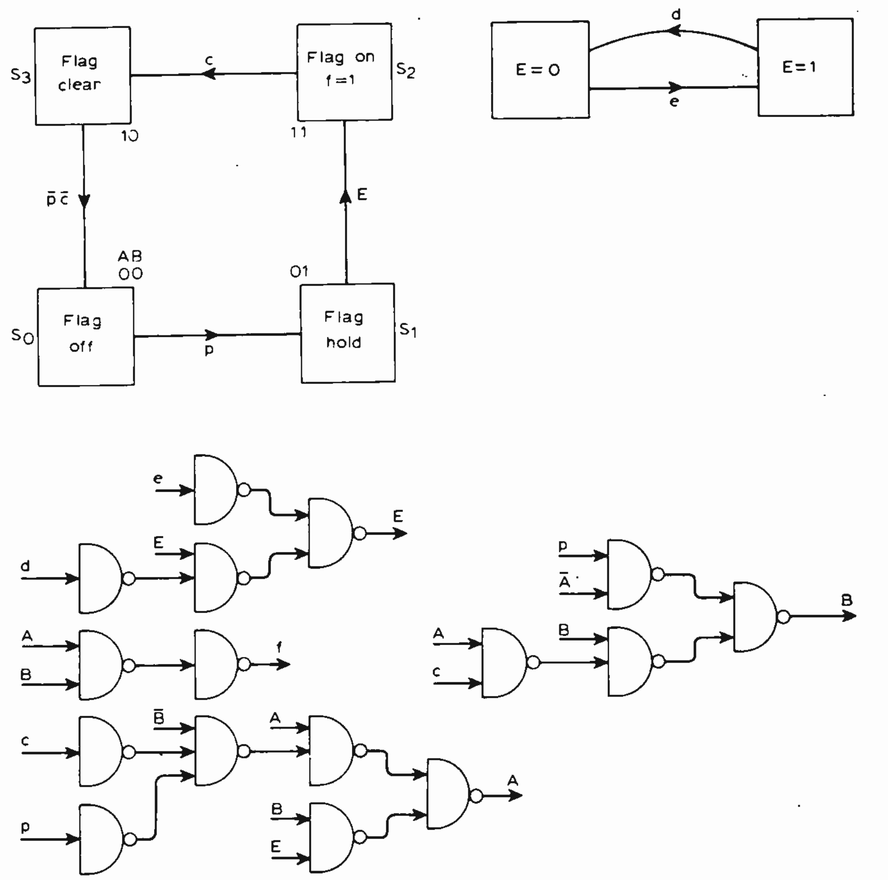
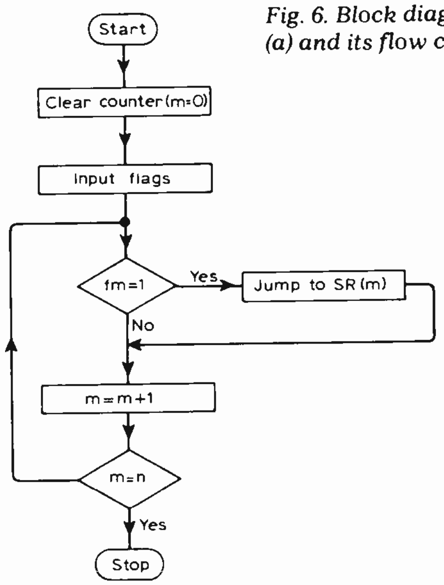


Fig. 5. State diagram for circuit 3 enable (a) and flags (b). Circuit diagram is at (c).

Fig. 6. Block diagram of p flag identifier (a) and its flow chart (b).



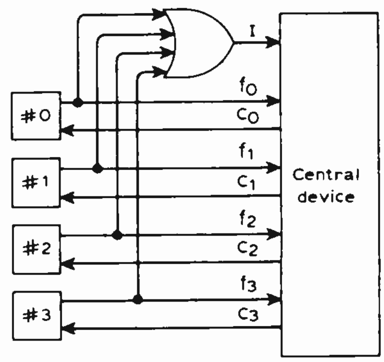
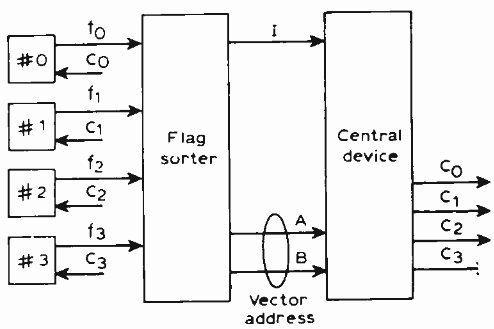
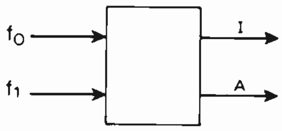


Fig. 7. Use of a flag sorter.





Inputs		Outputs	
f0	f1	I	A
0	0	0	0
X	1	1	1
1	0	1	0

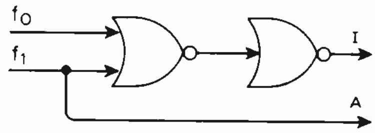
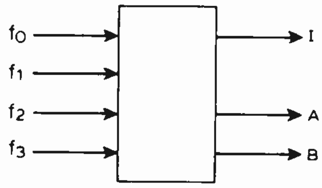


Fig. 8. Block diagram (a), truth table (b) and circuit (c) for a two-flag sorter.



Inputs				Outputs		
f0	f1	f2	f3	I	A	B
0	0	0	0	0	0	0
X	X	X	1	1	1	1
X	X	1	0	1	0	1
X	1	0	0	1	1	0
1	0	0	0	1	0	0

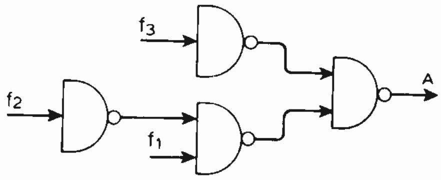
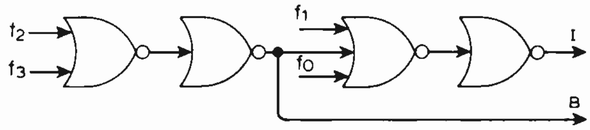


Fig. 9. Four-flag sorter.



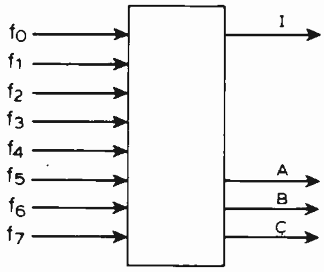
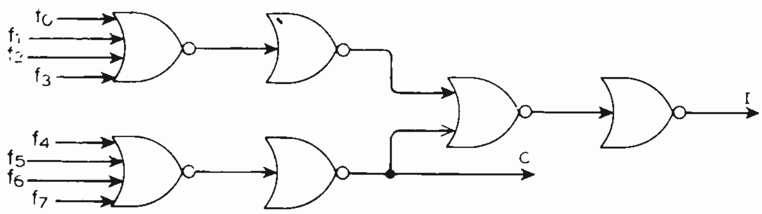
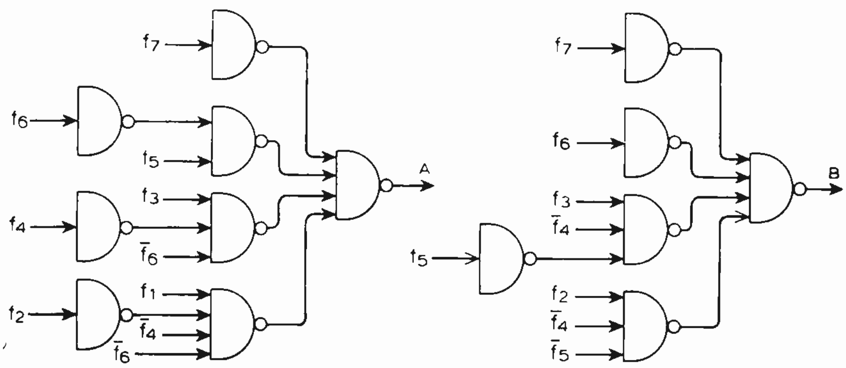


Fig. 10. Eight-flag sorter.

Inputs								Outputs			
f0	f1	f2	f3	f4	f5	f6	f7	I	A	B	C
0	0	0	0	0	0	0	0	0	0	0	0
X	X	X	X	X	X	X	1	1	1	1	1
X	X	X	X	X	X	1	0	1	0	1	1
X	X	X	X	X	1	0	0	1	1	0	1
X	X	X	X	1	0	0	0	1	0	0	1
X	X	X	1	0	0	0	0	1	1	1	0
X	X	1	0	0	0	0	0	1	0	1	0
X	1	0	0	0	0	0	0	1	1	0	0
1	0	0	0	0	0	0	0	1	0	0	0





in the case of the four-flag sorter shown in Fig. 7. For convenience, the address signals are generated in the binary (8-4-2-1) code, although any other code may equally well be used.

The design and implementation of flag sorters is straightforward, using conventional methods, either combinationally or sequentially. There are practical situations where a given flag signal must be given priority over the others. If it is present with other flag signals, its address must be given at the output, regardless of the state of the flag sorter: this is particularly the case in automatic plants, where certain alarm signals are given priority over other alarms. Unless it is otherwise specified, the higher the suffix of a flag the higher its priority.

Combinational flag sorters. The block diagram of a simple two-flag sorter is shown in Fig. 8(a). This circuit is required to generate an interrupt signal I to indicate one or more flags are present and an address signal A which can have the value 0 or 1 and is able to identify the two flag signals f_0 and f_1, where f_1 is the flag signal with the highest priority.

A truth table for the circuit is shown in Fig. 8(b). In this table the X entry is used to denote a 0 or a 1, and its use in the second row indicates that A=1 if $f_1=1$ irrespective of whether flag signal f_0 is present or not.

From the truth table the logic equations for A and I can be derived. They are:

$$I = \bar{f}_0 f_1 + f_0 f_1 + f_0 = f_1 + f_0$$
$$A = \bar{f}_0 f_1 + f_0 f_1 = f_1$$

The implementation of these equations is shown in Fig. 8(c).

The block diagram of a combinational four-flag sorter is shown in Fig. 9(a). In this case, to identify the four flags, two address signals are required. A truth table for the circuit is shown in Fig. 9(b), and the logic equations for I, A and B are derived directly from the entries in this table. The equations are:

$$I = f_0 + f_1 + f_2 + f_3$$
$$A = f_3 + \bar{f}_3\bar{f}_2 f_1 = f_3 + \bar{f}_2 f_1$$
$$B = f_3 + \bar{f}_3 f_2 = f_3 + f_2$$

As the number of flags to be sorted increases so does the complexity of the logic equations for the address signals. In the case of an eight-flag sorter three address signals A, B and C are required. The block diagram of the sorter is shown in Fig. 10(a) and the corresponding truth table is shown in Fig.10(b). The logic equations for I, A, B and C derived from the truth table are:

$$I = f_0 + f_1 + f_2 + f_3 + f_4 + f_5 + f_6 + f_7$$
$$A = f_7 + f_5\bar{f}_6\bar{f}_7 + f_3\bar{f}_4\bar{f}_5\bar{f}_6\bar{f}_7 + f_1\bar{f}_2\bar{f}_3\bar{f}_4\bar{f}_5\bar{f}_6\bar{f}_7$$
$$= f_7 + f_5\bar{f}_6 + f_3\bar{f}_4\bar{f}_6 + f_1\bar{f}_2\bar{f}_4\bar{f}_6$$
$$B = f_7 + f_6\bar{f}_7 + f_3\bar{f}_4\bar{f}_5\bar{f}_6\bar{f}_7 + f_2\bar{f}_3\bar{f}_4\bar{f}_5\bar{f}_6\bar{f}_7$$
$$= f_7 + f_6 + f_3\bar{f}_4\bar{f}_5 + f_2\bar{f}_4\bar{f}_5$$
$$C = f_7 + f_6\bar{f}_7 + f_5\bar{f}_6\bar{f}_7 + f_4\bar{f}_5\bar{f}_6\bar{f}_7$$
$$= f_7 + f_6 + f_5 + f_4$$

Sequential flag sorters. The main disadvantage of the combinational flag sorter is that the address signals may change whilst being read by the central device. For example, in the case of the eight-flag sorter, if the interrupt signal is raised by flag 3, and flag 4 subsequently arrives, the output of the flag sorter will be changing from ABC = 110 to ABC = 001. During the change signal C has to turnon whilst signals A and B have to turnoff. If C changes more rapidly than A and B the output is momentarily ABC = 111 and, assuming this occurs when the central device is reading the address of the flag sorter, address ABC = 111 will be recorded in error, resulting in circuit misoperation. It is for this reason that sequential flag sorters have been introduced.

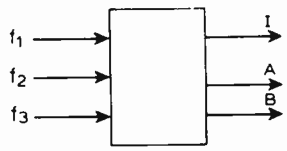
The sequential circuit, whose block diagram is shown in Fig. 11(a), has to generate an interrupt signal if any of the three flags f_1, f_2, or f_3 are raised and in this case it will be arranged that the flag signals are serviced in cyclic order. The flag signals may be regarded as if they are arranged in a circle which is scanned whenever a flag signal is raised. When there is no flag signal present, the circuit rests in a homing state.

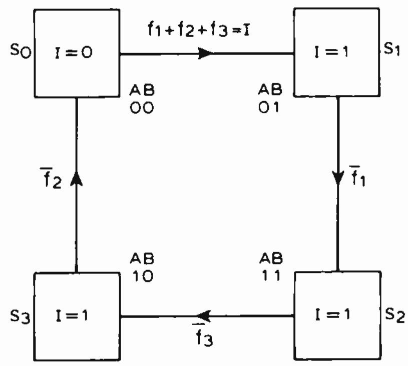
A suitable internal state diagram is shown in Fig. 11(b) where the addresses corresponding to flag signals f_1, f_2, and f_3 are AB = 01, AB = 10 and AB = 11. In order to avoid races between secondary signals, it is convenient to take these addresses in an order in which only one secondary signal changes at a time, allowing the use of the secondary signals directly as the address signals, and stipulating the cyclic order of the flags as f_1, f_3 and f_2.

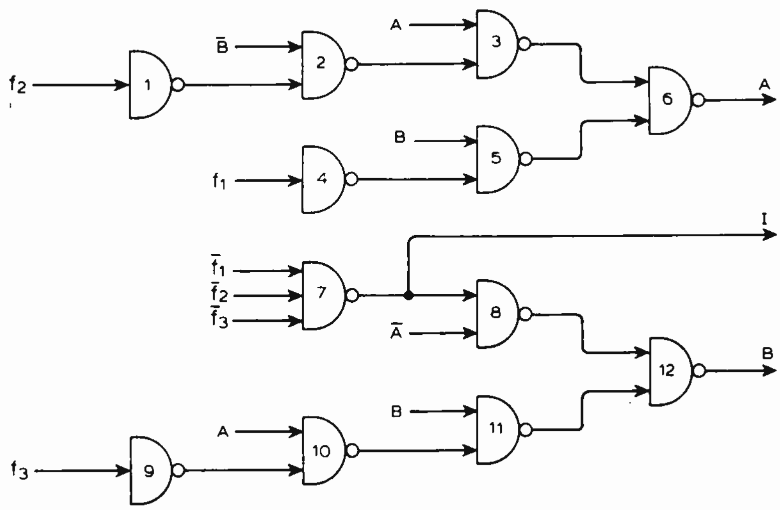
Assuming there are no flag signals present, the circuit takes up the homing state S_0 and the circuit outputs are I = 0 and AB = 00. If one or more flag signal is present at the input, $I = f_1 + f_2 + f_3 = 1$ and the circuit makes a transition from state S_0. For $f_1 = 1$ the circuit assumes the state S_1 where I = 1 and AB = 01. On the other hand, if $f_1 = 0$, the circuit assumes state S_2, I = 1 and AB = 11. Similarly if $f_3 = 0$ the circuit makes a transition to state S_3, AB = 10 and I = 1. The circuit will then return to the homing state when $f_2 = 0$.

Turn-on set of $A = B\bar{f}_1$,
Turn-off set of $A = \bar{B}\bar{f}_2$,
Turn-on set of $B = \bar{A}(f_1 + f_2 + f_3)$,
Turn-off set of $B = A\bar{f}_3$.
$A = B\bar{f}_1 + A(B + f_2)$.
$B = \bar{A}(f_1 + f_2 + f_3) + B(\bar{A} + f_3)$.
$= \bar{A}I + B(\bar{A} + f_3)$.
$I = f_1 + f_2 + f_3$.

The implementation of these equations is shown in Fig. 11(c).







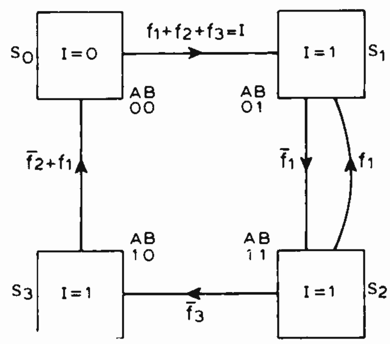
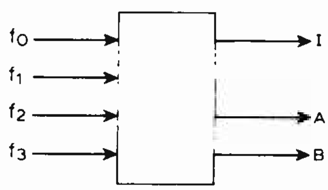
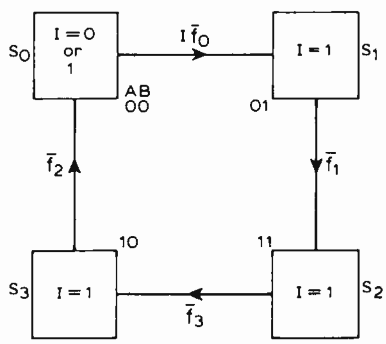


Fig. 11. Symbol (a) and state diagram (b) for a three-flag sequential sorter. Circuit is shown at (c). State diagram at (d) is for sorter having priority for flag 1.

Fig. 12. Four-flag sequential sorter.





If it is stipulated that the flag f_1 must always be given priority, then to satisfy this requirement, the internal state diagram must be modified as shown in Fig. 11 (d). An examination of this state diagram indicates that the modifications only change the turn-off conditions of the secondary signal A which now becomes:

$$A = B\bar{f}_1 + A(\overline{\bar{B}(\bar{f}_2 + f_1) + Bf_1})$$
$$= B\bar{f}_1 + A(B + f_2)\bar{f}_1.$$

The implementation of this equation only requires an additional signal $\bar{f}_1$ at the input of gate 3 in Fig. 11(c).

A suitable arrangement for the detection of four flags is shown in Fig. 12(a) and the corresponding internal state diagram in Fig. 12(b). The presence of any incoming flag signal causes signal I to be generated. If flag f_0 is raised, the circuit remains in state S_0 and the flag sorter outputs are $I = 1$, $A = 0$ and $B = 0$.

State S_0 is a homing state, because the flag sorter automatically assumes this state when the incoming signals f_0, f_1, f_2 and f_3 are cleared. The order in which the signal addresses are generated depends on the current state of the sorter. For example, when address AB = 00 is at the output, with $I = 1$, the incoming signals have the following priorities: priority No 1–f_1, priority No 2–f_3, priority No 3–f_2.

The flag sorter logic equations which can be developed from the internal state diagram are;

$$I = f_0 + f_1 + f_2 + f_3$$
$$A = B\bar{f}_1 + A(B + f_2)$$
$$B = \bar{A}\bar{f}_0 I + B(\bar{A} + f_3),$$

and the implementation of these equations is left to the reader.

Clearly, the state diagram and implementation of an eight-flag sorter can be developed in a similar manner, the state diagram being shown in Fig. 13.

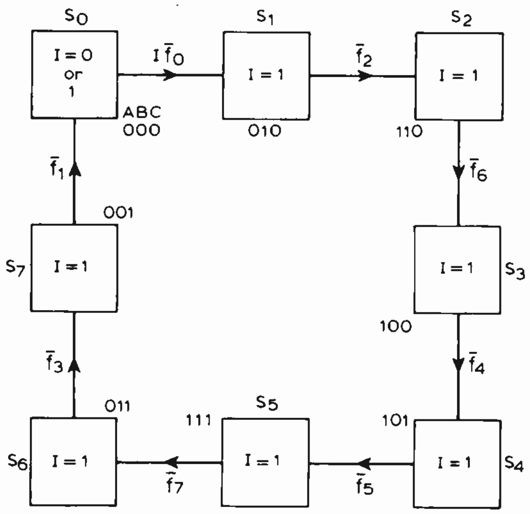


Fig. 13. State diagram for eight-flat sequential sorter.

Modular expansion

In the case of flag sorters for more than eight flags, it is more convenient to use a modular construction, which allows any number of flag signals to be identified. The design principle will be demonstrated for the case of 64 flags.

The incoming flags are arranged into eight groups of eight flags each, as shown in Fig. 14, the flags in each group being connected to an eight-flag sorter. Each flag sorter generates a signal g independently of the other sorters. Thus $g_0 = 1$ if any of the flags in group 0 are present, similarly for group flags $g_1, g_2, g_3, g_4, g_5, g_6$ and g_7. Individual flags are indentified by six binary suffices, the first three indicating the flag number and the second three the group number, for example, f_{010111}, refers to flag 2 in group 7. The second set of three digits is generated directly by the group selector, while the first three digits are generated by the flag sorter, whose

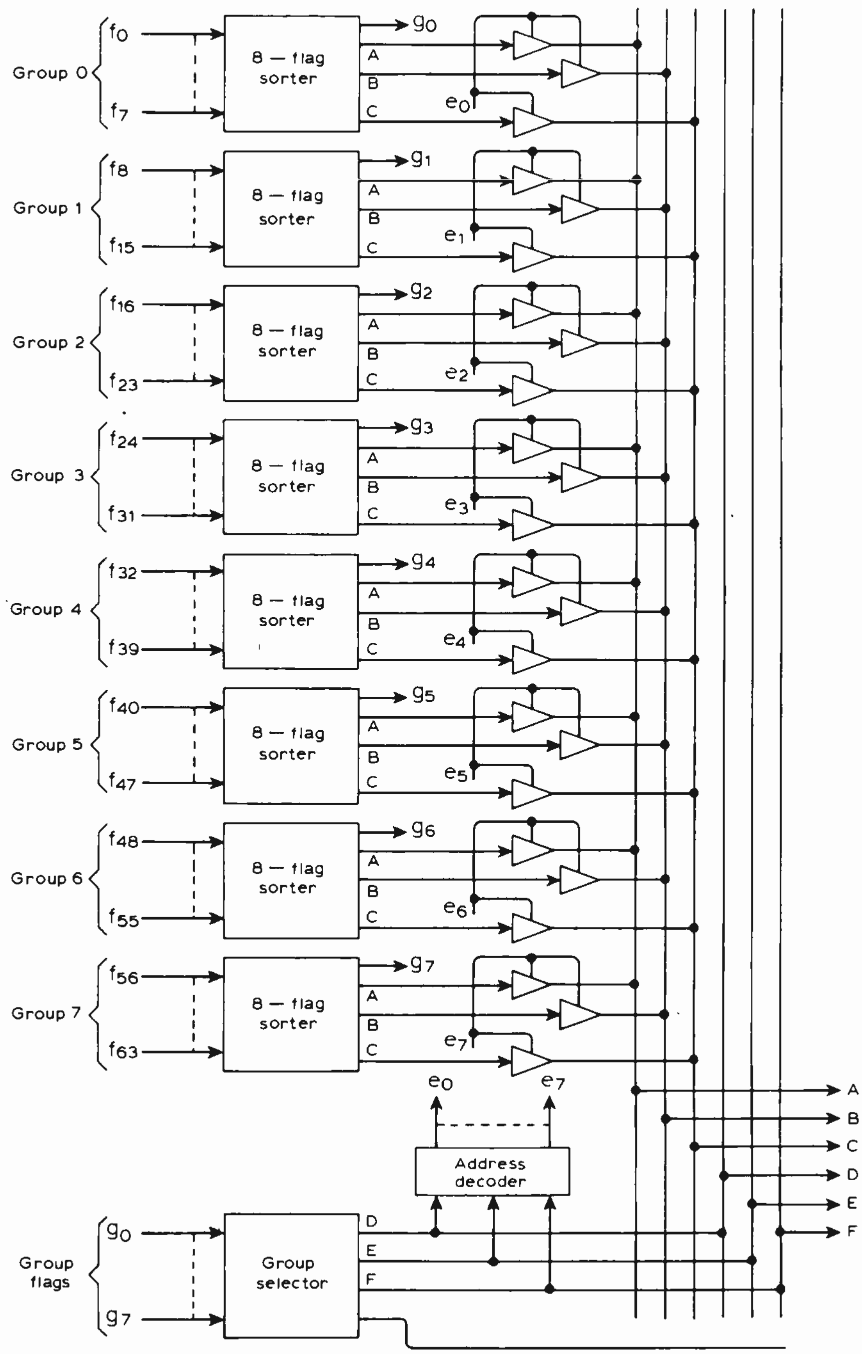


Fig. 14. 64-flag modular sorter.

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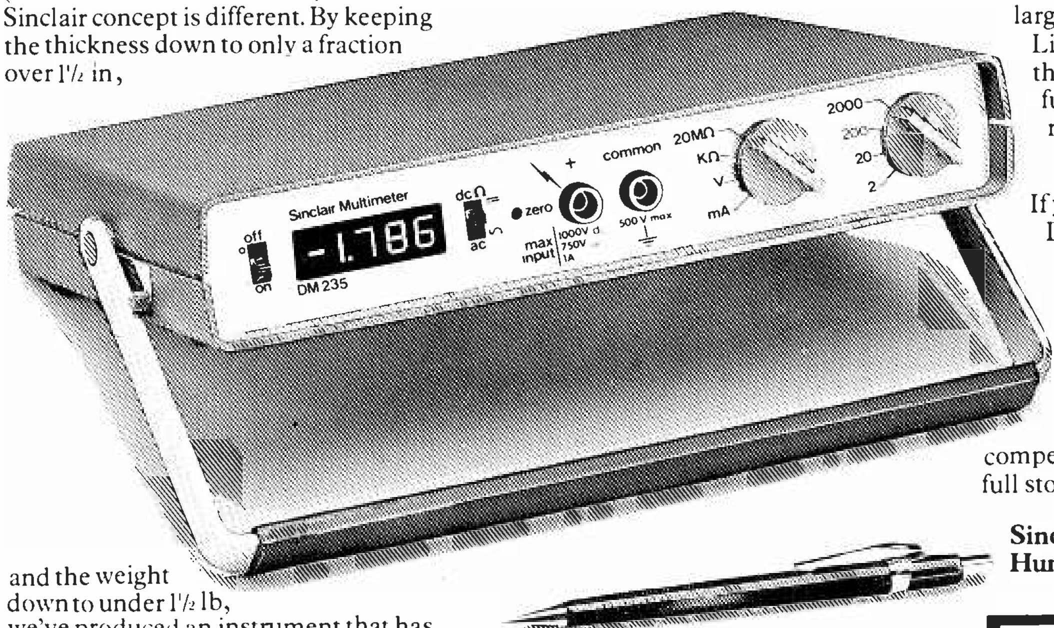

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AC Current	1 μA to 1 A
Resistance	1 Ω to 20 MΩ
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Generating ultra-short microwave pulses

Cancellation technique using readily-obtainable components

by **Alan G. Hood** M.Sc., M.I.E.E.

During an investigation into the behaviour of microwave radar receivers in the presence of high energy leakage spikes from the transmitter via the duplexer, a generator of very short pulses of microwave energy was needed. Standard magnetrons and modulators are not capable of producing directly the six to seven nanosecond pulses available by the method described.

THE PROBLEM OF GENERATING consistent-energy pulses at microwave frequencies a few nanoseconds long was approached by employing a pulse cancellation technique. The frequency employed was in X-band (8.2 to 12.4GHz), but the technique is also applicable to other microwave bands. A 160ns-long r.f. pulse was split in a "magic T", and the two halves recombined in antiphase after travelling different path lengths. Fig. 1 shows how this was achieved by using two short-circuited arms of different lengths on a magic T. The result was that the centre portion of the magnetron pulse cancelled leaving short pulses corresponding to the leading and trailing edges of the original pulse. The trailing edge pulse was removed by means of a pulsed p-i-n diode switch. A CV370 magnetron supplied 5kW peak pulses at 1,000 pulse/sec.

The electric field of the magnetron pulse may be represented by

$$E(t) = 2A(t)\sin(\omega t + \theta)$$

where $2A$ is the amplitude of the magnetron pulse, and is a function of time, ω is the angular frequency, and θ is an arbitrary phase angle. After travelling different path lengths, the two cancelling pulses are displaced in time by Δt, and the cancelled pulse is then

$$\tfrac{1}{2}[E(t+\Delta t) - E(t)]$$

where the factor ½ allows for the 6dB loss of power in the magic T. Substitution gives

$$(A+a)\sin(\omega t + \theta + \alpha) - A\sin(\omega t + \theta)$$

where a is the instantaneous amplitude difference between the two pulses and α their phase difference, nominally $2n\pi$ but which varies over the pulse length due to phase and frequency modulation. By appropriate manipulation this can be shown to be of the form $B\sin(\omega t + \beta)$, with

$$B = \sqrt{4A(A+a)\sin^2(\alpha/2) + a^2}$$

$$\text{and } \beta = \theta + \tan^{-1}\left[\frac{(A+a)\sin\alpha}{A(\cos\alpha - 1) + a\cos\alpha}\right]$$

All the terms A, a, α, θ and therefore B and β are functions of time. The situation is illustrated in the diagrams of Fig. 2. The trailing edge pulse is longer and of lower amplitude than the leading edge pulse because the magnetron fall time is much slower than its rise time.

The amplitude of the short pulse is given by the expression for B and in the

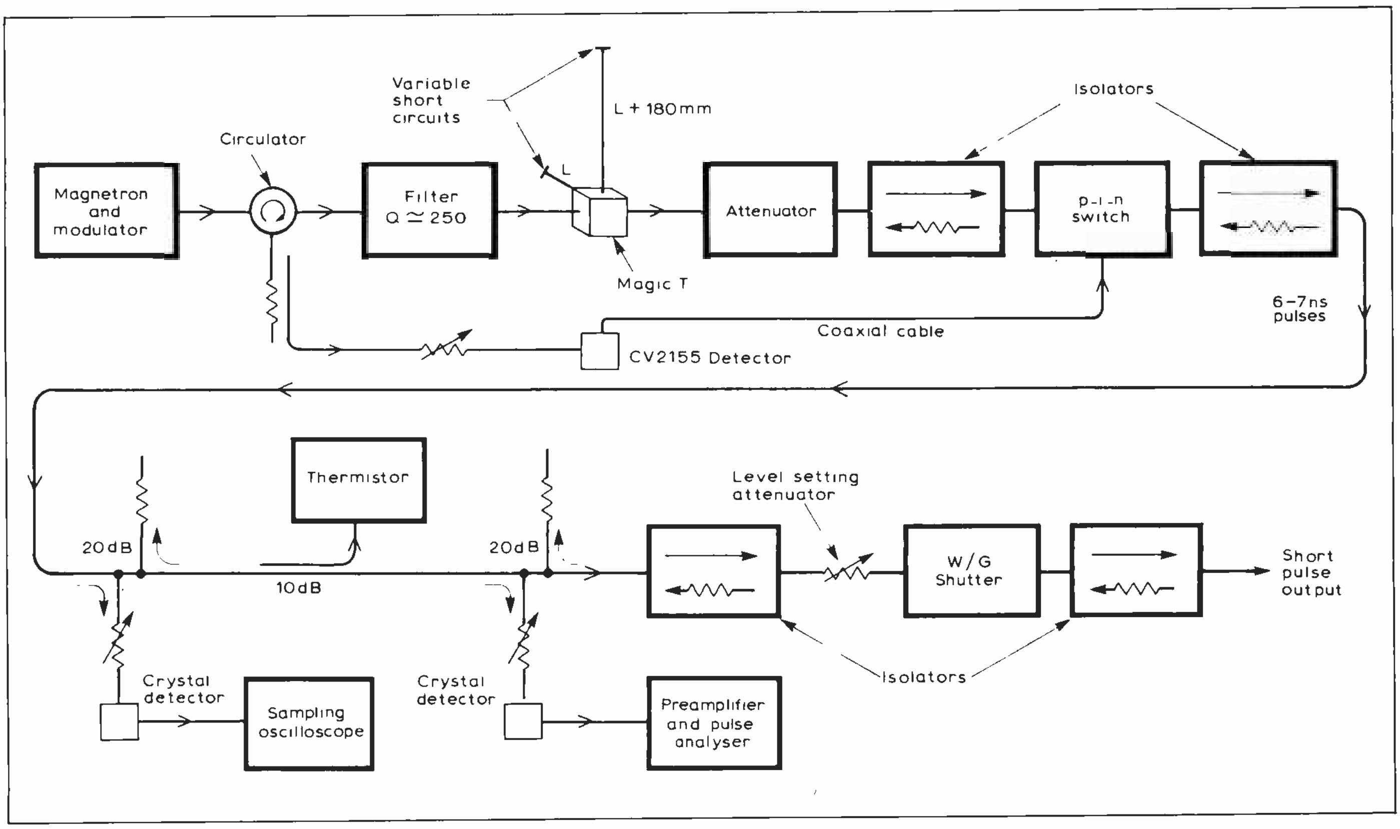


Fig. 1. *Waveguide layout for generating ultra-short pulses by cancelling differentially delayed pulses.*

ideal case of no phase or frequency modulation, $\alpha = 2n\pi$ and then $B = a$; otherwise $B > a$. In the region where $a = 0$, cancellation may be incomplete due to phase differences and the output will then be $B = 2A\sin(\alpha/2)$.

For high amplitude and minimum pulse length a fast rate of rise and minimum phase modulation of the magnetron pulse are required. The short pulse is centred on the region of maximum rate of change of the magnetron pulse's electric field. This is likely to be near the 50% field (25% power) level and there will not be a simple relation between the magnetron rise time from 10 to 90% power levels and the length of the short pulse.

In practice the apparently simple cancellation technique was complicated by significant direct leakage between the decoupled arms of the magic T, the phases of both reflected pulses had to be adjusted so that all three signals cancelled. The poor match of the magic T for the reflected pulses in the short circuited arms made the first re-reflected pulses significant, and modified the pulse shape.

It should be possible by the use of suitably placed mismatches to change the magnetron output coupling during the build-up of oscillation and hence modify the leading edge of the pulse. This was tried but results were inconclusive and the matter was not pursued.

Among the problems encountered were the elimination of the second or trailing edge pulse, and the reduction of the spread of pulse energies. A varactor diode switch was initially tried for the attenuation of the trailing edge pulse and behaved well at low levels. However it proved to have inadequate attentuation at the power levels required and was replaced by a p-i-n diode switch which has proved satisfactory. The switching pulse for this was obtained from the magnetron output via a CV2155 negative polarity crystal detector and a suitable delay.

A filter was added to guard against the possibility of "moding". If the magnetron generated power at different frequencies, proper cancellation would not be achieved. By selecting manetrons and modulators the energy spread was reduced so that one pulse in 10^6 exceeded the mean level by 1.25dB. A further improvement to 0.5dB was obtained by using a servo-controlled stabilizer for the supply voltage. Previously a slight drop in supply voltage (240 to 230V) changed the shape of the generated pulse and introduced noticeable jitter in addition to varying the magnetron output level.

A sampling oscilloscope is necessary to view pulses of such short duration. A tracing of an oscilloscope photograph showing the leading and trailing-edge pulses resulting from cancellation is shown in Fig. 3 (top) and the effect of the p-i-n switch is shown middle. The bottom trace is the short pulse on a reduced time scale.

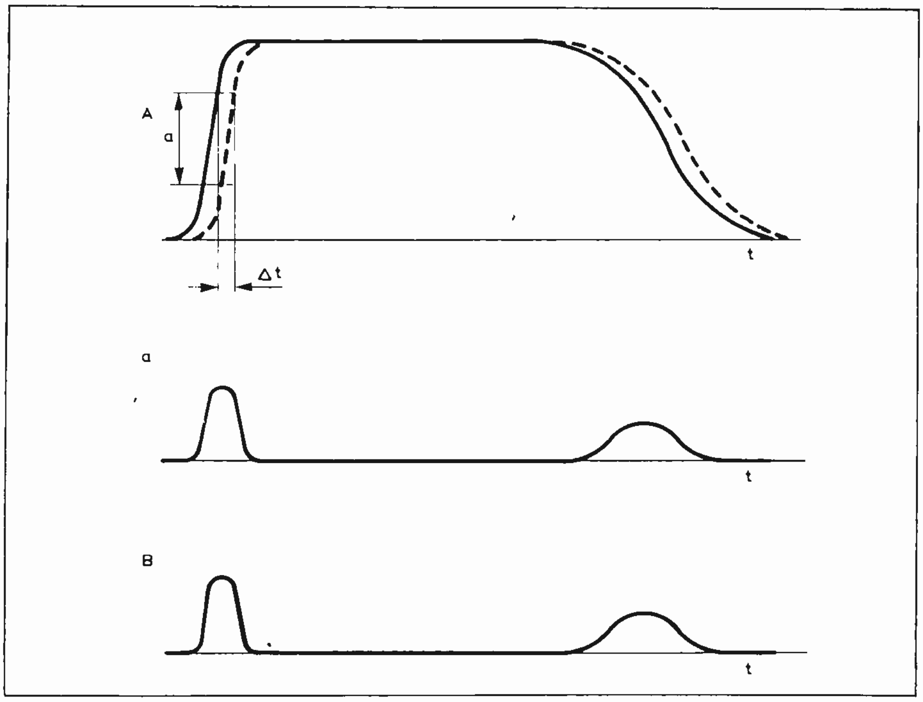


Fig. 2. *Diagrams show two r.f. pulses with a time difference Δt and the resulting leading and trailing-edge short pulses due to cancellation. (Diagrams show rectified envelopes of r.f. pulses.)*

Fig. 3. *Sampling oscilloscope displays showing leading and trailing-edge pulses resulting from cancellation (top, time scale 20ns/div), removal of trailing-edge pulse by p-i-n switch (middle trace, time scale 20ns/div), and the short pulse on expanded time scale (4ns/div). Diagrams show rectified envelopes of r.f. pulses.*

The short-pulse energy was measured as follows. The sampling oscilloscope was calibrated in amplitude using rectangular pulses of known duration together with an average power measurement using a thermistor bridge. The short pulse amplitude was then measured by means of this amplitude calibration. An accurate rotary-vane waveguide attenuator brought the short pulse amplitude on the oscilloscope to the reference level, thus eliminating any errors due to detector non-linearity. Amplitude was then calculated knowing the reference level power, and the number of dB difference in waveguide attenuation. The short pulse energy was then the product of short-pulse power and pulse width at half power (−3dB level).

The pulse generator had a useful output of 6 to 7 ns pulses with an energy of 1,000nJ and, on average, one pulse in 10^6 had an energy of 0.5dB above the mean. □

This article reflects a small part of the work that led to a degree thesis at Dundee University. Alan Hood studied for his M.Sc. part time whilst working with Ferranti Ltd on microwave radar system components. He became a part-time lecturer at Dundee College of Technology in electrical engineering and is now a lecturer at Kingsway Technical College, Dundee and a tutor/counsellor with the Open University.

How good are l.e.ds?

Ageing characteristics of infra-red emitters

by **J. Skinner** Leafields Engineering Ltd

The GaAs infra-red emitter has been in use for over ten years, and is now widely used throughout industry. Because the author wanted high performance from a relatively simple system it was decided to examine several devices to find out how their degradation characteristics behaved.

The size of paired modules such as opto-couplers made them impractical to test so discrete emitters with light outputs from 1 to 10mV were used. Tests were also carried out on suitable sensors but the results from these showed no significant variation with age.

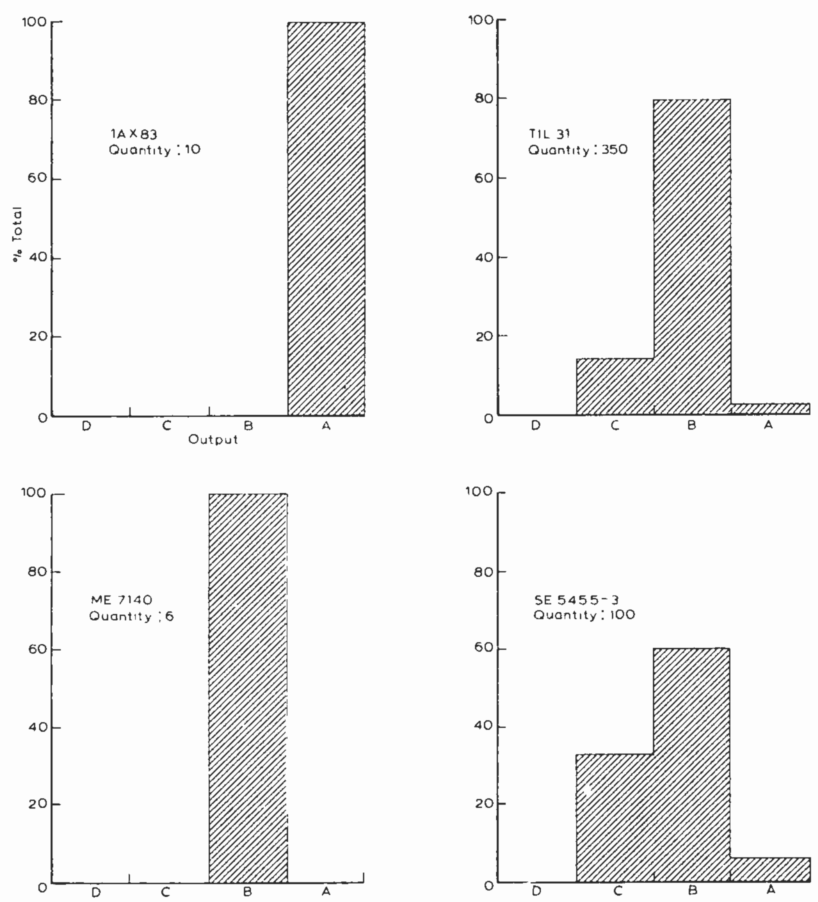
The amount of forward current is important in practical applications and in tests. A report from NASA[1], which describes an exhaustive examination of the TIL31 device, confirms that degradation is reduced by conservative operation, and shows that no degradation occurs at 25% rating. A paper produced by Hafo[2] contains this interpreted statement:

"A substantially more rapid result of the operational test could be obtained if the l.e.ds were measured at a current lower than the operating current. The deterioration could occur somewhat faster with a low operating and measuring current than with a high one. This result had hardly been expected."

A second statement concludes, "the rate of deterioration may be greater at low rather than high currents." Hafo is one of the few manufacturers who have openly admitted that ageing of l.e.ds is a problem although they now claim to have eliminated the problem completely but have not explained how this has been achieved.

The rated current for a device under consideration is usually specified as 100mA. Because our application required a forward current of around 20mA, burn-in tests were run at 50mA and the tests run at 20mA per device, thus accelerating the running life. The NASA report suggests that light output increases for a period and then falls off continuously. It is therefore necessary to operate for a period which will contain any peak that may occur. Devices were tested for periods up to 1000hrs with a minimum burn-in period of 200hrs. The results obtained are summarized in the tables.

As the tests have been carried out over a 1000hr period it is important to know whether the degradation process continues. In the light of our field experience it does, apparently at a logarithmic rate, similar to that in the short period. Therefore, a device having low degradation during a short period will continue to degrade at a low rate for a long time. These remarks can only be taken as generalisations; nevertheless, short term burn-in can raise q.a. confidence enormously. Measurements of output, before and after burn-in, are however tedious and expensive. We have found that an acceptable compromise is to measure the output after a 200hr burn-in period. A minimum threshold is determined for each application and devices are graded accordingly. Both output and degradation characteristics thus require consideration in selecting suitable devices.



Output	
A	> 50μA
B	25-50μA
C	5-25 uA
D	0-5 uA

Fig. 1. L.e.d. outputs prior to burn-in. The outputs were measured with an Optron light standard type OP666 mounted in a blackened tube at a fixed distance from the emitter. Forward current in all cases was 20mA.

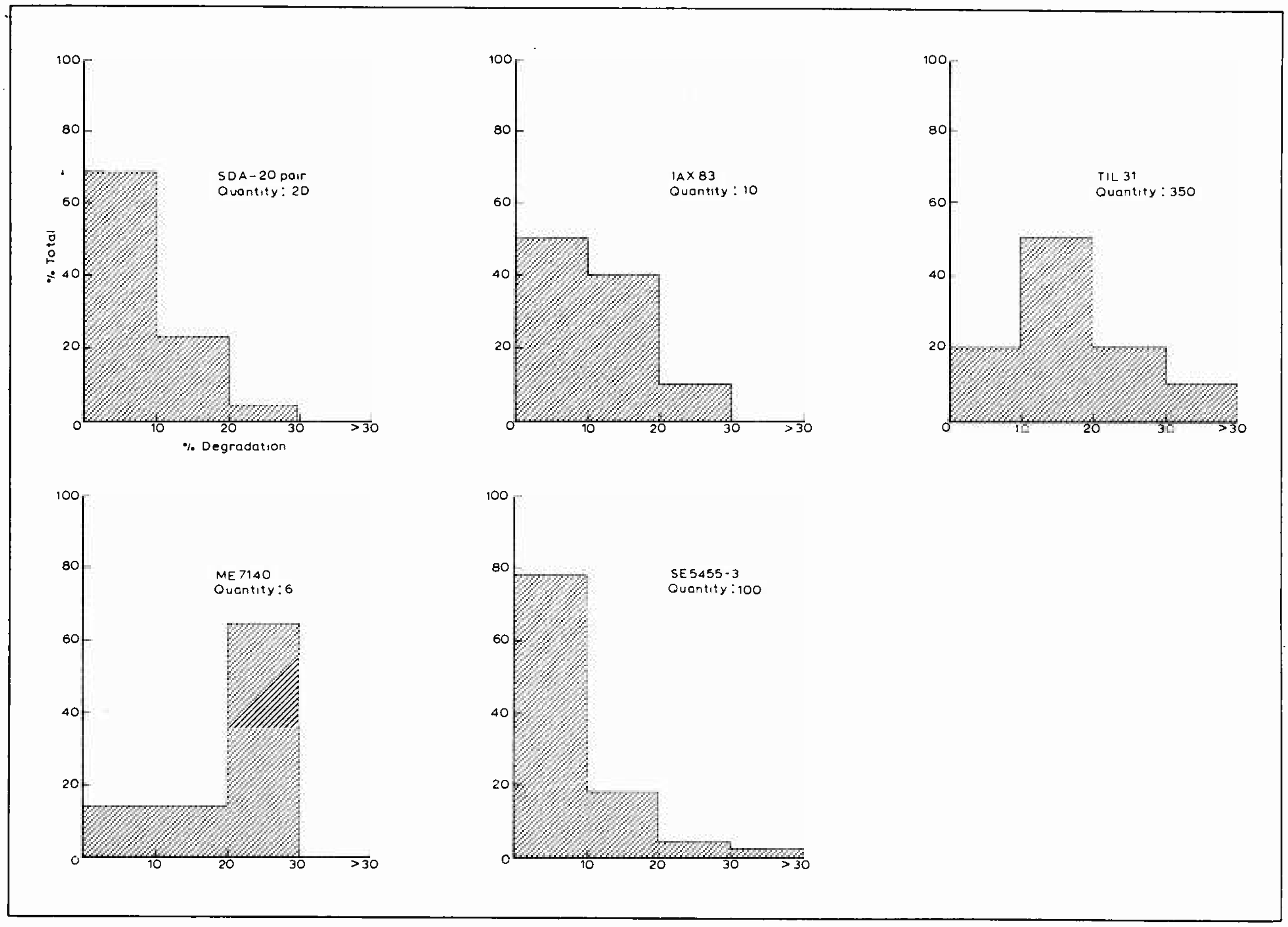


Fig. 2. Degradation of l.e.ds with ageing. The devices were operated for 1000hrs at a forward current of 20mA except for the SDA-20 which was operated at 50mA for comparison.

References

1. Thomas, E. F. Changes in the performance characteristics of GaAs near infra-red l.e.ds when exposed to various current and thermal stresses, Goddard Space Flight Center, ref. 08-005, June 1974.
2. Nettelbladt, H. Hur lange lever Lysdioden? eltenik med aktuell electronik 3/74. (See also *Electronics Weekly*, March 10, 1976, p.13.)

Further notes from the Paris Show

There was a great deal of emphasis at the Paris Components Show on opto-electronics, particularly for the secure transmission of data. Well over 100 of the 1,100 exhibitors were showing fibre-optic or opto-electronic devices of some kind. When the notorious urban Parisian telephone system begins to reach saturation, between 1981 and 1985, optical fibre will be used to increase capacity, and the authorities expect that they will be using 10,000km a year by the end of the decade for that purpose.

Displays seem to be getting bigger and more detailed. Thomson CSF are now offering plasma panels for alpha-numeric and graphic displays. The larger of the two ranges has 256 by 256 dot and 512 by 512 dot matrices with 0.64mm pitch. All elements are addressable individually. The electronics and character stores are built into the devices, though they could hardly be described as flat. The French Commissariat a l'Energie Atomique appear to have developed a liquid crystal matrix display which can show pictures with 16,384 elements and an eight level grey scale which can be changed from five to ten times a second. Each line is scanned sequentially with an alternating voltage of 50V. The video signal is 6V applied to the columns in parallel, the relative phase of the column voltage to that of the line signal determining the grey level.

The Zyklomat universal tachometer caused quite a bit of interest. It is a light gun with a meter on the back. You fire it at a piece of rotating machinery whose speed is read immediately on the meter.

Logic design 13 *continued from page 82*

group number is that specified by the output of the group selector.

The operation of this flag sorter will be explained by direct reference to Fig. 14. Since more than one group signal may be present at any one time, an eight-flag sorter is used to lock out all but one of the group signals. This flag sorter is called the group selector. It will be assumed that two flags in group 1 (say f_3 and f_5) and one flag (say f_6) in group 4 are raised, that is $g_1 = 1$ and $g_4 = 1$. By direct reference to Fig. 13 it can be seen that the group selector leaves the homing state S_0 and assumes state S_3. When in state S_3 the group selector's output is 100. This output is decoded, causing signal e_4 to assume 1, thus enabling the group 4 flag sorter. The output of flag sorter 4(110) is connected to lines A, B and C of the data bus, whilst the output of the group selector 100 are connected to lines D, E and F of the data bus. The signals on these six lines ABCDEF = 110100 will identify the flag to be served, namely flag 6 in group 4. At the same time the group selector will also generate the interrupt signal I.

References

1. "Problems and solutions in Logic Design" D. Zissos, Oxford University Press 1976.
2. "Digital Interface Design" D. Zissos and F. G. Duncan, Oxford University Press 1973. □

NEW PRODUCTS

Dual-trace oscilloscope

One of the products introduced at the Instruments, Electronics and Automation Exhibition earlier this year was the LBO-508 dual-trace oscilloscope. This instrument, which has a bandwidth of 20MHz and a sensitivity of 10mV/cm, uses a display screen measuring 8 × 10cms and its stabilized power supplies ensure a measuring accuracy of ±3%. Fixed and variable controls on the instrument provide a sensitivity range from 10mV/cm to 50V/cm, and an add function and a second-channel trace invert facility enable the inputs to be added or subtracted. Triggering may be selected from both channels and the circuit will extract sync signals from tv line and frame signals. The timebase allows adjustment from 0.5μs/cm to 0.2s/cm and includes a variable control and a times-five magnification. Other features include automatic and normal triggering, an external trigger input and a function switch for changing one input to the horizontal axis for X-Y display. Martron Limited, 20 Park Street, Princes Risborough, Bucks.
WW 301

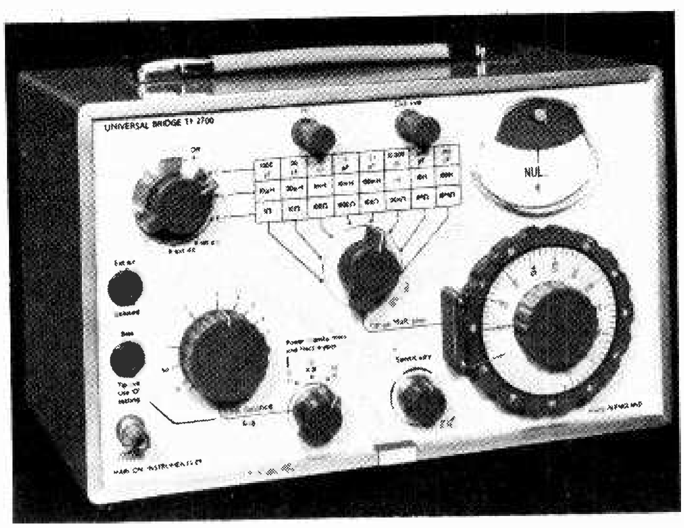
Noise and exposure time meter

At a push of a single switch the maximum-permissible noise exposure time for employees is shown direct on the scale of the Pulsar 85E, an industrial sound level meter. The maximum time for which an employee may be safely exposed to high noise levels in a working day is defined by the Department of Employment's code of practice. At 90dBA an employee may work a full eight hours but if the level increases to 93dBA, a barely audible increase, the energy content is doubled and hence the safe working time is reduced to only four hours. Similarly, the time is halved for every further increase of 3dBA. At a typical discotheque level of 110dBA, the exposure limit is under five minutes per day. The main feature of the Pulsar 85E is its measuring range of 85dBA to 114dBA with the Code of Practice exposure times shown on the same scale from 8h at 90dBA to 3.75 min at 111dBA. To ensure measuring accuracy the electret condenser microphone is mounted on a pull-out boom to minimise case reflections. The 85E meets the requirements of not only IEC 123 and BS 3489 but also the more stringent American ANSI S1.4 Type S2A. Price is £125. Pulsar Instruments, 40-42 Westborough, Scarborough, North Yorks YO11 1UN.
WW 302

Universal bridge

The Marconi TF2700 is a self-contained battery-powered bridge for testing resistance, capacitance and inductance. Although traditional bridge configurations are used, with an internal 1kHz source, provision has been made for the connection of many external facilities, enabling more specialised measurements to be undertaken. It has eight ranges for each of the three parameters and includes a separate, loss balance-control giving indications of D and Q values. The capacitance ranges are from 100pF to 1000μF full scale, the inductance ranges are from 10μH to 100H full scale, and the resistance ranges extend from 1Ω to 10MΩ. External sources of between 20Hz and 20kHz. may be used for all measurements, and resistance may also be measured with direct current. In addition, the bridge may be biased for measurements that require polarization. Electroplan Limited, P.O. Box 19, Orchard Road, Royston, Herts SG8 5HH.
WW 303

WW 301



WW 303

Minature frequency standards

Oven crystal oscillators in the PMTP5 range, from CEPE, have ageing rates down to 5×10^{-11} per day and retraceability characteristics which ensure that the frequency is within 5×10^{-9} sixty minutes after switching on from cold. Nine varieties of ageing rates and ambient temperature ranges are available, five which function at 5MHz, and the remainder which function at any specified frequency between 4 and 6MHz. All of the oscillators are the same size, 67 × 60 × 40mm, and weigh approximately 180g. Frequency adjustment is provided by external potentiometer and by a control voltage permitting recalibration for at least seven years. The oscillators, which are powered by a 12V ±5% negative-earth supply, consume 8W at switch-on and 1.5 to 2.4W at 25°C. Thomson-CSF Components and Materials Ltd, Ringway House, Bell Road, Daneshill, Basingstoke, Hants RG24 0QG.
WW 304

Intrinsically safe pocket phone

The PF2UBIIC, a personal radiotelephone introduced by Pye Telecommunications Ltd, is the first two-way private mobile radio to receive the BASEFA certificate of approval to SFA3012. This standard, which is for equipment used in hazardous atmospheres, replaces the older

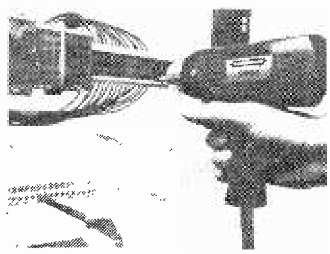
BS1259/1958 standard and is considerably more stringent – in particular, the risk of auto ignition is considered for the first time. The introduction of this standard brings the British intrinsic safety standard into line with IEC groupings and markings. The PF2UBIIC, which is designed for three-channel working in the 405 to 470MHz u.h.f. band, is certified for use in zones 1 and 2 with gases in groups IIA, IIB and IIC. It measures only 194 × 85 × 36mm. Pye Telecommunications Ltd, St. Andrews Road, Cambridge CB4 1DP.
WW 305

Sound-system i.c.

The TDA 1190Z i.c. incorporates the functions of two devices in one chip. It is designed for use in televisions and provides the i.f. amplifier, the low-pass filter, the f.m. detector, the audio preamplifier, the power amplifier and the d.c. volume control. The system is sensitive to an input limiting threshold-voltage of 40μV. Its harmonic distortion is typically 0.75% for an output power of 50mW and its carrier frequency is 4.5MHz (for a Δf of ± 7.5kHz), with a modulating frequency of 400Hz. The signal-to-noise ratio is typically 65dB for an input threshold of greater than 1mW and an audio voltage of 4V. It may be supplied from a 9 to 28V supply and drives a 16Ω loudspeaker. Motorola Limited, Semiconductor Products Division, York House, Empire Way, Wembley, Middlesex HA9 0PR.
WW 306

Electric screwdriver

An electric screwdriver, called the Electrodriver DMS1, is claimed to be unique in that it is the only model on the market to



combine continuously-variable speed control, direction reversal, and preselectable torque settings. The tool, from Klippon Electricals Ltd, is suitable for applications throughout industry where the fast repetitive insertion and removal of screws up to M4 size is required. The Electrodriver is mains operated and weighs only 1.35kg, enabling it to be held in one hand, leaving the other free to support components. Power consumption is only 45W and the speed is continuously variable up to 700rev/min. Klippon Electricals Ltd, Terminal Works, Power Station Road, Sheerness, Kent ME12 3AD.
WW 307

Protective pads

Small-profile, self-adhesive pads, which will protect items from scuffing, sliding or vibrating, have been added to the Bumpon range of products available from 3M. The pads, designated as SJ5008 Bumpons, are 12.7mm square by 3mm high and are made from resilient elastomeric material. They are available in black, white or grey colours in boxes of 1000. Industrial Specialities Group, 3M United Kingdom Limited, 3M House, P.O. Box 1, Bracknell, Berkshire RG12 1JU.
WW 308

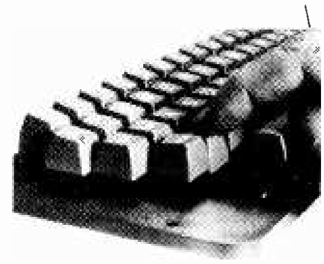
Sinad meter

The Sinadder 3 combines the well-known Sinadder, from Helper Instruments, with an audio voltmeter. In addition, it has an internal loudspeaker for audible monitoring in both the sinad and audio volts modes of measurement. An internal 1kHz tone is provided for modulating the operator's signal generator in

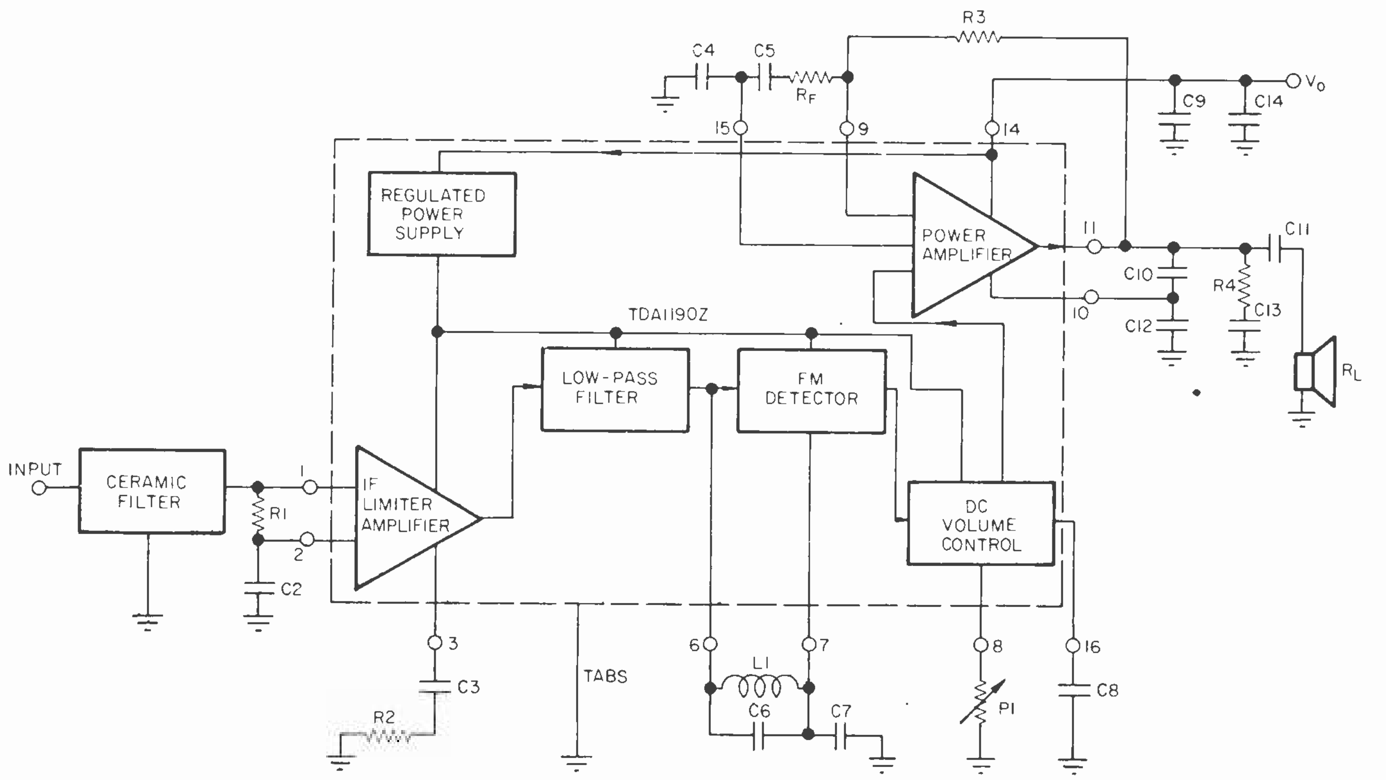
the sinad mode, or as a test tone for setting transmitter modulation and remote control levels. A 115/230V transformer and a 12V plug are supplied as standard. Lyons Instruments Limited, Hoddesdon, Herts EN11 9DX.
WW 309

Alphanumeric keyboards

The Model EA alphanumeric keyboard, which is the latest addition to Steatite's Chomerics range of keyboard systems, has 59 keys and a space bar. Its keys have a "soft-touch" feel, according to the makers, and a 3.18mm key travel. This model is based on long-life (10 million operations) screened Mylar switch technology, and it is suitable for data



TYPICAL TV SOUND SYSTEM USING TDA1190Z



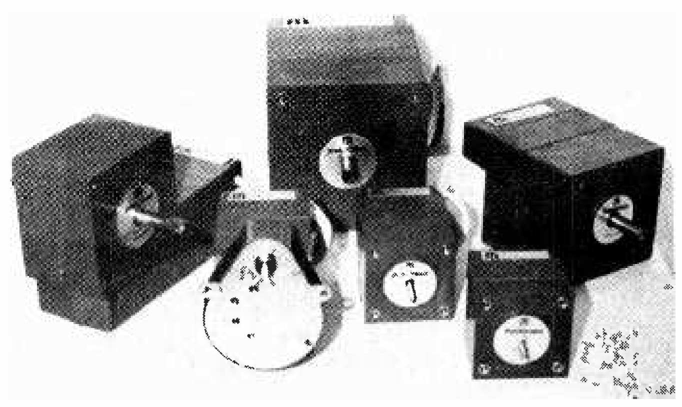
entry terminals and house computer systems. It has two flex-tail terminations with 18 output lines encoded in an 18 × 10 matrix (basically an 8 × 8 matrix plus two extra rows for shift and control outputs) allowing it to be directly connected to an ASCII encoder chip or a programmable keyboard interface chip. As such, the standard EA model is particularly suitable for microprocessor systems designed around an 8-bit bus structure. Steatite Group of Companies, Hagley House, Hagley Road, Birmingham B16 8QW.
WW 310

Analyser store

The ADS1 is a digital store which has been introduced by Wayne Kerr to complement their RA200 a.f. response analyser. The RA 200/ADS1 provides a continuous response curve which is continuously updated so that there is no chance of missing a sharp spike at one point and there is no need for internal filters or integrators which can distort the response pattern. Up to four complete curves may be recorded by the store, and retained for at least two weeks, even with the RA200 switched off. The contents of any store can be updated at any time, either wholly or in selected parts of the spectrum, without interrupting the display. Any two stores can be selected, and their difference displayed, and if necessary amplified and stored. Wilmot Breeden Electronics Ltd, 442 Bath Road, Slough SL1 6BB.
WW 311

Viewdata module

Two p.c.b.s. consituting a Viewdata module for inclusion in tv sets have been introduced by GEC Semiconductors. One is a self-displaying page store, comprising four l.s.i. circuits (one MA406 display circuit, one MA401 store address and control circuit, and two MA414 r.a.ms) and is designed with address, data and control buses. The 11-bit address bus determines any store location to be accessed while the 7-bit data bus carries the content of the store location determined by the particular address. The control bus is a 5-bit bus. Outputs from the page store include red, green and blue video and blanking signals. The MA406 display circuit is an n-channel silicon gate device and generates outputs at 14Mbit/s. The Viewdata system can be controlled via a standard keypad or a hard wired teleprinter keyboard and is fully compatible with the GEC Viewdata Line Unit LTU11. GEC Semiconductors Ltd, East Lane, Wembley, Middlesex HA9 7PP.
WW 312



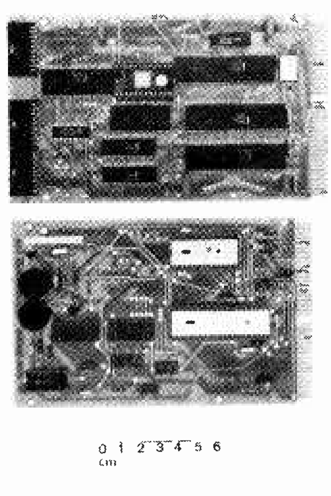
WW 313

Synchronous stepping motors

Synchronous/stepping motors in the All-Square series, from Memotrace Controls Ltd, range in size from 40 to 78mm square and produce torques from 80 to 3000g.cm without gearing. All of the motors can be stalled against an end-stop without risk of overheating, and reversed without switching when used in the random mode. The motors will operate synchronously at 250, 375 or 500 rev/min on a 50Hz supply and start using a capacitor. When used in the d.c.-hold and stepping mode, for variable-speed operation, steps per rev of 24, 32 or 48 are available up to 250 steps per second. Memotrace Controls Limited, 13 The Avenue, Spinney Hill, Northampton NN3 1BA.
WW 313

Fibre-core resistors

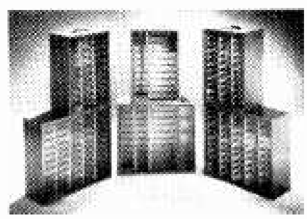
A range of low-cost, wirewound fibre-core resistors, the FC series from The CGS Resistance Co. Ltd, specifies the range 0.33Ω to 12kΩ, with standard tolerances of ±10%, and power dissipations from 2 to 10W. The resistors are available with two different heights of tag for use in printed circuit boards giving a maximum back-of-board temperature, on the FCB type, of 60°C. They meet the flammability requirements of BS 415, clause 20.1, and the solderability test of IEC 68-2-20, 1A. The temperature coefficient is ±200ppm, and the maximum change after 1000h is ±3%. After 10 times nominal wattage loading for five seconds the change is ±2%. The CGS Resistance Company Limited, Marsh Lane, Gosport Street, Lymington, Hampshire SO4 9YQ.
WW 314



WW 312

Storage cabinets

A range of component storage cabinets has been introduced by Quiller Components Ltd of Bournemouth. The standard cabinets, which can be wall-mounted or stacked, consist of a robust steel



frame and a choice of three sizes of transparent plastic trays. There are seven types, ranging from an all-plastic 9-tray unit, to the standard metal-and-plastic 50-tray unit. Prices range from £3.40 to £15.80 and, according to the makers, their appearance makes the cabinets suitable for office, home or workshop. Quiller Components Limited, Cardigan House, Winton, Bournemouth, Dorset BH9 1AU.
WW 315

Pocket terminal

Based on the Intel 8048 device, this pocket terminal from GR Electronics is an improvement on their existing hand held keyboard which was announced in 1976. The new unit, which has been designed for use by computer engineers and programmers, contains 40 keys and is capable of sending/receiving data in eight-bit serial ASCII code. The terminal has eight 16-segment displays which can generate all 64 ASCII upper case alphanumerics. Selectable baud rates are also provided and a 30-character internal memory may be accessed for display in blocks of eight adjacent characters.

Two versions of the terminal are available; one is interfaced for operation with a 20mA current loop, the other is interfaced for V24/RS232 levels. Both types are fitted with an internal bleeper for an audio response to the "BEL" code.

The complete terminal requires a regulated power supply of +5V ± 5% with a current rating around 400mA. G.R. Electronics Ltd, Fairoak House, Church Road, Newport, Gwent NP7 7EJ.
WW 316

Soldering bits for thick film

At the request of a Marconi company, Light Soldering Developments Ltd have developed two long-life soldering bits specially for soldering thick-film circuits. Long, thin extensions on the bits overcome the access problem in high density applications. The bits will fit Litesold ETC/2 and PC/2 soldering systems and the Conqueror soldering iron. Light Soldering Developments Ltd, 97-99 Gloucester Road, Croydon, Surrey.
WW 317

100A transistors

Devices in the 100SC series, announced by GPD, are claimed to be the first single-chip power transistors with collector current ratings of 100A. The design is based on an unusually large germanium junction – a 0.475in-diameter chip. Typical applications for the transistors, which are available with various operating voltages, are in inverters, switching regulators, power amplifiers and similar high-current circuits. Wintronics, Southon House, Edenbridge, Kent.
WW 318

Correction

The Mk IX family of colour television cameras recently announced by Marconi Communications Systems Ltd as a successor to the Mk VIII uses three lead-oxide camera pick-up tubes, of which several varieties can be fitted, and not four Plumbicons as stated in our last issue. The quantity and quality of integrated circuits used in the Mk IX family has been increased over those in the Mk VIII range, which did not use any thin-film circuitry.

SIDEBANDS by Mixer

Big is beautiful

Has anyone noticed how enormous some of the latest portable radio receivers are? Funny how fashions change, isn't it? When transistors were first used to make life miserable the idea was to make the radios as small as possible or to make them look like something else. (I remember a dog, with a speaker in its mouth, a tuning knob for its left eye and the volume/on-off control as its right. It didn't wag its tail much, if memory serves me).

The newer ones, though, seem to get bigger every time I look in a shop window, which isn't very often because I get this pain in the head when I see the prices. Some recent designs are nearly as big as the "table wireless sets" we used to have before the war, which had to be that size because of the valves, big electrolytics and transformers they used. That necessity was a blessing in disguise, because it meant that a decent-sized loudspeaker could be used, and the cabinet was big enough to handle it.

Transistors need no large components and tended, at first, to be used in a gimmicky way simply for a size reduction — and to blazes with the sound. So I see it as encouraging that radio designers are overcoming this imagined need for small, tinny trannies and are trying to provide a decent sound at last. At least, I hope they are. Doubts are raised, though, by the description of some of these sets as "stereo" receivers. Given a pair of headphones and a jack on the receiver this is fine, but some of them have two speakers, indicating that one is intended to sit there, solemnly gazing at the set about a foot away. I haven't checked, but if any of these sets don't provide for headphone listening, there could be a violation of the trade descriptions regulations.

Peel me a grape

These youngsters go too fast for me. Once again I have to report a conversation which took place in our brainstorm generation department – the Dorset House canteen. The talk deviated slightly, from rhetorical enquiry into the precise nature of the late animal we were coping with, to a demand for information on computer programming from our gadgeteer (he's the only man I know with a laser in his living room, and now he wants a computer).

It isn't that he doesn't understand it, but he does feel that the "stupid great list" of instructions is far too much like work to be tolerated. Instead of feeling immeasurably grateful that several pages of algebra and arithmetic can be reduced to a few computer instructions, he feels that the instructions ought to be done away with as well. Well, that's youth for you! What he wants to do, it seems, is to write the question out, in Queen's English, show it briefly to a microcomputer and tell it to get on with it. Languages don't come much higher in level than that and it makes me wonder if he isn't forgetting something. If the computer is bright enough to understand an instruction to stop gazing into space and do something constructive, it might just come back and ask him if he's paralysed or something, and why not do the job himself, if he's so keen?

A clash of symbols

Someone is usually cross with us about something – a thick skin is as much an essential to this line of work as big feet are to a policeman – and, as often as not, the subject that seems to get up peoples' noses is graphic symbols. Some readers have only to spot an OR gate drawn in a way they disagree with to get their nether underwear all of a twist.

Now, we all have our own ideas about symbols – logic symbols in particular. Some like semicircles, some still use circles and others, including the British Standards Institution, use rectangles. Respectful as we are of that august body, it seems to all of us here that since BSI stopped consulting *Wireless World* on symbol design some time ago the state of graphic symbology has become akin to that of Denmark. Regular readers will have noticed that diagrams in *Wireless World* use the semicircle and spearhead for logic symbols, the preference being for symbols which are clear, unambiguous and logical, if you will pardon the expression.

But, whichever symbols are shown in a diagram, I refuse to believe that anyone would be so completely put off by unfamiliar drawings as to be in difficulties with the logic diagram. Greater degrees of departure from the familiar are encountered whenever, for example, an American "upside-down" circuit diagram is seen or a European diagram with "rectangular" resistors and single-turn mains transformers is used, and yet I don't think the differences are great enough to cause anyone difficulty.

Avos into space

There are times when a leaning towards the technical can be a drawback and can also gain you a reputation as a know-all wet blanket, if you can visualize such a creature. Film-makers are much better at maintaining accuracy than they used to be, but one can still see the odd Messerschmitt 108B masquerading as an Me 109E, and nothing is more liable to release carefully built-up tension than a squadron of sinister Mitsubishi Zeros being revealed as innocent Harvard trainers in wolf's clothing.

As I have already mentioned, I am a pushover for sci-fi series on the box; and I become very annoyed with myself when a character is desperately trying to activate a rocket's main drive motor by means of a highly technical-looking piece of gear which I immediately recognize as a Marconi audio signal generator. I once saw an alien life form being held at bay by a small grid-dip oscillator — a procedure only marginally more effective as a deterrent than a soldering gun with its bit missing. All this is very distracting and I do wish the producers of these series would begin to draw on some other discipline for their hardware. I should think any decent toolmaker's workshop could supply a few menacing-looking gizmos and chemical laboratories are full of highly entertaining bits of gadgetry. Knowing little of these black arts, I could then experience a full measure of terror without wondering how a BC109 with its legs bent up is going to work as the heart of an anti-gravity machine.

More haste — more speed

That the imminent arrival in one's island home of a million or so gentlemen singing the Horst Wessel song is quite enough to concentrate the mind has been made very clear by the BBC "Secret War" television series. Once our physicists and engineers had got the idea that it was largely up to them there was no stopping them; the inventions came forth in a steady stream. The astonishing feature, though, was not the amount of stuff churned out, but the sheer speed of development from the nutty idea stage to the point where the Heinkels didn't know whether they were coming or going.

In an age in which gestation periods of electronic equipment designs extend into years it is truly remarkable that complete systems were conceived, developed and bolted into aircraft in a matter of weeks. The radar bombing aid which probably influenced the course of the war more than any other, H_2S, was taken from bright idea to prototype in eight months. A further seven months sufficed for the production of enough sets to enable Pathfinders of Bomber Command to flatten Hamburg.

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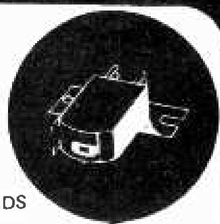

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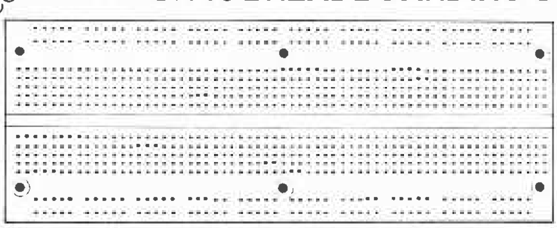

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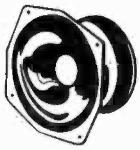

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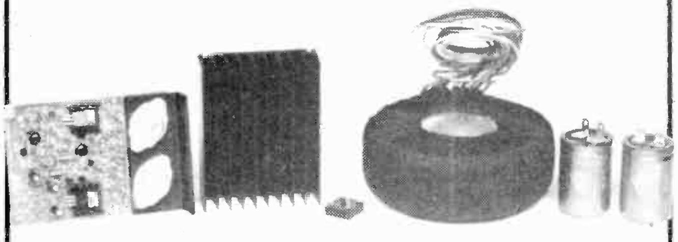

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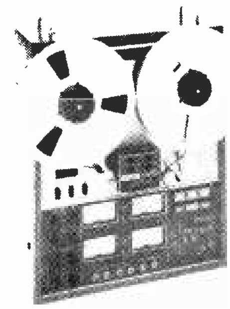

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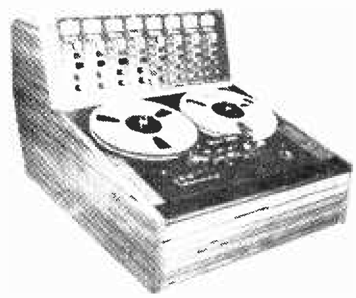

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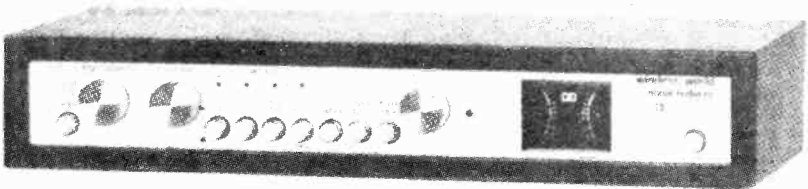
Wireless World Dolby(TM) noise reducer

Trademark of Dolby Laboratories Inc.



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

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

Complete Kit **PRICE: £39.90** + VAT

Also available ready built and tested .... **Price £54.00** + VAT

Calibration tapes are available for open-reel use and for cassette (specify which) .... **Price £2.20** + VAT *

Single channel plug-in Dolby(TM) PROCESSOR BOARDS (92 x 87mm) with gold plated contacts are available with all components .... **Price £8.20** + VAT

Single channel board with selected fet .... **Price £2.50** + VAT

Gold Plated edge connector .... **Price £1.50** + VAT *

Selected FETs **60p** each + VAT, **100p** + VAT for two, **£1.90** + VAT for four

Please add VAT @ 12½% unless marked thus*, when 8% applies (or current rates)

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

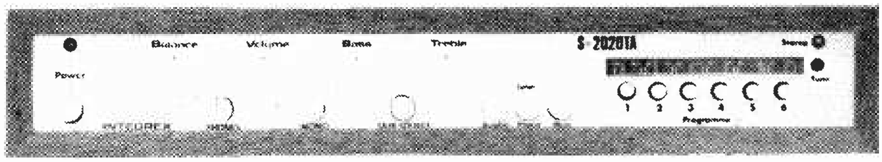
INTEGREX LTD.

Please send SAE for complete lists and specifications
Portwood Industrial Estate, Church Gresley,
Burton-on-Trent, Staffs DE11 9PT
Burton-on-Trent (0283) 215432 Telex 377106

INTEGREX

S-2020TA STEREO TUNER/AMPLIFIER KIT

SOLID MAHOGANY CABINET



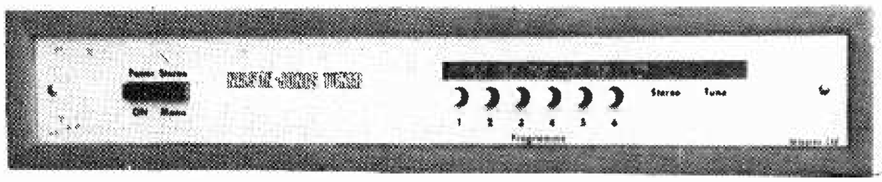
A high-quality push-button FM Varicap Stereo Tuner combined with a 24W r.m.s. per channel Stereo Amplifier.

Brief Spec. Amplifier Low field Toroidal transformer, Mag, input, Tape In/Out facility (for noise reduction unit, etc.), THD less than 0.1% at 20W into 8 ohms. Power on/off FET transient protection. All sockets, fuses, etc., are PC mounted for ease of assembly. Tuner section uses 3302 FET module requiring no RF alignment, ceramic IF, INTERSTATION MUTE, and phase-locked IC stereo decoder. LED tuning and stereo indicators. Tuning range 88—104MHz. 30dB mono S/N @ 1.2μV. THD 0.3%. Pre-decoder 'birdy' filter.

PRICE: £58.95+VAT

NELSON-JONES STEREO FM TUNER KIT

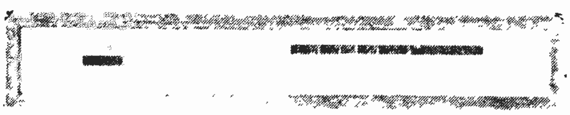
A very high performance tuner with dual gate MOSFET RF and Mixer front end, triple gang varicap tuning, and dual ceramic filter/dual IC IF amp.



Brief Spec. Tuning range 88—104MHz. 20dB mono quieting @ 0.75μV. Image rejection — 70dB. IF rejection — 85dB. THD typically 0.4%.
IC stabilized PSU and LED tuning indicators. Push-button tuning and AFC unit. Choice of either mono or stereo with a choice of stereo decoders.

Compare this spec. with tuners costing twice the price.

Mono £32.40+VAT
With ICPL Decoder £36.67+VAT
With Portus-Haywood Decoder £39.20+VAT



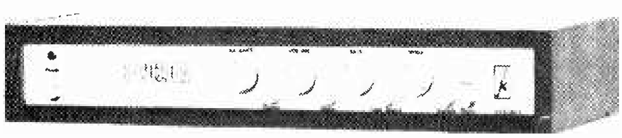
Sens. 30dB S/N mono @ 1.2μV
THD typically 0.3%
Tuning range 88—104MHz
LED sig. strength and stereo indicator

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 £31.95+VAT

S-2020A AMPLIFIER KIT



Developed in our laboratories from the highly successful "TEXAN" design. PC mounting potentiometers, switches, sockets and fuses are used for ease of assembly and to minimize wiring

Power 'on/off' FET transient protection.

Typ Spec. 24+24W r.m.s. into 8-ohm load at less than 0.1% THD. Mag. PU input S/N 60dB. Radio input S/N 72dB. Headphone output. Tape In/Out facility (for noise reduction unit, etc.). Toroidal mains transformer.

PRICE: £33.95+VAT

ALL THE ABOVE KITS ARE SUPPLIED COMPLETE WITH ALL METALWORK, SOCKETS, FUSES, NUTS AND BOLTS, KNOBS, FRONT PANELS, SOLID MAHOGANY CABINETS AND COMPREHENSIVE INSTRUCTIONS

BASIC NELSON-JONES TUNER KIT	**£14.28**+VAT	**PHASE-LOCKED IC DECODER KIT** ...	**£4.47**+VAT
BASIC MODULE TUNER KIT (stereo)	**£16.75**+VAT	**PUSH-BUTTON UNIT**	**£5.00**+VAT

PORTUS-HAYWOOD PHASE-LOCKED STEREO DECODER KIT .... **£8.00**+VAT

BOOKS AND COMPONENTS

BOOKS BY BABANI

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

BP2	Handbook of Radio, TV & Industrial & Transmitting Tube & Value Equivalents	60p†
BP3	Handbook of Tested Transistor Circuits	40p†
BP6	Engineers and Machinists Reference Tables	40p†
BP7	Radio & Electronic Colour Codes Data	15p†
BP10	Modern Crystal and Transistor Set Circuits for beginners	95p†
BP16	Construction Manual of Electronic Circuits for the Home	50p†
BP16	Handbook of Electronic Circuits for the Amateur Photographer	60p†
BP18	Boys and Beginners Book of Practical Radio and Electronics	60p†
BP22	79 Electronic Novelty Circuits	75p†
BP23	First book of Practical Electronic Projects	75p†
BP24	52 Projects Using IC741 (or equivalents)	75p†
BP26	Radio Antenna Handbook for Long Distance Reception and Transmission	85p†
BP27	Giant Chart of Radio Electronic Semiconductor and Logic Symbols	60†
BP29	Major Solid State Audio Hi-Fi Construction	85p†
BP32	How to Build Your Own Metal & Treasure Locators	85p†
BP34	Practical Repair & Renovation of Colour TVs	95p†
BP35	Handbook of IC Audio Preamplifier & Power Amplifier Construction	95p†
BP36	50 Circuits Using Germanium, Silicon & Zener Diodes	75p†
BP37	50 Projects Using Relays, SCRs and TRIACS	1.10†
BP39	50 (FET) Field Effect Transistor Projects	1.25†
129	Universal Gram-motor Speed Indicator	8p†
160	Coil Design and Construction Manual	75p†
161	Radio, TV and Electronics Data Book	60p†
196	AF-RF Reactance — Frequency Chart for Constructors	15p†
202	Handbook of Integrated Circuits (ICs) Equivalents and Substitutes	75p†
205	First Book of Hi-Fi Loudspeaker Enclosures	75p†
213	Electronic Circuits for Model Railways	85p†
214	Audio Enthusiasts Handbook	85p†
216	Electronic Gadgets and Games	85p†
217	Solid State Power Supply Handbook	85p†
219	Solid State Novelty Projects	85p†
220	Build Your Own Solid State Hi-Fi and Audio Accessories	85p†
222	Solid State Short Wave Receivers for Beginners	95p†
223	50 Projects Using IC CA3130	95p†
224	50 CMOS IC Projects	95p†
225	A Practical Introduction to Digital ICs	95p†
226	How to Build Advanced Short Wave Receivers	1.20†
RCC	Resistor Colour Code Disc Calculator	10p†

BOOKS BY NEWNES

No 229	Beginners Guide to Electronics	Price £2.25†
No 230	Beginners Guide to Television	Price £2.25†
No 231	Beginners Guide to Transistors	Price £2.25†
No 233	Beginners Guide to Radio	Price £2.75†
No 234	Beginners Guide to Colour Television	Price £2.25†
No 235	Electronic Diagrams	Price £1.80†
No 236	Electronic Components	Price £1.08†
No 237	Printed Circuit Assembly	Price £1.08†
No 238	Transistor Pocket Book	Price £3.90†
No 225	110 Thyristor Projects Using SCRs & Triacs	Price £2.50†
No 227	110 COS/MOS Digital IC Projects for the Home Constructor	Price £2.25†
No 226	110 Operational Amplifier Projects for the Home Constructor	Price £2.50†
No 242	Electronics Pocket Book	Price £3.90†
No 239	30 Photoelectric Circuits & Systems	Price £1.80†

NUTS AND BOLTS

BA BOLTS — packs of BA threaded cadmium plated screws slotted, cheese head

Supplied in multiples of 50

Type	No.	Price	Type	No.	Price
1in 0BA	839	£1.20	½in 4BA	846	£0.32
½in 0BA	840	£0.75	¼in 4BA	847	£0.25
1in 2BA	842	£0.65	1in 6BA	848	£0.40
½in 2BA	843	£0.45	½in 6BA	849	£0.21
¼in 2BA	844	£0.52	¼in 6BA	850	£0.25
1in 4BA	845	£0.44			

BA NUTS — packs of cadmium plated full nuts in multiples of 50

Type	No.	Price	Type	No.	Price
0BA	855	£0.72	4BA	857	£0.30
2BA	856	£0.48	6BA	858	£0.24

BA WASHERS — flat cadmium plated plain stamped washers supplied in multiples of 50.

Type	No.	Price	Type	No.	Price
0BA	859	£0.14	4BA	851	£0.12
2BA	860	£0.12	6BA	862	£0.12

SOLDER TAGS — hot tinned, supplied in multiples of 50.

Type	No.	Price	Type	No.	Price
0BA	851	£0.40	4BA	853	£0.22
2BA	852	£0.28	6BA	854	£0.22

SWITCHES

Description	No.	Price
DPDT miniature slide	1973	£0.10*
DPDT standard slide	1974	£0.12*
Toggle switch SPST 1½ amp 250V a c	1975	£0.33*
Toggle switch DPDT 1 amp 250V a.c	1976	£0.36*
Rotary on-off mains switch	1977	£0.42*
Push switch — Push to make	1978	£0.13*
Push switch — Push to break	1979	£0.18*

ROCKER SWITCH
A range of rocker switches SPST — moulded in high insulation material available in a choice of colours, ideal for small apparatus

Colour	No.	Price
RED	1980	£0.26*
BLACK	1981	£0.26*
WHITE	1982	£0.26*
BLUE	1983	£0.26*
YELLOW	1984	£0.26*
LUMINOUS	1985	£0.22*

Description	No.	Price
Miniature SPST toggle, 2 amp 250V a c	1958	£0.50*
Miniature SPST toggle 2 amp 250V a.c	1959	£0.55*
Miniature DPDT toggle, 2 amp 250V a c	1960	£0.70*
Miniature DPDT toggle, centre off 2 amp 250V a c	1961	£0.85*
Push button SPST, 2 amp 250V a c	1962	£0.78*
Push button SPST, 2 amp 250V a c	1963	£0.83*
Push button DPDT, 2 amp 250V a c	1964	£0.98*

MIDGET WAFER SWITCHES
Single-bank wafer type — suitable for switching at 250V a c 100mA or 150V d c in non-reactiver loads make-before-break contacts These switches have a spindle 0 25in dia and 30° indexing

Description	Order No.	Price
1 pole 12 way	1965	£0.48*
2 pole 6 way	1966	£0.48*
3 pole 4 way	1967	£0.48*
4 pole 3 way	1968	£0.48*

MICRO SWITCHES

Description	Order No.	Price
Plastic button gives simple on-off action Rating 10 amp 250V a.c	1969	£0.20
Button gives 1 pole change over action Rating 10 amp 250V a.c	1970	£0.25

FUSE HOLDERS AND FUSES

Description	Order No.	Price
20mm x 5mm chassis mounting	506	£0.07*
1¼in x ¼in chassis mounting	507	£0.12*
1¼in car inline type	508	£0.15*
Panel mounting 20mm	509	£0.20*
Panel mounting 1¼in	510	£0.30

QUICK BLOW 20mm

Type	No	Type	No	Type	No
150mA	611	1A	615	3A	619
150mA	512	1·5A	616	4A	620
550mA	613	2A	617	5A	621
800mA	614	2·5A	618		

616 **7p ea.** All remainder **5p ea**

ANTI-SURGE 20mm

Type	No	Type	No	Type	No
100mA	622	1A	625	2·5A	628
250mA	623	2A	626	3·15A	629
500mA	624	1·6A	627	5A	630

All 7p each

QUICK BLOW 1¼in

Type	No	Type	No	Type	No
250mA	631	500mA	632	800mA	634

All 7p each

Type	No	Type	No	Type	No
1A	635	2·5A	638	4A	641
1·6A	636	3A	639	5A	642
2A	637	**All 6p each**			

CASES AND BOXES

INSTRUMENT CASES. In two sections vinyl covered top and sides, aluminium bottom, front and back.

No.	Length	Width	Height	Price
155	8in	5¼in	2in	£1.40*
156	11in	6in	3in	£1.80*
157	6in	4¾in	1¾in	£1.25*
158	9in	5¼in	2½in	£1.60*

ALUMINIUM BOXES. Made from bright all., folded construction each box complete with half inch deep lid and screws.

No	Length	Width	Height	Price
159	5¼in	2¼in	1½in	62p*
160	4in	4in	1½in	62p*
161	4in	2¼in	1½in	62p*
162	5¼in	4in	1½in	74p*
163	4in	2½in	2in	64p*
164	3in	2in	1in	44p*
165	7in	5in	2½in	£1.04*
166	8in	6in	3in	£1.32*
167	6in	4in	2in	86p*

MIDGET WAFER SWITCHES

1965	— 1 pole 12 way	48p*
1966	— 2 pole 6 way	48p*
1967	— 3 pole 4 way	48p*
1968	— 4 pole 3 way	48p*

TRANSFORMERS

MINIATURE MAINS Primary 240V

No	Secondary		Price
2021	6V-0-6V	100mA	90p*
2022	9V-0-9V	100mA	90p*
2023	12V-0-12V	100mA	95p*

MINIATURE MAINS Primary 24V with two independent secondary windings

No	Type	Price
2024	MT280-0-6V 0-6V RMS	£1.50*
2025	MT150-0-12V 0-12V RMS	£1.50*

1-AMP MAINS Primary 240V

No	Secondary		Price	
2026	6V-0-6V	1 amp	£2.50*	P&P 45p
2027	9V-0-9V	1 amp	£2.00*	P&P 45p
2028	12V-0-12V	1 amp	£2.60*	P&P 55p
2029	15V-0-15V	1 amp	£2.75*	P&P 66p
2030	30V-0-30V	1 amp	£3.45*	P&P 86p

STANDARD MAINS Primary 240V
Multi-tapped secondary mains transformers available in ½ amp, 1 amp and 2 amp current rating. Secondary taps are 0-19-25-33-40-50V

Voltages available by use of taps
4, 7, 8, 10, 14, 15, 17, 19, 25, 31, 33, 40, 50, 25-0-25V

No	Rating	Price	
2031	½ amp	£5.50*	P&P 86p
2032	1 amp	£6.60*	P&P 86p
2033	2 amp	£8.40*	P&P £1.10

AUDIO LEADS

107	FM Indoor Ribbon Aerial	£0.£0.80*
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 and skt	£1.10*
117	AC mains connecting lead for cassette recorders and radios 2 metres	£0.68*
118	5 pin DIN phono plug to stereo headphone jack socket	£1.05*
119	2+2 pin DIN plug 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 and combination units Supplied with inline 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 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	£1.80*
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 inline 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	£0.68*

AVDEL BOND CYANOACRYLATE G2

The wonder adhesive which works in seconds Bonds plastic rubber transistors components permanently — immediately!

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V.A.T. Add 12½% to prices marked*. 8% to those unmarked. Items marked are zero rated
P&P. 35p unless otherwise shown

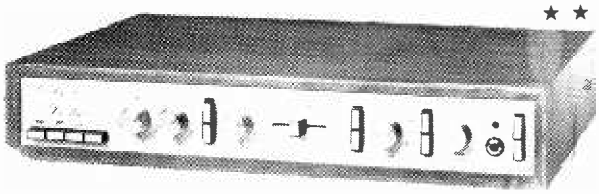
BI-PAK

Dept. WW6, P.O. Box 6, Ware, Herts

COMPONENTS SHOP 18 BALDOCK STREET, WARE, HERTS.

AUDIO KITS OF DISTINCTION FROM POWERTRAN

NEW! DE LUXE EASY TO BUILD LINSLEY-HOOD 75W AMPLIFIER



AVAILABLE AS SEPARATE PACKS
PRICES IN OUR FREE CATALOGUE

SPECIAL PRICE FOR COMPLETE KIT £99.30

The standard model of our kit for Mr Linsley-Hood's 75 watt design has for a long time offered exceptional performance at a very modest cost with high quality high power ready built units of comparable quality generally being over three times the price

Features of the amplifier include very low distortion (less than 0 01%) 75W rms per channel power output rumble filter variable slope scratch filter variable transition frequency tone controls tape monitoring facilities and individually adjustable inputs This model is based on 5 circuit boards which not having the controls mounted on them can if desired be effectively used separately in high performance audio systems not based on our metalwork

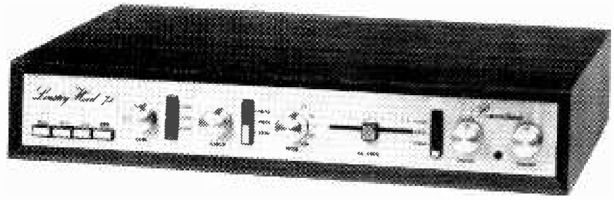
Our new De Luxe model uses 14 boards which interconnect with gold plated contacts and are designed to have the potentiometers and switches mounted upon them This system almost eliminates internal wiring making installation after their assembly delightfully straightforward and as each board can be easily removed in seconds from the chassis checking and maintenance is so simple that even newcomers to electronics will be able to cope competently with the kit Additional features of our new model are inclusion of the latest circuit improvements generously sized heat sinks for heavy duty use even in tropical climates and metal oxide resistors throughout for long term stability and reliability

PACK PRICES FOR STANDARD KIT

Pack		Price
1.	Fibreglass printed circuit board for power amp	£1.15
2.	Set of resistors, capacitors, pre-sets for power amp	£2.50
3.	Set of semiconductors for power amp	£6.50
4.	Pair of 2 drilled, finned heat sinks	£1.10
5.	Fibreglass printed-circuit board for pre-amp	£1.90
6.	Set of low noise resistors, capacitors, pre-sets for pre-amp	£4.10
7.	Set of low noise, high gain semiconductors for pre-amp	£2.40
8.	Set of potentiometers (including mains switch)	£3.50
9.	Set of 4 push-button switches, rotary mode switch	£5.40
10.	Toroidal transformer complete with magnetic screen/ housing primary: 0 117-234 V: secondaries: 33-0-33 V, 25-0-25 V	£12.95
11.	Fibreglass printed-circuit board for power supply	£0.85
12.	Set of resistors, capacitors, secondary fuses, semiconductors for power supply	£5.40
13.	Set of miscellaneous parts including DIN skts., mains input skt., fuse holder, interconnecting cable, control knobs	£6.20
14.	Set of metalwork parts including silk screen printed fascia panel and all brackets, fixing parts, etc.	£8.20
15.	Handbook	£0.30
16.	High Quality Teak Veneer cabinet 18.3" x 12.7" x 3.1"	£10.70

2 each of packs 1-7, 1 each of packs 8-16 inclusive are required for complete stereo amplifier. Total cost of individually purchased packs £92.80

STANDARD LINSLEY-HOOD 75W AMPLIFIER



SPECIAL PRICE FOR COMPLETE KIT £79.80

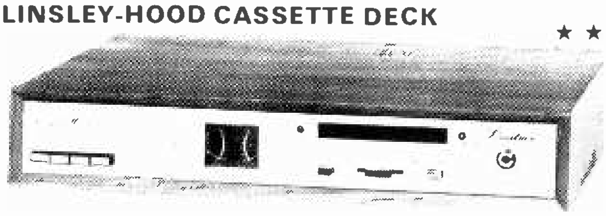
WIRELESS WORLD FM TUNER

SPECIAL PRICE FOR COMPLETE KIT £70.20

Designed in response to demand for a tuner to complement the world-wide acclaimed Linsley-Hood 75W Amplifier, this kit provides the perfect match The Wireless World (Skingley and Thompson) published original circuit has been developed further for inclusion into this outstanding slimline unit and features a pre-aligned front end module, excellent a.m rejection and temperature compensated varicap tuning, which may be controlled either continuously or by push-button pre-selection Frequencies are indicated by a frequency meter and sliding LED indicators, attached to each channel selector pre-set The PLL stereo decoder incorporates active filters for "birdy" suppression and power is supplied via a toroidal transformer and integrated regulator For long term stability metal oxide resistors are used throughout

AVAILABLE AS SEPARATE PACKS — PRICES IN OUR FREE CATALOGUE

LINSLEY-HOOD CASSETTE DECK



SPECIAL PRICE FOR COMPLETE KIT £79.60

Pack		Price
1.	Stereo PCB (accommodates 2 rep. amps. 2 meter amps. bias/erase osc. relay)	£3.35
2.	Stereo set of capacitors. M.O. resistors. potentiometers for above	£7.95
3.	Stereo set of semiconductors for above	£8.50
4.	Miniature relay with socket	£2.90
5.	PCB. all components for solenoid. speed control circuits	£3.80
6.	Goldring-Lenco mechanism as specified	£18.50
7.	Function switch. knobs	£1.90
8.	Dual VU meter with illuminating lamp	£6.95
9.	Toroidal transformer with E.S. screen prim. 0-117V. 234V. Sec. 15V	£4.90
10.	Set of capacitors. rectifiers. I.C. voltage regulator P.C.B. for power supply (Powertran design)	£2.80
11.	Set of miscellaneous parts. including sockets. fuse holder. fuses. interconnecting wire. etc	£3.40
12.	Set of metalwork including silk screened fascia panel. internal screen. fixing parts. etc	£7.10
13.	Construction notes	£0.25
14.	High Quality Teak Veneer cabinet 18.3" x 12.7" x 3.1"	£10.70

One each of packs 1-14 inclusive are required for complete stereo cassette deck. Total cost of individually purchased packs £83.00

Matsushita WY 436 AZ head (optional extra) . £4.50 (free with compete kit)

Published in Wireless World (May. June. August 1976) by Mr Linsley-Hood this design, although straightforward and relatively low cost nevertheless provides a very high standard of performance. To permit circuit optimization separate record and replay amplifiers are used, the latter using a discrete component front-end designed such that the noise level is below that of the tape back ground Push button switches are used to provide a choice of equalization time constants, a choice of bias levels and also an option of using an additional pre-amplifier for microphone use The mechanism used is the Goldring-Lenco CRV, a unit distinguished in its robustness and ease of operation. Speed control and automatic cassette ejection are both implemented by electronic circuitry This unit which is powered by a toroidal transformer and uses metal oxide resistors throughout offers an excellent match for the Wireless World Tuner and the Linsley-Hood 75 Watt Amplifier Circuit changes as published in February, 1978, follow-up article are included in the kit AT NO EXTRA COST! A higher performance head (Matsushita WY 436 AZ head as recommended in the follow-up article) is offered as an optional extra but this will be automatically supplied FREE OF CHARGE with all orders for complete kits!

T20+20 AND T30+30 20W, 30W AMPLIFIERS

Pack		T20	T30
1.	Set of low noise resistors	£1.60	£1.70
2.	Set of small capacitors	£2.60	£3.40
3.	Set of power supply capacitors	£2.20	£2.50
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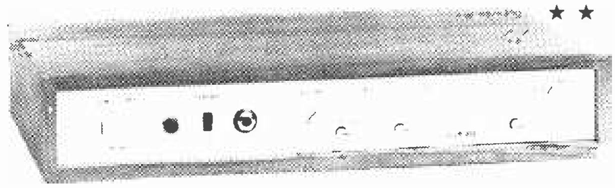

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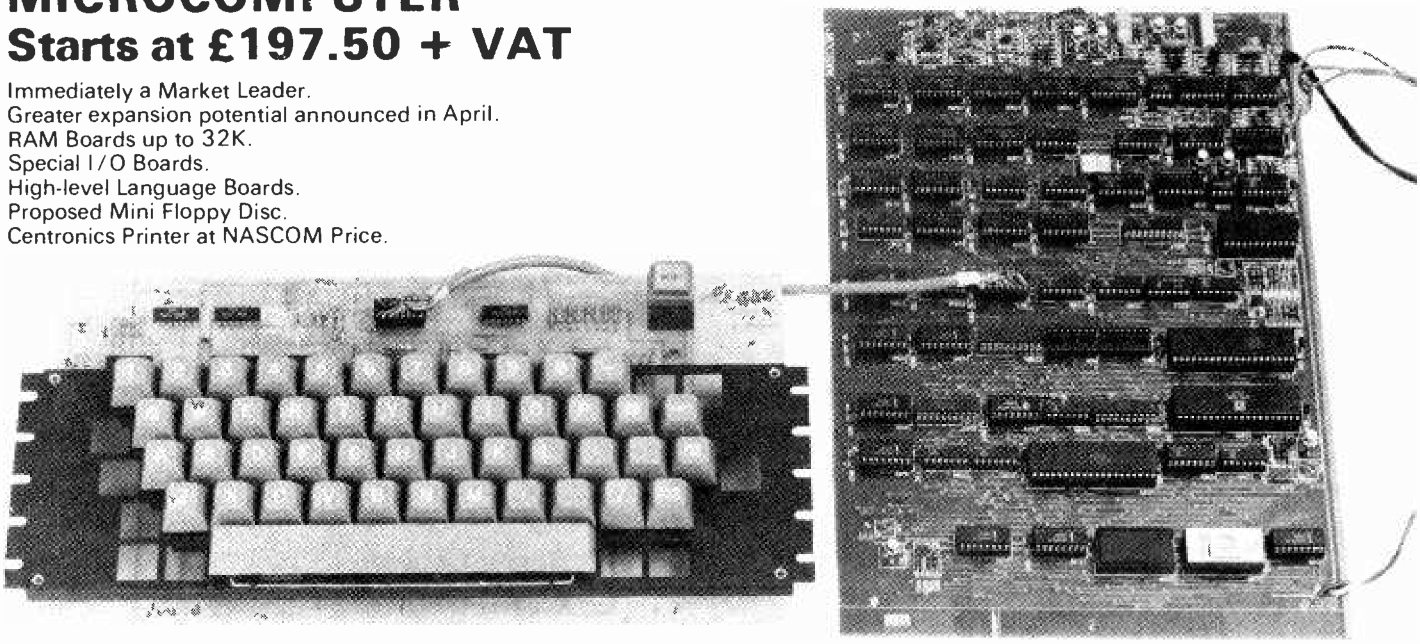

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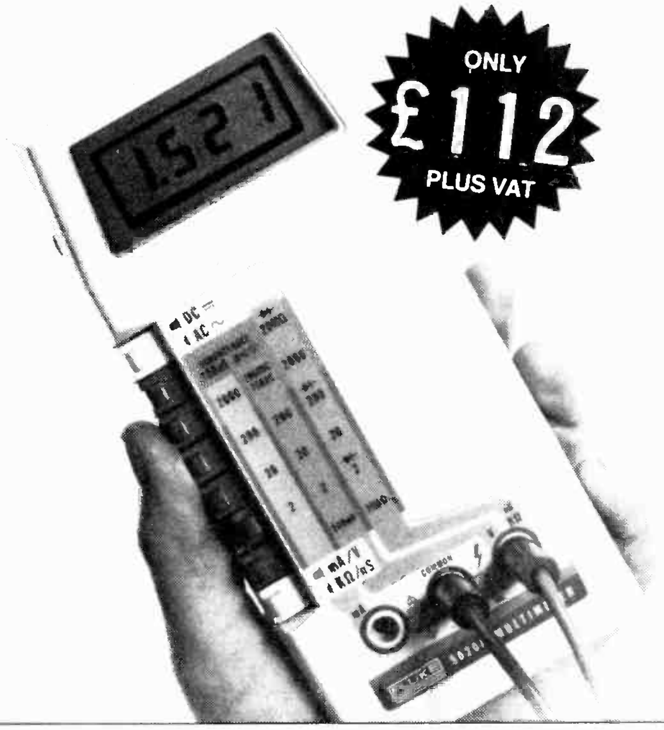

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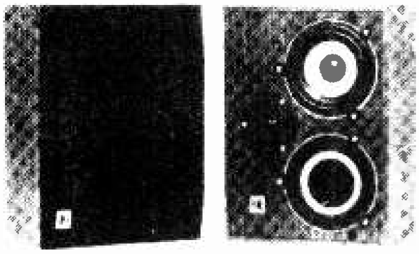


Celestion's UL6s

Up to this point you could say the products described are competent by present standards, or even very good. Celestion's UL6 loudspeakers hooked up to the end are unequivocably the best budget loudspeakers I have heard or in some particular respects the *best* loudspeakers I have heard without the qualification of price. Around the time of their introduction a small group of audio journalists was asked by an importer of a certain well known Japanese brand to give opinions on the quality of a loudspeaker they were about to import. For comparison about eight popular British loudspeakers had been assembled and connected to a comparator. At the end of the session there was one point on which everybody seemed agreed and that was the fact that Celestion's UL6 appeared to sound significantly smoother and more evenly balanced than any of the other makes. Since the difference appeared so great even against significantly more expensive models I at least wondered whether the particular listening conditions had by some quirk favoured the UL6's by an unusually large degree.

Now about one year after I find that it wasn't providence and that the speaker easily beats most others into second place by integrity ability. It was suggested to me for instance and I think this is true that the UL6 can be recommended irrespective of taste. Because it's so completely natural and free from major imbalances or defects I believe most people would admit to 1 liking it and 2 finding that they could live with them no matter what they had been previously used to. According to taste you may prefer another loudspeaker with its own peculiar sound but you would have to admit that this sounds right.

It is common when describing the sound of a loudspeaker to split the audio band into bass midrange and treble regions then deal with each separately. This is often provoked by the loudspeaker itself because most do the same thing and don't present a coherent picture but a fractured programme where bass output might be say soft and distant whilst treble is bright and forward.

This split in quality and relative levels is as usual fairly well compensated for by the brain after a short learning and adjustment process. Since it is so common the effect is also tolerated and one does expect to adjust to a speaker's own peculiar sound quality. The most immediately striking feature of the UL6 and the one that caused it to sound superior to all others on that group listening test described earlier is the fact that adjustment hardly seems necessary or called for. There aren't splits suck-outs or inbalances. The treble doesn't leap out or disappear and you don't have to decide whether you like such-and-such an effect or not. At a broad fundamental level the UL6 just sounds unusually *right*. I cannot say that behind this overall feeling detail criticisms are impossible but the UL6 certainly transcends its price category and cannot be approached I feel by most speakers costing around £200 or less.

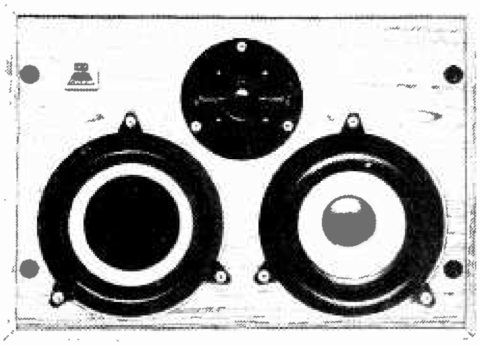
If you want to hear a speaker with the whole of the audio range present and transmitted as a smooth coherent whole listen to the UL6. It's as detailed as any of the best speakers but doesn't achieve this by false upper midrange or treble prominence. An ABR (Auxiliary Bass Radiator) is used to augment bass response and for the first time I can recall it doesn't produce soggy indefinite bass quality. The main weakness I felt was some wooden nasality ... but this was the only form of ... identifiable.

Percussion instruments were astonishingly powerful and realistic for a speaker of the size and perhaps just a small amount of resonant boom contributed to this very large and excellent performance which will I assure you make a majority of budget equivalents sound like neutered cats (which they are in spite of belief by some that real bass can be wrought from a tarted up shoe box).

Extremely go...

It was the loudsp... tem around from so... tent (that's my fa... mediocre to a who... tems of far greater ... cartridge and amp... sound balance fo... and as I said at th... ings became o... price the resul... extremely go... There's ... the ... ned this sys...

Now listen to this...



We don't expect you to take everything you see in the hi-fi magazines about speakers as read. Relying on someone else's ears – even when they are as expert and sensitive as Philip Mount's – isn't quite the same as getting the "message" first hand! But we're more than confident that you will find very little to disagree with once you've heard the UL6 demonstrated.

Celestion

Why not take one of your own records or tapes along to a Celestion dealer and listen.

name ______________________

address ______________________

____

07.15.06

Rola Celestion Ltd., Ditton Works, Foxhall Road, Ipswich, Suffolk IP3 8JP.
Telephone: Ipswich (0473) 73131.
Cables: Voicecoil Ipswich. Telex: 98365.

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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 3¼in. Below motor board 2½in with Sonotone V100 magnetic cartridge

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

NEW BSR SINGLE PLAYER £19.95
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HEAVY METAL PLINTHS
With P V.C Cover. Cut out for most BSR or Garrard decks Silver grey finish **£6.50** Post £1.50
Model "A" Size 12½ x 14¾ x 7½in
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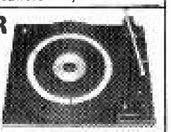
BSR SINGLE PLAYER



Ideal replacement or disco deck with cueing device and stereo ceramic cartridge. 3 speeds Large turntable, modern design
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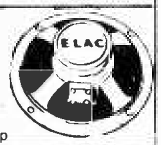
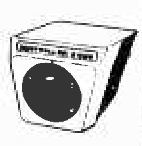
ELAC HI-FI SPEAKER 8in. TWIN CONE



Dual cone plastic roll surround
Large ceramic magnet 50-16,000 c/s
Bass resonance 40 c/s 8 ohm impedance
10 watts RMS **£5.95** Post 35p

SMITH'S CLOCKWORK 15 AMP TIME SWITCH
0-6 HOURS £3.30 Post 35p



Single pole two-way. Surface mounting with fixing screws Will replace existing wall switch to give light for return home garage, automatic anti-burglar lights, etc Variable knob. Turn on or off at full or intermediate settings. Brand new

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

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

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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.**

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Ideal 625 and colour.
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ELAC 9 × 5in HI-FI SPEAKER TYPE 59RM £3.45
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This famous unit now available. 10 watts. 8 ohm

E.M.I. 13½ x 8in. SPEAKER SALE!

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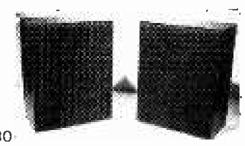

Teak or White
13 × 10 × 6in approx
50 to 14,000 cps
10 watts rms. 4 ohms
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These little marvels of modern sound reproduction are ideally suited for today's domestic audio set-up. Two of these smart spheres, each with 5 watt deep throated ceramic magnets, will produce superb stereo reproduction.
The globe shaped cases in high gloss mouldings of red 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
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Impedance 8 ohms
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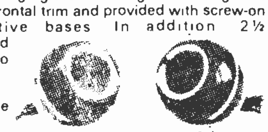

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1.5V d.c. operation over 300 hours continuous on SP2 battery, fully adjustable swing and speed. Ideal displays, teaching electro magnetism or for metronome, strobe, etc. **95p** Post 30p

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30-14,500 c/s. 12in. double cone, woofer and tweeter cone together with a BAKER ceramic magnet assembly having a flux density of 14,000 gauss and a total flux of 145,000 Maxwells. Bass resonance 40 c/s Rated 25W. NOTE 4 or 8 or 16 ohms must be stated.

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12in 30W **£12.00**	12in 40W **£14.00**	15in. 75W **£26.00**
4 or 8 or 16 ohm	4 or 8 or 16 ohm	8 or 16 ohm

BAKER LOUDSPEAKER, 12 INCH. 60 WATT.
GROUP 50/12, 4 OR 8 OR 16 OHM HIGH POWER.
FULL RANGE PROFESSIONAL QUALITY.
RESPONSE 30-16,000 CPS **£21.00**
MASSIVE CERAMIC MAGNET Post £1.60
WITH ALUMINIUM PRESENCE CENTRE DOME

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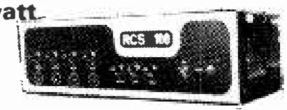
SPEAKER COVERING MATERIALS. Samples Large S.A.E
LOUDSPEAKER CABINET WADDING 18in wide **20p** ft

R.C.S. 100 watt VALVE AMPLIFIER CHASSIS



Four inputs. Four way mixing, master volume, treble and bass controls Suits all speakers This professional quality amplifier chassis is suitable for all groups, disco, P.A., where high quality power is required. 5 speaker outputs A/C mains operated. Slave output socket Produced by demand for a quality valve amplifier 100V line output to order. Send for leaflet.
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Handles up to 100 watts No crossover required

Black Plastic Construction Box with brushed aluminium facia. Sturdy job. Size 6¼ x 4¾ x 2in. **£1.50**

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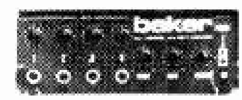

All purpose transistorised Ideal for Groups, Disco and P.A. 4 inputs speech and music. 4 way mixing. Output 4 8/16 ohms. a.c. Mains. Separate treble and bass controls. Master volume control. Guaranteed. Details S A.E **£75** £1.50 carr.

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Standard 12in. diameter fixing with cut sides 10⅜ square 14 000 Gauss magnet 30 watts R.M S 4 ohm imp Bass resonance = 30 c.p s Frequency response 30-8000 c.p.s
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ALUMINIUM HEAT SINKS. FINNED TYPE.
Sizes 6½" × 4½" × 2¼" **95p.** 6½" × 2" × 2¼" **65p.**
BALANCED TWIN RIBBON FEEDER 300 ohms. 5p yd.
JACK SOCKET Std. open-circuit 20p, closed circuit 25p; Chrome Lead-Socket 45p. Mono or Stereo.
Phono Plugs 8p. Phono Socket 8p.
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DIN SOCKETS Chassis 3-pin 10p. 5-pin 10p.
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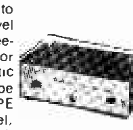
TV CONVERGENCE POTS 15p each
Values = 5, 7, 10, 20, 50, 100, 200, 250, 470, 2000 ohms

MONO PRE-AMPLIFIER. Mains operated solid state pre-amplifier unit designed to complement amplifiers without low level phono and tape input stages. This free-standing cabinet incorporates circuitry for automatic R I A A equalisation on magnetic phono input and N.A.B. equalisation for tape heads Power ON/OFF, PHONO/TAPE switches and pilot lamp are on the front panel, phono socket input and output are rear located.



£4.50 each or £8 pair. Post 50p.

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THAT EVERYBODY CAN AFFORD

Due to a large purchase we have an assembly consisting of frame with X & Y assemblies (no pen — but provision provided), pulleys and cords; and **YES** two high quality stepping motors, these alone are worth the asking price for the entire assembly. Two basic sizes are available, with various stepping motor options. All motors 200 steps per rev; 20oz. inch torque.

120V Stepping Motor 750-0-750 ohm will step at 50V
Bed Size 6 x 4½ **£26.50** ea.
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120V Stepping Motor 1000-0-1000 ohm.
These can be changed with care to 12 or 24V. Data supplied.
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P&P ALL OPTIONS £2 each

STEPPING MOTORS ONLY
120V Stepping Motor 1000-0-1000 ohm
Can be changed with care to 12/24/48V. Data Supplied.
£8 each. P&P £1
Supplied for 12/24V operation. **£13 each.** P&P £1
Just think about the uses!

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THE TELEFUNKEN D14-131 REPLACEMENT TUBES FOR SOLARTRON (SCHLUMBERGER) CD 1740 COSSOR CDU 150 S.E. LABS SM112 and the GEC/MOV 1474 TUBE

These tubes were fitted in one of the above oscilloscopes, but were removed on the authority of the British Ministry because they were not of British manufacture. They are warranted by us as being of as new condition.
PRICE £55 EA. P&P £2.75

ALSO BRAND NEW TUBES FOR THE FOLLOWING OSCILLOSCOPES TELEQUIPMENT

S52 @ **£10** ea. D53A @ **£20** ea.
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AND MULLARD & BRIMAR OSCILLOSCOPE TUBES BRAND NEW — BOXED — ALL RECTANGULAR

D13-46GM P7 **£35** ea.
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AC107	0.75
AC125	0.30
AC126	0.25
AC127	0.25
AC128	0.25
AC141	0.20
AC141K	0.35
AC142	0.20
AC142K	0.30
AC176	0.25
AC187	0.25
AC188	0.25
ACY17	0.65
ACY18	0.65
ACY19	0.65
ACY20	0.65
ACY21	0.65
ACY39	1.25
AD149	0.70
AD161	0.75
AD162	0.75
AF106	0.45
AF114	0.25
AF115	0.25
AF116	0.25
AF117	0.25
AF139	0.40
AF186	1.50
AF239	0.45
AFZ11	2.75
AFZ12	2.75
ASY26	0.45
ASY27	0.50

ASZ15	1.25
ASZ16	1.25
ASZ17	1.25
ASZ20	0.75
ASZ21	1.50
AU113	1.70*
AUY10	1.70*
BA145	0.15*
BA148	0.15*
BA154	0.10
BA155	0.12
BA156	0.13
BAW62	0.05
BAX13	0.07
BAX16	0.07
BC107	0.12
BC108	0.12
BC109	0.13
BC113	0.15*
BC114	0.18*
BC115	0.19*
BC116	0.19*
BC117	0.22*
BC118	0.16*
BC125	0.18*
BC126	0.25*
BC135	0.15*
BC136	0.19*
BC137	0.16*
BC147	0.10*
BC148	0.10*
BC149	0.13*
BC157	0.12*
BC158	0.11*
BC159	0.13*
BC167	0.13*
BC170	0.16*
BC171	0.14*
BC172	0.13*
BC173	0.15*

BC177	0.19
BC178	0.18
BC179	0.20
BC182	0.11*
BC183	0.11*
BC184	0.12*
BC212	0.14*
BC213	0.14*
BC214	0.17*
BC237	0.17*
BC238	0.12*
BC301	0.45
BC303	0.60
BC307	0.20*
BC308	0.18*
BC327	0.22*
BC328	0.18*
BC337	0.19*
BC338	0.18*
BCY30	1.00
BCY31	1.00
BCY32	1.00
BCY33	0.90
BCY34	0.90
BCY39	3.00
BCY40	1.25
BCY42	0.30
BCY43	0.32
BCY58	0.23
BCY70	0.18
BCY71	0.22
BCY72	0.17
BCZ11	1.50
BD115	0.60
BD121	1.50
BD123	1.50
BD124	1.30
BD131	0.51
BD132	0.54
BD135	0.35*

BD136	0.36*
BD137	0.37*
BD138	0.40*
BD139	0.43*
BD140	0.47*
BD144	2.00
BD181	1.38
BD182	1.48
BD237	0.80
BD238	0.85
BDX10	0.75
BDX32	2.25
BDY20	1.42
BDY60	0.75
BF115	0.39
BF152	0.25
BF153	0.25
BF154	0.25
BF159	0.35
BF160	0.30
BF167	0.39
BF173	0.39
BF177	0.38
BF178	0.45
BF179	0.48
BF180	0.45
BF181	0.45
BF182	0.45
BF183	0.45
BF184	0.39
BF185	0.37
BF194	0.12*
BF195	0.11*
BF196	0.13*
BF197	0.14*
BF200	0.32
BF224	0.20*
BF244	0.35*
BF257	0.37
BF258	0.42
BF259	0.45

BF336	0.50*
BF337	0.53*
BF338	0.55*
BFS21	2.27
BFS28	1.38
BFS61	0.25*
BFS98	0.25*
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BFW11	0.90
BFX84	0.38
BFX85	0.41
BFX87	0.35
BFX88	0.32
BFY50	0.28
BFY51	0.26
BFY52	0.26
BFY64	6.30
BFY90	1.32
BSX19	0.34
BSX20	0.34
BSX21	0.32
BT106	1.25
BTY79/400R	3.19
BU205	2.25*
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BY100	0.45
BY126	0.14
BY127	0.15
BZX61	0.20
Series	
BZY88	0.13
Series	
CRS1/05	0.45
CRS1/40	0.60
CRS3/05	0.45
CRS3/40	0.75
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GEX66	1.50
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GJ3M	0.75
GM0378A	1.50
KS100A	0.40*
MJE340	0.58
MJE370	0.65
MJE371	0.81
MJE520	0.65
MJE521	0.75
MJE2955	1.25
MJE3055	0.75
MPF102	0.30*
MPF103	0.30*
MPF104	0.30*
MPF105	0.30*
MPSA06	0.25*
MPSA56	0.25*
MPSU01	0.32*
MPSU06	0.40*
MPSU56	0.45*
NKT401	2.00
NKT403	1.73
NKT404	1.73
NE555	0.45
OA5	0.75
OA7	0.55
OA10	0.55
OA47	0.14
OA70	0.30
OA79	0.30
OA81	0.30
OA85	0.30
OA90	0.08
OA91	0.08
OA95	0.08
OA200	0.10
OA202	0.11
OA210	0.75
OA211	0.75
OAZ200	0.65
OAZ201	0.65
OAZ206	0.65

OAZ207	0.65
OC16	1.25
OC20	2.00
OC22	2.50
OC23	2.75
OC24	3.50
OC25	0.90
OC26	0.90
OC28	2.00
OC29	2.00
OC35	1.50
OC36	1.50
OC41	0.50
OC42	0.50
OC43	1.50
OC44	0.50
OC45	0.50
OC71	0.45
OC72	0.45
OC73	1.00
OC74	0.75
OC75	0.60
OC76	0.50
OC77	1.20
OC81	0.75
OC81Z	1.00
OC82	0.75
OC83	0.55
OC84	0.60
OC122	1.50
OC123	1.55
OC139	2.25
OC140	1.95
OC141	2.25
OC170	0.75
OC171	0.75
OC200	1.00
OC201	1.50
OC202	1.25
OC203	1.75
OC204	1.25

OC205	1.75
OC206	1.75
OC207	1.25
OCP71	1.25
ORP12	0.83
R2008B	2.25*
R2009	2.25*
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TIC44	0.36
TIC226D	1.30
TIL209	0.25
TIP29A	0.50*
TIP30A	0.60*
TIP31A	0.62
TIP32A	0.75
TIP33A	1.00
TIP34A	1.20
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TIP42A	0.90
TIP2955	1.00
TIP3055	0.50
TIS43	0.35*
ZS140	0.25*
ZS170	0.12*
ZS178	0.54*
ZS271	0.22*
ZS278	0.56*
ZTX107	0.11*
ZTX108	0.10*
ZTX109	0.12*
ZTX300	0.12*
ZTX301	0.13*
ZTX302	0.17*
ZTX303	0.17*
ZTX304	0.19*
ZTX311	0.12*
ZTX314	0.20*
ZTX500	0.13*
ZTX501	0.14*
ZTX502	0.16*
ZTX503	0.17*

ZTX504	0.20*
ZTX531	0.20*
ZTX550	0.16*
1N914	0.07
1N916	0.07
1N4001	0.06
1N4002	0.07
1N4003	0.08
1N4004	0.09
1N4005	0.13
1N4006	0.15
1N4007	0.15
1N4009	0.15
1N4148	0.07
1N5400	0.14
1N5401	0.16
1S44	0.06
1S920	0.08
1S921	0.08
2G301	1.00
2G302	1.00
2G306	1.10
2N404	0.60
2N696	0.25
2N697	0.16
2N698	0.30
2N705	0.80
2N706	0.12
2N708	0.21
2N930	0.26
2N1131	0.26
2N1132	0.28
2N1303	0.37
2N1304	0.45
2N1305	0.45
2N1306	0.50
2N1307	0.50
2N1308	0.60
2N1309	0.60
2N1613	0.33

2N1671	1.50
2N1893	0.33
2N2147	1.40
2N2148	1.65
2N2218	0.33
2N2219	0.42
2N2220	0.35
2N2221	0.22
2N2222	0.25
2N2223	2.75
2N2368	0.17
2N2369A	0.21
2N2484	0.21
2N2646	0.50
2N2904	0.35
2N2905	0.35
2N2906	0.25
2N2907	0.21
2N2924	0.15*
2N2925	0.17*
2N2926	0.13*
2N3053	0.25
2N3054	0.50
2N3055	0.65
2N3440	0.60
2N3441	0.80
2N3442	1.20
2N3525	0.90
2N3614	1.20
2N3702	0.15*
2N3703	0.15*
2N3704	0.15*
2N3705	0.15*
2N3706	0.14*
2N3707	0.18*
2N3708	0.14*
2N3709	0.15*
2N3710	0.14*
2N3711	0.15*
2N3771	1.60
2N3772	1.70

2N3773	2.65
2N3819	0.36*
2N3820	0.46*
2N3823	0.60*
2N3866	1.00
2N3904	0.21*
2N3905	0.22*
2N3906	0.22*
2N4058	0.20*
2N4059	0.15*
2N4060	0.20*
2N4061	0.17*
2N4062	0.18*
2N4124	0.17*
2N4126	0.17*
2N4286	0.20*
2N4288	0.25*
2N4289	0.25*
2N5457	0.35*
2N5458	0.35*
2N5459	0.35*
3N125	1.75
2S017	6.50
2S019	6.50
2S026	12.00
2S103	1.50
2S302	0.75
2S303	0.75
2S322	0.80
2S324	1.25
2S701	1.50
2S703	1.50
2S721	3.00
2S745A	0.35
2S746A	0.35

VALVES

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A2087	10.48
A2134	4.81
A2293	4.10
A2426	8.20
A2521	8.53
A2900	4.85
A3343	18.43
AZ31	1.10*
AZ41	1.15*
BK448	62.70
BK484	84.70
BS90	27.25
BS810	27.75
BT5	31.15
BT17	55.64
BT19	19.00
BT29	169.70
BT69	173.65
BT75	72.25
BT95	66.80
CBL31	1.50*
CL33	2.00*
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C1K	10.00
C3A	10.00
C3JA	10.00
DA41	16.85
DA42	8.81
DA100	31.86
DAF91†	0.40*
DAF96	1.00*
DET22	15.12
DET24	41.00
DF91†	0.40*
DF96	1.00*
DK91†	0.55*
DK92	1.25*
DK96	1.10*
DL92	0.75*
DL94	1.20*
DL96	1.10*
DLS10	8.25
DLS15	8.25
DLS16	8.25
DLS19	8.25
DM70	1.25
DM71	1.25
DM160	1.50
DY86/7†	0.45*
DY802	0.80*
E55L	21.89
E80CC	4.97
E80CF	6.40
E80F	5.71
E80L	5.48
E81CC	5.76
E81L	5.75
E82CC	6.12
E83CC	6.23
E86C	8.93
E88C	5.38
E88CC†	1.00
E90CC	5.06
E90F	5.16
E9111	4.65

E92CC	4.97
E99F	5.51
E130L	16.85
E180CC	5.36
E180F	5.80
E182CC	5.71
E186F	7.90
E188CC	5.06
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EA76	1.50
EABC80	0.40*
EAC91†	0.50*
EAF42	1.25*
EAF801	1.75*
EB41	1.75*
EB91†	0.30*
EBC33	1.75*
EBC41	1.25*
EBC81	1.10*
EBC90†	0.65*
EBF80	0.45*
EBF83	1.25*
EBF89†	0.40*
EBL31	2.50*
EC90†	0.40*
EC91†	2.80*
EC92	1.25*
EC157	208.00
ECC33	3.50*
ECC35	3.50*
ECC40	1.25*
ECC81†	0.50*
ECC82†	0.47*
ECC83†	0.55*
ECC84†	0.50*
ECC85†	0.55*
ECC86	2.00*
ECC88†	0.75*
ECC89	0.75*
ECC91†	0.55
ECC189	1.00*
ECC807	1.75
ECC808	2.25*
ECF80†	0.60*
ECF82†	0.60*
ECF86	0.75*
ECH35	2.00*
ECH42	1.15*
ECH81†	0.50*
ECH83	0.85*
ECH84†	0.85*
ECL80†	0.60*
ECL81	0.75*
ECL82	0.55*
ECL83	1.50*
ECL84	0.90*
ECL85	1.12*
ECL86†	0.65*
ECLL800	7.00*
EF37A†	1.60*
EF39†	1.60*
EF40	1.15*
EF41	1.20*
EF42	2.00*
EF50†	0.60*
EF54	5.00*

EF55	2.50*
EF80†	0.45*
EF83	1.75*
EF85†	0.50*
EF86†	0.45*
EF89	0.60*
EF91†	0.65*
EF92†	0.75*
EF93†	0.50*
EF94†	0.55*
EF95†	0.30*
EF98	1.25*
EF183†	0.50*
EF184†	0.50*
EF804S	6.50
EF805S	7.00
EH90	0.75*
EK90†	0.65*
EL32	1.50*
EL33	3.50*
EL36	0.75*
EL41	1.25*
EL42	1.75*
EL81	1.10*
EL83	1.25*
EL84	0.45*
EL86†	0.50*
EL90†	0.75*
EL91	3.85
EL95†	0.80*
EL156	16.25
EL360	2.75*
EL500/504	1.50*
EL509	3.16*
EL821	4.42
EL822	5.61
EM80	1.10*
EM81	1.00*
EM84	1.00*
EM85	1.25*
EM87	1.50*
EN32	15.66
EN91†	0.55
EN92	5.81
EY51†	0.75*
EY81	1.65*
EY83	1.75*
EY84	3.95
EY86†	0.50*
EY88	1.75*
EY500A	1.36*
EY802	0.82*
EZ35	0.55*
EZ40	1.25*
EZ41	1.25*
EZ80†	0.30*
EZ81†	0.35*
EZ90†	0.45*
FW4-500	2.50*
FW4-800	2.50*
G1-371K	15.00
G55-1K	9.50
G180-2M	12.90
G240-2D	11.75
G400-1K	13.50
GN4	4.50
GN4A	4.50
GS16	9.00
GT1C	6.95

GU50	9.66
GU51	9.80
GXU1	10.43
GXU2	17.20
GXU3	21.42
GXU4	21.94
GY501	1.32*
GZ32	0.75*
GZ33	4.00*
GZ34†	1.52*
GZ37	4.00*
KT61	3.50*
KT66	4.50*
KT88	6.25*
KTW61	1.75*
KTW62	1.75*
KTW63	1.75*
M8079	8.40
M8080	3.80
M8081	6.33
M8082	4.65
M8083	5.61
M8091	7.71
M8096	3.75
M8097	3.56
M8098	3.20
M8099	5.20
M8100	5.92
M8136	6.12
M8137	6.23
M8140	4.50
M8141	4.85
M8142	4.00
M8144	3.75
M8149	5.10
M8161	5.76
M8162	5.75
M8163	4.50
M8190	4.60
M8195	3.70
M8196	3.40
M8204	3.50
M8212	8.63
M8223	2.30
M8224	2.80
M8225	2.60
M8248	6.72
MU14	1.00*
MX119	20.00
MX123	34.50
MX145	27.15
MX151	11.69
MX152	74.00
MX161	76.50
MX163	12.60
MX164	12.56
MX166	105.00
MX168	24.00
N78	7.50*
OA2†	0.45
OA3	1.10
OA4	1.10
OB2†	0.45
OB3	0.75
OC2	2.30
OC3†	0.45
OD3†	0.45
OZ4	0.75*
PC86†	0.85*

PC88†	0.85*
PC95	0.70*
PC97	1.08*
PC900†	0.75*
PCC84†	0.45*
PCC85	0.45*
PCC88	0.65*
PCC89†	1.05*
PCC189†	0.65*
PCC805†	0.95*
PCC806†	0.95*
PCE82†	1.72
PCF80	96p
PCF82†	0.50*
PCF86†	0.65*
PCF87†	1.00*
PCF200†	1.05*
PCF201†	1.05*
PCF801†	0.55*
PCF802†	0.88*
PCF805	1.41*
PCF806	0.80*
PCF808	1.44*
PCL82†	0.50*
PCL83†	0.92*
PCL84†	0.50*
PCL85†	0.96*
PCL86†	0.65*
PCL805/85†	0.96*
PD500	3.60*
PE06-40N	27.30
PFL200	1.12*
PL36†	1.12*
PL81	0.55*
PL81A†	1.12*
PL82	0.60*
PL83†	0.55*
PL84†	0.60*
PL504/505†	1.20*
PL508†	1.60*
PL509†	2.72*
PL519†	3.60*
PL801	1.10*
PL802†	2.16*
PY33	0.68*
PY81†	0.72*
PY82	0.45*
PY83	0.60*
PY88†	1.16*
PY500A†	1.60*
PY800/81†	0.92*
PY801	0.92*
QQV02-6	9.60
QQV03-10†	2.00
QQV03-20A†	10.50
QQV06-40A†	13.00
QQV07-50	36.70
QQZ03-20A	27.50
QQZ06-40A	42.60
QU37	11.00
QV03-12	3.00
QV04-7	2.50

QV08-100	85.60
QY3-65	42.80
QY3-125†	12.00
QY4-250	51.30
QY4-400	58.30
QY5-500	127.50
QY5-3000A	212.00
QZ06-20	18.40
R10	5.00
R17	1.65*
R18	3.95
R19	1.00*
R20	1.44
RG3-250	21.51
RG3-250A	23.28
RG3-1250	20.95
RG4-1250	27.50
RG4-3000	113.09
RR3-250	34.77
RR3-1250	62.37
S11E12	18.00
S130	2.00
S130P	2.50
STV80/40	10.00
STV280/80	20.00
SU41	2.50
SU42	9.00
TD03-10	15.00
TD03-10E	17.50
TD03-10F	17.50
TT15	22.00
TT21	7.00
TT22	7.00
TT100	37.50
TY2-125	40.20
TY4-400	56.10
TY4-500	73.20
TY5-500	160.00
TY6-800	145.00
TY6-5000A	198.00
TY6-5000B	206.00
TY6-5000W	178.00
TY7-6000A	216.00
TY7-6000W	175.00
TZ40	15.00
U18-20	2.50*
U19	8.11
U25	1.16*
U26	1.44*
U37	11.00
UABC80†	0.50*
UAF42	0.75*
UB41	1.25*
UBC41†	0.75*
UBF89	0.50
UCC84	0.75*
UCC85†	0.50*
UCF80	0.75*
UCH42	1.20*
UCH81†	0.50*
UCL82†	0.50*

UCL83	1.44*
UF41	0.75*
UF42	1.25*
UF80†	0.50*
UF85†	0.50*
UF89†	0.50*
UL41	1.00*
UL84†	0.60*
UM80	1.00*
UY41†	0.75*
UY85†	0.65*
VL5631	8.22
XG1-2500	23.10
XG5-500	16.80
XG2-6400	64.95
XGQ2-6400	74.15
XR1-1600A	19.05
XR1-3200	54.00
XR1-3200A	54.00
XR1-6400	59.10
XR1-6400A	59.10
YD1120	206.00
YD1240	206.00
Z759	6.50
ZM1000	4.60
ZM1001	5.38
ZM1020	8.55
ZM1021	7.96
ZM1022	8.23
ZM1023	7.66
ZM1040	11.57
ZM1041	9.67
ZM1042	11.08
ZX1051	87.00
1B3GT†	0.55
1B24	10.00
1B35A	17.00
1B63	45.00
1R5†	0.55*
1S5†	0.40*
1T4†	0.40*
2A515	10.00
2C39A†	9.00
2C43	18.00
2D21†	0.55
2E26	3.00
2J42	60.00
2J55	175.00
2J70A	235.00
2J70B	250.00
2K25†	9.50
3-400Z	35.00
3-500Z	35.00
3A5	1.35
3B24	5.00
3B28†	4.00
3B29	10.00
3B-240M	15.00
3B241M	15.00
3C23	10.00
3C45†	6.00
3CX100A5	20.00
3E29†	5.50
3S4†	0.75*

3V4†	1.00*
4-65A	25.35
4-125A†	12.00
4-250A	36.00
4-400A	37.00
4B32	10.00
4C35	40.00
4CX250B	17.50
4CX350A	31.35
4CX150A	21.00
4X150D	25.00
5B-254M	11.25
5B-255M	11.25
5C22	40.00
5J-180E	495.00
5R4GY†	1.00*
5U4G	1.52*
5U4GB	1.00*
5V4G†	0.65*
5Y3GT	0.85*
5Z3	1.50*
5Z4G	1.12
5Z4GT	1.00*
6-30L2	1.00*
6AB4	0.75*
6AB7	0.75*
6AC7	0.75*
6AF4A†	0.70*
6AG7	0.75*
6AH6†	0.70*
6AK5†	0.30
6AK6	0.95*
6AL5†	0.30*
6AM4	2.30*
6AM5	3.85
6AM6†	0.65*
6AN5	2.50*
6AN8A†	0.70*
6AQ5†	0.75*
6AR5	0.70*
6AS6†	0.80*
6AS7G†	1.50*
6AT6†	0.65
6AU5GT	4.26*
6AU6†	0.55*
6AV5GT	3.74*
6AV6†	0.50*
6AX5GT	3.10*
6B7	0.75
6B8	0.75
6BA6†	0.50
6BA7	5.12
6BA8A	3.75
6BC4	3.71
6BE6†	0.45*
6BH6†	1.20*
6BJ6†	0.80*
6BK4	4.21*
6BL6	85.00
6BL7GT	3.86*
6BM6	85.00
6BN6	0.80*
6BQ7A	1.55*
6BR7	4.00*
6BR8†	1.20*
6BS7	4.00*
6BW6	3.75*
6BW7	1.40*
6BX7GT	4.96*

6BZ6	1.78*
6C4†	0.40*
6CB6A†	0.50*
6CD6GA	4.00*
6CG7	1.72*
6CH6	4.42
6CL6†	0.75*
6CW4	4.72*
6D2†	0.30*
6DK6	2.49*
6DQ6B	3.04*
6EA8	2.21*
6EB8	2.12*
6EW6	0.80*
6F6	0.75*
6F23	1.60*
6F28	1.16*
6F33	10.75
6H1	8.00
6H2N	0.75*
6H3N	0.75*
6H6	0.75*
6J4†	0.75*
6J6†	0.55
6J7	0.75*
6K4N	0.75*
6K6GT	0.75*
6K7	0.75*
6K8	0.75*
6KD6	4.79*
6L6G	2.50*
6L6GA	1.50*
6L6GT	0.85*
6L6GC	1.75*
6L7	0.75*
6N2P	0.75*
6N3P	0.75*
6N7	0.75*
6P25	3.60*
6Q7	0.80*
6R7	0.80*
6SA7	0.80*
6SC7	0.80*
6SF7	0.80*
6SH7	0.80*
6SJ7	0.80*
6SK7	0.80*
6SL7GT†	0.70*
6SN7GT†	0.70*
6SQ7	0.75*
6SR7	0.75*
6SS7	0.75*
6U5G	2.00*
6U8†	0.40*
6U8A†	0.55*
6V6GT†	0.60*
6X4†	0.45*
6X5GT†	0.55*
7B7	1.00*
7C5	1.75*
7C6	1.25*
7H7	1.00*
7R7	1.50*
7S7	2.25*
7Y4	0.75*
7Z4	0.75*
11E3	34.00
12AT6	0.45*
12AT7†	0.45*

12AU6	0.50*
12AU7†	0.45*
12AV6	0.60*
12AV7	2.84*
12AX7†	0.45*
12AY7†	0.82*
12B4A†	1.00*
12BA6	0.50*
12BE6	1.60*
12BH7†	0.60*
12BY7†	0.80*
12E1	4.00
12E14	19.80
13E1	43.55
19H4	16.88
19H5	22.50
24B9	30.50
30C15	1.56*
30C17	1.56*
30C18	1.44*
30F5	1.60
30FL1/2	1.12*
30FL12	1.72*
30FL14	1.44*
30L1	0.84*
30L15	1.72*
30L17	1.72*
30P4	0.92*
30P19	1.12*
30PL1	1.32*
30PL13	1.72*
30PL14	1.68*
30PL15	1.72*
35W4	0.60*
50C5	0.70*
75B1	3.15
75C1	1.55
85A1	7.50
85A2	1.50
90AG	7.26
90AV	7.16
90C1	1.50
90CG	5.74
90CV	5.99
92AG	7.26
92AV	7.16
95A1	4.15
150B2	1.80
150B3	3.30
150C2	1.50
150C4	2.30
211	5.00
723AB†	8.00
803	10.00
805	20.00
807†	1.00
811A†	3.80
812A	7.25
813†	10.00
833A	30.00
866A	8.85
872A	11.40
922	4.36
931A	12.24
1624	1.25
1625	1.00
2050	2.50
4212E	118.95
4212H	118.95

5544	54.00
5545	59.00
5551A	62.70
5552A	84.70
5553A	225.30
5642	3.16*
5654	3.61*
5651	1.80*
5670	2.86*
5675	9.09*
5687	4.30*
5696	1.94*
5718	3.36*
5725	3.40*
5726	2.20
5727	3.50*
5749	3.30*
5751	2.93*
5763	3.12*
5814A	2.60*
5840	4.40
5842	6.90
5876A	9.38
5879	3.16*
5886	10.50
5963	1.87*
5965	2.36*
6005	3.65*
6021	4.46
6057	6.23
6058	8.40
6059	4.00
6061	4.25
6062	3.75
6063	3.65
6064	5.60
6067	6.12
6072	3.77
6080	6.85
6097A×B×C	40.00
6146A	4.27
6146B	4.65
6159	6.00
6189	6.08
6201	4.84
6442	15.00
6883B	4.93
6973	2.61
7025†	1.20
7551	3.65
7586	6.79
7587	12.54
7609	31.80
7868	2.93*
7895	7.48
8005	25.00*
8068	5.50
8122	33.15
8136	1.54
8417	3.40
18042	5.31
18045	5.71

BASES

B7G unskirted	0.15
B7G skirted	0.30
B9A unskirted	0.15
B9A skirted	0.30
Int Octal	0.20
Nuvistor	0.55
Loctal	0.55
8 pin DIL	0.15
14 pin DIL	0.15
16 pin DIL	0.17
Valve screening cans all sizes	0.30

CRTs

2AP1*	8.50
2BP1*	9.00
3BP1	8.00
3DP1*	5.00
3EG1*	7.00
3FP7*	3.00
3GP1	6.00
3JP1*	8.00
3JP2*	8.00
3JP7*	10.00
3KP1*	15.00
3RP1*	35.00

4EP1	25.00
4EP7	25.00
4EP11	25.00
5ADP1	35.00
5BP1*	10.00
5CP1*	5.00
5CP1A	40.00
5FP15A	5.00
5UP7*	5.00
DG7-5	25.00
DG7-32	36.00
DH3-91	31.00
DH7-11	68.00
VCR97*	5.00

VCR138*	10.00
VCR138A*	12.50
VCR139A*	8.00
VCR517A*	10.00
VCR517B*	6.00
VCR517C	6.00

Tube Bases 0.75
* = Surplus
VAT 8%

INTEGRATED CIRCUITS

7400	0.20
7401	0.20
7402	0.20
7403	0.20
7404	0.26
7405	0.23
7406	0.55
7407	0.55
7408	0.28
7409	0.28
7410	0.20
7412	0.26
7413	0.45
7416	0.40
7417	0.40
7420	0.20

7422	0.25
7423	0.35
7425	0.35
7427	0.35
7428	0.50
7430	0.20
7432	0.36
7433	0.37
7437	0.42
7438	0.37
7440	0.22
7441AN	0.92
7442	0.78
7447AN	1.20
7450	0.20
7451	0.20

7453	0.20
7454	0.20
7460	0.20
7470	0.35
7472	0.36
7473	0.36
7474	0.40
7475	0.59
7476	0.42
7480	0.60
7482	0.85
7483	1.00
7484	1.00
7486	0.40
7490	0.52
7491AN	0.85

7492	0.60
7493	0.70
7494	0.80
7495	0.80
7496	0.90
7497	3.67
74100	1.75
74107	0.45
74109	0.86
74110	0.57
74111	0.86
74116	1.89
74118	0.95
74119	2.00
74120	1.10
74121	0.45
74122	0.60
74123	1.00

74125	0.80
74126	0.80
74128	0.80
74132	0.80
74136	0.68
74141	0.85
74142	3.00
74143	3.00
74144	3.00
74145	1.00
74147	2.45
74148	2.00
74150	1.75
74151	0.90
74154	2.00
74155	0.90
74156	0.90
74157	0.90

74159	2.50
74170	2.60
74172	5.00
74173	1.75
74174	1.57
74175	1.00
74176	1.10
74178	1.65
74179	1.65
74180	1.65
74190	1.48
74191	1.48
74192	1.25
74193	1.25
74194	1.25
74195	1.10
74196	1.20
74197	1.00

74198	2.25
74199	2.25
76013N	1.75*
TAA570	2.30*
TAA630S	3.50*
TBA480Q	1.84*
TBA520Q	2.30*
TBA530	1.98*
TBA540Q	2.30*
TBA550Q	3.22*
TBA 560CQ	3.22*
TBA673	2.19*
TBA700	1.52*
TBA720Q	2.30*
TBA750Q	2.07*
TBA990Q	2.99*
TCA270Q	2.99*
TCA760A	1.38*

Terms of business: CWO. Postage and packing valves and semiconductors 25p per order. CRTs 75p. Items marked * add 12½% VAT. Others 8%. P&P at 8%.

† Indicates cheap quality version or surplus, but also available by leading UK and USA manufacturers. Price ruling at time of despatch.

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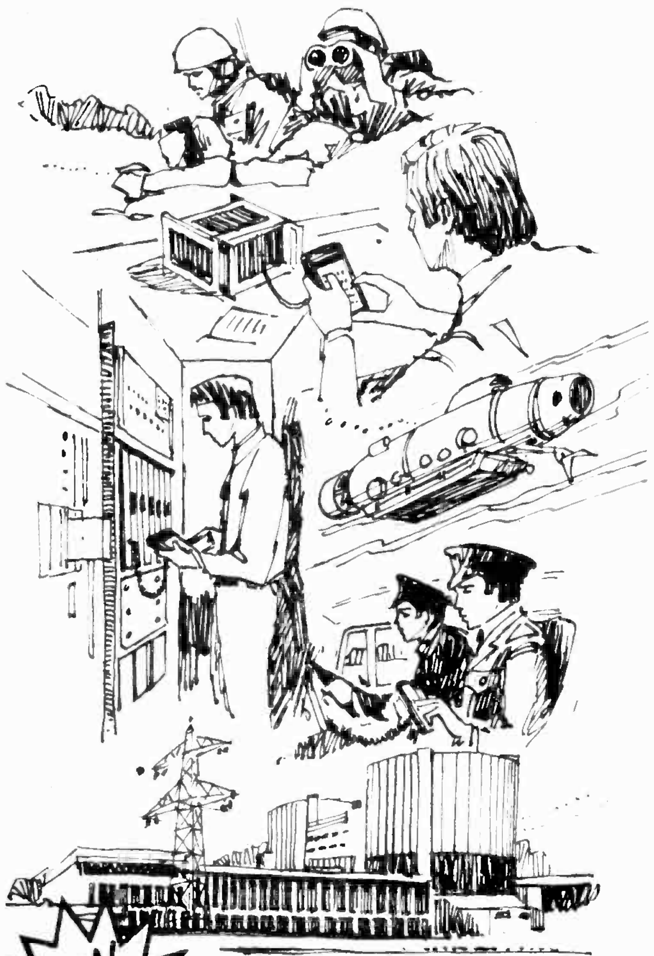

NEW

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Midget duplex unit with man-sized facilities

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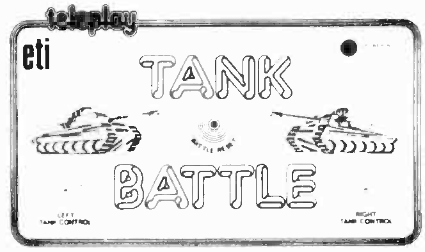

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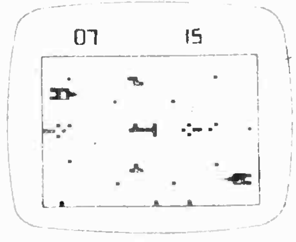

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7408	25p	74128	75p
7409	27p	74132	70p
7410	18p	74136	75p
74H10	28p	74141	75p
7411	24p	74142	320p
7412	25p	74145	90p
7413	36p	74147	190p
7414	75p	74148	160p
7416	33p	74150	140p
7417	36p	74151	72p
7420	18p	74153	85p
7421	40p	74154	150p
7422	22p	74155	90p
7423	37p	74156	90p
7425	30p	74157	90p
7427	37p	74159	190p
7428	36p	74160	100p
7430	18p	74161	100p
7432	36p	74162	120p
7437	36p	74163	120p
7438	36p	74164	120p
7440	19p	74165	220p
7441	75p	74166	160p
7442	70p	74167	340p
7443	140p	74170	250p
7444	140p	74172	720p
7445	120p	74173	160p
7446	100p	74174	120p
7447	70p	74175	85p
7448	80p	74176	120p
7450	18p	74177	120p
7451	20p	74179	160p
7453	20p	74180	110p
7454	18p	74181	298p
7460	18p	74182	82p
7470	36p	74184	160p
7472	30p	74185	150p
7473	34p	74186	920p
7474	34p	74190	120p
74LS74	56p	74191	120p
7475	45p	74192	120p
7476	36p	74193	120p
7480	50p	74194	120p
7481	95p	74195	95p
7482	90p	74196	120p
7483	90p	74197	120p
7484	110p	74198	250p
7485	120p	74199	250p
7486	34p	74221	160p
7489	320p	74251	140p
7490	36p	74265	90p
7491	85p	74278	290p
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CD4025AE	22p
CD4026AE	170p
CD4027AE	65p
CD4028AE	98p
CD4029AE	120p
CD4030AE	55p
CD4035AE	131p
CD4040AE	120p
CD4042AE	90p
CD4043AE	100p
CD4046AE	140p
CD4047AE	100p
CD4049AE	63p
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★SN76023N	Pwr Aud Amp with int HS	16 pin DIL	140p
★SN76033N	Pwr Aud Amp with int HS	16 pin DIL	230p
★SP8515	Prescaler 450MHz ÷ 10	16 pin DIL	675p
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★TAA661B	FM IF Amp Limiter/Det	QIL	120p
★TBA641B	Audio Amp	QIL	250p
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★TBA810	7W Audio Amp	QIL	100p
★TBA820	2W Audio Amp	QIL	80p
★TCA940	10W Audio Amp	QIL	200p
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			C106D		
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3A400V	Stud	100p	2N3525		
7A400V	TO5+HS	90p	5A/400V	TO-66	120p
12A400V	Plastic	160p	2N4444		
16A100V	Plastic	160p	8A/600V	Plastic	185p
16A400V	Plastic	180p	★2N5060		
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15V	7815	100p	15V	7915	120p
18V	7818	100p	18V	7918	120p
24V	7824	100p	24V	7924	120p

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+12V	70p
+15V	70p
−5V	80p
−12V	80p

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AC127	25p
AC128	25p
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AC142	20p
AC176	25p
AC187	25p
AC187K	30p
AC188	25p
AC188K	30p
AD149	65p
AD161	45p
AD162	45p
AF114	30p
AF115	30p
AF116	30p
AF117	30p
AF127	25p
AF139	43p
AF239	48p
BC107/B	9p
BC108/B	9p
BC109/B	10p
BC109C	12p
★BC117	22p
★BC147	9p
★BC148	9p
★BC149C	10p
★BC157	11p
★BC158	10p
★BC159	11p
★BC169C	12p
★BC172	11p
BC177	18p
BC178	17p
BC179	18p
★BC182	12p
★BC183	12p
★BC184	13p
BC187	30p
★BC212	11p
★BC213	10p
★BC214	14p
BC461	36p
BC478	30p
★BC516	60p
★BC517	65p
BCY70	18p
BCY71	22p
BCY72	18p
BD131	63p
BD132	65p
★BD135	48p
★BD136	50p
★BD139	52p
★BD140	58p
BDY56	200p
BF115	22p
BF167	23p
BF170	23p
BF173	25p
BF177	26p
BF178	28p
BF179	33p
BF180	33p
BF184	22p
★BF194	10p
★BF195	9p
★BF196	14p
★BF197	15p
BF200	32p
BF257	32p
BF258	36p
BF259	45p
BF337	30p
★BFR39	30p
★BFR40	30p
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★BFR80	30p
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BFX84	30p
BFX85	30p
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★TIP30C	60p
TIP31A	52p
TIP31C	52p
TIP32A	58p
TIP32C	82p
TIP33A	90p
TIP33C	115p
TIP34A	115p
TIP34C	160p
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2N1132	18p
2N1304	75p
2N1305	75p
2N1306	75p
2N1307	75p
2N1308	75p
2N1309	75p
2N1613	25p
2N1711	25p
2N1893	30p
2N2102	55p
2N2219	20p
2N2222	20p
2N2369	14p
2N2484	30p
2N2904/A	25p
2N2905/A	25p
2N2906/A	24p
★2N2926R	7p
★2N2926B	7p
★2N2926O	10p
★2N2926Y	12p
★2N2926G	12p
2N3053	22p
2N3054	65p

2N3055	48p
2N3439	67p
2N3442	140p
★2N3565	30p
★2N3643	48p
★2N3644	48p
★2N3702	12p
★2N3703	12p
★2N3704	12p
★2N3705	12p
★2N3706	12p
★2N3707	12p
★2N3708	12p
★2N3709	12p
2N3773	300p
2N3866	90p
★2N3903	18p
★2N3904	16p
★2N3905	20p
★2N3906	16p
2N4036	70p
2N4058	15p
★2N4059	10p
★2N4060	13p
★2N4123	22p
★2N4124	22p
★2N4125	22p
★2N4126	22p
★2N4289	20p
★2N4401	27p
★2N4403	27p
2N4427	90p
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2N5194	90p
2N5296	55p
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2N6034	160p
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2N6247	190p
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2N6292	65p
40290	250p
40360	40p
40361	45p
40362	45p
40364	120p
40409	80p
40410	85p
40411	300p
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40594	100p
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★2A 100V	35p
★2A 200V	40p
★2A 400V	45p
★3A 200V	60p
★3A 600V	72p
★4A 100V	84p
★4A 400V	90p
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MOTOROLA 6800 microcomputer system with 28K c.p. memory, VDU, CENTRONICS matrix printer, twin floppy disc drives and various spares and interfaces incl. A-D/D-A converter & R.T. Clock. **£2700.00**
INTERSCAN 6100 minicomputer with VDU, twin floppy disc drives and LOGABAX matrix printer. **p.o.a.**
PDP 8L minicomputer with 12K memory and TTY interface. **£950.00.**
PDP 8S Minicomputer with 4K memory, TTY interface and software incl. BASIC and FOCAL. **£325.00.**
IBM 1130 comprising 8K x 16 processor, E.D.U., selectric keyboard/printer and reader/punch. Software includes FORTRAN IV & disc operating system. **£1875.00.**
LITTON model ABS 1231 with ROYTRON reader/punch, & 40 c.p.s. single-unit typehead printer. **£250.00.**
TELETYPE model ASR 33, with 20 mA interface now available from **£395.00.**
OLIVETTI Model TE 328 Terminal, teletype compatible but with upper/lower case. **£345.00.**
TELETYPE Model KSR 33 in portable 'suitcase' version with RS 232 interface. Nearly new. **£295.00.**
UNIVAC Model 100 semi-intelligent VDU with RS 232 interface. **£350.00.**
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MOORE REED acoustic coupler for RS 232 or 20 mA terminal. 110 Baud only. **£48.00.**
TEXAS INSTRUMENTS Silent 700 terminal for 300 Baud operation. **£525.00.**
LOGABAX Model LX180 dot-matrix printer. 120 c.p.s. In ex-demo condition. **£750.00.**
DIGITAL EQUIPMENT DECwriter II Model LA36. Terminal with matrix printer. New £695.00.
REPCO 120 c.p.s. dot-matrix with parallel TTL interface. **£225.00.**
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TELETYPE model BRPE 110 high speed paper tape punch. **£95.00.**
ROYTRON 50 c.p.s. tape punch (similar to PDP 8/11 punch). **£75.00.**
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DIABLO model 31 exchangeable disc unit. 12 megabit capacity. **£495.00.**
DIGITAL COMPUTER CONTROLS INC. Model D112 4K x 12 memory (substantially PDP 8 compatible). **£75.00.**
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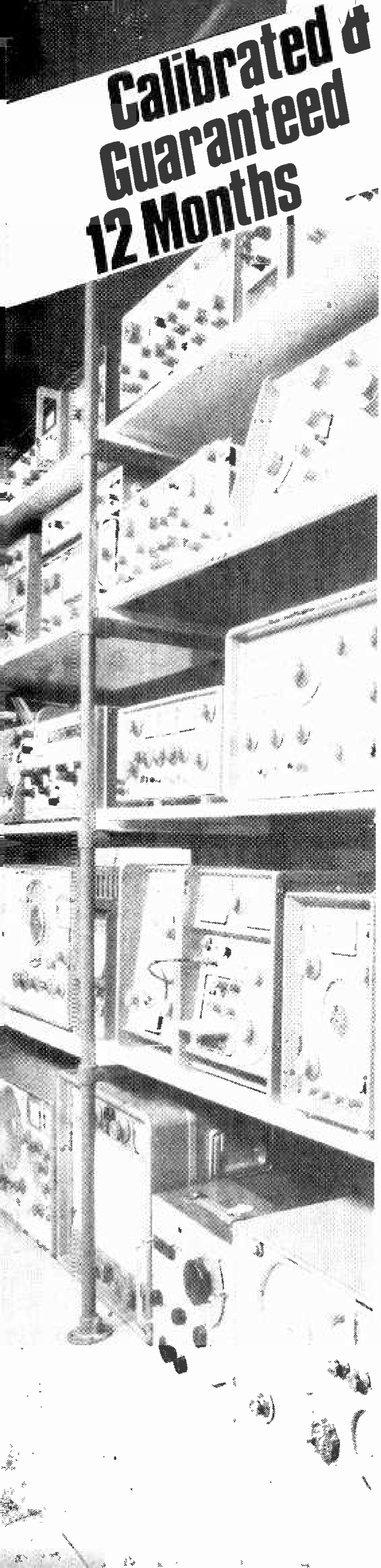
RACAL Lineplexer II. High speed data communications unit. New. **£1500.00.**
TEKTRONIX Model 585 oscilloscope DC-80 MHz and sweep delay. **£275.00**
SE LABS DC-100 Mhz portable oscilloscope with sweep delay. **£450.00.**
GOULD ADVANCE model 232C oscilloscope. Double beam. DC-10 MHz. As new. **£100.00.**
SOLARTRON model L1604/05 AC 4½ digit D.V.M. with internal standard. **£98.00.**
SEFRAM chart recorder, 5-channel. **£75.00.** (Several other recorders available)
FERRANTI Argon-ion LASER with p.s.u., probably in 2-5 mW range. **£75.00.**



Electronic

The Test Equipment People

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Stereocoder Type MSC. BN4192/2. Superb condition £1,200.00
Stereodecoder MSDC. BN4193. Superb condition £850.00
Z-g Diagraph ZDU £860.00
Selective Level Voltmeter . USWV. 30-400 MHZ 10μV-3V £800.00
U.H.F. Millivoltmeter. URV. 1 KHZ-1.6 GHz . . . £235.00

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True R.M.S. Voltmeter 3400A. 1mV-300V (12 ranges) dB range −72-+52 dBm Frequency range 10Hz to 10MHz . . . £415.00
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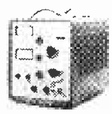
Digital Multimeter 34702A. C/w 34740 display 4½ digit 4 ranges of A.C. & D.C. & 6 ranges of ohms. A.C = 45Hz-100kHz. £350.00



U.H.F. Signal Generator 612A. 450-1200MHz in 1 band. Output Voltage 0.1μV to 0.5V Output impedance 50Ω A.M 0-90% Ext A.M Facility Pulse mod facility Various modern versions from £900.00-£1250.00
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Portable Oscilloscope 1700B. DC-35MHz 10mV/div sensitivity Dual Channel Solid State £575.00

A.C. Voltmeter 400EL. 1 mV-300V 12 Ranges 10HZ-10MHZ BRAND NEW £325.00

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Frequency Synthesiser 6011A. Performs function of an oscillator, counter and level meter 10Hz-11MHz Output 0.4mV-5V r.m.s 7 digit LED display Accuracy ±3 parts in 10' for one year Freq storage Full spec on request . . £2650.00

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Electronic Voltmeter 1806A. AC+DC voltage 9 resistance ranges ±2% accuracy Wide frequency range — up to 1500MHz £175.00

Adjustable Attenuator 874 GAL. 100MHz to 4GHz 120 dB range 50Ω Impedance BRAND NEW £150.00

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Leads, prods & croc clips for models 7, 8 & 9 £4.50 set

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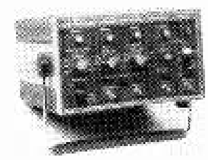
100MHz Double Output Pulse Generator PM5776. Specification on request £900.00

50MHz Pulse Generator PM5712
£495.00



Specification on request

50MHz Pulse Generator PM5715. Specification on request £600.00
Low Frequency Generator PM5105. 10Hz-100kHz sine & Square wave . . £156.00
Sine & Square Wave Oscillator PM5125. 10Hz-1MHz £145.00
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Freq. Period Meter 9520. 5Hz-10MHz. £110.00
Universal Counter Timer 9838. Frequency, single and multiple period, time interval Freq range 10Hz-100MHz . £285.00
H.F. Communications Receiver RA117E. 1-30MHz Full specification on request £350.00
Modulation Meter 210A. 2.5-300MHz. A.M range 0-100%. F.M. range 0 to ±100kHz £245.00-£285.00
A.M./F.M. Modulation Meter 409. Freq. 3-1500MHz A.M 0-100% F.M 0-+600kHz . £345.00

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L.F. Signal Generator G1165B. Solid State, 10Hz-100kHz 1mV-10V 600Ω impedance Square Wave facility £195.00
Wow & Flutter Meter WF971. DIN & CCIR i/p signal 20mV-20V Flutter ±0.1% ±0.3% ±1% i/p impedance 10KΩ . £210.00
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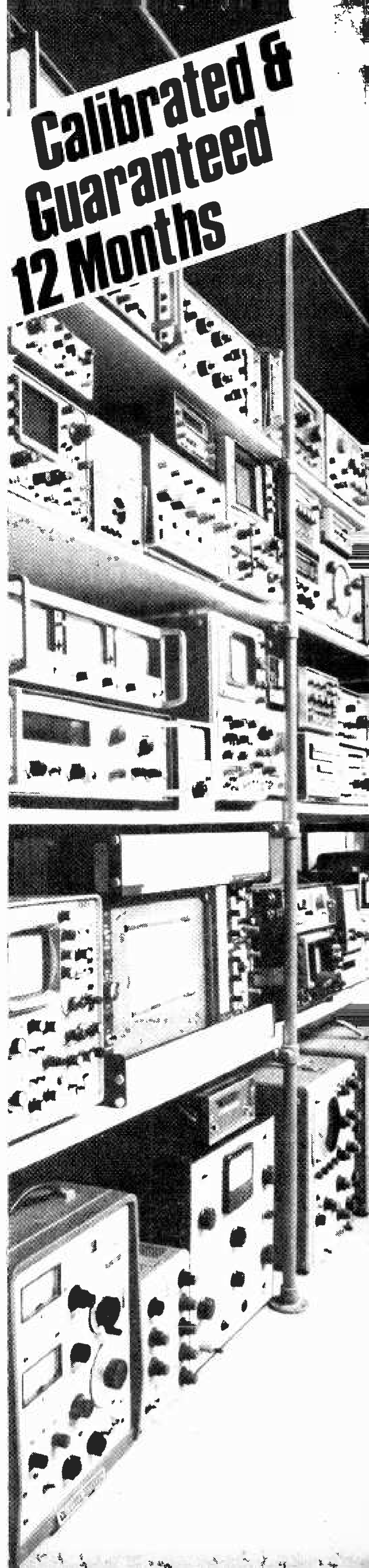


TELEQUIPMENT

Portable Oscilloscope D75. DC-50MHz at 5mV/Div Dual Trace. Delay/Mixed Sweep **£575.00**

MARCONI INSTRUMENTS

Signal Generator TF867. 15kHz-30MHz o/p 0.4μV-4V. Int. & Ext. mod. Supplied with Terminating Unit **£185.00**

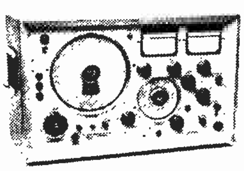
F.M./A.M. Signal Generator TF995B/2. Frequency Range 200kHz to 220MHz in five bands. Output· 0.1μV-200mv. Output Impedance 75Ω. Modulation (F.M.). Normal deviation continuously variable in two ranges ±25kHz and ±75KHz on all bands. Greater deviation is available on most bands. Modulating Frequency Internal FM· 1kHz. External FM. 50Hz to 15kHz. Modulation (A.M.) Internal AM 1kHz, 0-50%. External AM 50Hz to 10kHz, 0-50% . . **£675.00**

U.H.F. Signal Generator TF1060. Frequency range 450-1250MHz (1 band). Output 0.15μV to 445mV. Output Impedance 50Ω. Int. sine A.M.-1kHz. Ext. pulse mod. **£400.00**

A.M. Signal Generator TF144H & H/S. Frequency range 10kHz to 72MHz in twelve overlapping bands. Output Attenuator. 2μV to 2V. Output Impedance 50Ω. Modulation Internal AM: 400Hz & 1kHz to 0 to 80%. External AM 20Hz to 20kHz, 0 to 80% . . . . **£275.00-£400.00**

A.M. Signal Generator TF144H/4. A later version of TF144H with similar spec. . . . . **£375.00-£600.00**

A.M. Signal Generator TF144H/4S. Electrical specification, as TF144H/4 . . . . **£375.00-£700.00**



A.M. Signal Generator TF801D/1. Frequency Range 10MHz to 470MHz in five bands. Output Attenuator 0 1μV to 1V. Output Impedance. 50Ω (Type N connector). Modulation Internal AM 1kHz, 0 to 90% External AM. 30Hz to 20kHz, 0 to 90% . . . . **£400.00-£750.00**

Carrier Deviation Meter TF791D. Carrier Freq. range 4 to 1024MHz. Deviation range up to ±125kHz. Modulating Frequency range Up to 35kHz. Late models **£295.00**

20MHz Sweep Generator TF1099. Video sweep output Lower limit 100kHz fixed Upper limit continuously variable up to 20MHz. 0 3 to 3V p-p. Z=75Ω. Input & Output detector probes. Markers at 1MHz intervals **£295.00**
Oscillator TF1247 (can be used with Q Meter TF1245). 20MHz-300MHz **£350.00**

A.M. Signal Generator TF801D/8S. Same spec as TF801D/1S + freq counter o/p facility **£695.00**

F.M./A.M. Signal Generator TF995A/2M. 1 5 to 220MHz. 2μV to 200mV. int. & Ext A.M. Int. F M at 1kHz deviation 0-75kHz **£375.00-£475.00**

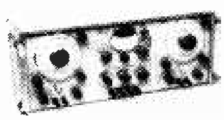
Sensitive Valve Voltmeter TF2600. 12 ranges 1mV-300V f.s.d. 1% accuracy up to 500kHz Usable up to 10MHz . **£175.00**

R.F. Electronic Voltmeter TF2604. 7 ranges 300mV-300V f.s.d. from 20Hz-1500MHz 8 ranges 300mV-1kV DC. 7 ranges. Resistance 500Ω to 500MΩ **£225.00**

U.H.F. Signal Generator TF1060/3A. Frequency range 500 to 1200MHz. Remainder of spec. on TF1060 **£575.00**

R-C Oscillator TF1101. Frequency Range 20Hz to 200kHz in four bands Output Attenuator 1mV to 20V. Maximum Output 20V across external 600Ω load Output impedance 600Ω **£120.00**

Phase A.M. Signal Generator TF2003. 0.4-12MHz **£150.00**



Two-Tone Signal Source TF2005R. Frequency Range 20Hz-20kHz in six bands (each oscillation can be adjusted and used independently). Harmonic Distortion. Less than 0.05% between 63Hz and 6kHz when using unbalanced output. Intermodulation Below 80 dB with respect to the wanted signal Amplitude Reference Level Up to +10dBm from each oscillator. Output Attenuator 111dB in 0.1dB steps . . **£415.00**

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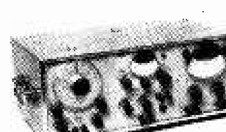
M.F. Oscillator TF2101. 30c/s to 550kc/s Stable frequency. Low distortion. Output Impedance 600Ω unbalanced **£115.00**

F.M./A.M. Modulation meter TF2300S. Incorporating Oscillator TM8045/1 3 5 to 1000MHz Full specification on request . **£825.00**



M.F. Transmission Measuring Set TF2333. Frequency range 30Hz to 550kHz. The TF2333 is a transmission measuring set of the conventional type that normally forms part of the essential test gear for audio and baseband equipment of multi-channel telecommunications systems. Signal Source. oscillator-frequency range 30Hz to 550kHz in five ranges Attenuator, Range 70dB in 10dB and 1dB steps **£600.00**

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M.F. Attenuator TF2162. DC-1MHz 0-111dB in steps of 0 1dB **£120.00**
Also TF1073A Spec as A/2S . **£55.00**
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100-Watt R.F. Power Meter: TF1020A Series. Frequency range D C to 250 MHz. Two power ranges 50 and 100W full scale Output Impedance 75Ω . **£105.00**
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R.F. Power Meter TF1020A/4M1. 75 ohms. 1-50 watts & 2-100 watts. DC-250MHz . **£120.00**
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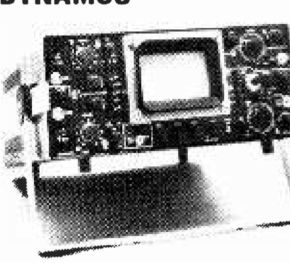
Noise Generator TF1106. 1-200MHz 71 ohm impedance **£150.00**

DYNAMCO



Portable Solid State 'Scope 7500. DC-40MHz 10mV/div sensitivity ×10 gain extends sensitivity to 1mV/div (3Hz-5MHz) Mixed & calibrated sweep delay Dual trace AC & DC coupled Z mod
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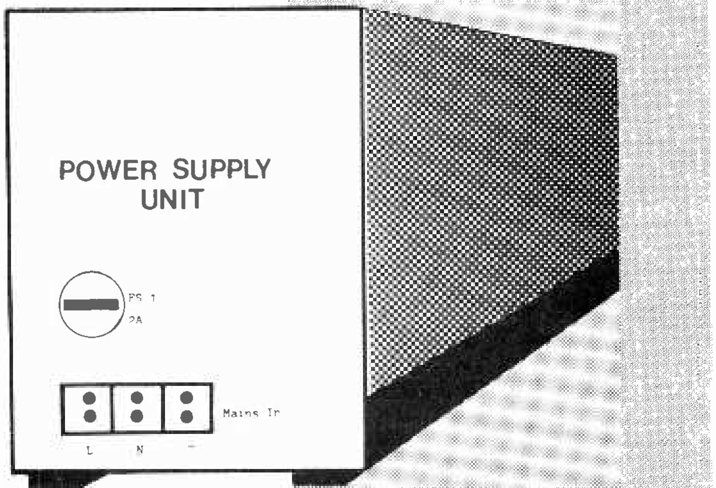
Specifically designed for supplying power for up to 4 diskette (floppy disk) drives.



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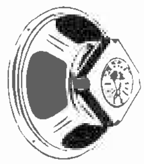

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18" FANE CRESCENDO 18A	101 05	72.95
18' FANE CRESCENDO BASS	89 95	59.95
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Please state impedance required

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CELESTION MH1000 25w	17 00	13.75
FANE 910 MK 150w	17 75	10.99
FANE 920 100w	59 95	44.50
FANE 144 30 50w	7 95	4.95
FANE J73 50w	11 75	7.95
FANE J104 50 70w	16 95	10.95

HIGH POWER 'CROSS-OVERS' Carr 35p	List Value £	Sonic Price £
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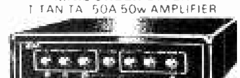

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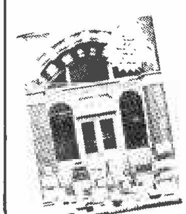

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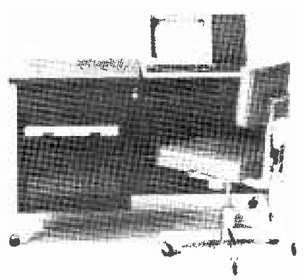

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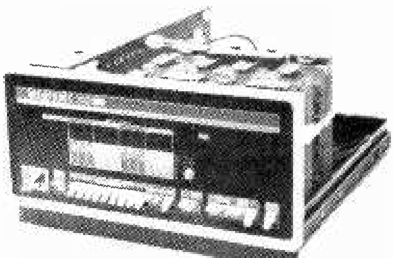

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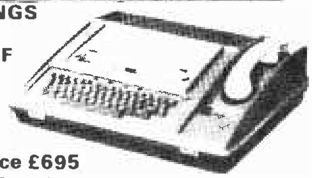

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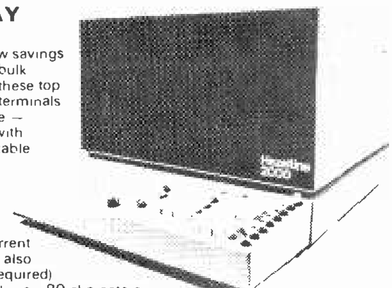

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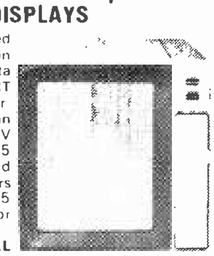

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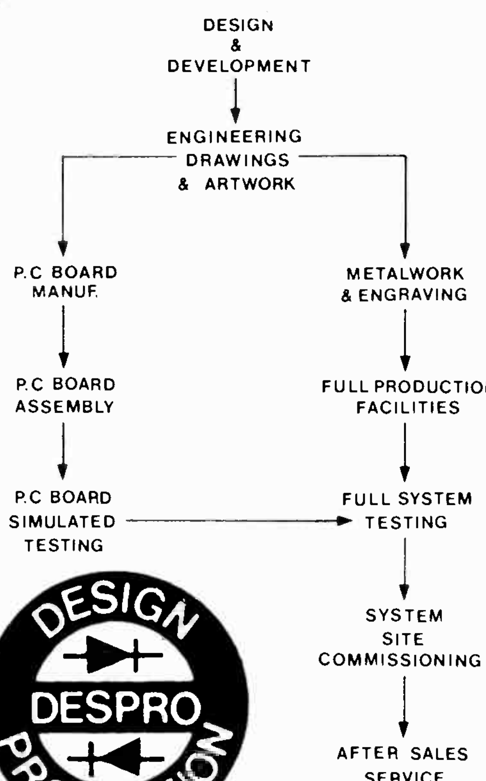

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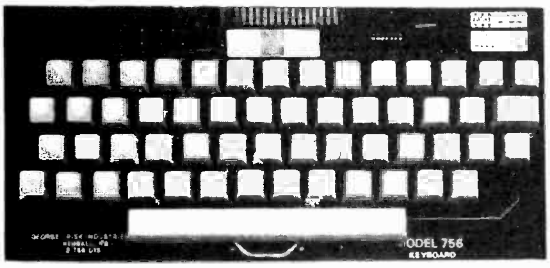

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Full ASCII
Keyboard

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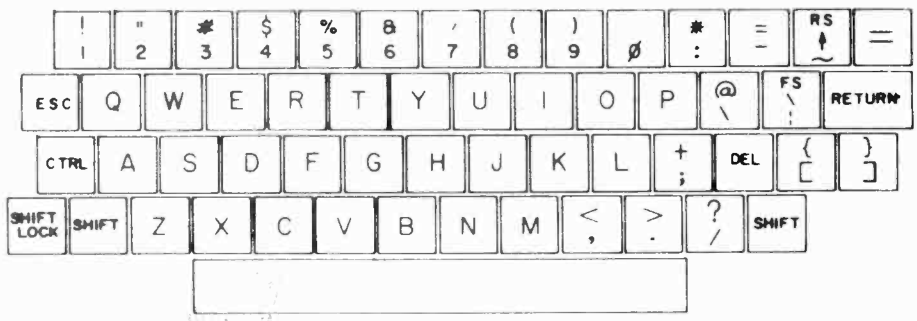

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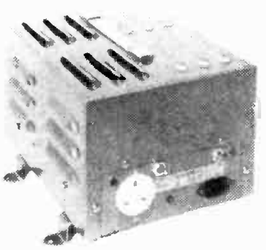

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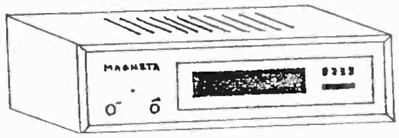

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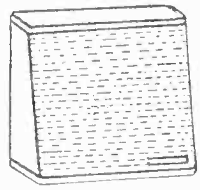
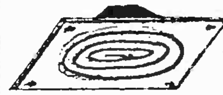
with internal mains psu and 25 watt mono amplifier (100V line). To plat standard 8-track cartridges. All contained in a smart veneered wood cabinet, size approx. 14" wide x 5½" high x 11" deep. Supplied with circuits. Brand new and boxed. SPECIAL OFFER £35.00 each + 12½% VAT.



TYPE L4 PORTABLE SPEAKER CABINET

Smart woodgrain Formica type finish with nylon grille. 15" high x 14" wide x 7" deep (tapering), containing 10" round 15 ohm full range speaker + 100V line transformer. £7.00 each + 12½% VAT.



TYPE M704 CEILING SPEAKERS

White plastic fascia 10" square, for recess mounting into ceiling, with 8" dia. 15 ohm full range speaker. £4.00 each + 12½% VAT.

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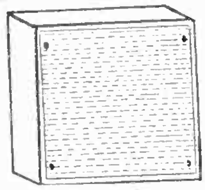
10" dia. 15 ohm. £5.00 each (or 2 for £9.00) + 12½% VAT.



SPEAKER CABINET TYPE M321

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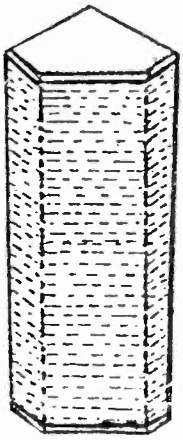

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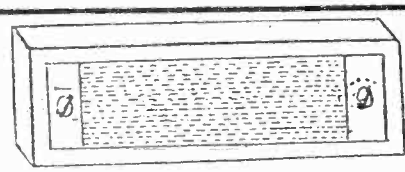

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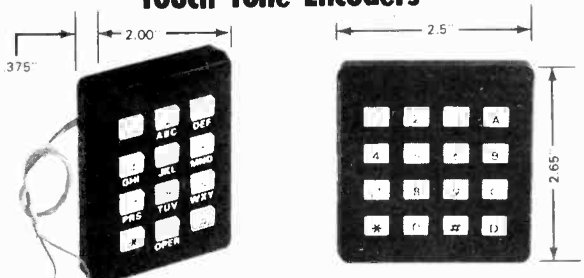

PP-1 PP-2

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(8196)

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(8125)

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8176

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Application forms from Personnel Officer, Royal Observatory, Blackford Hill, Edinburgh.

(8175)

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(TECHNICIAN GRADE 6)

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8131

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Period of Employment	Company & Location	Products	Job Title	Responsibilities	Reason for leaving	Final Salary
1. Current or last employment From: To:						
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☐ UHF/VHF. Comms.	☐ Microwave	☐ Radar/Navaids	☐ Medical Electronics
☐ Signalling Systems	☐ Security Eqpt.	☐ Avionics	☐ Simulators
☐ Weapons	☐ Scientific Eqpt.	☐ Data Recorders	☐ Photocopiers
☐ Phototypesetting	☐ Servo-mechs.	☐ Components-Active	☐ Components-Passive
☐ Production Eng.	☐ Electrical Eng.	☐	☐

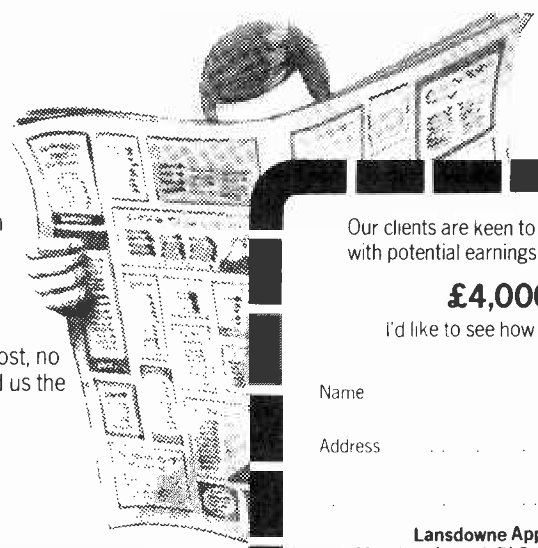
Others - Please state.

Please indicate any Companies you do not wish us to contact.

If you wish to detail further aspects of your experience or job requirements, please enclose on a separate sheet.

(8159) WW2

The job you're now looking for we've probably already found.



We're in touch with over 3000 major companies who are continually looking for key personnel like you – but who don't always advertise.
Instead, they send us a brief which we compare to the requirements of candidates on our register. Then we draw up a shortlist.
The next time we're asked, we could mention your name.
All you have to do is clip the coupon, we'll send you a confidential application form . . . consider it an interview and give us relevant details about yourself. There's no risk, no cost, no obligation and no time-wasting. Simply send us the form and we'll do the rest.
We'll find you one of those jobs you usually hear about after they've been filled.

Our clients are keen to meet men and women, aged 20-40 years with potential earnings of between

£4,000 and £7,000 p.a.

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Foreign and Commonwealth Office has a vacancy for an

Electrical/Electronic Draughtsman/Woman

Based at Kingstanding, near Crowborough, Sussex

The work is involved in Sound Broadcasting and associated services, including Power Supply Systems at HV and LV.

The successful applicant will have abilities in solid state and vacuum tube circuitry, PCB design, electrical control and power distribution systems.

Qualifications required:

ONC in Electrical or Electronic Engineering or an equivalent or higher qualification acceptable to the Civil Service Commissioners.

All candidates must have served an apprenticeship, or have had equivalent training of at least 3 years' appropriate to the duties of the post. In addition, they must have had not less than one year's full time experience of drawing office work.

SALARY: Starting salary is according to age, eg age 21—£2425 per annum; age 25—£2785 per annum and age 27 (or over on entry)—£2970 per annum. The maximum of the scale is £3450 per annum. In addition, all points on the salary scale attract Pay Supplements of £313.20 per annum and 5% of total salary with a minimum of £10.88 per month and a maximum of £17.40 per month.

Please apply to:
Recruitment Section, Foreign and Commonwealth Office
Hanslope Park, Hanslope, Milton Keynes MK19 7BH

(8185)

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facetiousness, flamboyant statements, and downright vulgarity to attract attention to our company's advertisements

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Like those illustrious ladies, we don't reveal all (our vacancies) — just sufficient to whet the appetite

1 PROJECT DESIGN ENGINEER

RF equipment particularly frequency synthesisers and spectrum analysers. To £7,000

South Coast

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Vacancies throughout UK for field service, permanent site, systems test or technical support. Salaries vary enormously, but up to £11,000 for IBM 360/370 experience

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Modems and multiplexers for dynamic group marketing US projects. To £6 500

Middlesex

4 DESIGN DEVELOPMENT ENGINEERS

For advanced projects group working on application of advanced technology to the widest range of communications imaginable. DC-Blue Light. To £7,000

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Always in demand
TEST ENGINEERS, COMMISSIONING ENGINEERS, TRIALS ENGINEERS, TECHNICIANS.
Also:
NEW GRADUATES, COLLEGE LEAVERS and H.M. FORCES PERSONNEL.

For further details of qualifications and experience required, salary levels and precise geographical locations, telephone 01-581 0286, or write to

(8173)

Charles Airey Associates
RECRUITMENT CONSULTANTS TO THE INDUSTRY. 155 Knightsbridge, LONDON SW1. Tel: 01-581 0286

Interested in Electrical/ Electronic Engineering

The Electrical/Electronic Function of Leyland Cars designs and develops a complete range of installations and components for our current and future models, ensuring they stringently adhere to performance and reliability standards and comply with company and world market legal requirements. Our existing engineers are involved with vehicle lighting, switchgear, fascia instruments, in-car entertainment and photometrics.

Do you have the qualifications or relevant experience to compliment our existing team? Our need is for ....

Design and Development Electrical/ Electronic Engineers

As we are prepared to consider "on the job" training applications are invited from people who have a fundamental knowledge of electrical circuitry, wiring installation design, automotive electrical/ electronic systems or similar technologies practised in other fields.

Appointments are available at...

Longbridge (a) Solihull (b) and Coventry (c) establishments in the Birmingham area.

Current rates of pay...

salaries will be in accordance with academic background and experience. Excellent prospects for promotion. We do have a few vacancies at the more senior level for which exceptional candidates may be considered.

Conditions of employment...

relocation assistance, discounts for car purchase and accessories, generous holiday entitlement and other benefits appropriate to a large company.

Amenities...

all the establishments are close to attractive rural surroundings with a wide range of available housing, Schools, Universities and facilities for leisure pursuits are all locally available.

How to apply...

Please write for an application form or post the coupon to me. Local interviews can then be arranged.

Leyland Cars

Name:.. Age:............

Address:...

....

Area: a b c *

Electrical/Electronic Design/Development *

*Please delete as appropriate. (8192)

M. D. Ray, Recruitment Co-ordinator, Product Engineering Division, Leyland Cars, Broad Oaks, 550 Streetsbrook Road, Solihull, West Midlands B91 1QX.

These vacancies are open to both male and female applicants.

DEPARTMENT OF CHEMICAL AND BIOCHEMICAL ENGINEERING

ELECTRONIC TECHNICIAN

Grade 6

required for the electronic workshop. Good knowledge of fault-finding and servicing standard electronic instruments required, together with the ability to work on prototype circuits. Salary in the range £4,119-£4,830 including London Weighting.

Application form and further details from Personnel Officer (Technical Staff EB10), University College London, Gower Street, WC1E 6BT

(8143)

STUDIO MAINTENANCE

A new Studio Complex at Dick James Music requires an experienced person to work on our MCI recording equipment. JH 500 desks. JH 16, 24 tracks JH 110 four and two tracks.

The complex includes main control room, mix down room, tape copy conference room and workshop. Salary negotiable.

If you are interested telephone **Terry Ralph-Knight on 01-242 6886, Ext. 265.**

8154

THE UNIVERSITY OF HULL

VISION / LIGHTING SUPERVISOR : AUDIO VISUAL CENTRE

Applications are invited for the above post which is available immediately. Candidates should have an HNC or equivalent qualification, and relevant experience in operations and maintainence in broadcast and/or educational television. Salary will be on the Grade 7 scale for University Technical Staff (£4,254 x 4 increments — £4,782)

Applications, giving details of age, qualifications, experience, and the names of two referees, should reach the Personnel Officer, University of Hull, HU6 7RX, by 2nd June. Further particulars are available. (8184)

UNIVERSITY OF ABERDEEN
THE DEPT. OF BIO-MEDICAL PHYSICS AND BIO-ENGINEERING

SCIENTIFIC OFFICER

for well equipped Electronic Section (staff 15 total) associated with design, servicing and maintenance of modern electronic equipment (including Nucleonics). Work in hospital as well as laboratory environment. Expected to guide technicians.

Salary on research and analogus scale R.A.S. (R.I.A.), £3660-£6178 per annum, with appropriate placing.

Further particulars from the Secretary, The University of Aberdeen with whom applications (2 copies) should be lodged not later than 10th June '78. (8198)

Radio Officers

Sea Sick?

If you've seen quite enough of the sea, and are thinking now of a shore-based job that suits your qualifications, the Post Office Maritime Service can offer you interesting work, job security, good pay, plus the pleasure of enjoying all the comforts of home where you appreciate them most – at home!

Vacancies exist at several coast stations for qualified Radio Officers to carry out a variety of duties that range from Morse and teleprinter operating to traffic circulation and radio telephone operating. And for those with ambition, the prospects of promotion to senior management are excellent.

You must have a United Kingdom Maritime Radio Communication Operator's General Certificate or First Class Certificate of proficiency in Radio-telegraphy or an equivalent certificate issued by a Commonwealth Administration or the Irish Republic. And, ideally, you should have some sea-going experience.

At 25 or over, salary starts around £4093 and after three years, rises to around £5093. (Starting salary for those between 19-24 varies between £3222-£3732.) Overtime is additional, and there is a good pension scheme, sick-pay benefits and at least 4 weeks' holiday a year.

For further information, please telephone Andree Trionfi on Freefone 2281 or write to her at the following address:
ETE Maritime Radio Services Division ( ),
ETE17.1.1.2, Room 643, Union House,
St. Martins-le-Grand, London EC1A 1AR.

Post Office Telecommunications

Service and Test Engineers

As aircraft and electronics equipments become more sophisticated and our servicing programme expands, the need for experienced Service and Test Engineers increases.

At Stanmore, we are involved in the provision of spares and the repair, maintenance and overhaul of a variety of British and American airborne electronic equipment.

We need Engineers who can successfully maintain the high standards and efficiency required both in the aircraft and the workshop.

It's skilled work, calling for sound practical experience of radio and electronics theory, ranging from audio to microwave and including the use of advanced test equipment for fault diagnosis. Training in this field will be given to suitable, less experienced engineers.

The Company offers excellent salaries and benefits together with first-class working conditions in well-equipped workshops. This Unit is conveniently situated in pleasant surroundings within easy reach of the A1 and M1.

MARCONI AVIONICS
A GEC-Marconi Electronics Company

If the job sounds interesting and you'd like to put us to the test, write with details of experience to:
Mrs. E. Wagg
Marconi Avionics Ltd.
22-26 Dalston Gardens, Stanmore, Middlesex
HA7 1BZ.
Tel: 01-204 3322

We pay top salaries for the right engineers
Starting at £4000 p.a. for Bench Engineers
Increasing appreciably for Field Service Engineers

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Knowledge or experience of mobile V.H.F. equipment is what we're looking for. Call Mike Rawlings or Bill Clarke on 01-328 5344 Now!
(7994)

London Communications
(Equipment) Ltd
30 Boundary Road London NW8 01 328 5344

IMPERIAL COLLEGE
TECHNICAL STAFF
Grade 5 Electronics

Vacancy for a competent technician in a university computing department. Candidates should have ONC or City and Guilds Electrical Technicians Part 1 Certificate or equivalent and have experience with construction and maintenance of computing equipment and peripherals. Salary in the range £3651-£4185 per annum. Five-day week 9.00 to 17.30 hours. Four weeks paid annual leave plus additional days at Christmas and Easter.

Please apply in writing with full details of qualifications and experience to Mr M. D. Cripps, Department of Computing and Control, Imperial College, London SW7 2BZ, as soon as possible.
(8129)

We like to think we're perfect. With your skills we could keep it that way.

As the ICL success story continues our Spares Division Operations Centre in Stevenage becomes even more important. We provide a computerised spares service for some 126,000 live line items to customers and engineers worldwide, along with our nationwide network of stores and workshops. Essential to our operation are the following people.

Project Leader
Test System Software
c£5500

We have an elite team of young graduates writing test programs for our Computer Aided Repair System F.I.Ts. This is a unique opportunity for a logic or circuit designer who is seeking a first management appointment in the field of microprocessor test equipment development. You will have a degree in physics, electronics or electrical engineering, understand the concepts of microprocessor techniques and have the ability to comprehend the hardware and software requirements in this field. Probably around 26 with good communication skills you should be able to motivate and work with the team already established. Ref. WW 1785/A.

Spares Analyst
c£5200

Your main responsibility will cover forward planning for equipment. As well as having a formal electrical engineering qualification, your experience will have equipped you to handle the long-term strategic planning and logistics of spares within economic constraints. We will be looking for someone with initiative and a high standard of literacy and accuracy, and preferably experience in the electronics industry. Ref WW 1785/B.

In addition to the salaries (which are due for review in June) you will be eligible to participate in our 1978 Productivity Bonus Scheme. We'd also like to tell you about our first-class training schemes, our subsidised canteen and our thriving local sports and social activities. Relocation assistance will be given in appropriate cases.

Interested? Send brief career details, quoting the appropriate reference, to: Jeff Neal at ICL, Spares Division, Cavendish Road, Stevenage or telephone him on Stevenage (0438) 3361 ext 555.

International Computers ICL

think computers – think ICL

(8122)

WAREHOUSE MANAGER

experienced in the electronics industry, required by small export company, to supervise usual warehouse activities, particularly branding, boxing, packing and testing of electronic values. Salary dependent on experience. Minimum £4 000 p a plus possible use of car

PLEASE RING: 01-348 3438 (8161)

THE ROYAL FREE HOSPITAL

MEDICAL PHYSICS TECHNICIANS (ELECTRONICS)

2 vacancies exist in the Electronics Workshop of this new major Teaching Hospital. Applicants should hold the City and Guilds Full Technological Certificate or an equivalent qualification. Experience in analogue and digital circuit techniques essential.

Salary on scale £3,776-£4 708 dependent on qualifications and experience and including all allowances

Application form and Job Description from the Personnel Department. The Royal Free Hospital 21 Pond Street Hampstead London NW3 2PN Tel 01-794 0431 Please quote refs 0758 and 0760

Camden and Islington A H A (T)

(8150)

VTR ENGINEERS

for Africa and Middle East

Up to

£24,000 p.a.

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(8177)

POSTDOCTORAL AND PREDOCTORAL OPENINGS

INTERDISCIPLINARY RESEARCH IN VISION, HEARING AND SOMATOSENSATION APPLIED TO MEDICAL AND AVIATION PROBLEMS

There are postdoctoral openings for candidates with a Ph.D. in physics, electrical (electronic) engineering, physiology or psychology (psychophysics).

There are predoctoral openings (M.A. and Ph.D. research for candidates with a strong quantitative background in one or more of the following areas: psychology (psychophysics), physiology, physics, electrical (electronic) engineering, medical physics, computer science.

Working within a Research Unit of Applied Psychology attached to the Medical School, postdoctoral fellows and graduate students learn to combine the skills of psychophysics, physics, electronics and physiology. They have the opportunity to work with patients, applying the results of basic research in vision, hearing and somatosensation to solving practical problems in neurology, ophthalmology, and otolaryngology. Contrasting research is directed towards identifying the ways in which the eye and visual pathway in skilled flyers, drivers and gamesplayers are better than average.

The three available areas of research are:

(1) Applying sensory psychophysics and techniques for recording electrical brain signals (evoked potentials) to aiding the diagnosis and management of organic diseases that affect sensory pathways (e.g., multiple sclerosis, squint, deafness).

(2) The development of psychophysical and evoked potential methods to detect damage to the sensory nervous system caused by exposure to toxic environmental pollutants.

(3) The application of fundamental research on visual psychophysics to improving safety and performance in aviation and road transport.

Further details from Dr. D. Regan, Research Unit of Applied Psychology, Department of Psychology, Dalhousie University, Halifax, Nova Scotia, B3H 4J1, Canada. Telephone: (902) 424-2552

Electronics Research and Development with Ferranti

Expansion and re-organisation within the Aircraft Equipment Department has created a number of interesting positions in the R & D laboratories at Bracknell.

The Department which is active in both Civil Aviation and Defence fields, with airborne and ground based equipment, covers a broad range of activities extending from medium/high power electronics to work with low power microcircuits.

The following positions have arisen:

SENIOR ENGINEER to lead a small group associated with light current equipment. The candidate should have at least two years experience in industry with a good knowledge of signal processing and use of digital techniques in the communications field. Ref: A/174/WW

SENIOR ENGINEER to work with control systems. The candidate should have proven design experience with low power circuits. A knowledge of the use of microprocessors would be an advantage. Ref: A/175/WW

The above positions are open to professionally qualified Electronics Engineers.

IN ADDITION we have a number of other interesting vacancies for candidates of graduate experience.

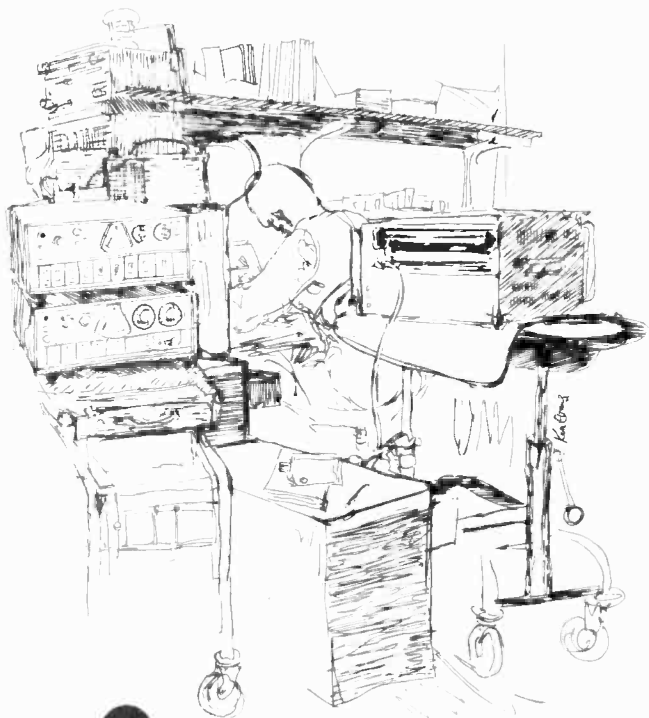
These posts should be regarded as stepping stones to higher positions within a technically orientated company. Highly competitive salaries will be paid. The laboratories are located in a pleasant manor house situated on the outskirts of Bracknell.

Application forms may be obtained by writing to Mrs. J. Hunt, Ferranti Limited, Lily Hill House, Lily Hill Road, Bracknell, Berkshire, or telephoning Bracknell 24001 ext. 8.

FERRANTI
Selling technology

(8152)

Marconi Instruments



ELECTRONIC TECHNICIANS

Opportunities for the experienced and sometimes inexperienced in St. Albans and Luton.
Work situations range from fault finding on PCB's and components, to batch product testing of equipment that utilise very advanced techniques including microprocessors and the repair/ calibration of all manner and types of test instruments.
Attractive salaries and, where appropriate, relocation are offered for the right candidates.
Further information may be obtained in confidence from John Prodger
Marconi Instruments Limited,
Longacres, St. Albans, Herts. tel: St. Albans, 59292

A GEC-MARCONI ELECTRONICS COMPANY

mi

UNIVERISTY OF SUSSEX
School of Engineering and Applied Sciences

RESEARCH VACANCIES

involving
Microprocessors
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A small number of research studentships are available for well qualified applicants. Application forms and further details from

P. Cooke
Postgraduate Admissions Tutor
School of Engineering and Applied Sciences
University of Sussex
Falmer, Brighton, Sussex
BN1 9QT (8179)

THE BRITISH COUNCIL
invites applications for the following post
King Abdul Aziz University, Jeddah, Saudi Arabia
English Language Centre

ELECTRICAL ENGINEER

to help service the language laboratories and studios.

The English Language Centre, which is fully established with its own graphic, photographic, reprographic, television and sound studies and two language laboratories, trains students in English medium study skills, mainly for the Colleges of Engineering and Medicine.

Salary scales depend on family circumstances. The following monthly scales may be taken as a guide:
Single SR 3895 to SR 4485.
Married with two children over 5 years old at post: SR 6480 to SR 7070.
At the end of the first year's service staff are eligible for an increment.

Free furnished accommodation is provided. Return air fares are provided at the beginning and end of each year of contract for the staff member and up to three members of his family.

The contract, which is for one year, and is renewable, is guaranteed by the British Council.

Please write briefly stating qualifications and length of appropriate experience, quoting relevant reference number 78 WW69 and title of post, for further details and application form to The British Council (Appointments), 65 Davies Street, London W1Y 2AA. (8149)

Teaching Telecommunications in Saudi Arabia

can earn you at least £14,400 tax free per two year contract.

Lockheed Aircraft International are responsible for a large number of major contracts covering telecommunication services throughout Saudi Arabia. There is now a requirement for a Technical Instructor to provide classroom, laboratory and on-the-job training covering a broad telecomms spectrum with particular emphasis on SHF, line of sight links and associated multi-channel equipment. Other areas will include HF, VHF, and UHF band equipments and FSK, VFT and message switching equipment.
Responsibilities will include preparation of all course material, syllabuses, training aids and student handouts as well as evaluation of student performance.

It requires an HNC or equivalent qualification with a good practical broad based telecommunications background and a minimum of three years' technical teaching experience.
There are excellent prospects of employment beyond the contract period. Benefits include:
- free bachelor accommodation, food and laundry,
- free medical care and life insurance,
- good recreational facilities,
- two free flights home to the UK annually.

Write with brief details, quoting Ref. 184, to International Aeradio Limited, Aeradio House, Hayes Road, Southall, Middlesex. Telephone: 01-574 5000.

IAL LOCKHEED INTERNATIONAL

AUTOMATIC TEST EQUIPMENT PROGRAMMER

Crosfield Electronics Limited, a division of the De La Rue Company Limited, design, develop and manufacture a wide variety of sophisticated printing press control products and the Magnascan range of Electronic Colour Scanners for the printing industry.

This Company is due shortly to take delivery of a GENRAD GR1799 ATE which will supplement the existing MEMBRAIN ATE operation. As a direct result of this expansion an additional Programmer, who should ideally have at least one year's previous experience in ATE programming, is currently sought. However, applicants with a background in Test Equipment Design or Electronic Testing that has involved some degree of Software Application would also be of interest to the Company.

The responsibilities of the successful candidate, either male or female, will include involvement in generating Test Programmes for Analogue and Digital Hybrid PCB's and the design of Interface Adaptors, all of which will require close positive liaison with the Research and Development Department. The position also entails providing a supporting role to the overall Test function.

In addition to an excellent salary, there are attractive fringe benefits and relocation costs will be met by the Company, where appropriate. Good career development prospects also exist in this rapidly growing Company.

Please write or telephone for an application form to:— Mrs. A. Ellis, Personnel Department, Crosfield Electronics (Westwood) Limited, Bretton Way, Bretton, Peterborough PE3 8YB.
Telephone Peterborough (0733) 267504

8172

Crosfield Electronics

A De La Rue Company

1973 1976

PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY

invites applications for the post of

TECHNICAL INSTRUCTOR (Communication)

in the Department of Electrical and Communication Engineering at the above-mentioned university.

Applicants should be qualified to at least technician engineer level and should be experienced in broadcasting, digital or microwave systems. Applicants with teaching experience at technician or technician engineering level are preferred.

Salary, which is paid in Kina, will commence at K8943 (K1 = 69p). In addition an allowance of K1300 (single), K2300 (married), plus K156 (per child), is payable annually. Conditions of appointment, which will be for a 3 year period, will also include furnished housing at a nominal rental, six weeks leave per year with fares assistance provided. Generous education allowance (including fares) for children undergoing secondary education overseas, and superannuation benefits.

Applications, which should be in duplicate, should state age, family particulars, qualifications, experience, present post and names and addresses of three referees from whom confidential enquiries may be made, and should be directed to The Registrar, The Papua New Guinea University of Technology, PO Box 793, Lae, Papua New Guinea. An additional copy of the application should be sent to the Association of Commonwealth Universities (Appts.), 36 Gordon Square, London WC1H 0PF, from whom further information can be obtained.

(8127)

APPOINTMENTS IN ELECTRONICS

Take your pick of the permanent posts in:

MISSILES — MEDICAL
COMPUTERS — COMMS
MICROWAVE — MARINE
HARDWARE — SOFTWARE

For expert advice and immediate action on career improvement, 'phone, or write to, Mike Gernat BSc

Technomark
Engineering and Technical Recruitment
11 Westbourne Grove
London W2 01-229 9239

ITN

Senior Engineers VTR Operations

Salary £5920 per annum

Independent Television News Ltd. has vacancies for Senior Engineers in the ITN Facilities Centre in Central London. Applicants should have several years' experience of broadcast VTR operation including editing and preferably maintenance.

The work covers a wide vareity of programmes including news, commercials and feature material.

Contributory pension scheme and free life assurance.

Please telephone the Personnel Office 01-637 3144 for an application form quoting reference number 8302

8205

Guy's Health District

Medical Physics Technician Grade III

for the **DEPARTMENT OF CLINICAL PHYSICS AND BIOENGINEERING based at Guy's Hospital.** The Technician will join a team of Physicists and Technicians engaged on design, development, maintenance and repair of a wide range of electromedical equipment. Minimum qualifications are an O.N.C. and at least 3 years' experience as a qualified electronics/electrical technician.

Salary £3,776 p.a. rising to £4,708 p.a. inclusive (increase pending).

Apply to Mrs. C. Drew, Personnel Officer, Guy's Hospital, London, SE1 9RT. Telephone: 01-407 7600, Ext. 3462.

8151

TELEVISION ENGINEERS

The Media Department of the British Council has two vacancies for broadcast engineers in its studios in Tavistock Square, London. The studios are used to train personnel from countries overseas in broadcasting techniques and for the production of videotapes, films and other audio-visual programmes.

For the more senior post we are looking for someone who will be responsible for the operation and maintenance of the TV Studio and its associated equipment. Experience in TV studio operations, vision control and camera line-up is essential, and experience in quad videotape and lighting operations desirable. Applicants should have broadcast engineering training, or be in possession of a full City and Guilds Telecommunications Certificate, HNC or equivalent. Annual starting salary is £4767 rising by three annual increments to £5202. (Pay rise pending.)

For the less senior post we require someone with some studio experience who will be responsible for the operation and maintenance, under supervision, of the TV sound area. Experience of camera, videotape and lighting equipment would be an advantage. Applicants should have the City and Guilds Telecommunications Intermediate Certificate, or ONC or broadcast engineering training. Annual starting salary is according to age ranging from £3489 at 21 to £4462 at 28 and over. Thereafter salary rises by annual increments to £4767. (Pay rise pending.)

Some of the training takes place overseas and there may be occasional opportunities for travel. Annual leave for both posts is 22 days plus 2½ privilege days and there is a non-contributory pension scheme.

For further details and an application form telephone 01-499 8011 extension 3028 or write to Staff Recruitment Department, The British Council, 65 Davies Street, London W1Y 2AA, quoting reference HS/7.

(8132)

TECHNICAL ASSISTANTS TRANSMITTER DEPARTMENT

We have vacancies for Technical Assistants to work as members of engineering teams based at Radio, Television Transmitting Stations throughout Great Britain.

These staff will be involved in the operation and maintenance of a wide range of transmitting and receiving equipment. They will receive full time training, successful completion of which they will qualify internally as BBC Engineers and will have received a BBC certificate.

Applicants, male or female, should be aged between 18 and 26 and have normal colour vision and hearing and a good general education offering 'O' levels (grades A, B, or C) in English, Mathematics and Physics and have read up to 'A' level in Mathematics and Physics. Alternatively an ONC or Part 1 of the City & Guilds T.T.C. (No. 271) would be acceptable.

Candidates should have a relevant practical interest in transmission or electronic techniques and be able to demonstrate their ability to apply their knowledge of electrical principles to practical problems.

Salary: Depending upon experience will be in the range of £2,500 - £2,720 p.a. Additional payments may be made for shift working irregular hours and overtime.

For further details and application form write to **The Engineering Recruitment Officer, BBC Broadcasting House, London W1A 1AA** quoting reference No. 78.E.(TX)4042/WW and enclose an addressed envelope at least 9" x 4." Closing date for completed application forms is 14 days after publication.

BBC

8144

ORBITRON ELECTRONICS LTD.
require an

AUDIO ENGINEER

Small Audio Manufacturing Company requires young electronics engineer with interest in Audio effects and amplifiers, capable of taking projects from prototype through to production. The Company is growing and requires someone to grow with it. Salary negotiable.

Apply in writing to
ORBITRON ELECTRONIC PRODUCTS LTD.
449B Alexandra Avenue
South Harrow, Middx. (8158)

THE DECCA NAVIGATOR, one of the Decca Group of Companies specialising in sophisticated avionic navigation systems, require experienced

ENGINEERS

for repair and overhaul of airborne, avionic equipments. To be based West of London.

Applications will be considered from engineers with experience of complex Electronic equipment.

These positions provide a support to customers both in UK and abroad and successful applicants may be required to travel within the UK and for short visits overseas.

Generous remuneration depending upon experience and qualifications.

Please write, giving details of age, experience and present salary, to:

Miss B. J. Eatly-Hunt
DECCA NAVIGATOR COMPANY LIMITED
Spur Road, Feltham, Middlesex

Microprocessor Development

An Engineer with Microprocessor and CMOS/TTL design experience is required to undertake the development of an automatic batch weighing system. It is intended that the successful candidate will be uniquely responsible for this particular project within the development team.

Control Systems Engineers

Isca Electronics is an expanding Company in the field of automatic batch weighing and process control. Vacancies exist for Project Engineers and Assistant Project Engineers with an electronics background. The positions offer good salary, interesting and varied work and include some travelling.

Please contact Mr. P. Avon.

(8153)

ISCA

Isca Electronics Limited,
Newtown Industrial Estate,
Crosskeys, Newport, Gwent.
NP1 7PX Great Britain.
Tel: Crosskeys (0495) 270671
Telex: 497437

We are broadening the scope of the technical services to our engineering laboratories and need to appoint an additional

STANDARDS ENGINEER

The Job

To provide a total component selection service to our development engineering staff from a well established standards base.

Our immediate objective is to publish internally a range of catalogues of preferred components and the control of working party activities in this role is important.

A working knowledge of BS9000 and CECC specification systems is required and success in the job may lead to representation in appropriate Trade Association and BSI activities

The Person

Applicants (men/women) should have a sound engineering background and a thorough knowledge of electro-mechanical components and their applications, allied to experience and understanding of the role of standards in engineering. Formal qualification to HNC level in electronics is desirable, although this is secondary to the main attributes outlined.

The Company

Designs and manufactures a wide range of capital electronics equipment for both civil and military environments. We are based in Chelmsford, the County town of Essex, which is situated within easy reach of London, the coast and countryside. Locally there are good facilities for education and recreation and housing is relatively plentiful.

For more information concerning the job please ring TED ELLIS on CHELMSFORD 53221 Ext. 80.

Application forms are available from Mr R STANNARD, Personnel Officer, Marconi Communication Systems Ltd., New Street, Chelmsford, Essex, CM1 1PL. Telephone Chelmsford 53221 Ext. 474.

A GEC-Marconi Electronics Company

MARCONI COMMUNICATION SYSTEMS

8138

YOUNG T.V./AUDIO ENGINEER

required at our New Watford premises

We are looking for a young engineer with experience of practical Radio and Television servicing, who will be capable after training at our Woolwich Department of dealing with repairs to complete receivers, PCB panels, car radios and Hi-Fi equipment.

Some technical qualifications are desirable but not essential.

Excellent starting salary is offered, and the benefits include

★ Office hours Monday to Friday
★ Three weeks' holiday rising to four weeks
★ Pension Scheme, Life Assurance ★ Yearly bonus
★ Luncheon vouchers 60p per day

If you have the above experience, and are seeking a really progressive position please write or telephone

John Daniel
Senior Engineer

Mitsubishi Electric (UK) Ltd.

Engineering & Service Dept.
17 Westfield Street, Woolwich, S.E.18
Tel: 01-317 9049/7696/0582

(8168)

Gilbert Islands

Technical Officer-Telecommunications

If you hold a City and Guilds. Telecommunications Technician's Certificate or equivalent with radio specialisation, and have experience in the installation and maintenance of MF, HF and VHF equipment, you are invited to apply for the following post in these attractive Pacific Islands.

You would be responsible for the installation, maintenance and repair of telecommunications equipment throughout the group, and for the supervision and practical training of local staff.

Salary is up to the equivalent of £7372 pa including a substantial tax-free allowance paid under Britain's overseas aid programme Basic salary attracts 25% tax-free gratuity

Benefits include free passages, generous paid leave, children's holiday visit passages and education allowances, outfit allowance, subsidised housing, appointment grant and interest-free car loan.

For full details and application form write quoting MX/320/WD

Crown Agents

The Crown Agents for Oversea Governments and Administrations. Recruitment Division.
4 Millbank, London SW1P 3JD

8147

SEISMIC ENGINEERS

We are looking for two young electronics engineers with degree or equivalent qualifications, to join our marine seismic acquisition company.

This is a field position, with the successful applicants joining the technical crew of our exploration vessel M/V GOEL EGEDE for on-board training in seismic technicques. They will start as Assistant Technicians with a salary of £6,000+ per annum, and one month's leave after each two months on the crew.

The seismic industry offers an interesting career with world-wide travel, and rapid promotion for the right person.

Geophysical Offshore Exploration is a member of the Sefel Group, which has seismic processing centres in Houston, Denver, Calgary and London.

Please write with full curriculum vitae to

SEFEL

General Manager
Geophysical Offshore Exploration
Turriff Building
Great West Road
Brentford
Middlesex TW8 9HY

(8182)

TECHNICIANS

Skilled staff required for the workshop overhaul of electronic equipment installed in civil aircraft.

Applicants not familiar with aircraft equipment should have experience with industrial electronics. City and Guilds or O.N.C. qualifications desirable.

Apply: Mrs. E. J. Bramley, Canford Aircraft Equipment, Stansted Airport, Stansted, Essex.

(8174)

AUDIO VISUAL ENGINEER

A.V. Service incl. Systems Form Electrosonic, Wollensak, Revox, Kodak, Teac, JVC Video, etc.

Phone or write
Ian Cuthbertson
Sound And Vision
Communications
23 Redan Place
London W2
Tel. 01-229 4406

(8197)

Polytechnic of Central London
Educational Development Unit
Audio Visual Services

TECHNICIAN

GRADE 4/LANGUAGE LABS
£3441-£3891

Duties will involve responsibility for day to day servicing and maintenance of language labs in PCL and will also include some work with basic audio visual equipment. Good working knowledge of tape recorders and preferably experience of language laboratory work is required. Qualifications C & G and/or between 7/9 years' experience. From from the Establishment Officer

PCL 309 Regent Street
London W1R 8AL
01-580 2020 ext. 212

(8216)

TRAINEE ELECTRONICS ENGINEER

Geller Business Equipment Ltd., require a young person (18 yrs. approx.) with some experience or qualification in digital electronics.
The successful applicant will be trained to work in micro-processor based cash registered and calculators. Every opportunity for further advancement in this career opportunity. Good starting salary.
Phone Mr Norman on 01-580 1614
GELLER BUSINESS EQUIPMENT LTD.
15 Percy St., Tottenham Court Rd., London W1
(8204)

ARMAGH OBSERVATORY
Armagh, Northern Ireland
Applications are invited for the newly created post of

TECHNICAL OFFICER

(Computers/Electronics)
The successful candidate will assume responsibility for the development and maintenance of digital and other electronic equipment in our small but dynamic research institute and will also assist the research staff in programming and computer operation.
Applicants should have a degree in electronic engineering or H.N.C. with a keen interest in computer programming and with a minimum of 3 years' relevant experience.
Salary on the IB ar IA scales for Research and Analogues Staff.
Further particulars are available from The Secretary, Armagh Observatory, Armagh BT61 9DG, Northern Ireland. Applications close on 30 June, 1978.
(8170)

MACHINE TOOLS

Electrical/Electronic Service Engineer required to install and service CNC lathes, die sinking and spark erosion machines. The applicant should be London based but prepared to travel nationwide. A good electrical/electronic background essential but product training will be given.

Salary will be commensurate with experience, company car provided, pension and life assurance scheme.

Apply in writing giving full details of experience to

Mr. B. C. F. Serjent
ELGAR MACHINE TOOL COMPANY LTD.
BEC House, Victoria Road
London NW10 6NY (8181)

ROYAL NATIONAL INSTITUTE FOR THE BLIND

AUDIO TECHNICIAN

(for our new premises in Goswell Rd.

Our Student Tape Library needs an experienced person to maintain REVOX, NEAL and other equipment and to maintain and operate Telex 300 cassette duplicators. Hours 9.00-5.15. Salary circa £3,200 p.a. plus free lunch in staff restaurant.
Written applications with details of experience including present post and salary to Personnel Officer, 224 Great Portland Street, London W1N 6AA. (8126)

Senior Electronics Service Engineer

A SENIOR MAINTENANCE ENGINEER IS REQUIRED FOR THE REPAIR AND CALIBRATION OF PROFESSIONAL EQUIPMENT USED IN THE EXECUTION OF RESEARCH PROGRAMMES AT THE LABORATORY.

This involves the maintenance of oscilloscopes, pulse generators, counters, digital voltmeter, precision high power magnet controller and analysers of various kinds. Experience in fault finding on some of the equipment is necessary.

It is hoped to gradually extend the maintenance capability to include microprocessors, computers and associated peripherals.

Please send for an application form to M. L. Malpass, Personnel Manager, Philips Research Laboratories, Cross Oak Lane, Redhill, Surrey, quoting reference 113.

PHILIPS Research Laboratories

PHILIPS

8203

Controls Engineers [Electronic]

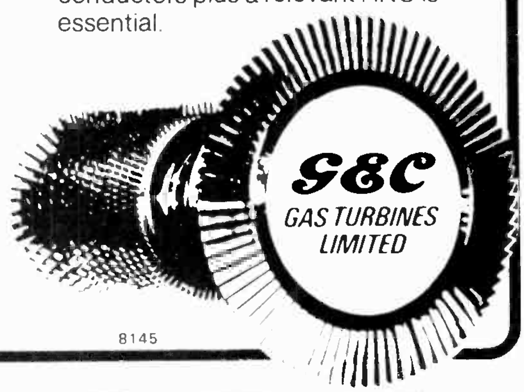
Location: E.Midlands

To join a team of engineers responsible for the design and development of electronic control units for aero-powered and industrial gas turbines.

We are now progressing from analogue to digital systems using mini computers and microprocessors, so there is ample opportunity to diversify.

He or she should be conversant with the latest codes and practices of engineering drawing. Experience in electrical/electronic engineering, particularly with light current semi conductors plus a relevant HNC is essential.

Write today, or telephone, quoting ref. S244, to
H.P. Cross
GEC GAS TURBINES LIMITED
Whetstone Leicester Tel: Leic. 863434



8145

UNIVERSITY OF WARWICK

Electronics Technician

Grade 6/7

A first-class practical Electronics Technician is required to take charge of the Electronics Workshop in the Department of Physics, and be responsible for detailed design, construction, maintenance and application of a wide range of electronic equipment. Ability to carry out detailed design work from outline instructions is essential. The successful applicant will probably hold an appropriate HNC or equivalent and have considerable practical experience, partly in a supervisory capacity. Appointment in Grade 6 (£3,654-£4,365 p.a.) or Grade 7 (£4,254-£4,782 p.a.); grade and starting point depending on age, qualifications and experience. Applications should be made by letter giving full details of past experience, age, etc., and the names of two referees. Further particulars may be obtained from and letters of application should be addressed to the Academic Registrar, University of Warwick, Coventry CV4 7AL, quoting Ref. No. 34/T/78.
(8148)

RUFFLER & DEITH LTD.

A major computer and distributor of electronic video games have the following vacancies in the electronics dept

ELECTRONIC WORKSHOP MANAGER

To take charge of the day to day running of the electronics workshop, controlling a small team of bench engineers engaged in the trouble shooting and repair of all types of TTL and microprocessor videogames

Experience in the amusement industry would be an advantage but is not strictly necessary. Salary will be commensurate with qualifications and experience.

ELECTRONICS ENGINEER

The troubleshoot and repair of all types of TTL and microprocessor and video games to component level. The successful applicant will ideally be between the ages of 20 to 35 years and possess a working knowledge of at least 3 of the following Power supplies, televisions, TTL logic and microprocessor systems.

Salary commensurate with experience.

For both appointments telephone Adrian Shaw on 870-5224 for an interview.

(8171)

SITUATIONS VACANT

SURREY EDUCATION COMMITTEE
GUILDFORD COUNTY COLLEGE OF TECHNOLOGY
Stoke Park, Guildford, Surrey
Principal: E. L. Ellison, BSc, ARCS, CEng, MIMechE

Applications are invited for the following posts
Appointments will be from 1st September, 1978

DEPARTMENT OF SCIENCE AND ELECTROTECHNOLOGY

SENIOR LECTURER

To be responsible for the running and continuing development of the College's high quality CLOSED CIRCUIT TELEVISION UNIT. Someone with adequate technical knowledge and experience is sought who is able to promote CCTV as a teaching aid, and to help integrate this service into the overall media resources of the College. The successful applicant will also be expected to teach for a significant number of hours.

Salary scales (currently under review).

Senior Lecturer £5,523-£6,909. Plus £150 Fringe Area Allowance.

Generous relocation expenses.

Further details and application form available from the Principal, on receipt of a S.A.E. Completed forms should be returned to the College within two weeks of the appearance of this advertisement.

(8186)

UNIVERSITY OF CAPE TOWN

MARINE ELECTRONICS TECHNICAL OFFICER

An electronics Technical Officer is required to assume duty as soon as possible in the Marine Geoscience Group of the Department of Geology. Duties will include the maintenance and development of marine geophysical equipment both in the laboratory and at sea. Some experience in this field would be a recommendation. The successful applicant will spend several 2-3 week cruises per year aboard the University's research vessel "Thomas B. Davie".

The salary will be on the scale R4 020 x 180 – 5 100 x 240 – 5 580// x 240 – 6 300 // x 360 – 6 660 per annum plus a pensionable allowance of 15.5% of salary (i.e. maximum monthly salary of R641). In addition, the University offers a housing subsidy, plus medical and pension schemes.

Further details may be obtained from the Professor of Marine Geoscience, Department of Geology, University of Cape Town, Rondebosch, 7700 South Africa.

Applications giving names of two referees must reach the Registrar, University of Cape Town, Private Bag 18, Rondebosch 7700, by 30th June, 1978.

The University's policy is not to discriminate in the appointment of staff or the selection of students on the grounds of sex, race, religion or colour. Further information on the implementation of this policy is set out in a memorandum which is obtainable from the Registrar.

(8178)

ELECTRONIC INSTRUMENT MAINTENANCE. Rank Research Laboratories Ltd., a Company within the Rank Organisation require a TECHNICIAN with an electrical/electronics background. The successful applicant man or woman will be required to maintain all instruments, test gear and electrical apparatus in working order. The person we are looking for will have already spent some years in industry or the Services in a similar capacity. Salary will be negotiable according to age and experience, backed up by the Rank Organisation benefits package. Write or phone in the first instance for an application form to: W. A. Palmer, Rank Research Laborories Ltd., PO Box 33, Phoenix Works, Great West Road, Brentford, Middlesex, TW8 9AG. Tel: 01-568 9766 ext 13. (8194

VICKERS SHIPBUILDING GROUP LIMITED

Barrow Shipbuilding Works
Barrow-in-Furness

(A member company of British Shipbuilders)

INSTRUMENT TECHNICIANS

Instrument Technicians are required by the Barrow Shipbuilding Works Instrumentation Laboratory.

Candidates should be qualified to at least O.N.C. standard in Electrical Engineering or Physics, and will have suitable technical backgrounds. They will have experience in the setting to work and operation of multichannel data recording systems, signal conditioning equipment and transducers, and/or the repair of electronic test and measuring equipment.

Applicants, of either sex, should apply in writing, giving relevant career and personal details to:

Personnel Officer,
Vickers Shipbuilding Group Limited, (S280/IT/DQ),
Barrow Shipbuilding Works, P.O. Box 6,
Barrow-in-Furness, Cumbria LA14 1AB.

Vickers Shipbuilding Group Limited

A member company of British Shipbuilders

8130

L+RC Recruitment Division

c. £5000 pa for DESIGN DRAUGHTSMEN

Our clients are a major British company in East Anglia with advanced Development Laboratories and extensive overseas markets. They are currently seeking PRINTED CIRCUIT DESIGN DRAUGHTSMEN (male and female) who can convert a circuit diagram into a printed circuit of the analogue nature, to the level required in product development for the specialised market of professional broadcast equipment.
Applicants should have an up to date knowledge of electronic component technology and HNC or equivalent experience. Salaries are negotiable but will range around £5000 per annum. In addition generous relocation expenses are available plus the benefits normally associated with a progressive multi-national company.
To obtain an application form, please write in the first instance, stating any companies to whom your application should not be forwarded, to:

Recruitment Division, Lovell & Rupert Curtis Limited,
30 Bouverie Street, London EC4Y 8DQ

THE UNIVERSITY OF MANCHESTER. TECHNICIAN IN THE DEPARTMENT OF PSYCHOLOGY. A vacancy exists in the Department of Psychology for an Electronics Technician (Grade 5). The successful applicant will be required to develop and construct specialised electronic equipment for research and teaching purposes. He/she will also be expected to maintain a wide range of electronic equipment, and assist in the training of Junior staff. Applicants should have ONC or equivalent qualification and at least seven years' relevant experience. Salary scale £3,186-£3,720 p.a. Applications with full details of age, qualifications and previous experience should be sent to Professor J. T. Reason, Department of Psychology, The University, Manchester M13 9PL. (8160

EXPERIENCED TECHNICIAN, 13 years civil/mil. HF/VHF comms. digi/analogue, field/prod., conscientious, competent in design, supervision, training. CG quals, 31 yrs, UK national, radio amateur, African contract expires Sept '78. Open to offers Middle East/Europe, etc. 8166

V.H.F. SERVICE TECHNICIAN required by London Car Telephones to work on base station and mobile radio equipment. Very well equipped busy workshop in Croydon, but also field service engineers required in the home counties. Ample opportunities for unlimited overtime. Experienced persons only. Salary and bonuses commensurate with ability. Contact J. S. CLARK, 01-680 1010. (7987

BUSINESS OPPORTUNITIES

BOARD FINANCE COMPANY EXECUTIVE based in the East Midlands and with some spare capital seeks electronics genius with marketable idea and preferably some capital as business partner. Any sphere of electronics considered especially audio. Write in confidence to W. E. Lyon, 36 Clipson Walk, Peterborough PE3 7EE. (8167

ARTICLES FOR SALE

WE INVITE ENQUIRIES from anywhere in the world. We have in stock several million carbon resistors ⅛, ¼, ½, and 1 watt, ½ million wire wound resistors 5 and 10 watt — 1 million capacitors — 1 million electrolytic condensers — ¼ million transistors and diodes, thousands of potentiometers, and hosts of other components. Write, phone or call at our warehouse. — Broadfields and Mayco Disposals Ltd., 21 Lodge Lane, North Finchley London, N.12. 01-445 0749, 445 2713. (5907)

OSCILLOSCOPE TEKTRONIX 545 time delay. Two plug-ins L + CA 33 MHZ. £215. Tel. 0273-731391 Hove. (8200

SITUATIONS VACANT

Electronic Instruments

Test & Service

To £5,000+ **N. London**

- + Bonus
- + Day Release
- + Job Variety
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These are just some of the benefits you could receive working with our client, a really progressive Company dealing with almost every test instrument on the market — from a 'simple' DVM to computer based ATE and Integrated Circuit test systems.

If you have experience in the Test/Calibration or Field Service of analogue or digital test instruments, and are interested in a progressive job with a great future, then contact: Mike Gernat (Ref. MB3)

Technomark
Engineering and Technical Recruitment

5-11 Westbourne Grove, London W2.
Telephone 01-229 9239

8193

CALIBRATION ENGINEER

We require an experienced Calibration Engineer to calibrate and repair proprietary and special to purpose test gear. Previous experience of microwave calibration would be useful.

If you are interested in furthering your career in the marine electronics field with the excellent benefits a large company group can offer, please write giving brief details of your career to Lesley Buckland, Personnel Officer, Kelvin Hughes, New North Road, Hainault, Ilford, Essex.

KH KELVIN HUGHES
A DIVISION OF SMITHS INDUSTRIES LIMITED

(8214)

SENIOR VIDEO ENGINEER

A vacancy will shortly occur at the Distributive Industry Training Board's Knutsford Video Centre for a Senior Video Engineer answerable to the Technical Manager.

The Knutsford Centre is a custom-built television studio equipped with Philips LDH.20 cameras and RCA 2" quad TR600 VTR's. Its function is to produce training programmes for the Board and films within the distributive industry.

The successful applicant will have a sound knowledge of the operation and first line maintenance of broadcast television equipment with several years' experience in one or more of the following specialised fields.
Studio Lighting, Sound or Racks Engineering.

The commencing salary is £3873 per annum rising to £4989 per annum by annual increments.

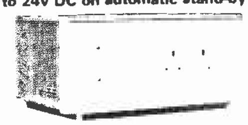
Please write for an application form quoting REF: ID/25 to the Personnel Manager, Distributive Industry Training Board, MacLaren House, Talbot Road, Stretford, Manchester M32 0FP, within the next SEVEN days.

(8206)

ARTICLES FOR SALE

INVERTERS

To operate mains equipment from 12v to 24v DC on automatic stand-by



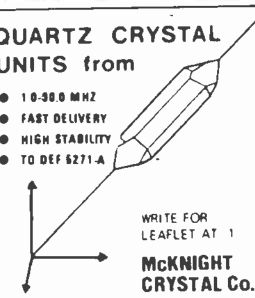
Charging safety control to 2kVA at 2.35 v per cell 3-60 amp.

MAINS-STORE
Send for information to
Interport Mains-Store Ltd
30 Old Bond Street, London W1
Tel: 01-727 7042 or 0225 310916

(7979)

QUARTZ CRYSTAL UNITS from

- 1.0-30.0 MHZ
- FAST DELIVERY
- HIGH STABILITY
- TO DEF 5271-A



WRITE FOR LEAFLET AT :
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HARDLEY INDUSTRIAL ESTATE HYTHE SOUTHAMPTON SO4 6ZY
TEL HYTHE 848961 STD CODE 0703

(6044)

ARTICLES FOR SALE

HALLICRAFTERS frequency synthesizers. Ex-USAF, 2-34 MHz in 25Hz steps. Variable r.f. output in 5 volts. 1 MHz and 100Hz frequency standard outputs. Circuit diagram and technical information supplied, £50 plus carriage. New plug-ins for CD1212 Scopes. Dualbeam 24 MHZ CX1252 £25 plus p & p. Single beam 40 MHZ CX1251 £15 plus p & p. Wide range miscellaneous modern electronic supplies callers welcome. Closed all day Tuesday. Skipton Electronic Supplies, 29 Keithley Road, Skipton, Yorks. Tel: 0756 4397.

SEEN MY CAT? 5000 odds and ends. Mechanical. Electrical. Cat free. Whiston Dept. WW, New Mills, Stockport. (7983

SPECIAL OFFER: If you can buy the same for less, we will refund the difference. Brand new and full specification pots, switches, transformers, linears, TTL, CMOS, transistors, and other semiconductors. Send large SAE for catalogue. Delta Tech (W) & Co., 62 Naylor Road, London N20. (8140

AUTOMATIC TRANSISTOR TESTER model 1500 by Optimised Devices, Inc. Fully automatic with manual programming. Automatic programming and data-logging are possible but not included. Offers. Hughes Micro Electronics Limited, Fullerton Road, Glenrothes, Fife. Tel. (0592) 754311. (8115

LOGIC PROBE suitable TTL/CMOS 5-15V indicates logic states and trigger pulses £12 inc. C. Marshall, 22 Oakfield Road, Croydon, Surrey, CRO 2IIA. (8207

NATIONAL 81L595 OCTAL TRI-STATE BUFFERS. One-up 105p. Ten-up 95p. Postage 20p/order. J. Hawthorne, 23 Iver Lane, Cowley, Middx. UB8 2JD. (8167

DYMAR "LYNX" RADIO-TELEPHONES, brand new, with fitting kit and six month warranty £220 each (H.B. 20 watt). Nolton Communications, Cheshunt. Phone Waltham Cross 33555. (8164

PHILIPS EL3400A 1in VTR VID/HF output, 24 tapes, spares, slight attention required £80. Jacobs. Tel: 04548-207 business hours only. (8162

BATTERY INDICATOR/level meters, moving coil, flush mounting. Large quantity surplus 50p each in 100's. Sample £1. Also quarter ton new reeled Nichrome resistance wire. 0076 350 HMS per foot. Offers all or part. EES Ltd, Clifford Road, Monks Road, Exeter. Phone 56280 36489. (8199

SCREWS 0-16 BA brass steel cadmium nickel plated. List R3 Clerkenwell Screws, 109 Clerkenwell Road, London EC1 405-6504. (8165

ADAPTOR AERIAL TO TRANSMITTER ZA56234 MWB/XB/940- highwattage, first class engineering, wide communications frequency range, £45. CT423 Calorimeter power meter for radar frequencies, ex W.D. 10AF/6625-99-943-9347, £50. Scam Clark 40ft pneumatic mast, superb quality in unopened original pack, £300. 10 way 300 volt max. cable 7/010 max temp. 80°C. All prices plus carriage and V.A.T. will negotiate for quantity. Many wholesale and retail bargains for callers. Surplus purchased — established over 20 years. G. W. M. Radio Ltd., 40/42 Portland Road, Worthing, Sussex. Tel. 34897.

TELETYPE KSR33, complete unit includes ASCII coded keyboard, stand, P.S.U., excellent working condition, £200. — Phone Upminster 28233, evenings. (8188

OSCILLOSCOPE, tel equipment D65 £240. Waveform generator, feedback TWG 501, £65. Dual power supply, advance PMD 18-1, £35. All as new, privately used only. — Tel 0305 852136. (8190

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EXCLUSIVE OFFER

HIGHEST QUALITY 19" RACK MOUNTING CABINETS

Over 60 types available from 12" to 90" high. Also twins, triples & consoles. Below are only a few types. Please send for full list

Ref	Ht"	Width"	Depth"	Price
PE	10	21	13	£10.00
LL10	54	21	18	£20.00
TT	64	25	26	£45.00
SL	71	25	26	£50.00
PT	72	20	21	£20.00
TL	75	22	21	£20.00
ST	85	22	24	£70.00
Racal cabinets for RA 17	117			£30.00

AUDIO AND INSTRUMENTATION-TAPE RECORDER-REPRODUCERS

- ★ Plessey ID33 Digital Units, 7 track ½"
- ★ Plessey M5500 Digital Unit, 7 tracks ½"
- ★ Ampex FR-1100, 6 speeds, stereo ¼"
- ★ Ampex FR600, 4 speeds, 7 tracks ½"
- ★ D.R.I. RM1, 4 speeds, 4 tracks ¼"
- ★ EMI TR90 2 speeds, 1 track ½"
- ★ Mincom CMP-100, 6 speeds, 7 tracks ¼, ½, 1"
- ★ Leevers Rich DA-2P, 2 speeds, 2 tracks 1¼"
- ★ Leevers Rich Console 2 track ¼", 2 speeds

Prices of above £70 to £500

Also Transport Decks only available

We have a large quantity of "bits and pieces" we cannot list — please send us your requirements, we can probably help — all enquiries answered

All our aerial equipment is professional MOD quality

- ★ Ficord 101S Tape Recorders £24.00
- ★ Stenorette L Tape Recorders £29.00
- ★ DG-7-32 C.R.T.s £4.00
- ★ DG-7-5 C R.T.s £4.00
- ★ EMI R-301 Tape Recorders for parts £15.00
- ★ Racal SA Counters Several types .... P.U.R.
- ★ Uniselectors, 10 Bank 25-way £3.50
- ★ Solartron LM 1420 D.V.M's £140.00
- ★ Marconi O A/1094A Spectron Analysers £190.00
- ★ 40ft. Sectional Aluminium Masts, complete £55.00
- ★ Racal MA-79 Universal Drive Units £450.00
- ★ Racal RA-17P Receivers (new) £950.00
- ★ Tone Coded Voice Frequency Teleprinters .... P.U.R.
- ★ Rhode & Schwarz ESM Tunable VHF Receivers
- ★ 180-300 M/cs £285.00
- ★ Rhode & Schwarz HFH Field Strength HF Loop Aerials £140.00
- ★ Narda 504 Freq. meters 200/500 M/cs £45.00
- ★ Cossor CT454 Electronic Volt ohm meters £50.00
- ★ B&K 2409 Electronic Multimeters £55.00
- ★ Multi-purpose Trolleys with Jacks 19"x 17" £16.00
- ★ Racal RA-17L Receivers £325.00
- ★ Rhode & Schwarz fibreglass HA Diversity Dipoles £120.00
- ★ Ion pump power supply, E.H.T £44.00
- ★ SE4/2B CRTs £16.00
- ★ SE5/2A CRTs £18.00
- ★ 3AZP 2 (DMN/9/11) CRTs £18.00
- ★ E.M.I Documents CCTV Outfit £250.00
- ★ Advance 3KVA CV Transformers £150.00
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- ★ Metal V.D.U. Tables 30" x 36" x 30" £24.00
- ★ Davian Logic Testers £20.00
- ★ General Radio Strobotacs £30.00

MANUALS

We have a quantity of Technical Manuals of Electronic Equipment, not photostats, 1940 to 1960. British and American. No lists. Enquiries invited.

- ★ Data Efficiency Respoolers 240v £28.00
- ★ Belling Lee 100 Amp Interference Filters £76.00
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- ★ Solartron CD 524 Oscilloscopes £90.00
- ★ AVO VT Voltmeters CT-471A £75.00
- ★ Racal MA197B pre-Selectors £65.00
- ★ Collins 500 watt 2/18 mcs. Transmitters £1000.00
- ★ Collins KWT6 SSB 500w Transceivers £1250.00
- ★ Collins KWT6 200 m/w AM Transceivers £750.00
- ★ STC Rx5 2/25 mcs Receivers Diversity £140.00
- ★ Rack Mounting Operator Tables £10.00
- ★ Gaumont Kalee 564 Flutter Meters £75.00
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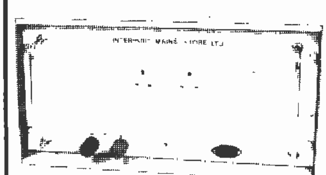

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Ersin Multicore – the international solder

Ersin Multicore 5-Core Solder

The proved superiority of ERSIN Multicore Solder for over thirty years is due to many factors. We have specialised throughout this period in the manufacture of cored solders. Consequently our research and manufacturing staff have been able to devote all their energies to the development of Multicore Solders. All alloys are of highest purity, carefully formulated and checked.

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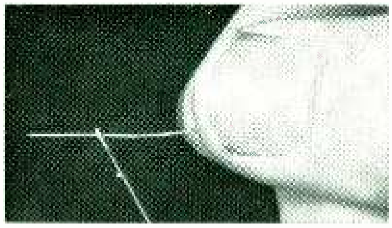
Our Quality Control at all stages of manufacture is guaranteed and recorded by the batch number on every reel.

Needle fine gauges



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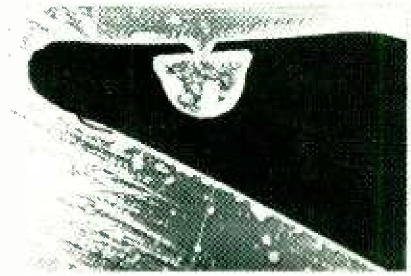
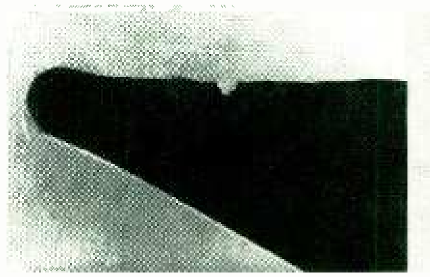


Sectioned iron-plated bit, after 40,000 simulated operations using 60/40 Solder.



Sectioned iron-plated bit, after 40,000 simulated operations using SAVBIT Solder.

ALLOY Composition (nominal major elements)	Grade	Melting Temperature Solidus °C	Liquidus °C	Specification
50/32/18 Sn/Pb/Cd	TLC	145	145	B.S.219
62/36/2 Sn/Pb/Ag	LMP	179	179	B.S.219
62/35.7/2/0.3 Sn/Pb/Ag/Sb	Sn62	179	179	QQ-S-57 1E
63/36.7/0.3 Sn/Pb/Sb	Sn63	183	183	QQ-S-57 1E
60/40 Sn/Pb	KP	183	188	B.S.219
60/39.7/0.3 Sn/Pb/Sb	Sn60	183	188	QQ-S-57 1E
50/50 Sn/Pb	F	183	212	B.S.219
50/49.7/0.3 Sn/Pb/Sb	Sn50	183	212	QQ-S-57 1E
50/48.5/1.5 Sn/Pb/Cu	Savbit 1	183	215	DTD 900/4535A DIN 1707
45/55 Sn/Pb	R	183	224	B.S.219
40/60 Sn/Pb	G	183	234	B.S.219
30/70 Sn/Pb	J	183	255	B.S.219
20/80 Sn/Pb	V	183	275	B.S.219
96/4 Sn/Ag	96S	221	221	B.S.219
15/85 Sn/Pb	W	225	290	B.S.219
Pure Tin	P.T.	232	232	B.S.3252
95/5 Sn/Sb	95A	236	243	B.S.219
5/93.5/1.5 Sn/Pb/Ag	H.M.P.	296	301	B.S.219

ERSIN Multicore 5 CORE SOLDER

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