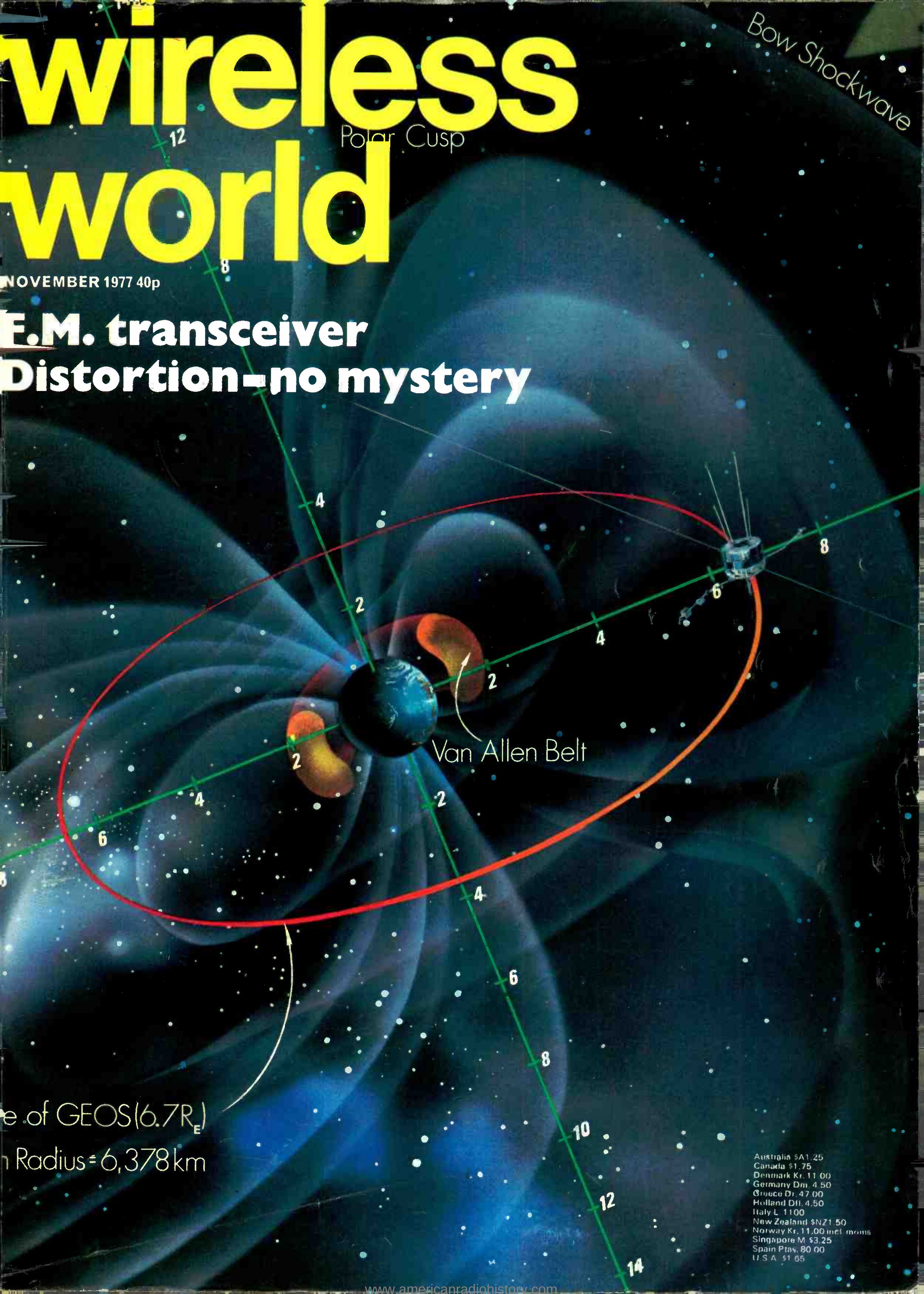
wireless world

NOVEMBER 1977 40p

F.M. transceiver
Distortion–no mystery



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10 kHz

120 MHz

NEW

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

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

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

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

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

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

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

Digital Synchronizer

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

Full information gladly supplied on request.

mi MARCONI INSTRUMENTS

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WW—001 FOR FURTHER DETAILS

wireless world

Electronics, Television, Radio, Audio

NOVEMBER 1977 Vol 83 No 1503

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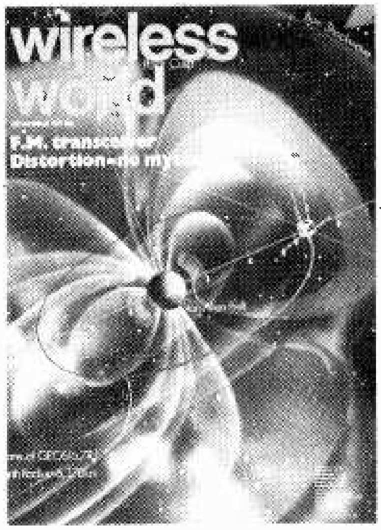

Front cover is an imaginative painting by J. G. Dougherty, of the GEOS satellite in orbit, showing the natural phenomena it was designed to investigate. A report on GEOS appeared in the August issue, p.33. Picture by courtesy of British Aircraft Corporation.

IN OUR NEXT ISSUE

Telext decoder modifications. An article describing the circuit changes and additions needed to enable the *Wireless World* decoder design to decode the latest control characters — graphics hold, double height, separated graphics and background colour.

Ernie Lowinger describes how to make a **thread-suspended pickup arm,** as expected to be shown this month on *Tomorrow's World*. This one doesn't need a lathe!

Current issue price 40p, back issues (if available) 50p, at Retail and Trade Counter, Paris Garden, London SE1. By post, current issue 55p, back issues (if available) 50p, order and payments to Room 11, Dorset House, London SE1 9LU.
Editorial & Advertising offices: Dorset House, Stamford Street, London SE1 9LU.
Telephones: Editorial 01-261 8620. Advertising 01-261 8339.
Telegrams/Telex: Wiworld Bisnespres 25137 BISPRS G. Cables: Ethaworld, London SE1.
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Subscriptions: Oakfield House, Perrymount Rd, Haywards Heath, Sussex RH16 3DH. Telephone 0444 59188. Subscribers are requested to notify a change of address.
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16 amp rocker choice?

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WW-062 FOR FURTHER DETAILS

LOW COST TESTERS

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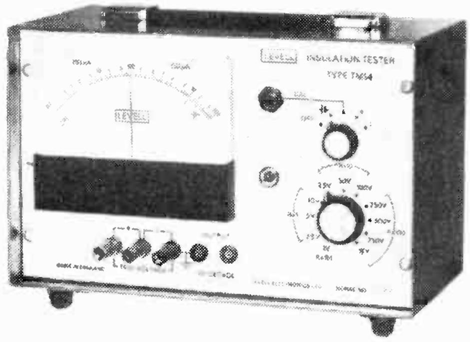
INSULATION TESTER



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

RESISTANCE RANGES

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

CURRENT RANGE

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

MEASUREMENT TIME

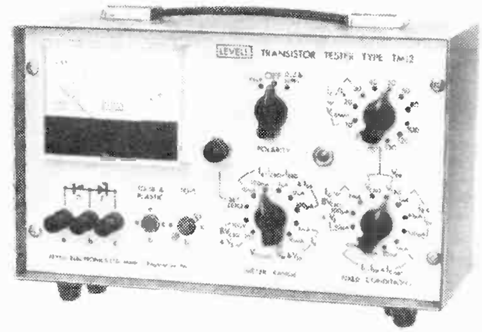
< 3s for resistance on all ranges relative to CAL position.
< 10s for resistance of 10G Ω across 1 µF on 50V to 500V.
Discharge time to 1% is 0.1s per µF on CAL position.

RECORDER OUTPUT

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

type TM14 **£120**

TRANSISTOR TESTER



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

TRANSISTOR RANGES (PNP OR NPN)

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

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

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

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

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

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

DIODE & ZENER DIODE RANGES

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

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

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

type TM12 **£110**

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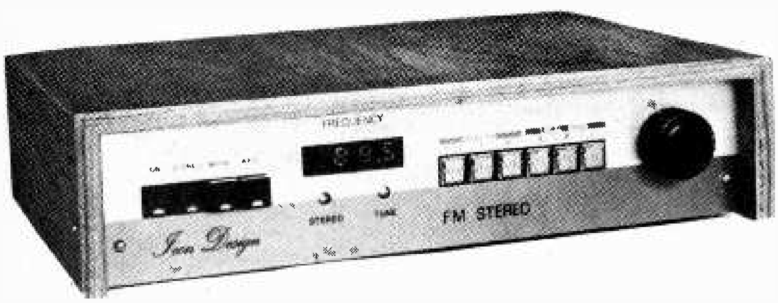
WW — 068 FOR FURTHER DETAILS

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



This tuner must surely provide the best value for money available today. Combining the best of the modules shown below, it includes a full digital readout of frequency to a resolution of 0.1 MHz, so that exact station identification can be made. In addition, six pre-set stations may be selected by touch controls having internal solid state lamps, while manual tuning allows easy searching for distant stations under the guidance of the digital meter.

A switchable mute system allows reception of the weakest stations while muting inter-station noise and spurious responses. Perfect reception is assured by not permitting any station to be heard which is far enough out of tune to cause distortion. The tuning indicator lamp provides a means of very fine tuning, and is automatically extinguished between stations.

A powerful A.F.C. system is also incorporated which holds all stations in tune, while not preventing manual tuning.

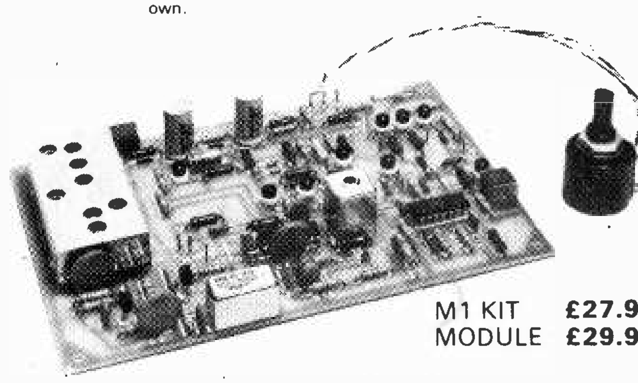
Good stereo reception is assured by the use of a phase locked decoder with full 'birdie' and spurious output filtering.

Finally, but not least, the external appearance and styling bring a fresh new look to Hi-Fi. The sturdy wooden cabinet is finished in mat teak veneer, housing an attractive gold and brown, anodised aluminium front panel, which carries black controls and inscriptions. The indicator lamps and digital displays are in red, giving the finishing touches to a tuner you will be proud to own.

	Tuner	Kit
T2 TOUCH TUNED	£121.00	£109.00
T3 DIGITAL (AS SHOWN)	£149.00	£139.00

MAIN RECEIVER MODULE M1

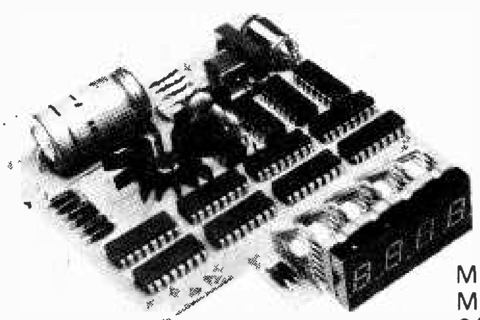
We have claimed before that this F.M. system is the most advanced on the market, and after nearly three years we repeat our claim. Some have borrowed ideas, some have not, but no other tuner gives you all the features of this unit. How many tuners mute the spurious tuning effects found at either side of a correctly tuned station? How many tuners fade the sound out as you tune too far off station for good quality sound? How many tuners kill the tuning indicator so that it does not indicate when there is no station there? How many offer you drift free tuning? We could go on. If you want a tuner that has been well thought out and engineered, start with this module.



M1 KIT £27.95
MODULE £29.95

DIGITAL FREQUENCY METER M6

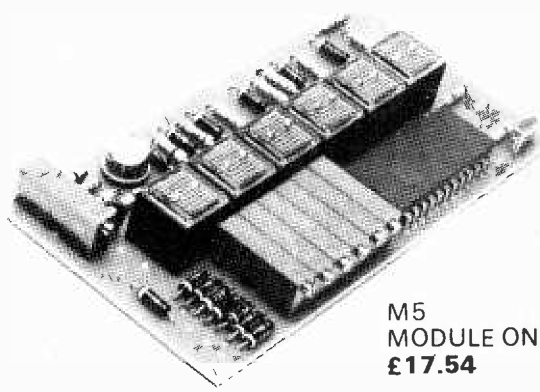
We are very proud of this one. We don't have to say it's the best, as far as we know it's the only one! On a board less than 4" square is all the electronics of a stable counter with i.f. offset (added) and a stabilized power supply! With the aid of a small daughter board (not shown) which fits neatly into the above module (M1), the exact station frequency is displayed to the nearest 0.1 MHz. It's a tuning scale 20" long with accurate calibrations every 0.1"! You get the transformer, daughter board (ready wired in), polarized filter, and a list of station frequencies. What more do you want?



M6
MODULE ONLY
£44.40

TOUCH TUNE MODULE M5

This module must put the finishing touches to an outstanding combination. Six pre-set stations at the touch of a button. No moving parts to go wrong, or contacts to get dirty. Internal illumination shows you which button has been touched, while the tuning adjustment is made using high reliability multi-turn cermet pots for repeatable selection of the most used stations, yet retaining the use of separate manual tuning. This module interfaces directly with the M1 above, being wired between the board and the normal manual tuning control. A touch of sheer genius!



M5
MODULE ONLY
£17.54

FULL CABINET/METALWORK KIT

(Including all Nuts and Bolts, Plugs and Sockets, etc.) **£28.16**

OTHER MODULES etc.

M2 Stereo decoder	£8.36	kit	£6.84
M4 Power supply	£6.93	kit	£6.49
SL1310 decoder IC	£1.95		
TBA750 f.m. i.f.	£1.55		
20v regulator IC	£1.50		
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Filter, SFJ10·7MA	£1.55		
7 segment L.E.D. (c/a)	£1.99		
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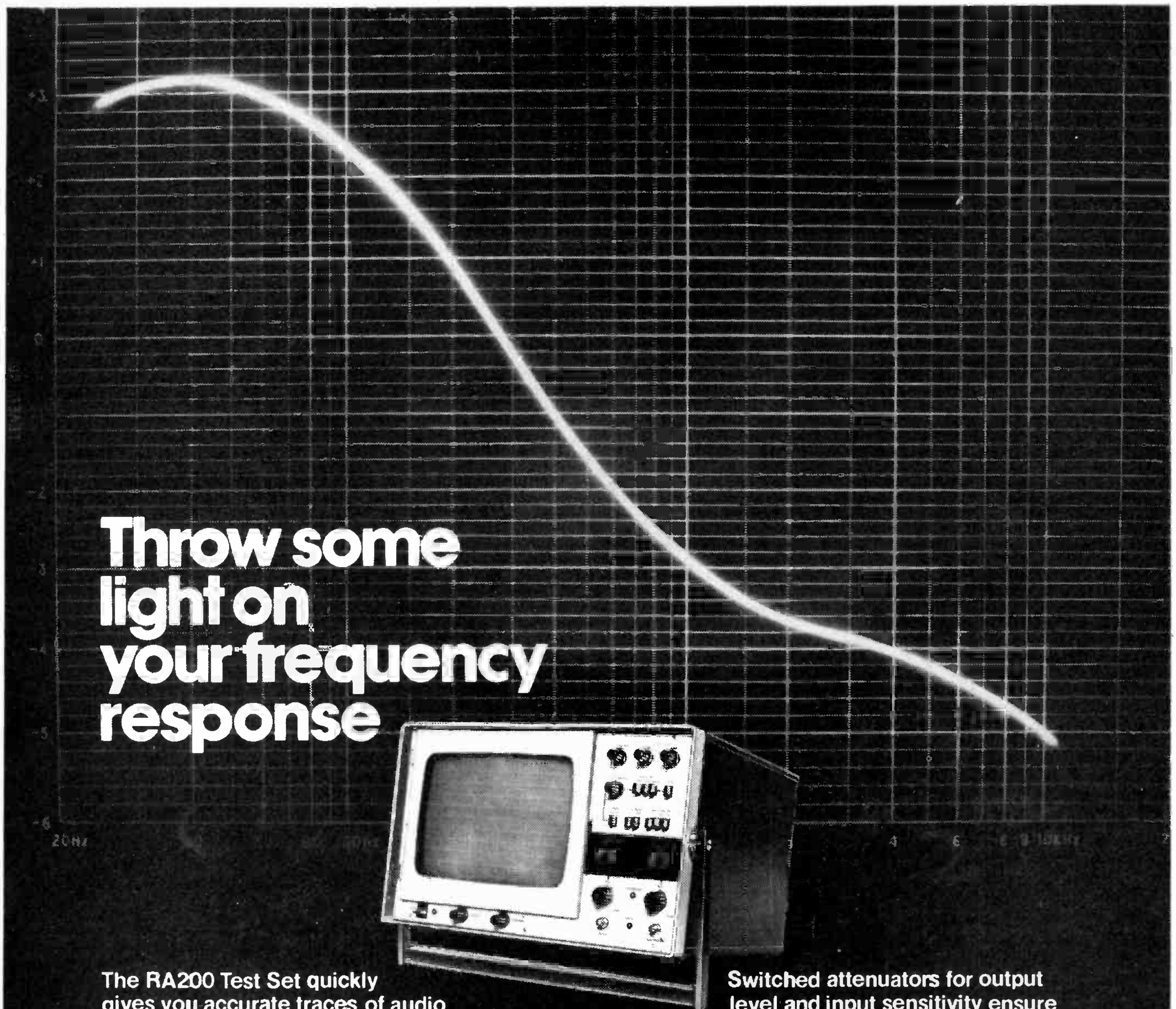

Throw some light on your frequency response

GEORG SIMON OHM

WW—048 FOR FURTHER DETAILS

My assistant thinks you need sorting out.

The other day my assistant gets this call.

Here, she says, there are some people who don't know the difference between getting buffered and not getting buffered.

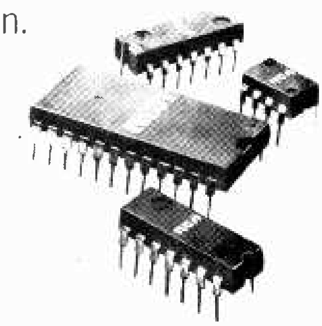
Now this makes me a bit uppity, being a sweet old-fashioned thing. I don't like to hear Lord Mayoring in the office–specially if it comes from someone who's blonde and got legs up to the third floor.

That's not ladylike, I says. No, she says –impatient like–COSMOS! That does it–wash your mouth out or explain.

She does, and I've quoted it word for word below. If you understand it you're a better man than her.

The COSMOS 4000A series gates are unbuffered.
But the COSMOS 4000B series gates can be buffered or unbuffered. If you want unbuffered gates, you add 'U' to the code–e.g. 4011UB. If you specify nothing, you get buffered automatically–e.g. 4011B.
The 4000B series devices are rated up to 20V, have a wider operating range, lower leakage current, symmetrical output and improved input current leakage ratings.

Have you ever heard anything like it? Personally, I reckon if you want to know more, you'd better buffer off and ask the smart alecs at Crellon.



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RCA

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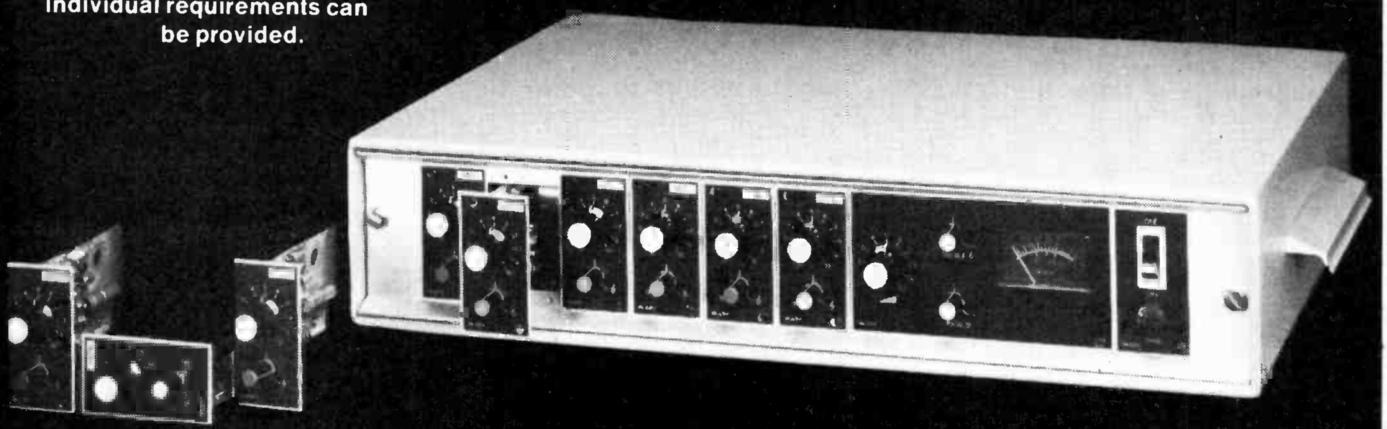

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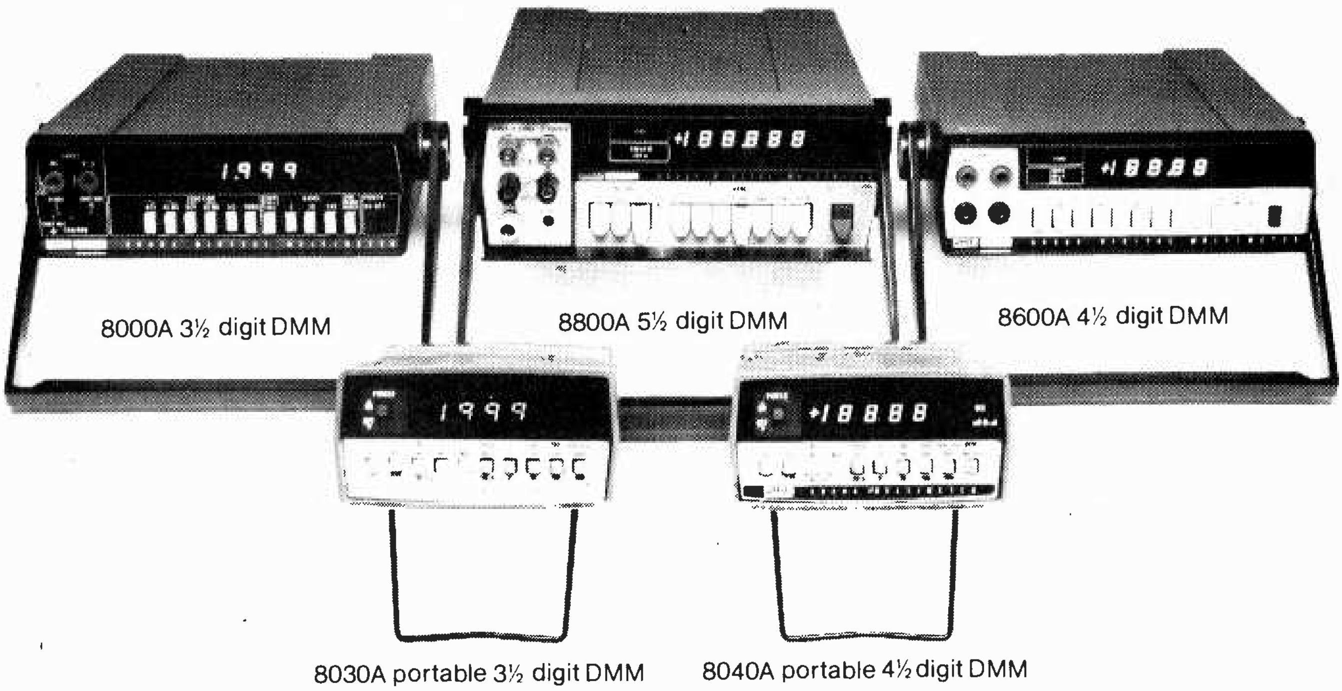

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NEC CQ 110 E DIGITAL

allband, HF, 300wattstransceiver, 160 / 80 / 40 / 20 / 15 / 11 / 10A / 10B / 10C / 10D / WWV, modes FSK, USB, LSB, CW, AM, with separate 8 pole X-tal lattice filters for each mode fitted.
Further features: Side tone at CW, VOX (automatic transmit-receive by talking into microphone), 11 meter CB band, all channels easily selectable through digital counter, excellent receiver sensitivity at extreme crossmodulation security by application for the 7360 low noise beam, deflection mixer tube.
This feature alone makes of the NEC CQ 110 E a toprider. Fixed channel communication on 22 channels is possible. A 60 page manual and a high quality dynamic microphone are supplied with the transceiver. Speaker, AC 100-235 volts and DC 13.5 volts power supplies are built in of course.

NEC CQ 301

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WW—026 FOR FURTHER DETAILS

*Illustration actual size

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The Impact of Electronics—Past, Present and Future, by Jack Akerman (Managing Director of Mullard Ltd., Chairman of the Electronic Component Industry Federation, and member of Electronics EDC).

The Impact of New Technology in Telecommunications, by Kenneth Corfield (Deputy Chairman and Managing Director of Standard Telephone and Cables Ltd., and Senior Officer of ITT in the United Kingdom).

The Microprocessor in the Home, by Dr Steve Forte (Managing Director of General Instrument Microelectronics Ltd since 1971 and has many years experience of the Semiconductor industry).

The Microcomputer in Industry and Commerce, by Alex d'Agapeyeff, OBE, (Chairman of Computer Analysts and Programmers Ltd).

The Impact of Microelectronics on Employment, by Dr Alfred Prommer (Vice President of Siemens AG, West Germany, and head of sales and marketing in the company's components group).

Lord Orr-Ewing, OBE, C.Eng. (Chairman of Ultra Electronics Ltd); Sir Ieuan Maddock, CB, OBE, FRS (Deputy Chairman of the National Electronics Council) and Lord Thorneycroft (Chairman of Pye of Cambridge Ltd) have all agreed to chair the sessions.

The concluding **Open Forum** will feature a panel of experts which will include William C Hittinger (Executive Vice President, research and engineering, RCA Corporation USA); Gerrit Jeelof (Chairman and Managing Director of Philips Industries UK); Derek Roberts (Managing Director of Plessey Microsystems Division) and Frank Chorley (Managing Director, Plessey Electronic Systems Ltd).

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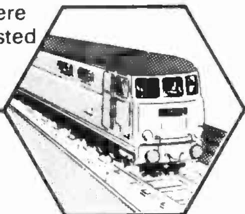

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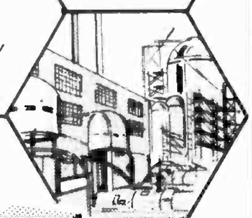

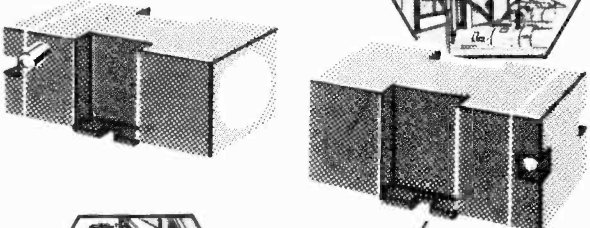

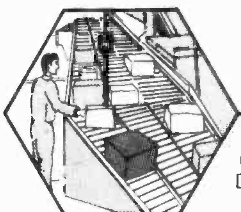

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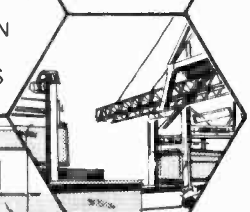

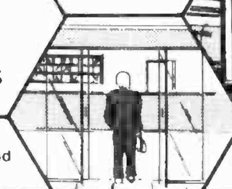

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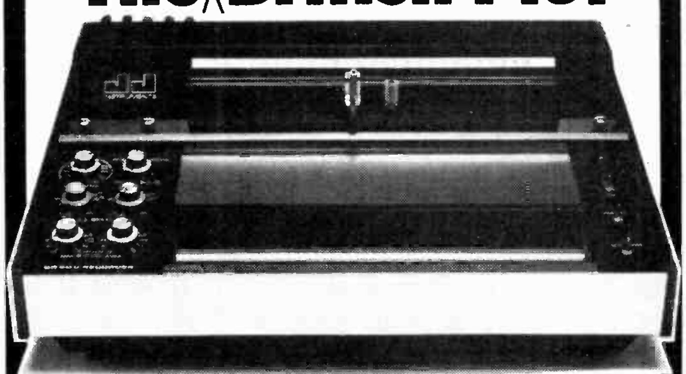

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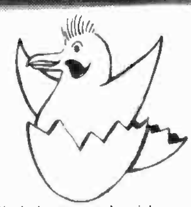

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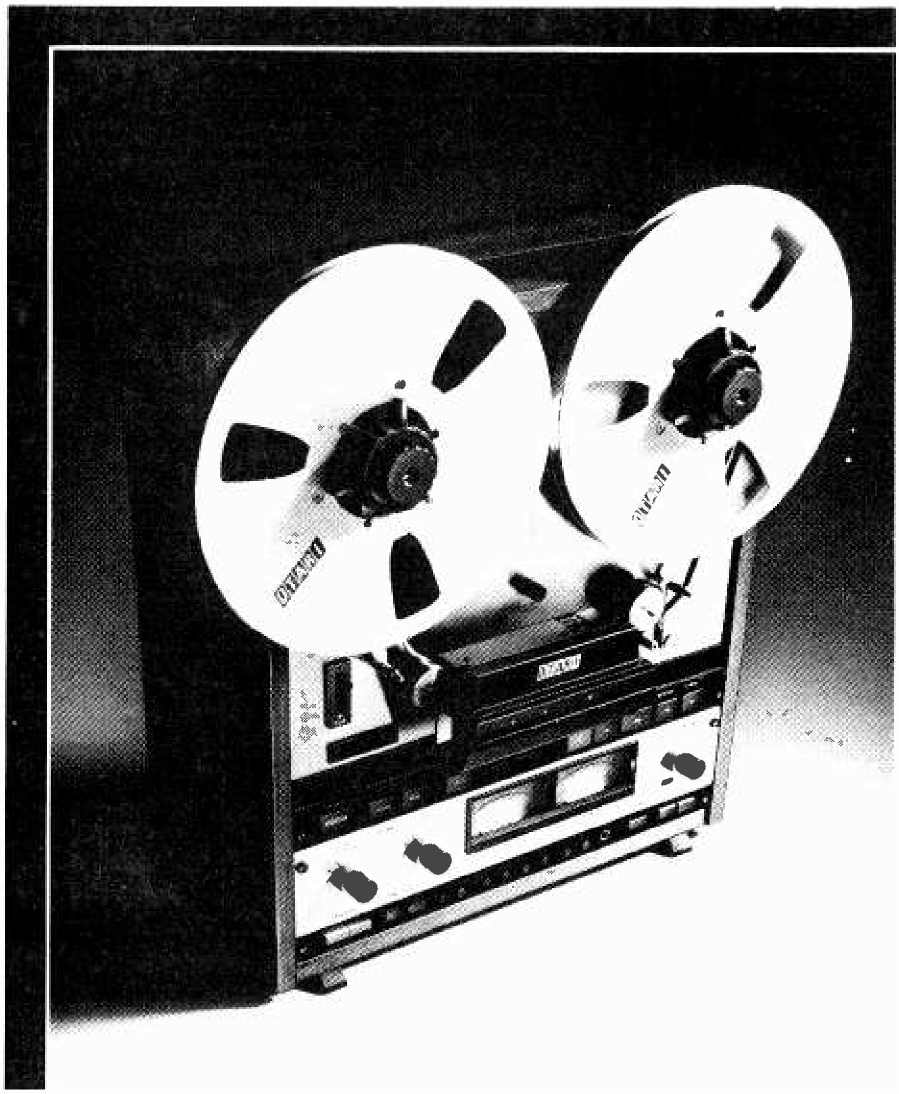

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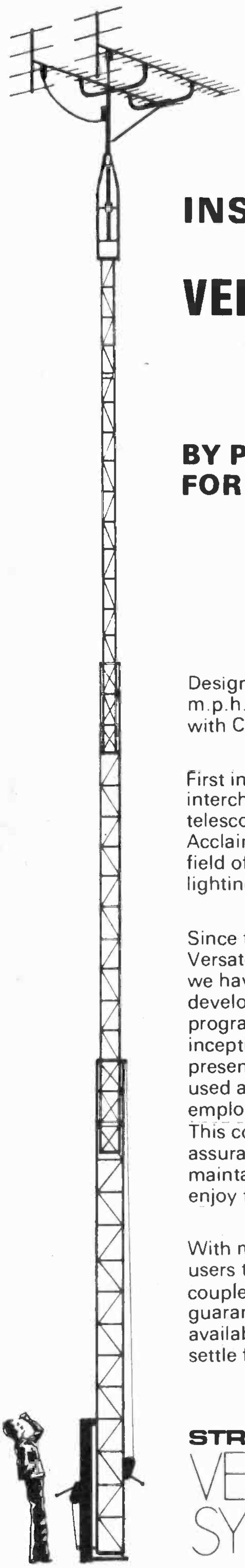
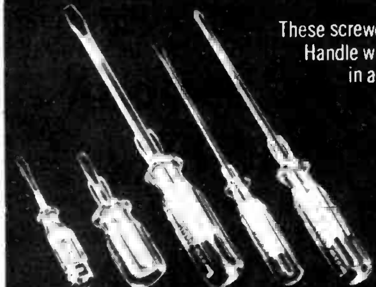
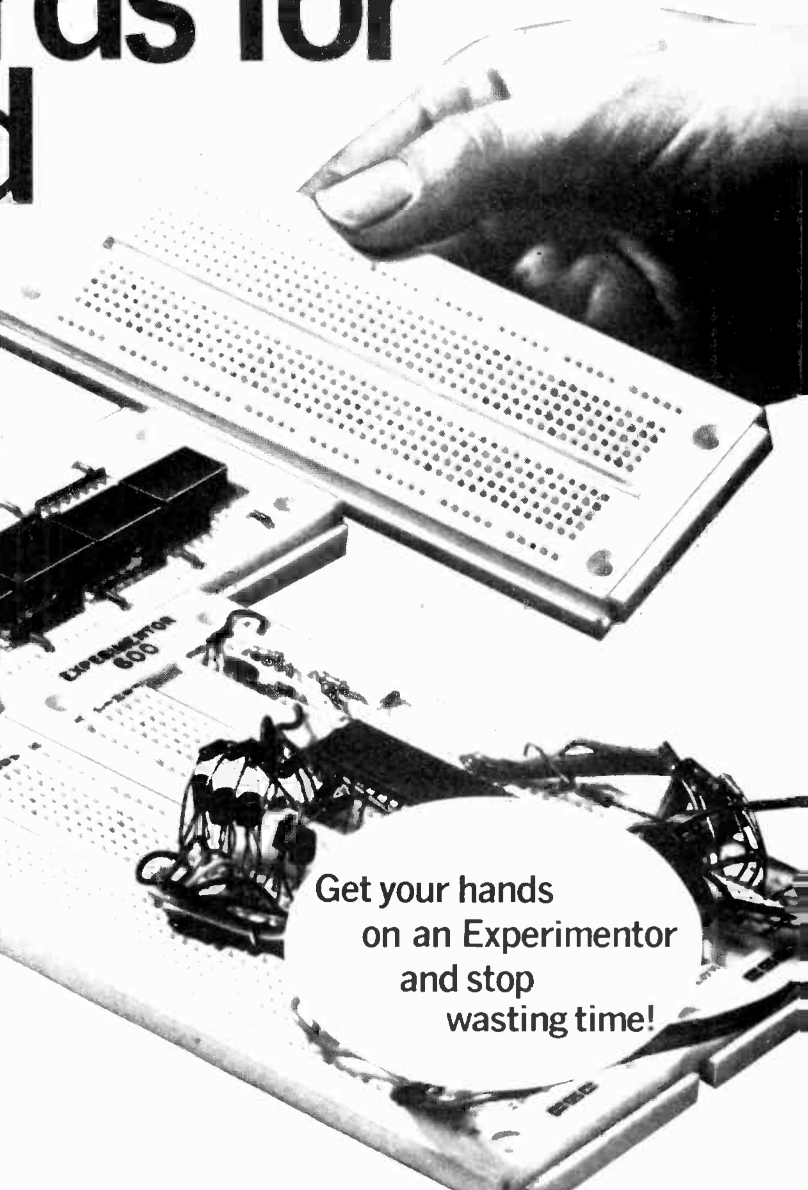




Mini-priced breadboards for maxi-sized projects.



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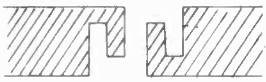

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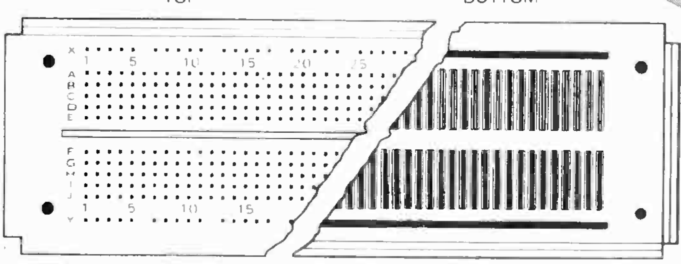
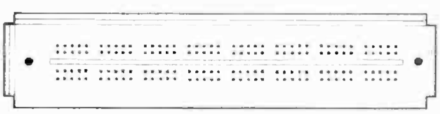


Contact resistance is a mere 0.4mΩ and interterminal capacitance is typically less than 5pF. The **Experimentor** is usable to over 100MHz.

Experimentor 600 and 650 models are ideal for RAM's ROM's and PROM's (0.6" centre IC's) while the 300 and 350 models are for smaller DIP's (0.3" centres). All four models, of course, also take all standard components, the 0.1" grid being compatible with transistors, diodes, LED's, capacitors, resistors, pots — in fact any component with lead sizes between 0.015" and 0.032".



A useful quad bus strip (EXP4B) further expands the versatility of the system for the MPU user.

Model	Length"	Width"	Centre channel"	5-way tie points	Bus	Price	All units are 0.330" deep.
EXP300	6.0	2.1	0.3	94(470)	2(80)	£6.77	Prices include VAT (8%) and p&p for
EXP350	3.6	2.1	0.3	46(230)	2(40)	£3.69	UK Orders.
EXP600	6.0	2.4	0.6	94(470)	2(80)	£7.35	Add 5% to all orders outside UK.
EXP650	3.6	2.4	0.6	46(230)	2(40)	£3.99	All prices and specifications correct
EXP4B	6.0	1.0	N/A	N/A	4(160)	£2.83	at the time of going to press.

Experimentor breadboards can be used alone or mounted on any convenient flat surface, thanks to moulded-in mounting holes and vinyl insulation backing that prevents short circuits. Mount them from the front with 4-40 flathead screws or from the rear with 6-32 self tapping screws.

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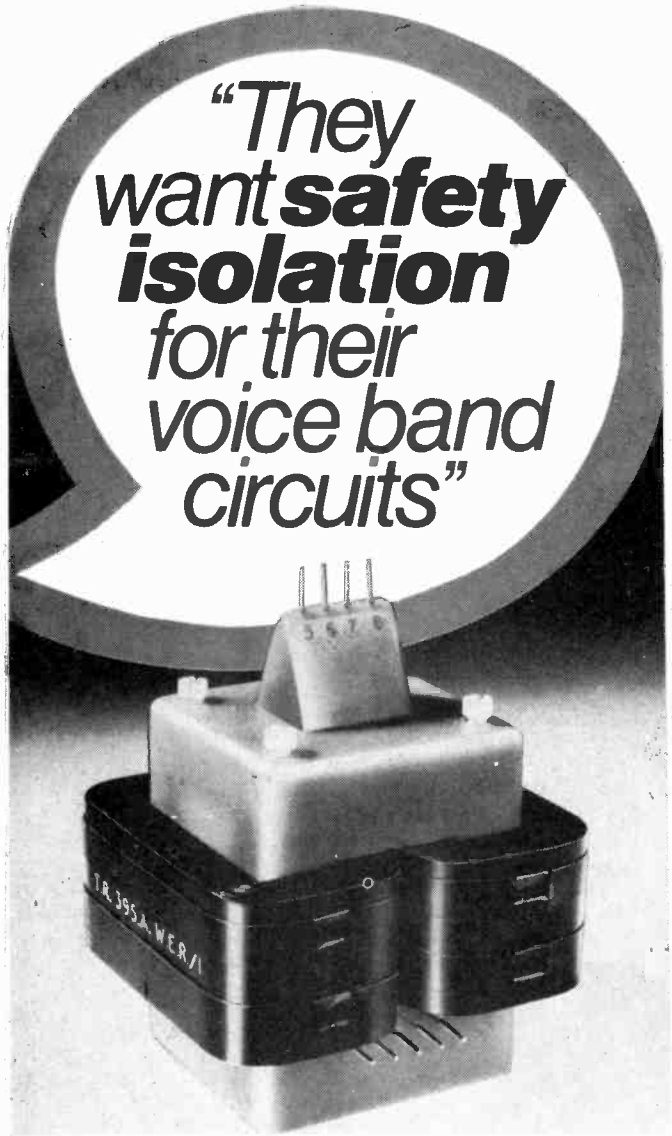

One more request item. We met it with a neat little transformer. Now, in two versions, it joins the list of useful Whiteley products, and everyone involved in communications system design will be interested in the protection they provide. Inserted in voice band circuits, they effectively isolate equipment from the hazards of adjacent high voltage power circuits on the 'line' side. High isolation level between line and equipment windings gives protection against voltage surges, lightning strikes and fault conditions. One version is designed for 17Hz signalling circuits, the other with several voltage ratios also suits a 50Hz ringing circuit. All are Post Office and C.E.G.B. approved, and the second version is also approved with extra protection diodes added. Requests for data sheets welcome. Or if you want to request a product spec of your own — we're always interested!

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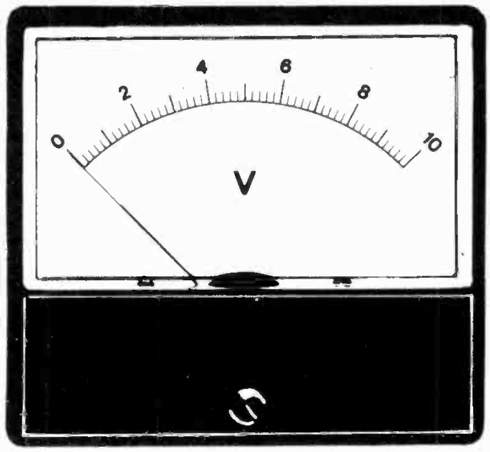

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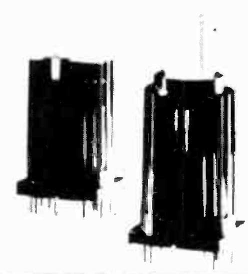

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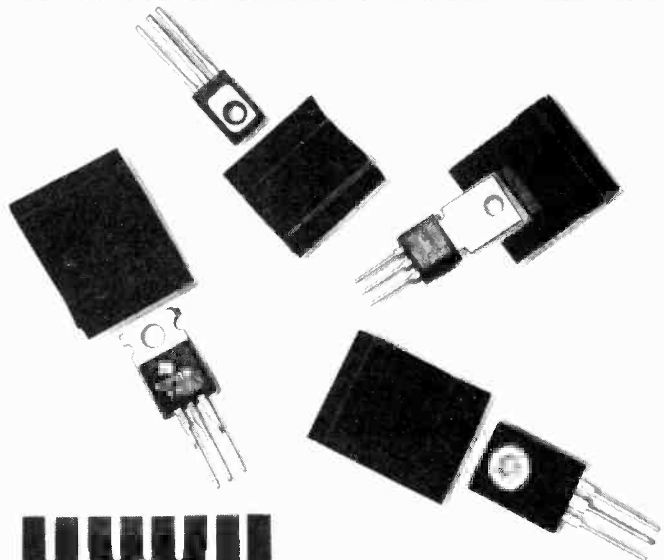

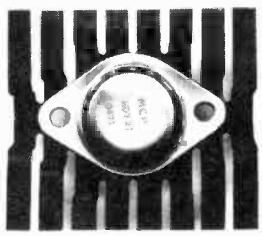

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Microcomputers and *Wireless World*

Computers, it has been said, are hard-working idiots. This means that they are ready and able to cope repetitively with masses of figures that a large company needs, or thinks it needs, to run its business efficiently. They can do this at high speed, without making mistakes, but have to be programmed to carry out the work and must be provided with the data on which to work.

All that seems a long way from the domestic use of computers. The amount of number-crunching going on in the average household is not, one would have thought, at a level which requires the assistance of a computer — even the Christmas-present four-tab calculator is usually grossly under-employed. But in spite of this, a growing number of private users are acquiring microcomputers and, presumably, using them.

The uses to which microcomputers are applied appear to be trivial when the cost of a useable machine is considered — "on the road", so to speak. But it is inevitable that not only will the cost of the electronics be reduced, but that worthwhile work for this still fairly expensive hardware to perform will emerge — perhaps in information retrieval or self-education.

To cater for this interest, a series will describe the construction of a set of equipment, preceded by a look at micro-computers in general. That being done, there will probably be a variety of interfaces and peripheral equipment to make and there this journal's involvement might be supposed to end. After all, *Wireless World* is a journal for those interested in electronics and programming is scarcely a related topic, unless the programme is concerned with the design of circuitry or systems. As an analogy, television is our concern, in so far as the studio, transmitter, transmission path and receiver are of interest to engineers, but programmes are not the business of *Wireless World.*

Nevertheless, processors and computers are probably going to have a marked effect on our kind of engineering and to ignore the applications of these devices would be unrealistic. The boom in the use of private computers in America may or may not be repeated here, but there is evidently a degree of interest here already and in due course readers will be provided with the type of information that they need. It seems probable that the educational and small-company use of microcomputers will come first, followed by hobby applications, but this is mere guesswork. Observations from readers will be welcome and will help us to decide on the way the subject is treated.

As a start, the first of a series of articles describing a general-purpose microcomputer is published in this issue. The series is not "constructional", but is an introduction to the subject to familarise readers with microcomputers, in general. At a later date, it is the intention to publish a set of articles on the assembly and use of a microcomputer.

Microcomputer design

1—Introduction to digital hardware based on a microprocessor

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

The low cost computing power of the microprocessor is now being used to replace not only other forms of digital electronics but also analogue electronics and electromechanical and pure mechanical control systems. It is not unreasonable to assume that within the next five years or so there will be hardly any companies engaged in electronics which are not using microprocessors in one area or another. One implication of this technology is that engineers skilled in the design of more conventional electronic circuits and systems now have to acquire new disciplines — those of digital computer system design and programming. This series of articles will present the theory and application of microcomputers by reference to a particular commercially available microprocessor, and to its use in a particular microcomputer system available to amateur experimenters as a kit (see panel). This low-cost kit includes memory, input/output circuits and a keyboard, and can be used in the home with a domestic television set as a display unit and an audio cassette recorder for permanent storage of programmes. The first article examines the hardware components and principles of operation of such a general purpose computer system. Future articles will explore programming languages, the organization of the central processing unit, and practical design techniques for both the hardware and software of microprocessor-based systems.

In its most general form a digital computer system has the structure shown in Fig. 1. The central processing unit (c.p.u.), memory and input and output units are the essential hardware blocks which any computer must have. The c.p.u. does the work, manipulating data as directed by a programme stored in the memory. The memory may also be used for storing data. Information is transferred to and from the outside world by the c.p.u. via the input and output units.

The c.p.u. being the most complex part and the heart of all operations in the system, will be examined first. It may be viewed as two parts. One part, called the arithmetic and logic unit, actually does the work, while another part controls the sequence in which the various functions are performed. For the moment our main attention will be given to the arithmetic and logic unit (a.l.u.).

Any digital computer, including a microprocessor-based system, performs its data manipulation operations by utilising various combinations of the basic Boolean logic functions AND, OR, NAND, NOR etc. Of course, in a processor system many of the operations are often compounded from these basic functions to provide more complex operations. Programme instructions are used to selectively activate the various logic and arithmetic functions of the processing unit in order to achieve the required result. Consequently, a processor may be viewed as a programmable, general purpose logic block.

In this concept lies one of the reasons

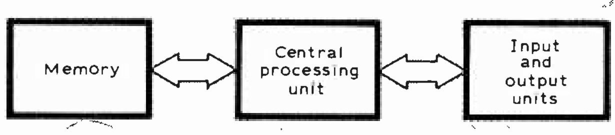


Fig 1

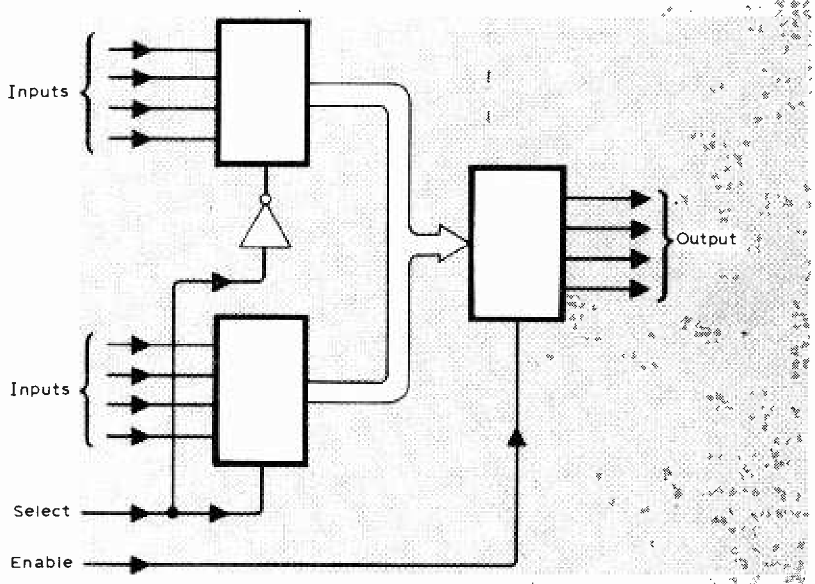


Fig 2

Fig. 1. Basic structure of a digital computer.
Fig. 2. A typical standard logic block, considered in the article as a step on the way to programmable logic.

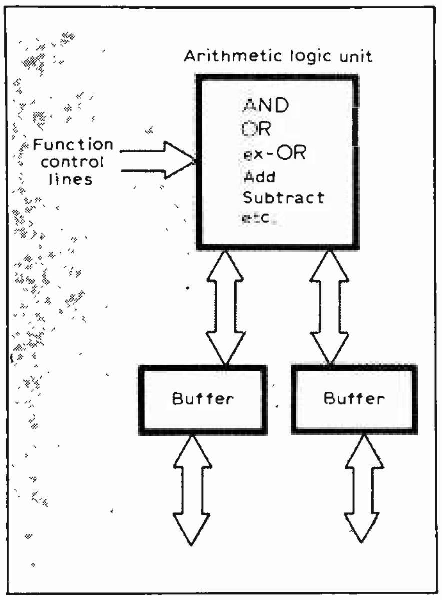


Fig. 3. A general purpose arithmetic/logic block.

for the use of the microprocessor, not only for the more usual computer type applications of data processing, but also for dedicated controllers and logic replacement devices. The low cost of microprocessors has now made them an economic solution for countless applications.

It is worth exploring this programmable logic concept further in order to understand more fully the operation and application of the central processing unit. Consider a standard quad 2-input multiplexer logic circuit as shown in Fig. 2. Here we see a standard logic block having a number of data input and output lines. The functions performed within the block are implemented with conventional logic gates. The exact function performed is dependent on the state of other inputs to the "system". The source of input data is determined by the state of the "select" line and the data is transmitted to the output under control of the "enable" line. Extending this concept further, we can arrive at the example of Fig. 3. The logic block has now been enhanced to include binary arithmetic functions. Also, there must be several more control lines available to select both the a.l.u. function and the data source and destination.

This programmable logic system now looks remarkably similar to the a.l.u. of a computer or microprocessor. In the processor the function control lines are derived, usually via decoding logic within the processor, from the binary instruction words which form the computer's programme. In order to control the sequential fetching and execution of the control codes, or instructions, from the programme memory the processor has a counter called a programme counter. If we now add a memory unit to the system of Fig. 3, together with additional a.l.u. operations to transfer data to and from the memory, the resulting structure is virtually identical to the general purpose computer of Fig.1.

Internally the c.p.u. processes information as parallel rows of bits (binary digits) and so information usually flows in and out in the same format. The multiplexer circuit example given in Fig. 2 receives and issues data in 4-bit parallel form. Common microprocessor organisations are based on 4-, 8-, 12- and 16-bit word lengths. Of these, the 4-bit devices were the earliest types to appear commercially, partly because they were useful in calculators operating with binary coded decimal data, but also because the a.l.u., being only 4 bits "wide," was less complex, this allowing more circuit functions for a given cost on a semiconductor chip of given area.

Nowadays the technology has developed such that a complex 8-bit processor or even a complete microcomputer can be built on a single chip, resulting in the fact that hardly any manufacturers are introducing new 4-bit designs now. Eight bits has proved to be the most popular word length for microprocessing since the majority of applications can conveniently be dealt with by 8-bit quantities. Also, 8 bits represents the best cost/performance trade-off compared with other word lengths. Current 16-bit microprocessors offer surprisingly little increase in performance over 8-bit machines, even for applications requiring the manipulation of 16-bit quantities. Using a 16-bit processor where an 8-bit one will suffice will also inevitably incur higher system hardware costs.

Microprocessor systems

By adding more detail to the diagram of Fig. 1 we can evolve a block diagram of a practical microprocessor system. In this case it represents part of the commercial microcomputer kit referred to above, which uses a Mostek Z80 microprocessor, and is shown in Fig. 4.

A microcomputer system is merely an l.s.i. (large scale integration) implementation of the basic computer structure. The c.p.u., or microprocessor, is usually a single integrated circuit containing the a.l.u. plus programme sequence control and instruction decoding logic. The internal structure of the Mostek Z80 c.p.u. is shown in Fig. 5. The memory may consist of anything from one to a great many components of various types of memory. The input and output circuits may transfer data in serial or parallel fashion, the number of bits in a transfer being determined by the design, or more specifically the word length, of the microprocessor. Broadly speaking, the majority of input/output circuits (commonly abbreviated to i/o) in a microprocessor system will be of a parallel nature. Each i/o block is commonly called a port, where again the number of bits constituting a port is given by the microprocessor's word length. Each i/o port may be a complete integrated circuit, although many microprocessor families, including the Z80, have circuits containing a number of i/o functions.

All microprocessors use some form of clock circuit as a basic timing reference for instruction executions, memory and i/o operations. In the case of the Z80 a single-phase square wave has to be supplied to the c.p.u. component. This is provided by a simple t.t.l. circuit in the kit.

In order to form a working system these components must, of course, be suitably interconnected. Herein lies the elegance of microcomputer hardware. The microprocessor has a number of external connexions which may be used directly or indirectly to provide three categories of information for the remainder of the system. These information "buses", as they are called (shown by broad arrows in the diagrams), are connected in a standard manner to the memory and i/o devices regardless of the end application and regardless of the number of memory and i/o components to be used. Consequently a microprocessor system

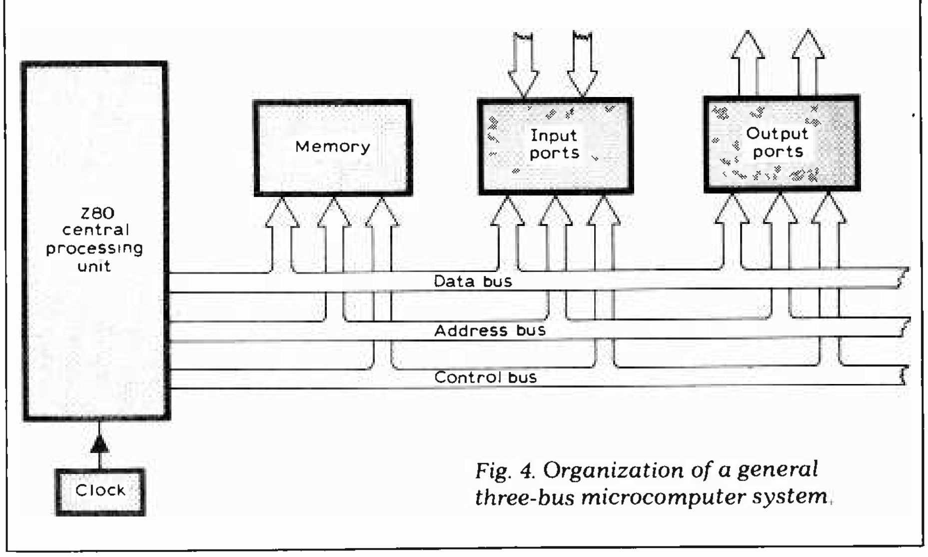


Fig. 4. Organization of a general three-bus microcomputer system.

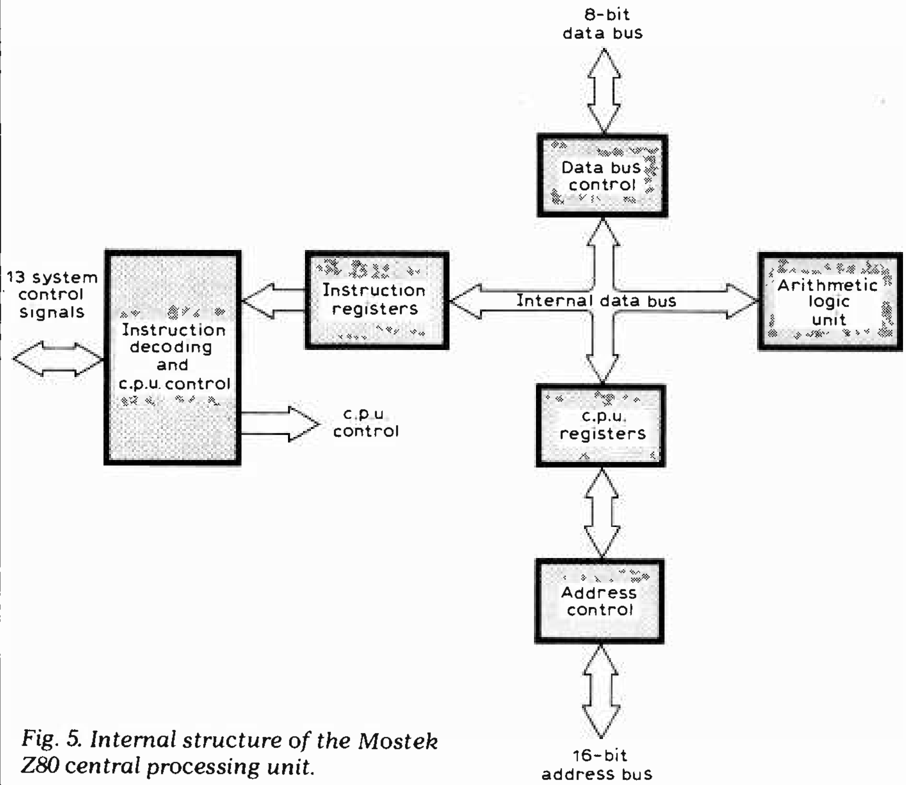


Fig. 5. Internal structure of the Mostek Z80 central processing unit.

may be usefully programmed and reprogrammed for a variety of applications. Similarly, a system with minimal hardware, if well designed, may be expanded at will to a more powerful configuration. This was the philosophy of the kit design.

Consider these three information buses which are shown in Fig. 4. They are the data bus, the address bus and the control bus. The data bus is a bidirectional one used for transfer of both data and instructions into and out of the c.p.u. The number of lines constituting the data bus is the same as the number of bits in the machine's word length. The Z80, being an 8-bit c.p.u., has a 8-bit data bus. This means that the system memory must also be organised as locations of 8 parallel bits. Similarly, i/o transfers will be to and from 8-bit ports. The data bus is connected around the components of the system such that all devices are placed on the common bus. All information transferred under programme control travels on this bus via the c.p.u.; for example, to transfer an item of data stored in the memory to a port, the data must first be fetched from the memory and passed into the c.p.u. and then sent from the c.p.u. to the output port.

Now let us consider the address bus. The number of bits constituting this bus has no direct relationship to the word length of the microprocessor. The address bus is used to select, or address, the location in the memory or the particular i/o port required for the current operation. The Z80 processor has an address bus of 16 bits, allowing the kit to be expanded to a maximum of 2^{16} = 65536 memory locations (or 64K bytes, where 1K = 1024). The value placed on the bus by the processor depends on the operation being performed, e.g. at the beginning of the instruction cycle the processor must supply the address of the next instruction in sequence to be fetched from programme memory. Then, during the execution of the instruction, data may be required to be moved between the c.p.u. and either the memory or an i/o port. If this is the case then the data memory address or i/o port address must be placed on the address bus by the c.p.u.

The third bus is the control bus. This is slightly different from the other two buses in that it is really a collection of individual control lines for memory, i/o and c.p.u. control. For example, in the case of the Z80 the main control signals are a "read" strobe pulse used to strobe data on the data bus into the c.p.u. from memory or i/o, and a "write" strobe to indicate that valid data is on the data bus from the c.p.u. to memory or i/o. This may be used to strobe data into a port or memory. Also there is an "input/output request" signal to indicate that the address bus contains a valid i/o port address, rather than a memory address. Similarly, there is a "memory request" signal indicating a valid memory address on the address bus, rather than an i/o address. Other control signals include a "reset" to the c.p.u., interrupt control (a concept explained later) and signals for suspending c.p.u. operation and de-activating the buses (useful in more complex, e.g. multiprocessor, systems).

A complete microcomputer system has now been evolved which contains all the necessary functional blocks. In a future article the Z80 c.p.u. (Fig. 5) will be explained in more detail, along with the concepts which influence its design and use. For now it is sufficient to say that in addition to the a.l.u., the c.p.u. contains various register stores. In the case of the Z80 there are 18 eight-bit registers and 4 sixteen-bit registers which are accessible to the programmer via the various c.p.u. instructions. Some of these registers serve special functions and others are general purpose stores similar to the main memory locations.

Memory organisation

It has already been implied that the memory of a computer system is used for two things – remembering instruction sequences (the programme) and remembering data. Semiconductor memory components may be one of two basic types, i.e. fixed, non-alterable memory and alterable, read/write memory. In dedicated microprocessor applications it is desirable to have the applications programmes fixed in permanent memory so that they are not lost when electrical power is removed. When power is applied, automatic operation of the system is then to be guaranteed. Such memory is called "read only memory" (r.o.m.). A true r.o.m. as such generally has its information fixed in it during the manufacturing process according to the particular customer's requirements. Consequently there is a minimum manufacturing quantity for this "customising" which is typically in the region of 100 to 1000 units. A popular alternative for lower volume and prototyping applications is the p.r.o.m. This is a programmable r.o.m. where the information may be fixed by the user by an electrical process which still results in permanent storage. A further development of this is the eraseable p.r.o.m. or e.p.r.o.m.. These devices may have their data erased by exposure to short wavelength ultra-violet light, thereby enabling them to be reprogrammed.

Strictly speaking all these memories have the feature of being "random access". This means that any memory location may be reached, or "accessed", with equal ease, at random, by applying the appropriate address. However, the term "random access memory", or r.a.m., has commonly come to mean a read/write, or alterable, memory, e.g. the type used as a data storage element in a microprocessor system. In a general purpose computer system this r.a.m. may also be used as a programme store, thereby enabling different programmes to be loaded and executed at will.

The microcomputer kit referred to above employs a combination of the memories just described. In order to allow meaningful user communications with this system there is a 1024-location

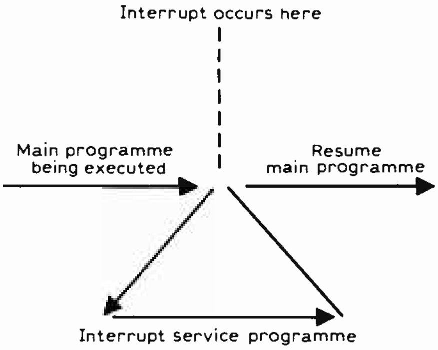


Fig. 6. Representation of the programme interrupt sequence.

(1K × 8 or 1K byte) e.p.r.o.m. containing a fixed programme. There is also a 2048-location (2K × 8 or 2K byte) r.a.m., a small amount of which is used for variable data required by this programme. However, the main purpose of this r.a.m. is to allow the system to function as a general purpose computer, i.e. the user may enter his own programmes to the r.a.m., via the i/o peripherals and under control of the e.p.r.o.m. programme, for subsequent execution.

Input/output organisation

Data may be transferred to and from a microprocessor system in several ways, some under programme control and some initiated by external events not under control of the processor. The most commonly used type of input/output operation is generally that which is initiated by programmed instructions. The Z80 can transfer an 8-bit value to or from an i/o port with an instruction taking 4 microseconds for its execution. Alternatively, a single instruction may be used to transfer a complete block of data at a rate of 8 microseconds per byte. The i/o instructions are used to transfer the state of data existing on the lines of an input port into the c.p.u. or, conversely, data from the c.p.u. to the lines of an output port. The circuits of the i/o ports frequently have the capability of temporarily storing the i/o data. That is, incoming data may be latched on the port by the peripheral device until it is accepted by the processor executing an input instruction. Similarly, data output from the processor is often latched on the port until required by the peripheral. A subsequent output to the same port could then change the state of the output lines.

Other ways of implementing input/output in a system are by direct memory access (d.m.a.) or by programme interrupts.

Programme interrupts are a method of initiating a data transfer independent of the normal programme flow. For example, suppose the processor has to interrogate several peripheral i/o ports to see if they have any data to be collected for processing. One way for the c.p.u. to handle such a situation is for the system programme to control a "polling" routine whereby each device is periodically examined in turn for data. The disadvantage of this is that a great deal of valuable processing time may be consumed by checking for valid data at a port when frequently there may be none ready. Interrupt operation overcomes this limitation. Now the c.p.u. does not have to periodically check for valid data: it is told, or interrupted, by the peripheral when this data is available. This interrupt, usually sent as a signal from a interrupt control circuit, has the effect of suspending the execution of the programme and then forcing the c.p.u. to a new programme which services the interrupting device. Upon completion of the service programme the c.p.u. is allowed to resume the previous execution of the programme. Fig. 6 shows the interrupt sequence diagrammatically. In a system with a number of separate interrupt sources it is usual to assign a priority to each one to ensure a sequence of servicing if multiple interrupts occur.

Direct memory access is generally a faster method of transferring data than may be achieved under programme control. D.m.a. transfers occur directly between the system's memory and the i/o device without involving the c.p.u. Consequently the speed of data transfer is limited essentially only by the speed of main memory. A typical d.m.a. transfer rate would be in excess of 1 megabyte/s. A special d.m.a. controller circuit initiates and controls the transfer in response to an external request. The c.p.u. operation must be suspended during the transfer and is allowed to resume operation when the transfer is complete. This is so that both c.p.u. and d.m.a. controller will not try to use the system buses simultaneously. D.m.a. is generally used in more complex systems when large blocks of data have to be transferred to or from peripherals at a speed greater than can be achieved by programme instructions. It is also possible to do single byte transfers under d.m.a., often without stopping the processor if the transfer can take place while the c.p.u. is not using the buses. This is often called "cycle stealing".

The actual i/o parts of a microprocessor may be implemented with standard t.t.l. logic circuits, e.g. 8-bit latches or buffers, or with the more integrated members of a manufacturer's l.s.i. microcomputer family.

Part 2 of this series will give a practical example of hardware and will also deal with software.

SPECIAL TERMINOLOGY

Microcomputer. A digital computer which uses a microprocessor as its central processing unit. The prefix "micro" does not mean literally "a millionth part of" but is derived from the word "microcircuit," an early name for the integrated circuit.

Microprocessor. A digital processing unit constructed as one or more integrated circuits, using l.s.i. manufacturing technology. Can be used as part of a microcomputer.

Instruction. An expression that defines a computer operation and identifies its operands.

Programme. A prepared list of instructions, written in a special "language" or code, to be carried out in sequence by a computer or other programmable device.

Bit. Abbreviated form of **binary digit.** The basic unit of binary coding (1 or 0) used to represent numbers, instructions or addresses.

Byte. Unit of binary information, normally consisting of eight bits.

Word. A group of binary digits representing a number, instruction or any other item of information. Often specified by its length, e.g. 16-bit word.

K. Abbreviation for 1024 (to be distinguished from the common lower-case prefix "k" that represents 1000).

Serial. Representation of binary information in which the binary digits occur in time sequence (e.g. on a single wire).

Parallel. Representation of binary information in which the binary digits occur simultaneously (e.g. 4 bits on 4 wires).

Bus. Abbreviated form of "bus-bar" derived from "omnibus". A group of conductors carrying words in parallel (one bit per conductor) in either direction; usually common to several devices and identified by function, e.g. address bus.

Microcomputer kit

This kit, known as NASCOM I, includes a Mostek Z80 microprocessor, MK3880; 2Kbyte of r.a.m. using Mostek 1024-bit r.a.ms, MK4102; 1Kbyte of e.p.r.o.m. using the Mostek 1024×8-bit e.p.r.o.m. MK2708; u.a.r.t. type M6402; character generator MCM6571A; i.cs. for video r.a.m. logic; zener diodes; 16MHz crystal; interfaces; a keyboard; and p.c. boards. Price £197.50 (ex. v.a.t.).

The microcomputer is designed to use a domestic tv set as a visual display and a standard audio cassette tape recorder for programme storage. It can be adapted for use with a teleprinter and allows memory expansion to 64Kbyte.

Further information from the suppliers: Lynx Electronics (London) Ltd., 92 Broad Street, Chesham, Bucks. (tel: Chesham (02405) 75154).

Television developments in Germany

A report from the Internationale Funkausstellung, Berlin

by Geoffrey Shorter

626,000 visitors/486 exhibitors from 27 countries/1000 new products/"reserved optimism" for entertainment electronics to 1980/8-10% increase for 1977/colour tv reaches 50% penetration/two techniques for picture insets/microprocessors, in tv?/set-makers sell r.o.m.-cartridge game/Videotext problems: publishers vs broadcasters/Viewdata plans/next IFA: Berlin 24.8-2.9 1979.

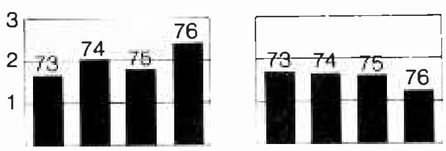
"There is justifiable reason for reserved short and medium-term optimism" was how Professor Dr H Jurgensen, director of the Hamburg Institute for European Economic Policy, assessed the immediate future of the entertainment electronics market in Germany. "Provided," he added, "the producers do not over-estimate the doubtlessly available market potential . . ." a clear reference to the embarrassing over-production of tv sets, which occurred earlier in the year.

Isolating the main market factors he cited the increasing percentage of adults in the population. From 1975 to 1980 the number of people between 16 and 30 will increase by two million – and with it the number of small households – the total population being due to fall by one million. The proportion of educated and highly skilled people with purchasing power is expected to increase and low income groups will become less significant, he said. (An income of 3000DM per month is already enjoyed by 90% of the self-employed and 10% of pensioners.) Expenditure on leisure and education, currently 10% in middle and higher income groups, is growing faster than incomes and has tripled in the decade from 1966. In addition, there are signs that consumers are getting more quality conscious, want greater participation and more variety in their entertainment, all trends which Prof Jurgensen argued will benefit entertainment electronics in coming years. "What all this adds up to," he concluded, are "well-above average" prospects to expand "with due caution."

Taking a wider view and putting numbers to their forecasts, Grundig, who are the colour tv market leaders, see business as "reasonably safe" in Europe and estimate a growth in demand of half-a-million sets a year. This would bring the total demand for colour tv in Western Europe up to 9.5 million units by 1980; an average rise of 5% per year, and giving a market penetration of 51%.

Manufacturing industry for entertainment electronics in Germany showed an increase in turnover last year of 1000 million DM or 20% (excluding record players) – a real revenue increase of 8.5% – mainly as a result of increased colour tv production. Production of black and white tv sets and radio receivers fell by 25% but was largely compensated for by increased production of portable radios, car radios and hi-fi systems.

Sales of German-made colour sets, 2.3 million, did particularly well (up to 24% in value, higher for exports which were a third of production) apparently at the expense of black and white sets, which sold 1.2 million units including exports (1975: 1.6 million). There is little doubt that the Olympic Games and



These figures, in millions of units, for German television production are derived by adding imports to home production and subtracting exports. Colour figures on left, black and white on right.

Bundestag elections helped achieve this high level of sales, though there are underlying trends beneath that surface. Now that colour television is becoming the norm in Germany – one in two households have a colour set (1976: 46%) – there is a gradual change from black and white to colour, as well as colour renewals now that colour tv in Germany is a decade old.

The only other equipment to get anywhere near the colour tv growth is car radio, increasing sales from 2.5 million in 1975 to over 3 million. First half figures for 1977 show a 17% growth. More than half the vehicles in Germany now have car radio, though how many sales are due to the traffic information system isn't clear. 1977 does not appear to be off to a good start in tv with a fall of 4% in sales in the first half compared with the same period in 1976 — colour share in this is up only 1.2% — but it is argued that the majority of business is done in the second half of the year, especially an IFA year.

In addition to falling demand for black and white tv sales (–15% first half of this year), market share for 67cm colour sets is falling whilst the share of smaller screen sizes is increasing. One forecast expects sales of 67cm sets to remain constant in Germany at around 1.7 million until 1982, when penetration would be 77%, with portables of 37 to 50cm increasing by 50% to give a share of 25%, and intermediate sizes increasing by 60%, the large screen slipping from 70 to 62% of the market. In Europe, the large screen size will have fallen from 64% in 1976 to 50% in 1980. In response to this manufacturers are fitting sales-attracting features on their portable sets, like remote control (half the sets in Germany now have remote control), automatic search tuning, and tv games.

The most significant aspect of receiver development in the decade of German colour television has been its conversion to semiconductor engineering. This has not only helped to keep prices stable — our 1967 Berlin show report gave the price of a large-screen colour set as 2,300DM about the same as now and production costs of equivalent table-model colour sets have in fact fallen by 15% – when the retail price index has increased by 57%, but has had a major effect on reliability as measured by repair calls. "The owner of a colour set using valves could expect an average of one to three repair calls a year," recalls Gunter Kroll of the manufacturers association ZVEI, "Whereas this need has been reduced to 0.15 to 0.5 calls in today's television sets."

Actually, the service technician has never had it so good. For as well as producing equipment of increasing reliability, manufacturers have made diagnosis a very simple affair with their various Servicefreundlichkeit aids, and repair straightforward with the modultechnik, now almost universal following the lead of Körting, and Grundig. But it must be considered, comments Kroll, to what extent modular construction is important for servicing when frequency of repairs is that low. Highly integrated circuits could "usurp the role of the module completely." (Could they not have their own fault diagnosis and indication circuitry built in, we ask?)

The attractions of avoiding mechanical tuning contraptions were appreciated fairly early in European tv sets, for both geographical and mechanical reasons. Mechanically, the use of variable-capacitance diodes meant that the tuner could be situated on the same p.c. board as the rest of the circuitry, it made it much easier to tune and band switch remotely. It was also easier to produce variants — there wouldn't be so much difference between a continental 16-channel model for the border areas, and, say, a UK-only set of three or four channels capability.

In our last Berlin show report we said Philip's proposed an all-electronic m.o.s. tuning system that would encompass search tuning with memory, memorized analogue control settings, on-screen displays and remote control. Now, the system is in use in Philips, Loewe-Opta and some other top-line sets and does away with the 8, 12, 16, or more tuning potentiometers, storing the station frequencies in a random access memory. In this frequency synthesis approach to digital tuning the frequency of the local oscillator is measured directly. Digital information representing a desired channel is called up from a memory i.c. and compared, coincidence causing a control i.c. to lock the tuning.

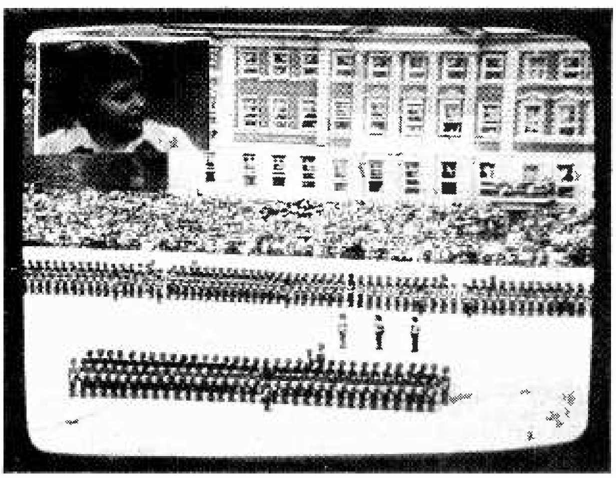
The system, called TRD for tuning, remote control and digital, originally needed four i.cs with an option of a further five for special functions like on-screen display and search tuning, but now Philips say they can provide all functions with seven. When a channel is ordered, a binary-coded oscillator frequency is recalled from a SAB2014 read-only memory and compared with the output from an SAB1078 e.c.l. prescaler, whose output is the oscillator frequency divided by 256. If the difference is more than a certain amount pulses are generated whose width is proportional to error and which are used to retune the oscillator until code parity is obtained. A further i.c. is a SAB2015 r.a.m. which can store b.c.d. information on 16 user-selected channels. The full technique permits direct channel selection without having to go through a fixed sequence, as well as automatic search and sequencing modes, and sets using it can be tuned without access to tv transmission. Cost is higher than the voltage-synthesis technique and is therefore only found on the luxury-class set.

Automatic search and elimination of tuning potentiometers were also primary aims with ITT Intermetall's open-loop voltage synthesis method. The tuning voltage is generated in steps and it is the number of steps required for accurate tuning that is stored. The two key m.o.s. i.cs, a SAA1021 control circuit and an SAA1020 static shift-register memory, are both compatible with two others, one for handling ultrasonic remote control codes SAA1130 and one for on-screen channel number display, an SAA1008 or a derivative that also acts as an on-screen indicator for tuning voltage, tv band, and brightness, colour saturation and volume control movements.

The 66/67cm in-line c.r.t dominate the German colour tv market, though 51 and 56cm sets are gaining a larger share and 36cm is the most popular size in portables. Precision in-line or PIL tubes have gained ground in medium-size sets, but "problems" in large screen sizes make the 20AX in-line variety the popular choice. By all accounts these two formats will be with us for some time to come. But while one industry spokesman was saying we couldn't expect "spectacular innovations providing visible advantages" in picture tubes, ITT Components were announcing a tube with a visibly brighter picture. By changing the glass colour, making some alteration to the slots in the mask, and improving the phosphor, they claim an increase in brightness of 70%. But with 600,000 sets unsold — half as much again at the same time in 1975 — there were feelings that its introduction should have been delayed. Nevertheless both ITT brands, Schaub-Lorenz and Graetz, and Körting have taken up the new tube: "We know Mullard are working on something," confessed an ITT spokesman.

As market penetration of colour television passes the half way mark, set makers will need to rely more on "convincing innovations and the rationalization of production," as Gunter Kroll puts it, than on having tv sets in the right place, at the right time and in the right quantity. Already the German TV market has probably seen more market-oriented innovations than any other, starting with diode tuning and band switching, switched-mode power supplies, provision for connecting external equipment, high quality sound, large-signal p-i-n diode tuners, touch sensor channel selection, ultrasonic remote control, modular chassis construction, self-diagnostic service aids, infra-red sound links, permanent pre-set control settings, on-screen colour display of control settings, on-screen, display of time and channel numbers, infra-red remote control, and automatic search tuning systems with memory. You name it. And this year adds reduced power dissipation, built-in games, inset second program pictures and microprocessors to the list.

In competing for new features the makers with the large market shares (Grundig is biggest with around 30%, Philips next with 12-14%, followed by Telefunken and Saba with around 10% each) have a built-in advantage. They have the production to justify the "¼ to ½ million quantities that the i.c. makers need" points out Dr Böhme, chief of Körting, alluding to Grundig's latest "Vollbild-im-bild" scoop, in which a reduced-size picture of another programme is inset into the main picture. With their enormous production — a million sets or more — Grundig have



Synchronization of inset black and white pictures of a second tv programme relies on closeness of sync pulses from different transmitters, but small differences give rise to inset movement. Banding is avoided by switching inset into different quadrants. Alternative is to read out the inset from a memory: new bucket-brigade charge transfer device can store 1 in 4 lines.

been able to tie up the ITT-Intermetall i.cs exclusively for a 6-month period. The tv manufacturing subsidiary of ITT, in Germany, Schaub-Lorenz, must be waiting to see how this expensive luxury goes down before committing themselves. They dropped the clock idea, which had added 200DM to the price of their tv sets, as a "silly gimmick". If they want to know the time, comments Charles J. Zsakovits, ITTs tv product manager, most people just look at their watch. And at an additional cost of 300DM for the Grundig/Intermetall inset picture approach, ITT must feel its appeal is fairly limited: "For that you can get another black and white set," muses Zsakovits.

In the face of such deals with semiconductor device manufacturers, firms with smaller shares of the market like Körting — Dr Böhme declined to give their share — had to think up ideas first.

On-screen colour display of control settings was a Körting idea of three or four years ago and their latest is the use of hi-fi loudspeakers as microphones and in tv, a set that *speaks* its channel number. They have other ideas anyway for implementing the picture-in-picture facility and they are investigating switching the local oscillator at 700MHz, Dr Böhme told *Wireless World*, so that only one r.f., i.f. and demodulator sections would be needed.

With the i.c. approach, a stable second picture location is made possible by using a memory to store the reduced-size picture. Video information is written in synchronism with a transmission to be inset but read out in sync with the main picture signal. Two new charge transfer devices, type UAA1000, of area or matrix format rather than line or row format, store and read the inset picture line-by-line under control of a third i.c., SAA3000. One of the memories is storing information while the other is reading, both under read, write and shift direction from the SAA3000 i.c. Only every fourth scan is stored – the inset picture is quarter-height — and horizontally the writing speed is limited to 1.5MHz with read out four times faster. The Belgian manufacturer Barco say they will also be using charge transfer devices in this application.

The other way of tackling the problem, adopted by Saba and Telefunken, relies on the 1 in 10^6 tolerance of the colour subcarrier and consequent closeness of sync pulses from different transmitters, making it possible to display part of a second programme with the receiver deflection circuits locked to a primary programme. The incomplete second picture with full resolution, measures 16 x 18cm on a 67cm tube. Snag is a horizontal wandering of the inset due to small errors in synchronization, but the marketeers are quick to point out that this gives a greater effective sampling area than would otherwise be the case! And these sync differences would also give rise to black horizontal or vertical bands some of the time; so logic circuitry is included that decides which corner of the screen to use for the inset so that the black bands do not show.

Nordmende had thought of it all before of course. Their Spectra Colour Studio with its three 20cm monitors beneath the main 66cm picture was wheeled out, as if to ask what all the fuss was about. Their set, or rather its predecessor, had simultaneous four-channel capability back in 1967!

The combination of large-scale integration with digital signal processing enables developments to be made in tv sets the cost of which would otherwise be prohibitive. Though memories are coming to tv sets in increasing numbers and complexity – still full-picture stores will soon be in sets – there are differences of opinion about microprocessors. While some manufacturers are dabbling with microprocessors, one engineer with the ZVEI asserts that in spite of inroads into process control and data handling, it is certain *not* to find use in TV sets in its present form. "In most cases," says Gunter Kroll, it is "not a suitable component for the functions required of a tv set – its capacity is too large," and argues that specific i.cs for tv use yield a better price-performance ratio. Time will tell whether Blaupunkt's use of a microprocessor will be confined to its luxury-class set.

In the Blaupunkt PS19 set, a 30-key remote unit is used to select any of 19 channels. The three-chip Fairchild F8 microprocessor allows storage of 20 switch-on, switch-off or switch-over commands, with or without date, selection of the desired channel, or switch off five minutes after transmitter close-down, as well as the other facilities common to digital tuning, remote control using the SAA1024 and on-screen display of time, date, tuning voltage, channel number and band. A non-volatile m.n.o.s. electrically alterable r.o.m. stores switching commands, coarse and fine tuning voltages and four standard values for the analogue controls of saturation, brightness, contrast and volume for up to 19 programmes.

The other European set maker to show sets using a microprocessor is Barco. A combination of Texas and National chips, enables a programme tuner to switch four pre-set programmes at chosen times, and to jump from one programme to another at eight-second intervals every minute or half-minute. The set uses the voltage-synthesis search tuning and storage technique.

A teletext version of their Gauguin set, which they say will be available next March, will switch to teletext at a pre-set time and is being made with reception of the French teletext system – Antiope – in mind.

Barco say their new tuner-amplifier incorporates a microprocessor. Using a frequency synthesizer technique for tuning in 1kHz, steps on the a.m. bands and in 25kHz, steps on f.m., up to 16 frequencies can be stored in the non-volatile memory. A search mode is available, which can select only stereo stations if required. Such facilities have been available for some years on other digital f.m. tuners, though not with a "32-function" remote control unit as far as we know, and it's not altogether clear what additional benefits the microprocessor confers.

Notorious for inducing boredom fairly quickly, the first generation of television games born in 1972 were never really marketed extensively in Europe. The second generation types, using purpose-designed integrated circuits, some of which offer a choice of up to ten "ball and paddle" games, are now being built into tv sets and selling alongside the newer third generation programmable games. The Fairchild programmable unit, which they call a "video entertainment system," was introduced in the USA in June 1976 and approved by the FCC last November, (In the USA games for connection to tv antenna sockets require FCC type approval to keep r.f. radiation below 15μV/m at 1m from the set.) Fairchilds entry on the European tv games market seemed to come at a time when they were experiencing problems in their watch business. "We took a fairly big bang in losing $8 million in three months," explained R. H. Bohnet, international marketing director, who told how Fairchild had gone "from zero to $80 million in digital watches in one year". They appear to have been successful in their European efforts. They cancelled a Berlin press conference, booked earlier in the year, because they "didn't need it." And Saba, now owned by General Telephone & Electronics, have the Fairchild game, selling it with their own markings. Luxor too, who have taken a commitment in Sweden, and "a lot of companies at the show are evaluating" according to Fairchild.

In the U.S.A. the unit sells to retailers (as 'Channel F') because of established links, but in Europe it is sold to the set maker for resale: "a tv set would cost too much if it were built in," they say. The game is based on the F-8 microprocessor with a range of Videocart r.o.m. cartridges – 10 now, 15 by the end of the year – with up to four games per cartridge. They include things like blackjack, various races, shooting gallery, doodles, tank fights, and one can store thousands of different mazes. The player control sticks are described as having "eight degrees of freedom" (they mean four) and both colour and size changes can be made from it. There are options for playing the "machine" as well. "It's not very interesting playing backgammon with a machine," admits Mr Bohnet, "but we're working on chess".

Out of the other r.o.m.-cartridge games recently approved by the FCC only the Atari game was seen in operation, on the Telefunken exhibit. They are test marketing the unit this autumn at 500DM and 50DM per cartridge (with a maximum of 50 programmes): similar pricing to Fairchilds. "The unit is too expensive to build into sets", said a Telefunken marketing executive "2,500DM is the magic barrier for colour tv".

But the biggest innovation that German colour television is likely to see in the near future are the text transmission systems and practically every European set maker at the IFA had to show their sets were text-capable. Some sections of the industry are setting their sights on 1982 as the starting year for a text service, assuming Medienpolitik problems are sorted out. "We don't want it before" Körting's boss told *Wireless World*. After the 2/3 penetration point has been reached and tv production falls off, he argues, is the time to introduce the system. Other interests may not agree, but it is difficult to see how there can be an early start to a broadcast system when there is no agreement over who should run it.

Different laws govern press freedom and broadcasters independence, neither having foreseen a hybrid service like teletext or Videotext as it is called in Germany. The problem is that newspaper publishers do not take to the idea of broadcasters controlling the written word – they say they should stick to the spoken word – while the broadcasters say that as long as the programme comes from a transmitter it is certainly a matter for them. "The newspaper industry is afraid of teletext," admits Dietrich Ratzke, managing editor of the *Frankfurter Allgemeine* and editorial consultant of Bildshirmzeitung, the publishers teletext. It's not that there is an immediate danger of newspapers disappearing, he explained, but that "it's not good for the long-term health of newspapers." And who will say that an alternative source of on-demand information traditionally supplied by newspapers – e.g. sports results, stock market data, entertainment guides and the like – will not affect them?

In Germany the radio and television stations are not state-controlled but are self-governing non-profit public corporations, with their legal basis either on Land legislation or in a treaty between Länder. Most Länder do not appear to want to authorize a newspaper-run text-transmission service, presumably because as the law stands, programmes can only be provided by the station and not by a private organisation. There are some special situations recognized but the wording is vague. Obviously the exhibition was deemed a special case and the Berlin Land gave permission for trials only on a closed-circuit basis and only for the duration of the exhibition.

Last autumn 24 newspapers belonging to the publishers association BDZV sent editors to form the Bildschirm Zeitung. They made numerous visits to London, consulting with GEC, and the BBC and IBA teletext units, preparing themselves for the two-week competition with the broadcasters at the Berlin show. The editing team took current affairs information, e.g. via telex from Springer, transcribed and edited it on the GEC stand and sent it round the exhibition on channel 35. The broadcasters for their part formed a joint ARD/ZDF Videotext unit and following test transmission during July (ZDF) and August (ARD) went on the air from the SFB transmitter on channels 7 and 39 for the duration of the exhibition.

G.E.C. stand was host to journalists producing Bildschirmzeitung, a teletext service run by newspaper publishers. Publishers want to run teletext in Germany, but how they can achieve this is still not clear.

"The publishers aim is clear" Alexander Kulpok of the joint Videotext unit at SFB told *Wireless World* "but they don't know how to achieve it. They are only interested in getting into the business." The answer, thought Kulpok, depended on "a political solution and upon the future of commercial television." The situation could change "if the Christian Democrats get in or if there is cable television within say five years." And a service could come very soon, he said, "if it comes to a fight" and a Court of Law had to decide.

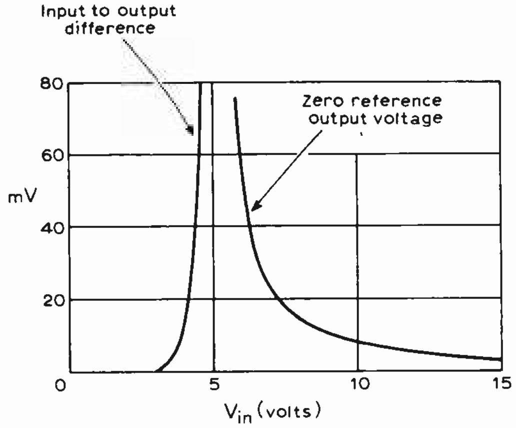
Now that the exhibition is over the publishers feel sure the ARD/ZDF unit at SFB will continue elsewhere, perhaps at Mainz with ZDF or Munich with IRT. And next move by the BDZV will probably be to seek permission to market a service from the respective Ländesregierung. But it's difficult to see an outcome that will please everyone; Ratzke thinks that the publishers will be allowed to run a service, but it would have to accept the ultimate control of the tv stations. "And what of the law that forbids outside control of the free press?"

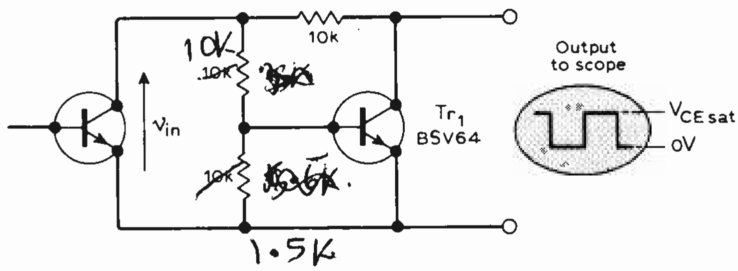
By comparison, the problems of the wired interactive version, given its first public showing in Berlin and which is identical to the UK Viewdata system even to the extent of using the same model of computer, are not so great. But until the question of whether viewdata, or Bildschirmtext as it is called, is purely telecommunications – the Bundespost argue it is a federal matter as the telephone is used – or whether it is also a broadcasting matter, the German post office are not allowed to operate a full service. "In strict adherence to the principle of fair network utilization," said Bundespost executive Theodor Irmer at a press conference, "the post office has expressly refrained in its demonstrations from the reproduction of any information having a content which has not been legally established as germane to the medium".

A Viewdata trial is starting immediately after the exhibition, the basis of which, Herr Irmer later explained, was that it will use "bilateral" information only in a non-public way up until 1980, when it is hoped the issue will be resolved. This phase will be followed by a field test for 2000 private subscribers, in effort to get answers to the questions of who wants to know what and when, and who will provide input, by 1982 when it is hoped a full public service can begin.

On August 23, a "substantial" contract between the British Post Office and the Bundespost was announced in which the Bundespost gets a duplicate of the Viewdata programme and expertise (they already have an identical computer). Under the contract, the technical information passed on by the Bundespost to German electronics firms is restricted for use only in Germany for the next three years, and German firms are not permitted to compete with British firms in exporting Viewdata equipment to other countries until after March 1980. This is unlikely to worry the German manufacturers, as it's highly improbable that there will be any large scale use of Viewdata before then, even in the U.K.

Circuit Ideas





Measuring VCE_{SAT} in power transistors

To determine the saturation loss in power transistors it is necessary to measure the saturation voltage, which may be about 1 to 2V. The measuring circuit must also accommodate the high collector voltage which is present when the switching transistor is in the off state. A problem therefore arises if a d.c. coupled oscilloscope is used as it is often difficult to obtain adequate voltage resolution without overloading the deflection amplifier during the off state of the transistor. Furthermore, a very small disparity between a.c. and d.c. gain in the deflection channel can lead to a substantial error in the apparent saturation voltage.

The circuit shown is inserted between the switching transistor and an oscilloscope which may then be a.c. coupled. Output to the oscilloscope is a rectangular waveform with a low voltage state representing 0V and the high voltage state being the transistor saturation voltage. Errors in the circuit are typically less than 10mV, and may be established by d.c. measurements if desired. Accurate measurements of saturation voltage may be made simply by reading the peak to peak voltage of the displayed waveform. When the collector voltage of the power switch is below 4V, Tr_1 is non-conducting. During the off state of the switch, its collector voltage is assumed to be greater than 10V in which case Tr_1 is heavily saturated and the zero reference output is typically less than 10mV. Note that Tr_1 is a large-chip transistor operating at low collector current. The same technique may be used to drive an integrating wattmeter which, by sampling collector current, will show saturation power loss directly.

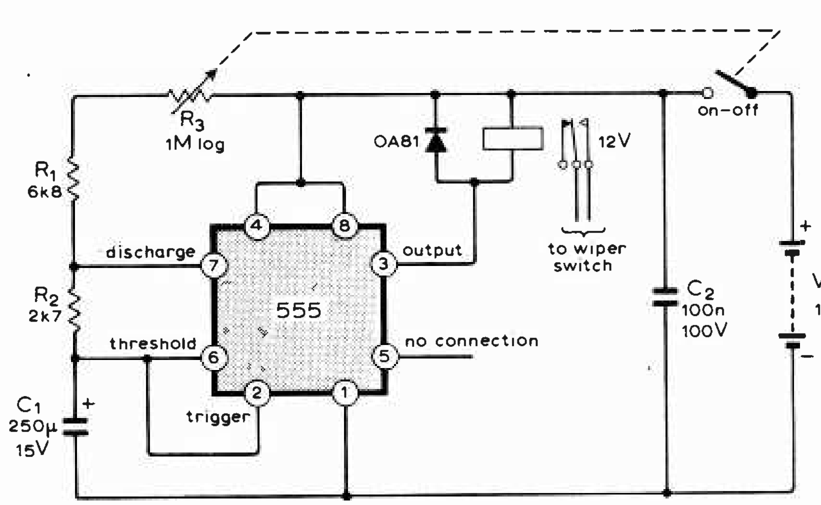
D. R. Boit,
Charlwood,
Surrey.

Windscreen wiper controller

The delay between successive sweeps of self-parking wiper blades can be altered by a single variable resistor. Any delay between approximately three seconds and three minutes can be obtained with the values shown. The wiper blades can easily be made to perform two or more successive sweeps between the delays instead of one double sweep. When the delay is set to the minimum value, the wipers operate almost continuously.

The relay contacts are connected across the existing wiper switch and merely override the existing controls.

J. B. Dance,
Alcester,
Warwicks.



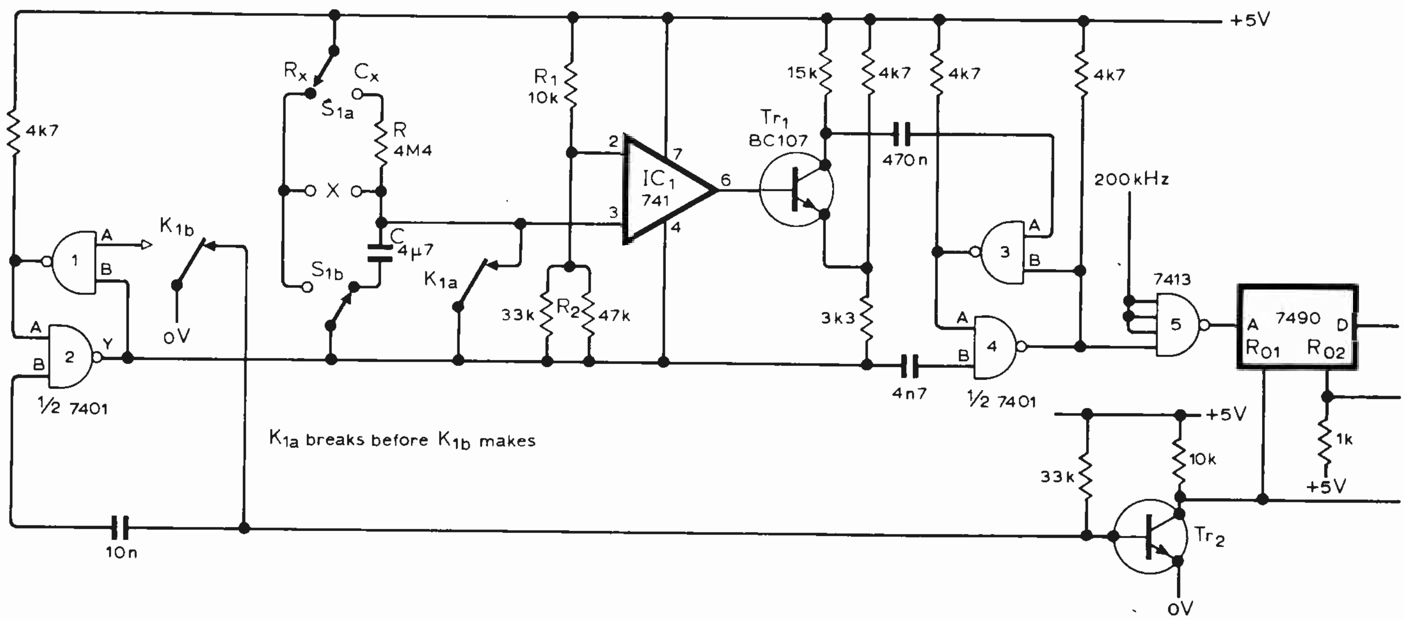
Resistance-capacitance meter

This circuit was designed as an addition to a six-digit frequency meter in which gate 5, with its following counters, drivers, and display, forms part of the instrument. It displays resistance in ohms up to 1MΩ or capacitance in pF up to 1μF. Gates 3, 4, 5 and the b.c.d. counters etc form a 200kHz stop-watch which is started and stopped by negative-going pulses at gate 4 and 3 respectively. Reset is achieved by applying a zero at the base of Tr_2. Resistor R_x or capacitor C_x is connected in series with capacitor C or resistor R, according to the position of S_1. When K_{1a} is normal, the output of gate 2 is high, C is short-circuited, IC_1 and Tr_1 are off and the counters are reset by Tr_2.

When operated, K_{1a} removes the short from C, and K_{1b} removes the reset condition from Tr_2 and applies a 0 at gate 1. Gate 4 receives a 0 from gate 2 and starts the stopwatch. Simultaneously, C starts to charge via R_x. After time $t = CR_x \log_e (R_1+R_2)/R_1 = 1.065CR_x$, the voltage at IC_1 pin 3 reaches that at pin 2 and the output goes high. Transistor Tr_1 then turns on and a negative pulse to gate 3 stops the timer. The meter, having counted 200kHz for t seconds, displays the value of R_x or C_x.

Although there are small errors developed in the circuit when measuring an unknown resistor or capacitor, this simple design is a useful addition to a frequency meter.

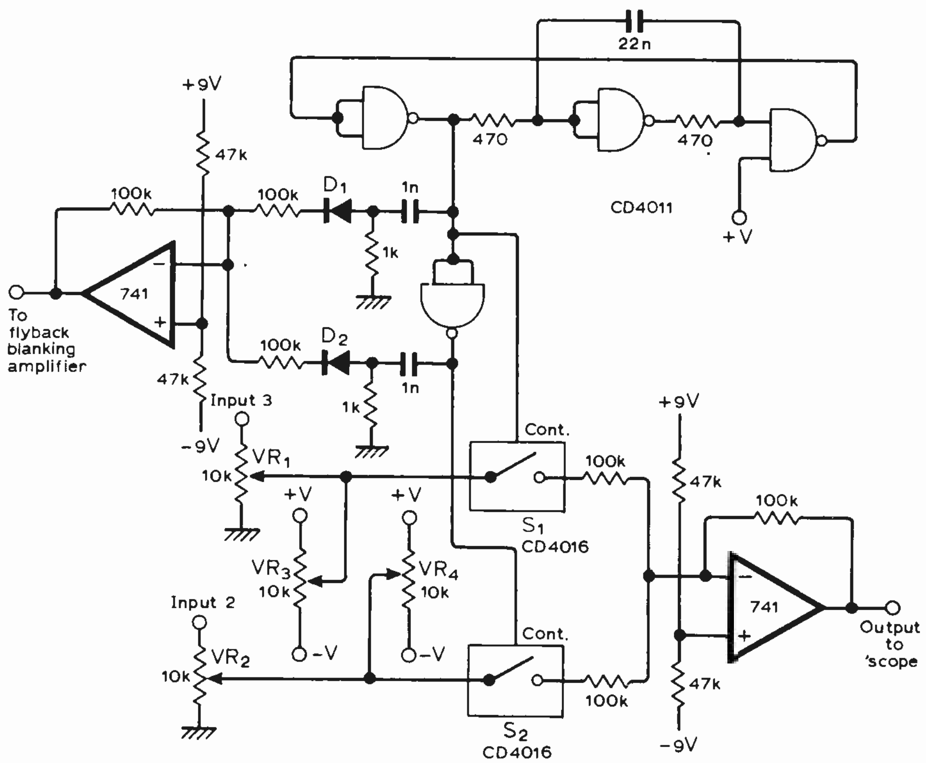
G. Jackson,
Creigiau,
Cardiff.

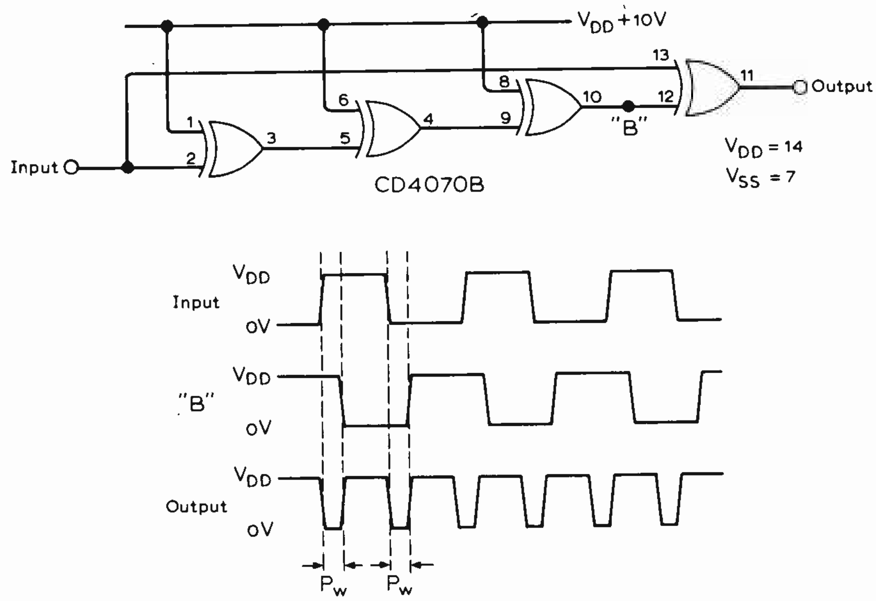


Oscilloscope trace doubler

The 4011 forms an astable oscillator with a frequency of 53kHz. Two out-of-phase pulse trains are fed to the 4016 which alternately switches two inputs into the unity gain mixer amplifier. The output of the 741 is then fed to an oscilloscope. Input levels are controlled by VR_1 and VR_2, and the position is controlled by VR_3 and VR_4. The remainder of the circuit is used to blank the beam between sweeps by differentiating the oscillator outputs to produce spikes. Positive spikes are then mixed and inverted by the 741 which drives the flyback blanking amplifier.

J. S. Paterson,
East Lothian,
Scotland.





Change-of-state detector

A conventional change-of-state detector uses the OR'ed outputs of two monostables triggering from opposite polarity edges. This circuit uses only one exclusive-OR gate i.c., and performs frequency doubling or change-of-state detection. The first three gates are connected as buffers and the final gate exclusive-ORs the output of the buffers and the input. An output pulse of width equal to the total propagation delay of the buffers is obtained, in practice about 100ns, from the CD4070B. This pulse may be extended if necessary by the addition of a <5nF capacitor from point B to ground.

If the line shown tied to V_{DD} is connected to V_{SS} instead, the output polarity is inverted.

S. Roberts,
Sheffield.

Audio overload monitor

This circuit uses two of the four comparators in an LM339 package to provide detection of excessive positive or negative signal peaks. Pulse-stretching is used to ensure that a clear indication of short-duration peaks is given. Bidirectional peak measurement is important as positive and negative peaks may vary by up to 8dB.

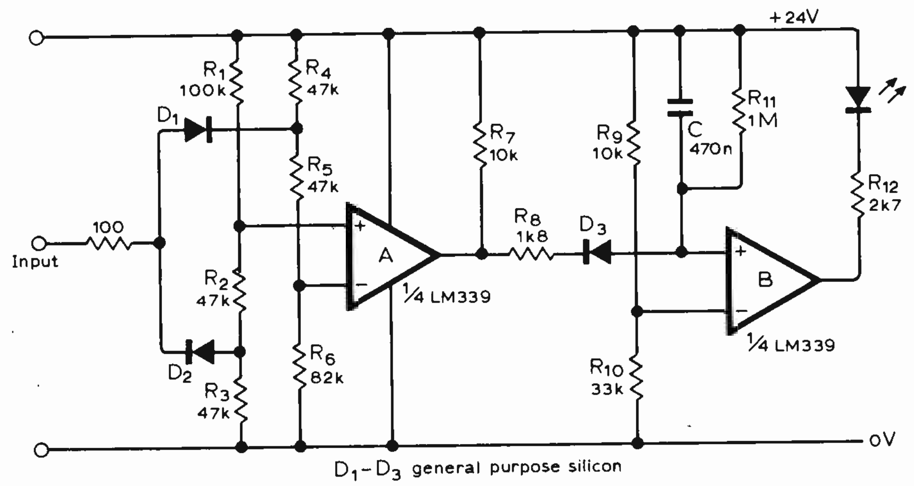
Comparator A detects peaks of either polarity, and the two potential dividers hold the inverting input 400mV below the non-inverting input. If the audio input exceeds the trip point on a positive peak, D_1 conducts which pulls up the inverting input and causes the comparator to change state. Likewise, a suitably large negative peak will make D_2 conduct and pull down the non-inverting input, again causing the comparator output to go low.

When output A goes low, storage capacitor C charges rapidly through D_3 and R_8. When the peak is past, C remains charged and keeps the output of comparator B low so the l.e.d. remains on. The output goes high again after C has discharged through R_{11}, and the l.e.d. is extinguished.

With the values shown, the circuit trips at a peak level equivalent to a 5V r.m.s. sine wave. This is 3dB below the maximum voltage swing to be expected from an amplifying stage operating from a 24V rail. Note that the circuit should not be driven from a high impedance point because the diodes may cause distortion.

A stereo version may be conventiently made using a single LM339 package.

D. Self,
London E.17.

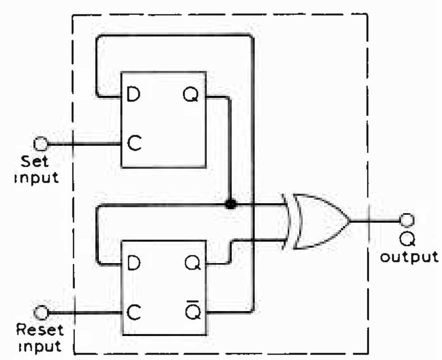


SR flip-flop

Using a c.m.o.s. dual D-type flip-flop and one exclusive-OR gate an SR flip-flop may be made which is triggered by a positive edge on either input, irrespective of the level of the other input.

A positive edge on the set input will force the two flip-flops into opposite states and hence one input to the exclusive-OR will be a 1 and the Q output will be a 1. A positive edge on the reset input will force both flip-flops to the same state, the two exclusive-OR inputs will be equal and the Q output will be a 0.

K. Dillon,
Epsom,
Surrey.



News of the Month

OTS failure: "no sabotage"

Those involved in the Orbital Test Satellite (OTS) project are adopting a philosophical attitude to the rocket failure that forced NASA control to destroy the craft seven miles above the launch pad. Nasa Engineers are still investigating the failure of the September 13 launch, but their report may be delayed if, as some suspect, the McDonnell Douglas Delta rocket turns out to be suffering signs of age or, as a Hawker Siddeley Dynamics spokesman put it, "shelf-lifing".

When Geos went wrong (*WW* August p.33) experimenters were quick to point out that it was suspicious that so many failures had lately coincided with European projects. That may be because ESA had not insured the scientific projects, and so the loss to those involved was that much harder to bear. The comparative cheerfulness of the OTS workers may be because ESA had decided, since the satellite was its first applications project, that it should be insured. An ESA spokesman told *Wireless World* that the $30 million price tag included "the integration and launch of the second flight, so the relaunch will cost ESA nothing". An earlier report in *The Times* had quoted Dr Roy Gibson, ESA's director general, as saying that although the rocket and launch costs were insured, for $17 million, the satellite was not, and a spokesman for the prime contractors, Hawker Siddeley, part of British Aerospace, agreed; their contract was worth £25 million, but this includes some work on the back up satellite.

ESA point out that the Delta launcher's success rate is over 90%. The OTS launcher, code named Delta 124, was the third launch of a Delta 3914, and the 3914's first failure. There are two possible causes: either a fault in one of the nine strap-on Thiokol solid fuel booster rockets, or a leak in the liquid oxygen tank of the first stage itself.

A new timetable will not be set until the results of the NASA enquiry are known, but engineers expect the new launch date to be between February and April next year. The accident is not expected to affect seriously the European Communications Satellite programme which OTS was to have forerun, and which was to comptet with communications projects by American firms like Hughes and Aeronutronic Ford. Had OTS been successful, a Hawker spokesman said," it would have given us credibility, but we can't identify any more concrete effect than that."

ESA said: "If OTS could be launched in about April '78 we don't think that would affect the communications programme. The main aim of OTS was to test the system due for launch in 1980 and this is just a six month delay. So if we work a bit harder we could still launch the 1980 project on time." It also appears that some of the markets the contractors were hoping to sell to, in Brazil and the Middle East, are having delays of their own, either for financial or organisational reasons.

As to sabotage, mentioned in some reports of the accident, Hawkers will say nothing publicly other than that it would have tarnished the reputation of Nasa and the Americans, and given greater credibility to the Ariane launch vehicle which will launch the ECS programme in 1980. ESA concur: "The rocket until now was going all right. It's bad for NASA, as well as us, bad for their image, and for McDonnell Douglas's marketing. No-one benefits from this."

The Panel investigating the failure are: George Hardy, manager of the Space Shuttle solid rocket booster project at Marshall space flight centre; Henry Plohr, associate chief of the space propulsion and power division, space systems and technology directorate, Lewis research centre, Cleveland, Ohio; Ison Rigell, Space Shuttle payload director at Kennedy centre; Alton Jones, deputy director of engineering, Goddard space centre, Maryland; Joseph Thibodaux jr, chief, propulsion and power division, directorate of engineering and development, Johnson space centre, Texas; Haggai Cohen, director, reliability, quality and safety, Nasa HQ, Washington; Harvey Herring, metallic materials division, materials and processing lab, Marshall centre; and observers appointed by the air force and ESA. The panel's first meeting was on September 16.

Consumer men split over controls

British leaders of the consumer electronics industry were recently given a good-natured but firm dressing down over their advocacy of protectionism. Mr James Goodson, vice president of ITT Consumer Products, told retailers and manufacturers at the Radio Industries Convention on September 14 that they should be directing their energies to the industry as such rather than to countering the imports from other countries, notably Japan. Speaking of the increasing threat of foreign imports he said: "Of course it's not fair. I'm not sure that the solution, however, is to go to the government. We can't expect help from governments. We have to get our own house in order regardless of what competition does and regardless of what governments do. . . . The answer isn't going to Whitehall to ask for protection. The attitude should be to build this industry into what it can be, to ask which is the greatest promotor and catalyst of technological progress in world trade. The options are absolutely unlimited."

It was a mistake to think that the best way to beat the competition was to cut corners: "The answer is not to make things cheaper, to cut costs. It's to put a few bells and whistles on the thing and sell it for a higher price."

On quality control he said: "The boys and girls on the line are the quality control. The Japanese don't need quality control because they think that's a duplication of effort."

On industrial relations: "Industrial relations is a question of motivation of effort. The Japanese have motivated people to the point where they feel it's their company."

On investment: "I do believe investment is the name of the game, spread over various countries and over various activities."

On protectionism: "If England starts cutting imports then they start cutting imports from the UK. We believe in free world trade so let's believe in it. Let's do our homework right, get our quality right and get the right features."

Mr Goodson appeared saddened by the willingness of the industry to face both ways. Earlier speeches had attacked the Government for even considering Hitachi's proposal to build a factory in Washington, Tyne and Wear, and for manipulating VAT rates to regulate demand without considering the consequences on the consumer industries involved. "We're been suffering from years of government interference," said Thorn chairman Sir Richard Cave. Yet he continued by saying: "The private enterprise system we all believe in and free trade all over the world don't seem to have worked very well for the tv industry . . . We do support free world trade. We don't believe the Japanese do. We see they can and do in times of world economic difficulty build up substantial world balances. Why? The answer is that if free world trade was encouraged in

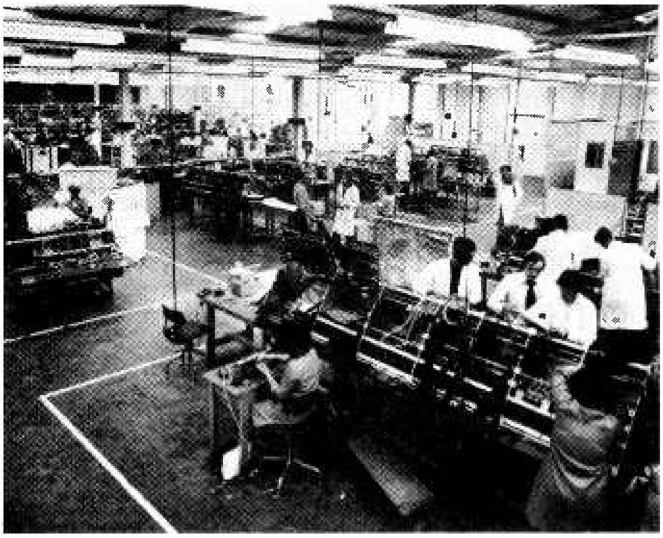
Japan as it is in Europe, would it be possible for them to achieve these results? The answer must be 'no' . . . We must either expect proper free trade to take place in Japan or we must realise that this is not happening and we must impose restrictions . . . We have got to go on lobbying government and explaining the position to them."

Mullard managing director Jack Akerman's view of his own industry was bluntly put: "The state of the British components industry is not good. In fact, if the lady at the back will forgive me, it's bloody awful." Ninety-two per cent of i.c.s, up to 75% of transistors and 60% of such components as capacitors were imported, he said. In view of the massive investments being made in l.s.i. manufacture being made in France, Germany and particularly Japan (£500 million over the next three years), the £25 million of government help for the industry was very small: "We're going to need to spend a lot more than that. We can't afford to go it alone." His proposal, echoed by other speakers, was for Europe to make joint efforts to defeat the Japanese and Americans. The electronic home, based around the colour tv set, Viewdata and teletext, would be here "in the late 1990s", and the industry must make ready for that.

Later James Goodson remarked that he had to disagree with that estimate. "It isn't the latter part of the 1990s, and even if it were we would have to accelerate it . . . If you wait until the late 1990s then everybody will leapfrog you."

Mr Akerman was not entirely gloomy. Apart from predicting a glowing future for developments based on Viewdata and teletext, disagreeing, incidentally with the view that teletext would "fade away" as Viewdata came into general use, he said: "Our strike record is good and the workforce works extremely well." He also noted the view that British manufacturers would not sacrifice short term profit for long term advantage, where the Japanese planned and invested 20 years ahead. "This," he added, "is at the root of our problems."

Not so cheerful was Dr Ian Mackintosh, of the firm of European electronics consultants, who said that, for example, his firm had predicted the large rise in the music centre market, which had caused falls in other parts of audio, three years ago. "It's sad that people didn't pick it up in time . . . The music centre boom was more clearly foreseen and acted upon by the Japanese than any other national producers in the world." He also asserted that "the development of Viewdata and teletext owes as much to our entrepreneurial public corporations as it does to industrial companies . . . I fear there will be a further slow deterioration in Britain's ability to compete, and when in ten years' time the Japanese have made the same inroads into your market as they did into the American market, ten years ago, then I think my company may be asked to conduct a post mortem into what went wrong."



Neve's new 20,000 ft² factory at Melbourn, Cambs, was opened by Mr Francis Pym MP, on September 20, and visited by the Duke of Kent the following week. Neve's turnover has quadrupled in five years and they now export over 75% of production. Recent orders went to Capitol Records, Sydney Opera House, Austrian Broadcasting (ORF), Kuwait, Iran, Citroen cars and Jacques Loussier's Miraval Studio, both in France, and Stockholm's Polyvox studio.

Doppler men fighting for m.l.s. decision

No agreement on an international microwave landing system (m.l.s.) is expected before May next year, but the British Civil Aviation Authority is conducting a campaign to make sure that the British Doppler system wins (See *Wireless World*, May 1977, p.66). The latest in a series of tests took place at Gatwick at the end of August, when a Royal Aircraft Establishment HS748 made five consecutive automatic landings on runway eight using a Doppler m.l.s. alongside the existing instrument landing system (i.l.s.). The Department of Industry, in a statement issued on behalf of the CAA, said they were "The first ever automatic landings at an international civil airport."

The trials have been conducted jointly by the CAA, the Department of Industry, the Ministry of Defence and Plessey, who are developing the system. After an abortive meeting of the All Weather Operations Panel last May, at which Britain abstained to show disapproval of the way the decision was being reached, the various protagonists went away to muster more information. The International Civil Aviation Organisation, and some of the countries represented, including Britain, felt that it was improper that the panel had tried to reach a decision when so little information about the competing systems was available. This accounted, they say, for the rather strange voting pattern.

The Americans assumed the aggressive and produced a computer simulation of conditions at Brussels airport which claimed to prove that the British system would not work there while the American time-reference scanning beam (t.r.s.b.) would. The British went ahead with their series of trials, which they hoped would refute the American evidence, and show that the Doppler system would work in various environments.

The British installed a system at Brussels, with the co-operation of the Belgian authorities. It seems that the British system worked, and that the Americans had fed incorrect data into their simulation: according to the CAA, they had put in a building that doesn't exist at Brussels airport. Learning a lesson from the Decca Navigator's failure to beat the American enroute navigation system many years ago, the CAA then took the gloves off. Until Brussels, they say, they had kept an open mind: "If it were proven that it was better then the British vote would have gone to t.r.s.b." But when the one month trial at Brussels came to an end this summer the view was that "We have now proved that the Doppler system is the best system."

After that "We adopted tactics which would never have been dreamt of in the 1950s. We had the Russians over here, for example, and showed them every nut and bolt on the thing." In doing this the British were willing to run the risk of the severe disapproval of other countries since the Russians had shown favour towards a German scheme based on the existing system, though it is no longer thought a serious contender.

The next step is to take the Doppler equipment to Norway as an example of what the system can do at airports whose terraine makes them "troublesome". When the Air Navigation Commission which set up the All Weather Operations Panel reports to its parent, the ICAO council, in May 1978 the decision will, it is hoped, be a foregone conclusion, avoiding the wrangling that has so far caused delays. And the CAA hopes they will have enough evidence to show that the t.r.s.b. is too expensive and inflexible to be adopted.

System X stirs

The Post Office's announcement of contracts worth £20 million for System X development, though following closely the criticisms by the Carter committee that the Post Office had been too slow to press ahead with the system, do not appear to be a response to those criticisms. After preparatory work which, they say, involved 500 engineers, the Corporation had merely reached a point where they felt ready to move into the next phase of development.

The orders are for the design of electronic trunk, tandem and small to medium capacity local exchanges. System X will be based on a number of sub-systems or modules which includes: stored program control (s.p.c.) processors; digital switching modules which interconnect digital circuits connected to the switch; signal interworking modules, used on calls to existing exchanges; A/D and D/A convertors; message transmission modules to transmit control and management information between s.p.c. processors in different exchanges.

GEC will develop the digital trunk and small to medium local exchanges, and the s.p.c. processors; System X will be based around the GEC 2BL processor. Plessey will be responsible for digital switching, signal interworking with existing exchanges, A/D convertors, network timing and synchronisation, and maintenance and exchange management software sub-systems, all for the Tandem exchanges. It is believed that Plessey's seven contracts are worth some £10 million of the £20 million total and will employ around 80 people each at Liverpool, Taplow and Poole by the end of next year.

STC will develop the message transmission systems which connect the exchanges' computers and form the data network which carries control and signalling information. STC also have a contract to develop the local administration centre monitoring and logging information on a network of exchanges. "Typically," say STC, "a centre will administer such tasks as recording maintenance information, keeping statistics on telephone traffic and recording call charges."

The Post Office say a large supply programme based on System X will begin in the 1980s, reaching a total of £100 million, though this will produce savings in capital and operating costs. The Post Office also emphasises that the three companies involved should be able to sell System X-based exchange equipment abroad. One supplier noted that the Post Office seemed more aware of the need for the telecommunications companies to make exportable equipment, as a result both of the Carter criticisms (*WW* September, p.72) and the strongly expressed views of the companies themselves.

News of the orders follows some delay in placing the contracts. In November 1975 the *Financial Times* reported that about a dozen major contracts were about to be placed but nothing has been heard until now. The entire development programme will cost at least £100 million of which between £50 and £60 million is to be spent on development work outside the Post Office. This leaves roughly £30 million unaccounted for, although some contracts, notably for the processor, have already been placed. A large part of the missing element will concern the large capacity local exchanges.

Another element missing from the present equipment is transmission equipment. The contracts just announced are largely for modules and control functions, with the smallest number of the just over a dozen contracts, perhaps a couple, going to STC, who are dealing with some of the transmission development. Even then, according to a report in *Electronics Weekly* STC will not be required to produce hardware when the first prototypes emerge in 1979. The Post Office say, however, that many orders for digital transmission equipment have been placed over the last few years, though they have not been linked with the development of System X.

Another sidelight on the project is that Pye TMC, who recently installed electronic directors for the Post Office (*WW* September, p.73) were not offered any of the contracts. One reason for this is that they have not been involved in switching for as long as the other three and the big three companies have said in the past that Pye could not be included in the programme because, as a subsidiary of Philips, they could be in competition with their own parent company.

This ignores the fact that STC is a subsidiary of ITT. Pye have also a long history of supplying the Post Office, notably in telegram retransmission and 60MHz transmission equipment. Without doubt the big three, who were first on the System X scene, feel that there is little enough to go round without a fourth party sharing the contracts.

However, that may be the final form of System X is still unclear, and it will remain so until the Post Office decides to give the project a name.

Libya buys British

Libya's £9 million order with Marconi for fast tuning systems at Tripoli and Benghazi airports, one of the largest ever, say Marconi, for civil aviation communications equipment, is but the latest in a series of orders that the Socialist People's Libyan Arab Jamahiriyah has placed in Britain. In June Marconi announced one £3 million order for tv cameras, telecines, vision mixers, OB vans and other equipment, and another worth nearly £½ million for radio equipment for the Arab Revolutionary News Agency. Marconi had already supplied the news agency with its original equipment in 1974.

More surprising, though, in view of Libya's export of arms to various terrorist groups, including the IRA, is that our own Post Office should be helping the Libyans set up their telephone network. The consultancy contract, also announced in June, was worth £6.75 million to the BPO, and followed one a year before worth £650,000 to help build the telephone link between Tripoli and Benghazi. Such trade is usually excused on the grounds that communications equipment is "neutral" and the way it is used is none of the supplier's business. Even if it were not neutral, the argument goes, someone else would supply it, otherwise any less distasteful regime than that of Colonel Gaddafi would find itself without vital parts of its infrastructure.

Our dependence on Libya for oil is now decreasing. Last year we imported only £128 million of our £4.3 billion oil imports from Libya, compared with roughly a third some years ago, but the Marconi statement emphasises "the rapidly increasing importance of Libya as the gateway between Europe and Africa." The country is "of paramount importance for the future development of civil aviation in the area." Clearly exports to Libya could lead to substantial sales in other parts of Africa.

The present Marconi contract is for four communications services for the two airports: access to the aeronautical fixed traffic network to provide long distance speech and teleprinter links to flight information centres in North Africa and the Mediterranean, an aeronautical mobile service for ground to air speech traffic, a search and rescue communications service, and facsimile and teletype links between meteorological centres.

Two types of Marconi fast tuning transmitter will be used, the 1kW H1040 and the 10kW H1140, both powered by the H1540 synthesised drive. All the receivers are type H2540. Marconi say the aerials they will supply at Tripoli will be among the most complex they have ever installed, including resonant and wideband dipoles, single and double rhombics, confians and directional and omnidirectional, fixed and rotatable log-periodics.

New tv game generation by Christmas

Predictions about the "electronic Home", based around teletext and Viewdata, are now falling thick and fast and some of them are quite surprising. Those concerned with Oracle, for example, are now trying to play down a prediction made by Mr George Cooper, Oracle's chairman, at a press conference to announce the service's expansion from updating 42 hours a week to 90. He foresaw "a national air call service with small pocket sets."

Each set would have a code, and when the code for a particular pocket set were transmitted, the set would emit a bleep. Using the broadcast network, a set could be called anywhere in the country, and the user would then telephone a pre-arranged number.

Since press reports of this have appeared the IBA have been flooded with phone calls asking where the bleepers can be bought, and of course the service, if it overcame the inevitable opposition of the mobile radio and paging lobby, wouldn't start until well into the next decade.

EMI and General Instrument Corporation have jointly applied for patents for a technique for storing up to 1.6 million bits on each side of a C60 cassette. GIM are to sell an electronic interface which can be used with standard cassette recorder heads to carry out data retrieval and error correction. The interface is to be part of a complete programmable television terminal microcircuit chip set, and GIM and EMI will collaborate in developing computer programs and voice and data cassettes which will be sold in tape and record shops.

GIMs decoder for teletext and Viewdata already contains a microprocessor, and they say they are developing a set of compatible m.o.s. circuits for interfacing the tv set with their CP1600 microprocessor family. These interface circuits could offer a wide range of extras to the standard tv culminating, say GIM, in a complete home computer system. The interfaces can decode teletext and Viewdata and the cassette mechanism can be connected through them to play back tv games and educational programs.

GI say the first of the home hardware will be available next summer, and EMI will make cassettes available for manufacturers to sell under their own names.

EMI say they have abandoned traditional error correction techniques to enable data to be stored on conventional audio cassette tape. The new method of error correction is to cope with dropouts which could otherwise destroy large chunks of data. They have not given further details but they say that very roughly 50,000 bits can be read from the cassette in 26s. EMI say they have duplicated the cassettes "above real time" without difficulty.

The new technique is necessary because of the use of ordinary audio tape, which is cheaper, and can store both data and sound through an ordinary mechanism and electronics. This makes the educational, language tuition and programmed learning market a natural target, with spoken commentaries matching text as it appears on the home TV screen.

EMI's target for the price of the hardware is between £100 and £200. When the first games appear on the American market next summer, probably five-move-ahead chess games, they should sell for around $5, a quarter to a third of the price of the equivalent r.o.m. cassette.

The r.o.m. plug-in cassettes will be on sale in Europe by Christmas. These are the next generation referred to by a new Mackintosh report. NISC examples by Fairchild, RCA and Otari were seen at the Chicago Consumer Electronics Show this year.

From next year GI begin to suply chips to manufacturers wishing to serve the home data market and EMI will supply the programmed cassettes. The competition in the home data market is now fierce and bound to become even more so. One familiar problem may crop up yet again, that of standardisation. This is not just a matter of which physical links to use in the system. If cassettes don't sweep the board the 16K r.o.m. attachment and associated electronics could be combined with a cassette mechanism to give the user the greatest benefit from his equipment. What is important is that the data contained in a r.o.m. can be understood by that on a cassette. The data will have to be in a common data "language", and it may be that, since the Post Office has a great influence on such matters in view of the importance of Viewdata to the whole idea, the programming language may be one that suits thePost Office. But what about the rest of the world? EMI stress they don't want another standards battle.

Mr George A. Cooper, chairman of the Oracle board of Independent Television, announced an increase in the number of hours during which the service would be updated. It is now, like the BBC Ceefax system, updated seven days a week. See "Electronic home".

News in brief

Soviet Scientists at the Lebedev Physics Institute, Moscow, claim that they have used a laser to move a 20,000 cm^3 helium-filled baloon. The laser operated on carbon dioxide and had an energy of "a few kilojoules". Laser pulses pushed the balloon to speeds of up to 2m/s, each flight lasting about 30s.

In April next year GEC is to deliver £2 million worth of 30 channel p.c.m. equipment to the Post Office, the largest order, they say, since the tests on a trial link between Liverpool and Formby were completed. The equipment will carry telephone and data signals. GEC are also designing interfaces between p.c.m. links and exchanges.

We have had a number of enquiries about part three of "Multi-system ambisonic decoder", by Michael Gerzon. The publication of this article has been delayed but we will publish it as soon as we are able.

Harrogate: the turntable war

The disc is one old contemptible that shows no sign of ill health

In the 100th year of sound reproduction Edison's original idea—a point thrown about in a moving groove — is still here, and even gaining ground. Why else would so many manufacturers still be introducing new turntables?

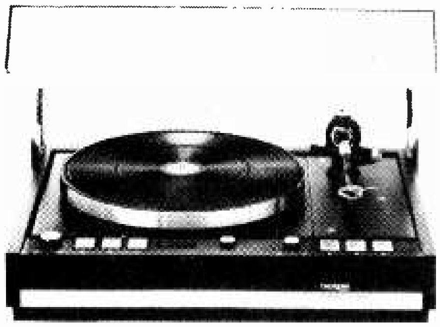
This might, of course, be interpreted as a sign of the disc's imminent demise: when the transistor became easy to get the valve improved astoundingly, and some of the turntables shown at Harrogate this year have become almost absurdly sophisticated. The disc, too, shows signs of improving to match the lack of breakfast noise that makes the cassette so attractive despite its disadvantages. A number of demonstrations at Harrogate used direct cut discs, a development whose results are very spectacular, but which a combination of its inconvenience to the studio engineer, who has come to rely on tape, and recording industry economics will prevent from coming into general use. Another disc development, the p.c.m. recording, is much more likely to succeed, though even here the improvement in sound quality is not one which addresses the main complaint about records. If music enthusiasts are turning to tape it is not because they do not like the tape hiss on records. The other improvements direct cutting brings do not compensate for the irregular intrusive noise caused by dust and scratches.

Perhaps that is why **Garrard** have sought to protect their turntable market by launching a scratch suppressor. It is interesting that they should do this just as they say they have established "a foothold" after a year in the cassette player market, and it would seem to show that the record market is still worth protecting. That market does not make Garrard reliant, as cassette players might, on buying mechanisms from abroad.

The scratch suppressor appears, on a brief hearing, to be very effective. The amount of suppression is continuously variable. It will be available towards the end of this year for just over £100.

Garrard have launched three new turntables this year, all the result, they say, of extensive market research. Surveys of this kind have been an easy target ever since the Ford Edsel, and it is little help to repeat Lord Reith's dictum that if you give people what they want they will want what they get. Garrard say their research has established that the punter wants an S-shaped arm, die-cast platter, a wood and metallic look, an acrylic dust cover, and an anti-static mat. So far so good, but it's a little worrying that Garrard should have been quite so ready, as they admit, to over-ride their engineers, who had good reason to object, for example, to plug-in headshells. It is sometimes better to temper the poll arithmetic with a little common sense. Does the product work, and is it well-finished? Some informed observers think Garrard haven't yet got it quite right, but it is good to see the new Garrard, under Derek Moon, keen to do battle with foreign competition.

Garrard's direct drive DD75, introduced last year. It has pitch and off-arm bias controls.



Thorens TD126 mk2. Note the straight arm and the 78 speed on the left. Like many of the turntables shown at Harrogate, this has a variable pitch control.

Trio's new KD2070 direct drive unit.

Garrard's research also seemed to show that parallel or tangential tracking arms are not popular in the UK. Such an arm, which they were to sell here, is now available only in the United States, and may even be withdrawn from there. Yet **Revox,** who don't have a strong image outside the tape market, choose to launch themselves on the disc tide with a radial arm. It won't be available until early next year, but the prototype demonstrated at Harrogate performed very well even when thumped or tilted severely. The platter uses direct drive.

Some years ago **Strathearn** also launched itself on the turntable market with a parallel tracker. As far as one could tell the prototypes worked beautifully, but they couldn't make them reliably. Now, under chairman Graham Bish, they say they have solved the production problems, though the range is now confined to conventional arms, and intend to sell 30,000 ST4 and SMA2 pivoted arm turntables in the next year with a rejection rate of no higher than one in 100, compared with the more normal three or four per cent. "We only have two bites at the cherry," Bish said, "not three."

Another product Strathearn say they have high hopes for is the planar speaker, which has been seen in a number of forms in the last few years.

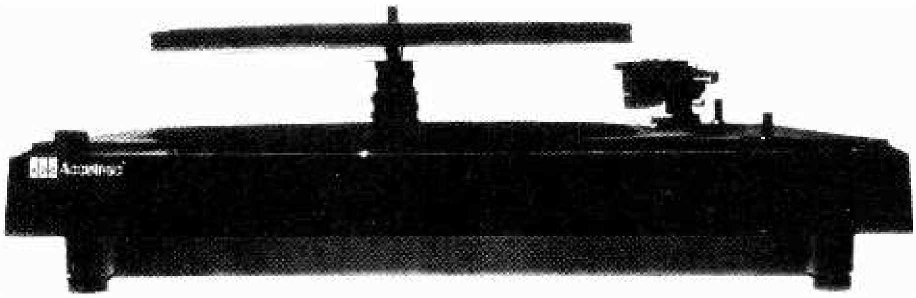
Now it has been separated from its bass units, and the combined mid and high frequency driver can be hung on a wall while the bass cabinet is hidden somewhere behind the furniture. Since bass notes appear to be non-directional the buyer could even get away with one bass unit and two planar speakers. **JR's** "Super Woofer", to be used with two of their cylindrical speakers, uses the same idea. The Strathearn speaker was demonstrated at Harrogate among an audience that seemed to become more and more enthusiastic.

BSR's new pickup arm also contradicts Garrard's research, since it's carbon fibre and straight. It comes in two versions, with and without plug-in headshell. **Thorens,** too, have launched a new series of turntables with integral arms based on the principle, they say, that "the shortest distance between two points is a straight line." It also results in lower mass. On the Thorens Isotrack arm the point of connection of the plug-in headshell is near the pivot, also to reduce the effective mass. When you change cartridges you also change about two-thirds of the arm.

The electronic control in the top Thorens deck, the TD126, will allow pitch variations of 6% either side of the three main speeds: 33, 45 and 78, also electronically controlled. Like many of the more expensive turntables at Harrogate, this one has a separate motor to drive the automatic arm functions. In Thorens's case this operates when the increase in speed of the arm towards the middle of the record is detected. To work well this will have to have some pretty complicated electronics. Thorens also make versions of their turntables without arms.

Another comment offered on the Thorens stand was that, "direct drive is a fashionable trend. There's a surge back to belt drive . . . It's not just a one way stream any more." The competing arguments for the two systems were echoed in various forms all round the Harrogate show, the only point of agreement being that the idler wheel or rim drive was out for all except the low fidelity market. Direct drive is not a new idea. According to Thorens, both they and Garrard were using it 40 years ago, and Thorens also say they had a belt drive patent in 1924.

The power behind direct drive is **Matsushita,** who make many of the motors in other makers' turntables, and there are some who believe that the growth in direct drive turntables, now a tenth of the market, according to Garrard's figures, has been as much the result of a skilful marketing excerise as of any intrinsic merit in the system. Certainly there is so much argument that whoever does have the advantage can't be leading by very much. Thorens say their lab tests have "proved" that belt drive is less prone to rumble. A man on the **Pickering** stand agreed: "Direct drives were the first turntables made and belt drives were an improvement on



Silhouette of the ADC Accutrac plus 6, showing the inner platter spiralling up to receive the bottom disc in the stack. This will then be lowered on to the platter.

them. Belt drive is preferred by the top end of the market, those who are interested in music, and not just buying because it's expensive." There was an audible difference at the top end, he said, which was "more detailed" on a belt drive turntable. If this is true, about which we make no comment, it may be attributed either to the notching effect, where the platter is driven round in tiny pulses of speed rather than smoothly, as from a synchronous motor, or by hum transferred to the cartridge by stray fields.

But Strathearn's Graham Bish has no doubts: "Belt drive is on its way out, fast. That was very obvious in Berlin. Belt drive is dead."

Along with speakers, turntables are one of the few things that British manufacturers are still selling well abroad, with a few exceptions. Even **Collaro,** now owned by Philips subsidiary Magnavox, is coming back into the battle with a range of cheap, idler-driven turntables for that part of the market that BSR exploited so effectively. **Goldring,** too, is back, though they weren't at Harrogate; Gerry Sharp has bought the assets, stock and goodwill of the company, now based at Bury St Edmunds. **Connoisseur** showed a large range of turntables, all belt-driven. Three-quarters of their production goes abroad.

Some aspects of the record player are changing. On many of them, such as the cheaper **Pioneer** models, the bias or anti-skating adjustment can be made while the record is playing, instead of lowering the stylus, lifting it, changing the bias, and lowering the stylus again. The thread and weight system seems to be losing ground.

Some decks were beyond the reach of most of us. **Harman,** now a subsidiary of the Beatrice Food Corporation since Sidney Harman joined the Carter administration, are agents for the Micro Seiki turntable, which costs £400. It is free-standing, having no plinth, and can take up to three arms. It looks, to say the least, distinctive, and, by contrast, the even more expensive **Technics** SP10 mk2, at £1,000 or so, looks plain. In between is the **ADC** Accutrac plus six, a belt-driven turntable which can be programmed to play, in any order, any number of tracks from six l.ps. The records are gently lowered on to the platter by an inner platter which spirals up through the centre of the turntable, and then they are raised back up to the starting position. The tracks are searched out and counted by a small beam of light which is reflected back to a detector between record bands, and scattered in the middle of bands. The functions can be controlled either at the deck or on a remote control unit, and the player also has a volume control.

ADC have also produced a new range of cartridges at the top end of which is the ZLM, available with an even tighter spec (10Hz to 20kHz ±½dB instead of within 1dB) for the lunatic fringe. At the Andromeda stand *Wireless World* was told, "The ADC cartridge is superb. It's the best cartridge here, and we've tried every one."

Another amazing record player was the **JVC** Quartz-controlled QL10, which uses a digital speed readout, and has an electronic pitch control which adjusts in steps of 1Hz. That costs £680 including VAT. Pioneer's PLC 590 had a fashionable look because there is no stroboscope round the rim of the platter. Pioneer say there's no need because speed is "perfect all the time," but other quartz-controlled decks in their range have strobes.

Andromeda have followed a philosophy of which perhaps **Bose** is the most well-known exponent, using four medium size speakers instead of one large bass unit. **Farnell** has the same idea, their speakers use one, two or four 5in. units.

Other underlying trends include the increasing use of separate amplifiers for moving coil pickup cartridges. Room equalisers may be one of the best sellers this year, and that bandwagon is carrying a number of manufacturers, including ADC again and JVC. One of the more notable things about the Harrogate show was the way electronic logic control is making it easier to use equipment, as in the Pioneer CTF1000 cassette deck. And **Stag Audio** appear to have found an answer to the surround sound system problem. They have an amplifier with a gap in it into which you can plug a decoding module of your choice, and they'll even be offering H matrix models. Perhaps the BBC might like to buy some.

Letters to the Editor

RADAR IN WAR

May I draw attention to the existence of a historical document of a unique character since it contains accounts of the doings of some 50 RAF ground radar stations in two-thirds of England and Wales between 1 December 1943 and 31 July 1944?

The country at this time was organised into four RAF radar "wings" each having a Senior Technical Officer with the rank of Wing Commander who was responsible for installation, maintenance and operations. Holding this post in 73 Wing I conceived the project of producing a brochure containing reports from official sources of the more important day-to-day work of the stations in defending Britain from air attack, directing our own outgoing and returning bombers, air-sea rescue work and what became probably the most useful work – the plotting of ships in the Irish Sea and North Sea. This was to be a tribute to some 4,000 officers, radar mechanics and operators (women and men) who did the work.

Our surveillance of the sea was a daily routine and involved shepherding convoys, plotting stragglers from these convoys, reporting the positions of individual units of the Royal Navy or ships of the merchant navy, reporting German E-boats which were engaged in attacking convoys or laying mines.

Although classic sea battles occurred, in most cases the E-boats engaged in mine-laying and by virtue of their high speed escaped unharmed. Nevertheless, by reporting their tracks, the naval authorities could send mine-sweepers to clear a channel and warn our surface vessels .Radar saved hundreds of vessels from following wrong courses and proceeding into mine-fields or even sandbanks. (Earlier in the war 400 vessels were wrecked on Happisburgh Sands.)

The brochure contains personal letters of appreciation and thanks from Admiral-of-the-Fleet Sir Jack Tovey (Nore Command), Admiral Sir William Whitworth (Rosyth Command) and Rear-Admiral J. S. M. Ritchie (I/C Liverpool).

All types of stations were involved in the radar activities of 73 Wing, some reporting aircraft, others being engaged in the exciting direction of our fighters against enemy bombers and 10cm "K" stations watching the sea. Before this confidential brochure was issued to our stations the overall work of the wing was generally unknown. Often a particular station was unaware of the degree that it had helped in a particular operation. Thus the bomber raid on Hull on 19 March 1944, which was repelled with nine German planes shot down, is here recounted by several stations – a triumph for radar. What was originally a morale-building exercise has now become a unique historical account.

The original is officially stamped "Historical Document for Permanent Preservation" but it is now no longer confidential and photocopies may be obtained post free from the Public Record Office, Chancery Lane, London WC2A 1LR, by sending a remittance of £6.24 and quoting "73 Wing in Action" Air 16 – 914.

But for the publicity given by this letter this document would remain unknown in the musty recesses of the Public Record Office.

John Scott-Taggart,
Beaconsfield,
Bucks.

GMT/BST CONVERTER

I would like to point out that there may have been an error in Mr C. G. Armstrong's Circuit Idea on a GMT/BST converter (August issue, p. 53).

The GMT/BST converter is required to add one hour to the transmitted code. The circuit given will work, but the "hours" converter needs to be a decade, not a binary, device, i.e. 74192 not 74193, since the 193 will only produce a "carry" out of pin 12 at 15-to-16 hours, whereas we need a "carry" at 9-to-10 hours.

So either two 74192s should be used or the hours and 10 hours devices changed over.

Pin 4 of both devices must be fixed at a "1" for the system to work reliably.

Russell Greenberg
Totteridge
London N20

Mr Armstrong replies:
I would like to thank Mr Greenberg for noting the error in my article. It is entirely my fault and a reversal of the types of i.cs used is sufficient for satisfactory working. In retrospect it would appear I must have paid more attention to a satisfactory working model than to the correct identification of the i.cs.

A logic "1" applied to pin four of both i.cs is, of course, correct technique. Being somewhat sloppy I chose to leave the pins "floating" and have found that the system works quite satisfactorily without the need for the additional wiring.

The pole identification of the GMT/BST switch should be reversed, as my original note only intended to identify the function of the switch as a unit.

Because of the time delay between submission and publication of the Circuit Idea it was not possible to state that the NPL have modified their code format to allow an automatic GMT/BST correction. By applying the bit immediately following the first parity bit to the pin 5 of the 7408 and disconnecting the switch the automatic facility is enabled.

C. G. Armstrong

SURROUND SOUND

In his letter in the September issue Mr J. E. A. Fison bases his criticism of the stereo compatibility of Matrix H on one transmission. Having listened to several broadcasts, I have concluded along with Messrs Ratliff and Meares that "images may be localized outside the space enclosed by the loudspeakers". Hence the sound completely fills the front quadrant.

Although 9dB may appear to be a poor figure for separation the phase difference is of the order of 45°. Since the human ear responds considerably to phase at mid band this factor is dominant. In addition, does Mr Fison realise that most stereo sources rarely have a separation exceeding 20dB? A typical pickup will have a separation of only 10dB at the limits of the spectrum. Similarly the acoustic separation when using a coincident pair of microphones is of this order of magnitude.

Mr Fison goes on to condemn Matrix H and praise Ambisonics. Since the two systems are almost identical except in detail how does he expect the 45J system to have a better separation? In listening to Matrix H in stereo I have concluded that in general the image width is satisfactory on loudspeakers and if anything is slightly too wide. Also, when listening on stereo headphones the effect is rather objectionable. For this reason it would be wise to reduce the front sector angle to 45° or less which would reduce the width of the stereo image.

On one point I will agree with Mr Fison. The BBC would be wise to change to 45J which would result in only a minor alteration to the results on H decoders but which would allow for the introduction of a logical and expandable quadraphonic system. I fear, however, that the BBC may dig in its heels.

R. T. White
Lancing
West Sussex

TELEPHONE EXCHANGE TECHNOLOGY

With regard to your article "Telephones and new technology," in the September issue, I suggest that Mr Dwyer examines his sources of information more closely. I quote from p. 72: "The Post office crossbar system does not use multifrequency signalling, as the foreign market requires." If this is so, then perhaps Mr Dwyer could tell me what I've been working on over the past few weeks. Although m.f. is by no means as venerable as Strowger equipment, or TXK, for that matter, I can unequivocally state that m.f., as an integral part of a Group Switching Centre signalling system, has been in operational use for some years.

I must also draw your attention to Mr Dwyer's glib assumption that there are no common areas between the basic exchange systems in common use. In TXK, (son of Strowger, remember?) interchangeability of components seems to be its main asset. Many of its circuits are, in fact, adapted TXS circuits, the actual electro-mechanical hardware being identical. It is also increasingly commonplace to find adapted TXE shelves mounted in cross-bar racks; (one look inside a sector switching centre will verify the fact).

A. Graver
Birchanger
Herts

John Dwyer replies: The source was STC's submission to the Carter committee, section five, paragraph 20, which STC have rechecked and say is correct. The Post Office at first agreed but, after we had asked Mr

Graver for more details, issued the following statement: "Technically the statement is incorrect in that both TXK1 and TXK4 do not (sic) provide multifrequency signalling facilities (SSMF2 which is the current UK national m.f. signalling system.) However in essence the article is probably correct because the context within which the statement appears refers to export possibilities and here the requirement is for the CCITT R2 m.f. signalling system and m.f. keyphones are not yet provided in the British Post Offices crossbar systems."

As to Mr Graver's second point, if he re-reads what I wrote he will discover that I did not even suggest the five systems had nothing in common.

AMPLIFIER DESIGN

While we do not want to join the present fashion of "knocking" audio amplifier designs, we do feel that we must make two comments, one specific and one general, concerning recent articles and correspondence.

First, Mr Taylor's RIAA pre-amplifier published in the September issue. Mr Taylor states his long-tailed pair input stage operates at a collector current of 90 μA per device, which will, with low gain devices, result in a base current of approximately 0.36 μA. Owing to the difference in resistance between the 47kΩ resistor and the parallel cartridge most of this current will flow through the cartridge. If one now calculates the signal current from the cartridge at an average output of 5mV the current is 0.106 μA, a factor of 3.4 less than the d.c. flowing in the cartridge. This must offset the cartridge magnetic circuit and may result in a significant increase in distortion from the cartridge. We wonder if Mr Taylor has consulted cartridge manufacturers on this point.

Secondly, there seems to be an amount of mysticism regarding transient intermodulation distortion and slew rate, which has never been explained as we see it. Any amplifier will have an open loop risetime depending on its open loop bandwidth and roll-off rate. If now under the closed loop condition the amplifier output is required to rise faster than the open loop risetime, the feedback is operating in a manner which speeds the amplifier up. This will result in an increased error within the loop, showing itself as a transient reduction in gain within the loop accompanied by a transient increase in distortion. Ultimately when the error stage saturates, the amplifier hits slew rate limit and its output will go no faster. From the point at which the closed loop output is required to rise faster than the open loop risetime to the point at which slew rate limit is reached, the t.i.d. obviously increases from zero to 100 per cent.

Mr Sundqvist's solution of making the first stage determine the open loop bandwidth is to some extent avoiding the point, as, unless the open loop bandwidth exceeds the audio range, at high audio frequencies, an increase in distortion and reduction in damping factor is inevitable. Thus, wide open loop bandwidth and large internal error capability are necessary, together with low open loop distortion.

A. Dytch and K. Bishop
Rugeley
Staffordshire

CITIZENS' BAND AND SOCIETY

Mr Dwyer's remark (*Wireless World*, January 1977, p.36) that a written constitution makes a difference in the adoption of citizens' band policies of the US and the UK is a reminder that the structures of societies make a big difference in the risks that technologies bring. Most of the US was not disturbed much by the blackout and looting of New York, and possibly many chambers of commerce felt it was good news for their growth programmes. The results for the UK of the same thing happening in London would probably be far more catastrophic since London is a governmental centre and a larger part of the country's gross national product. One might want to play with expectation formulae to establish a number and call it a Chaos Criterion, based on a country's currency value, per capita police ratio, number of languages, and other factors to find how many c.b. sets a country might expect to tolerate and not consider threatening to national security.

For instance, the number of cars and the ease of making Molotov cocktails might mean that with 15,000 c.b. sets loose, the South African police would have to contend with an army force more powerful than the tank divisions of the Warsaw Pact. The Soviet bloc may be more secure in terms of one ethnic group being outnumbered, but in terms of the number of languages is even more vulnerable. Since the Soviet bloc is so much bigger and has less economic tension and more recent memories of a major war than South Africa, I would say that its Chaos Criterion would be over one million sets.

The US may have about fifty million c.b. sets in the 1980s. It is also adopting a standard technique for secure encryption of digital transmissions. If such encryption becomes standard on a large percentage of the sets used in the US, the potential for abuse will be staggering. But then, so is the number of handguns.

Don Olliff,
La Mesa
California.

POST OFFICE RADIO INTERFERENCE SERVICE

Mr Doo of BREMA, writing in June letters, offers the comment that "the procedure whereby the Post Office notifies the appropriate manufacturer of an unresolved case of interference is often not being invoked". As an engineer with many years' practical experience, I have struggled continuously against this very situation which is brought about by public ignorance. The Post Office gives no publicity to its Radio Interference Service, and defends its position by saying that a Complaint Form A6328 is available at main offices.

Unfortunately there is absolutely no way in which a person can discover, in the first place, that such a service exists, until he is told by a third party already aware of it. The local general manager of the telephone service controls this specialist group of engineers, and one telephone call to the office is often sufficient. As the service is financed by a proportion of the television licence one would think that an obvious place for reference would be on the licence itself.

How many radio and tv users realize that they are supporting a free assistance service, which has always been available, and which offers expert technical advice to anyone with a radio or tv interference problem?

This unfortunately does nothing to help the owner of purely audio equipment. Present experience suggests that modern transistorised units respond to unwanted r.f. signals far too easily. This is amply demonstrated in their response to noise from thermostats on central heating systems etc., often discovered on the exchange of an older valve system for a more modern equivalent.

If BREMA gets too few complaints to justify taking general action it behoves all of us involved in these difficulties to ensure that the Post Office participates when it can do so, and that every complaint, even if solved locally, reaches the manufacturers.

G. Openshaw
Bolton
Lancs

BAND II FERRITE AERIAL UNIT

It should be pointed out to readers of Mr Thoday's article in the September issue that some portables, if fitted with an r.f. stage between the whip aerial and the input coil, will work satisfactorily (by "portable" standards) with the aerial completely closed. I possess a 1965 Sony receiver so fitted that picks up Wrotham indoors on the South Coast, with the whip pushed fully in. The set uses a BF180 r.f. stage rough peaked to 93MHz. Radio London is receivable by pulling out the aerial just 10cm — which can hardly be called "dangerous"!

Curiously, although the whip aerial is, naturally, vertical, it is markedly, though not annoyingly so, directional in a similar manner to the m.w.-l.w. ferrite rod. Whether the rod in some way contributes I have not investigated.

Certainly, it seems to me that the somewhat expensive device developed by the BBC seems unnecessary.

Ronald G. Young
Peacehaven
Sussex

THE OPERATING CLASS

Your September editorial "The engineering class" suggests that the "profession" has to earn rather than expect the esteem of the public. John Dwyer in his "Telephones and new technology" in the same issue points out that the intervention of electronic engineering in telecommunications is leading to the situation where "one worker will be needed where there were once 27" and adds "what will happen to the 26? Who will support them?". With electronic development engineering apparently so predominantly concerned not with creating new human activities but with de-skilling or eliminating altogether the need for ancillary workers or "operators" is it to be wondered that the public increasingly withholds its approbation from the engineering class?

Would society continue to have esteem for the medical profession if its main preoccupation was intentionally to remove from active life unnecessary humans? Or the legal profession if it was concerned solely with removing from society the innocent as well as the guilty?

Your "appointments" column further underlines the engineering view of equipment users. One finds an advertisement for a "radio telegraphy operator" who must be able: (1) to receive and transcribe on a typewriter Morse code at 25 wpm; (2) make aural or visual recognition of signalling codes used in communications systems; (3) be able to operate complex modern communications receivers; (4) be able to operate radio teleprinter equipment; (5) understand radio propagation and frequency usage; (6) be able to correct, log and identify incoming material; and (7) possess "perfect" hearing and be prepared to submit to entrance examinations in Morse typing and signal recognition.

Apparently, however, I am alone in regarding this as a demanding list of qualifications, since the basic salary offered is £2334 – or roughly some two-thirds of what appears to be the going rate for electronic technicians and less than about half that of those development engineers whose main purpose appears to be to eliminate "operator" jobs altogether!

Surely, to gain public esteem the electronics institutions should be prepared to prove that the engineer creates more socially-acceptable jobs than he destroys and does not regard those who use his equipment as so much electronic-fodder. Electronic automation, ergonomics and human-engineering were "sold" to society in such terms in the 1950s — were we only being conned?

Pat Hawker
London S.E.22

REQUEST FOR OLD SET

I am anxious to obtain a Romac personal radio receiver which is completely self-contained; the chassis, batteries and loudspeaker are housed in an all-metal body, camera shaped, finished in ripple black and polished chrome, and the aerial is contained in a flat p.v.c. covered black shoulder strap.

This receiver, the first miniature portable after the second world war, was manufactured by the Romac Radio Corporation Ltd., The Hyde, Hendon, London from 1946 to 1949.

Gordon Bussey
(Author, "Vintage Crystal Sets 1922-1927")
19 The Pines
Purley
Surrey

RADIO AND AIR SAFETY

Your correspondent Mr T. R. Wiltshire, under the heading "Radio and Air Safety", (August letters), makes the point that it is difficult to obtain a British made v.h.f. communication radio suitable for light and general aviation aircraft of adequate quality. This is not so and sets are available which show a price advantage over most of the American models, of which, it is agreed, there is a much greater variety.

There is an enormous discrepancy in the size of the market in the UK and that in the United States where the number of general aviation aircraft is over 40 times that existing here. This large market in the USA combined with their numerous well organized sales outlets, coupled with the American flair for mass production makes it surprising that British firms are able to compete at all.

Mr Wiltshire's suggestion that British manufacturers are badly placed because of the "enormous investment required due to complex Civil Aviation Authority regulations" is not valid. That Authority, pursuing its general policy of encouraging the use of airborne radio in sporting aviation, has been at great pains to minimize the cost of achieving approval. For light aircraft, over six different categories have been evolved dependent on the use to which a radio is put and each of these implies substantial concessions in the matter of testing when compared with the full transport category equipment. It must be obvious that a light aircraft flying in controlled air space to a busy airport must have equipment which is likely to have substantially the same performance and integrity as that in use by the scheduled airliners with which it will become involved.

Even so, an examination of the regulations will reveal that the cost of testing such a device has been contrived to be substantially less than that of the fully approved equipment. It may be of interest to Mr Wiltshire to know that the Authority has approved a number of home designed v.h.f. transceivers for use in gliders where the only requirements have been a power limitation of the transmitter output and proof that the frequency stability and the spurious radiation levels were in accordance with the ITU regulations.

In conclusion, I would state that the problem of effective audio quality is not simple. For example, microphone characteristics and microphone technique and the problem of acquainting the user when he is misusing a particular microphone all degrade quality significantly. This is recognized by the formulation of internationally agreed phraseology and forms of speech which provide appropriate information redundancy. Investigations of the misunderstandings which do occur from time to time show that these are frequently caused by users "short circuiting" some of the agreed phrases.

P. F. Cook
Civil Aviation Authority
Airworthiness Division
Redhill
Surrey

I think the majority of the aviation community would endorse Mr Townson's comments (October letters) on the desirability of reducing dependence on voice communications, although the rate of introduction of data link systems will be determined by cost and by the growth of confidence in their safety.

Regarding modulation standards, the relative merits of a.m. and f.m. in a 25kHz channel are debatable, but what is certain is that the vast amount of money which would be needed to convert all airborne transceivers would contribute more to air safety if spent in other fields (e.g. improving navigation aids).

An important consideration is the operational requirement for some ground stations to use up to 5 transmitters on a single channel to extend the service area. The offset-carrier (Climax) system is used, with carrier offsets of 4kHz minimum. This requires the receiver audio bandwidth, 8kHz at the detector, to be low-pass filtered to 2.5kHz to avoid 4kHz heterodyne whistles. Offset carrier techniques cannot be used with f.m., and while synchronous-carrier f.m. might allow slightly increased audio bandwidth, it is doubtful whether distortion would be acceptably low. (For further discussion of a.m./f.m. tradeoffs see Mr Drybrough's articles in *Wireless World*, November and December 1976 issues, and March 1977 issue).

R. A. Keall
Hawker Siddeley Aviation Ltd
Hatfield
Hertfordshire.

RIAA EQUALIZATION IN PRE-AMPLIFIERS

I was very interested to read the comments of Mr de Paravicini (Letters, May issue) on passive RIAA preamplifiers. From my own studies and limited tests and from discussions and reading, I have reached the following conclusions on amplifier design:

1. The greatest contribution to sound quality of feedback RIAA pre-amps is to split the equalisation into two stages.
2. The better the quality of the basic amplifier circuit, the less the advantage in using passive equalisation.
3. Because amplification stages are not perfect, they introduce conflicting problems with high frequency phase response, low frequency phase response, input impedance at the inverting input (which may not be constant and will include some capacitance), gain required to avoid stage overload or noise level of next stage. Careful design is needed at each stage to produce an amplifier capable of reproducing music.
4. The quality that each amplification stage can attain as a straight amplifier is an important factor in determining the overall sound quality. The nine transistor amplifiers described by Mr Self[2] in his advanced preamplifier (with a few slight modifications) are capable of better sound quality than any other amplifier stage I have tried.
5. The sound quality obtained by using passive equalisation and the nine transistor amplifiers in every stage can only be maintained if the number of touching contacts are kept to a minimum (potentiometers, switches, and plugs and sockets). Additional switches and connectors to facilitate A-B switching tend to make comparison between very high quality amplifiers difficult.
6. The sound quality can never be better than the weakest stage. If an amplifier is of such a quality that a simple emitter follower creates noticeable distortion [3] then that must be replaced by a stage comparable with the rest of the amplifier even if nine transistors have to be used.
7. The input capacitance to ground at the disc input should be kept to an absolute minimum. R.F. interference should be avoided by a series inductance and any high frequency response rise corrected by a lower input resistance. The purpose of the lower resistance is to avoid resonance which will impair the quality of sound produced by the cartridge. This point has been made by leading hi-fi reviewers. [4,5]
8. The sound quality of almost every commercial amplifier can be improved considerably at little extra cost.

To turn to transient distortion, I fail to see how the term "transient intermodulation distortion" can mean anything in the English language. To my understanding it is a description of a form of distortion to a transient waveform (musical signal) which occurs in passing through a circuit though that circuit introduces very little harmonic or intermodulation to a sine wave. Hence the term "intermodulation" is meaningless and confusing. No wonder that there is no one who understands it and can describe it in simple terms backed up by experimental evidence. In musical terms, it may seem like intermodulation between the sounds due to confused stereo images, but not in engineering terms.[6]

Finally I feel that it is unfortunate that Mr Vereker (June letters) finds it necessary to introduce a new term "loss of information". This is really the true meaning of the word "distortion".

Graham Nalty
Borrowash, Derby

References

1. T. de Paravicini, letter, *Wireless World*, May 1977.
2. D. Self, "Advanced pre-amplifier design". *Wireless World*, Nov. 1976.
3. A. King, letter, *Wireless World*, April 1977.
4. Angus McKenzie, "Reviewing reviewed". *Hi fi for Pleasure*, April 1977.
5. B. J. Webb, "Goldring 900SE" (review). *Hi fi News*, December 1976.
6. Graham Nalty, "Amplifiers examined – what is an amplifier?" *Practical Hi Fi & Audio*, July 1977.

DOPPLER RADAR

I was most interested in the article on Doppler radar by M. W. Hosking in the July issue. I was immediately reminded of a very simple set-up using mainly Government surplus equipment which a colleague and I put together whilst both employed at the Royal Military College of Science, Shrivenham, somewhere in the period 1949/1950.

Separate small 12-inch paraboloids were used for transmitting and receiving. A low power 3cm klystron was used in the transmitter. This was of the type commonly used as a local oscillator in radar equipment of the period, as was also the crystal diode used in the receiving assembly. The object of the exercise was to demonstrate the principles of Doppler radar to young officers on degree courses.

We were not anticipating a lot of success, and time and equipment available were both limited. However, we were encouraged by most satisfactory noises from the loudspeaker made by personnel and vehicles passing in our beam. We were of course aware that the Doppler output was a function of the size and range of the reflecting object. Imagine our surprise and pleasure therefore when, on directing the beam down the cricket pitch, some 150m distant, the flight of the ball towards the batsman produced most satisfactory squeals! It was not long after this that we added a simple frequency counter which also displayed the instantaneous velocity of the ball on a large meter. All arguments as to the fastest bowlers were subsequently scientifically settled! No doubt in these more enlightened days we would have fitted a digital counter with a stored maximum velocity read-out!

As may be imagined this proved for some time a most popular demonstration. It would be most interesting to hear from any young officers of that day who remember these events at Shrivenham.

K. J. Neighbour
Christchurch, Dorset

INTEGRATED CIRCUIT OF THE 1920s

Accompanying this letter is a photograph of a valve, type 3NF, believed to have been manufactured by the German company Loewe in the 1920s. In my experience this is the earliest attempt at integration for it contains in one envelope three separate triode valves and all RC coupling components for a simple wireless receiver. The only external components required are the aerial tuning circuit, loudspeaker and power supplies. The circuit diagram and operating data are given on the only part of the original carton which remains.

Each resistor and capacitor is separately encapsulated in glass, presumably to preserve the vacuum against outgassing of these components, and the circuit provides an object lesson in economy of components to enable the valve to be mounted on its 6-pin base. The base has sliding contacts (not plug in) and uses a bayonet fitting base with three staggered locating dowels.

I am indebted to a colleague, Mr R. F. Wright, for the opportunity to examine this valve and several other collectors' pieces which he retrieved while clearing his family home in Australia. I retained it for long enough to find that it is still in working order and gives good loudspeaker reception on local stations on about 6ft of wire as an aerial, giving 400mV r.f. at the first grid. In operation the valve is quite isolated acoustically from the loudspeaker to prevent microphonic oscillation.

I would be very interested if any of your readers could provide any historical information on this device or on the Loewe company, which is unknown to me.

T. R. Thompson
Dungeness 'B' Nuclear Power Station
Romney Marsh
Kent

Editor's note: The firm Loewe Opta of Berlin, maker of radio and television sets, is of course well known in Germany.

HOTEL RADIO

If one makes use of the switchable radio installations which are provided in the bedrooms of modern hotels, the result is almost invariably disappointing. They are seldom in full working order. Typical faults are:

- Mis-tuning of all or some channels, with subsequent distortion and even, in areas of low signal strength, ignition interference; or some channels wholly missing.
- Faults in the amplifier and distribution network, resulting again in distortion and large variations in power level at the loudspeaker.
- Noisy switches (usually press-button) and volume controls.

These faults are found all over the world. I recall two satisfactory switched systems: one in West Germany where the audio signals are fed via a rotary switch to a *valve* amplifier and a modern push-button system in East Germany. The best all-round solution is found in many hotels in the USA – a simple continuously tunable f.m. receiver, firmly screwed to the wall. Why do European hoteliers not follow this practice?

John Want
Pinner
Middlesex

TRAINING IN A DEVELOPING COUNTRY

I am writing to you on behalf of the International Voluntary Service in the Seychelles. We are part of the British Volunteer Programme, which is a voluntary organisation with a view to training technicians etc. in the developing countries. At present the college in which I am teaching has a City and Guilds of London 235A and 235B electricians course, and we are trying to start a basic electronics course, which is (in the electrical industry) a vital part of training.

The islands, I should explain, have just received independence, and of course have a limited budget, therefore we have problems in supplying texts for our students and component parts for building circuits. I would add that a lot of British technology is exported to the islands but only a limited training is available. Part of the plan is to expand on this training, so I would like to appeal to you and your readers to help in as many ways as possible. One very practical way would be with back issues of your magazines which I feel would be a tremendous help in the work. Also old or used textbooks would certainly be gratefully received, and, of course, what we call "junk," old p.c.bs, resistors, diodes, transistors (not too old), capacitors etc. The students are hard working and would be grateful for any help in developing the skills of our industry. My colleagues and I feel that the possibilities are excellent. The British people have given political independence to the Seychellois; we can give them economic independence by giving as generously as possible the technical training that they need.

Gordon Catto
Seychelles Technical School
P.O. Box 48
Victoria
Mahe, Seychelles

Audible amplifier distortion is not a mystery

Some things are believed because people feel as if they must *be true, and in such cases an immense weight of evidence is necessary to dispel the belief.* BERTRAND RUSSELL

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

There is a very widely held belief that all amplifiers sound different, and that the reasons for this are so subtle and mysterious that no-one has yet properly understood them. I do not agree with these views, and confidently maintain that all first-class, competently designed, amplifiers, tested under completely fair and carefully-controlled conditions, including the avoidance of overloading, sound absolutely indistinguishable on normal programme material no matter how refined the listening tests, or the listeners, may be; and that when an inferior amplifier is compared with a very good one and a subjective quality difference is genuinely and reliably established, it is always possible, by straightforward scientific investigation, to find a rational explanation for this difference.

Subjective reactions

When people claim to have detected a difference in the sound of two amplifiers, the true explanation for this may be any of the following:

- —the amplifiers actually did produce different audible distortions,
- —there was a slight difference, probably unsuspected, in the test conditions,
- —psychological factors were exerting an influence.

It is possible to be quite misled by some small physical effect, thought to be of no consequence at the time. I well remember a particular case some years ago when a friend claimed to be able to detect by ear the difference between a good valve amplifier and a good transistor amplifier. He invited me to his house and had a changeover switch which I was asked to operate, not knowing which position was which. I soon found I could indeed detect a slight difference, one position seeming just a little smoother and less "grainy" than the other. I supposed this to be the valve position, which was correct, and we were both pretty well convinced we were hearing a trace of crossover distortion. It then occurred to me to wonder just how accurately the volumes had been set to equality in the two positions, and the outcome of this was that we found that a reduction of not more than about 1dB in the volume from the transistor amplifier made it absolutely impossible for either of us to tell which amplifier was operating! More recently it was found that by choosing the moment of switchover in relation to the musical phrasing, to coincide with a change in sonority, one could produce the reaction that either one or the other of two systems was the better. This sort of thing can, of course, happen spontaneously, without anyone being aware of it. Another possible cause of deception is a trace of hum in one system but not in the other, due to insufficient care over earthing arrangements in the test set-up — this hum can get misinterpreted as a degradation in general quality.

With regard to psychological factors, I think it should be openly recognised that those of us claiming to have "golden ears" in matters of sound quality judgement can nevertheless be very easily led astray in various ways. For instance if, without being aware of it, we have listened for a long period to some equipment with, say, a 6dB dip in the frequency response at 3kHz, but otherwise of first-class performance, removal of the dip is very likely to produce the reaction, at least initially, that the reproduction has become too strident. However, if it was *known* to the listeners beforehand that a dip had been intentionally introduced, removal of it is then more likely to produce the reaction "Yes, now the violin tone is more realistic" or something of the sort! Such pre-conditioning and psychological influences are quite strong, and should be allowed for. Another psychological phenomenon, very significant I think, is that few of us like to admit that we "just cannot tell the slightest difference" in the presence of others who have professed to hear subtle differences. So most people will succeed in convincing themselves that they really have managed to notice small changes in sound quality. In properly conducted subjective tests, however, the participants should not know which system they are listening to at any given time, and the number of switchovers, some genuine and some not, should be large enough for a proper statistical interpretation of results to be made. Guesswork, maybe unconscious, is then largely prevented from influencing the results.

An amusing illustration of some of these psychological ideas arose on an exhibition stand by a well-known firm, who had arranged things so that visitors could listen, at precisely the same volume, to three of their amplifiers, being invited to identify the most expensive model. In fact it was found that voting for "the best amplifier" was about equally distributed between the three, so that, naturally, about a third of the visitors picked the right one. When told they had been successful, the almost universal reaction of these individuals was one of pleasure at their evident skill, whereas, of course, an equally logical reaction would have been to congratulate themselves on their good luck!

The BBC Research Department is well aware of the dangers of reaching quite wrong conclusions from subjective tests. Very careful precautions are taken to eliminate as many psychological and physical disturbing factors as possible, and even to derive, where appropriate, a quantitative estimate of the reliability of the results[3]. It is very evident that in many other places such precautions are not properly taken.

Recording systems and amplifiers

Unlike amplifiers, conventional tape and disc recorders, even those of the highest professional grade, have distortion levels and signal-to-noise ratio which are only just about good enough subjectively. A very instructive experiment is to record the same mono programme source on both tracks of a good stereo tape recorder, with a level difference of, say, 10dB. The replay gains are then adjusted to give outputs of equal magnitudes, and these are subtracted one from the other to give, ideally, nothing but noise and distortion. The distortion is mainly that of the more heavily recorded track, whereas the noise is mainly that of the weaker track. (In practice a little h.f., and possibly l.f., phase correction may be necessary to get fully satisfactory programme cancellation.) With gains set to give normal listening volume when only one track is reproduced, the distortion heard with both tracks operating is quite horrible and is loud enough to be very easily audible all over the room even in conditions of moderately high ambient noise level. This gritty, blasting, distortion is only somewhere about 40dB below the uncancelled programme level during loud passages, yet it is virtually unnoticeable when accompanied by the music. Tests with tone input show that the distortion is mainly third-harmonic, the percentage distortion being proportional to the square of the output voltage and reaching about 2% at peak recording level. The distortion is fairly independent of frequency over most of the audio band. Thus a first-class professional tape recorder gives distortion of about the same magnitude and character as a push-pull class A amplifier having a distortion figure of about 2%, assuming this also to be reasonably frequency-independent.

Experiments I have done with class A push-pull amplifier circuits, involving balancing out the programme and listening to the distortion by itself, do indeed show that it sounds much the same as that produced by a good tape recorder, and that 1 or 2% distortion is low enough for results of the highest quality, provided the amplifier performance is clean enough in all other respects.

Similar experiments with class B push-pull circuits, adjusted to give considerable crossover distortion, show, not surprisingly, that the distortion is rougher and more unpleasant sounding, and tends to be nearly as loud during fairly quiet parts of the programme as during the loud parts – it appears as an almost continuous background fuzz. For absolutely first-class quality, distortion of this type must be reduced to much less than 1% at all output levels and over most of the audio spectrum. This topic will be considered in greater detail later on.

In recording systems, unless very refined and expensive digital techniques are used, there is always the need for a careful compromise between signal-to-noise ratio and distortion. Compandor systems, of which 'dbx' is the latest, and very welcome, development[4,5], can achieve an impressive improvement in subjective signal-to-noise ratio, together with some reduction in peak distortion level, but they do not actually affect very greatly the signal-to-noise ratio existing during loud passages. Thus reliance is still being placed on the masking effect[6,7], whereby unwanted sounds, which would be very easily audible on their own, become virtually inaudible when accompanied by the wanted programme.

With amplifiers, on the other hand, it is comparatively easy to reduce the audible distortion and internally-generated noise to far lower levels than in any normal recording system, and this is what is done in equipment of the highest grade. Provided such amplifiers are tested under sufficiently carefully controlled and fair conditions, are free from faults such as hum and r.f. interference susceptibility, have insignificant differences in frequency response, and are not overloaded, the quite inevitable result is that one amplifier is absolutely indistinguishable from another, on normal programme material, no matter how "golden" may be the ears involved.

Quad have shown[8,9] that, with their transistor power amplifiers, if the amplifier distortion, including hum and noise, is reproduced by itself at its normal level, without the music, the result is *total silence* under ordinary listening conditions. This is enormously better than the result obtained when a somewhat similar test, as described above, is done on a high-grade professional recorder. But, to me, the most amazing thing is that Peter Walker tells me that few of the people who have witnessed this experiment seem able to appreciate its true significance, which is, quite inescapably, that such amplifiers are subjectively perfect with a large margin to spare and give an audible performance which can never be improved upon. Quad do not maintain, however, that theirs are the only amplifiers about which this may truly be said. Of course if, during the above experiment, such amplifiers are allowed to overload, even momentarily, the silence is broken and the distortion fairly cracks forth. But amplifiers should not be allowed to overload, and if they do, the only proper solutions are to turn the volume down or employ more powerful amplifiers.

A few people have raised the objection to the above experiment that though the distortion may be inaudible on its own, the ear and brain are exceedingly complex and subtle, and the effect of the distortion might conceivably be perceived when it is accompanied by the music. This, however, is quite contrary to what is found to happen in the tape-recorder experiment referred to earlier, where the distortion is easily heard on its own but is very well masked when accompanied by the music. Experiments I have done involving crossover distortion show that it too is fortunately subject to a considerable degree of masking in the presence of the associated programme.

A diagnostic tool

The technique employed by Quad[8,9] for listening to amplifier distortion by itself, on programme input, provides a very useful tool for assessing the subjective goodness of amplifiers in a quantitative manner and for establishing criteria that should be met if an amplifier is to be totally free from audible distortion. The technique can obviously be implemented in various detailed ways, and Fig. 1 shows one arrangement which is suitable when the amplifier under test is of the phase-inverting type. When, as is more usual, there is no phase-inversion, a very low-distortion phase inverter must be introduced into the circuit in one of several possible places.

For setting the circuit up, it is found in practice that an audio noise source is more suitable than normal programme input, since all frequencies are present all the time. Thus S_1 and S_2 are both closed, and P_1 plus the several adjustments in the frequency-response and phase-balancing network are adjusted for minimum output from the monitoring system. The potentiometer P_2 should initially be set to a low resistance value, the value being raised as the balance condition is made more and more nearly perfect. Potentiometer P_2 should finally be set so that, with S_1 or S_2 opened, the voltage fed to the monitor system loudspeaker is the same as that fed to the load circuit of the amplifier under test. With both switches again closed, the distortion alone will then be reproduced by the monitoring system loudspeaker at its proper level. Having thus got the circuit correctly set up – a rather tedious operation because of the number of adjustments involved – a little thought will show that a variety of interesting and very informative tests may then readily be done, such as:

- The gain of the monitoring system may be increased until the distortion does become audible by itself, thus obtaining a measure of the margin by which it was previously inaudible.
- The effect on the audible distortion of loading the amplifier under test with loudspeakers and/or dummy loads having various different impedance characteristics may be investigated. (When a loudspeaker load is used, it is necessary, of course, to prevent the sound from this loudspeaker from reaching the person listening to the distortion on the monitoring system loudspeaker. Rather than use well-separated rooms and very long leads, a more convenient procedure is to tape record the distortion and listen to it later on.)
- The two loudspeakers of Fig. 1 may be placed next to each other, P_2 then being adjusted to determine by how much the distortion may be increased above its "natural" level before a just-detectable degradation in music quality begins to become evident.
- With S_2 only closed, and then S_1 only closed, P_2 being set for a suitable listening volume from the monitoring-system loudspeaker, reproduction via the amplifier under test may be compared with that via the passive network. With a first-rate amplifier,

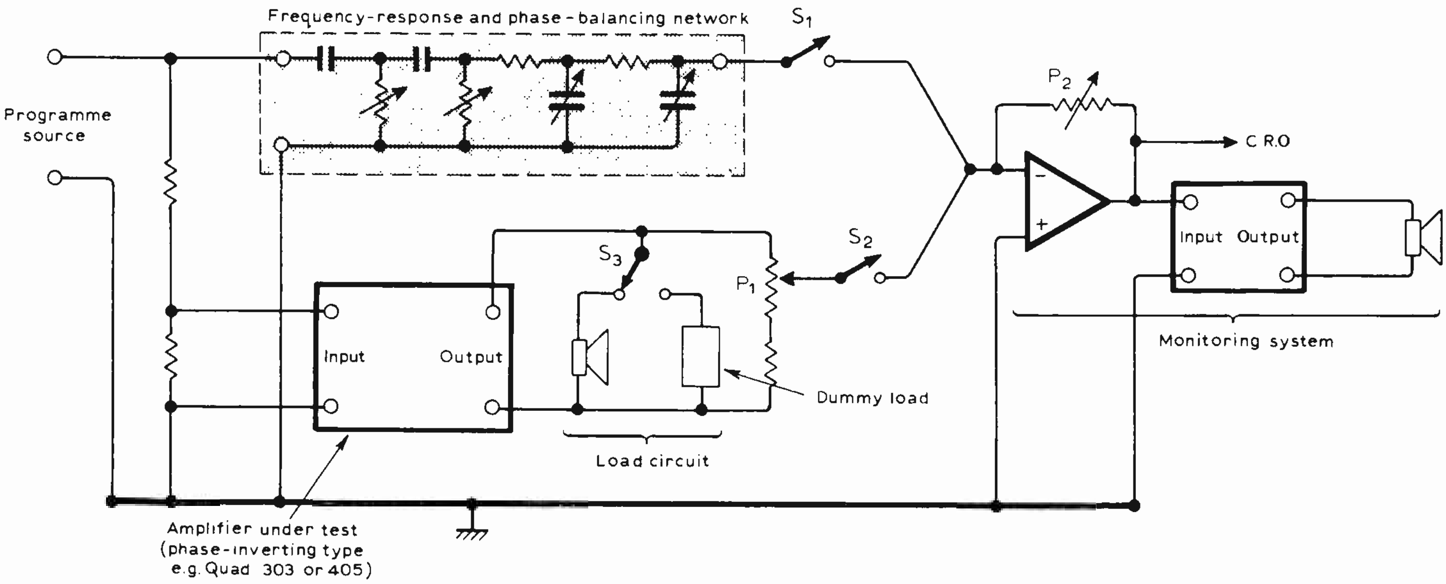


Fig. 1. The diagnostic set-up. A modified frequency-response and phase-balancing network may sometimes be required.

absolutely no difference whatsoever should be detectable on any kind of music programme input, provided that no overloading of the amplifier under test is allowed to occur. The test may be extended to assessing the degree of unpleasantness of various degrees of overloading, with and without protective circuits in operation, etc.

- When two amplifiers are found to sound genuinely different in ordinary subjective tests, they may then be tested in a circuit of the Fig. 1 type to see whether the distortion is audible when reproduced by itself. It may be found that the distortion is of an overloading type, though perhaps happening at a lower output level than the expected clipping level because of the operation of protective circuitry within the amplifier — or it may be that the amplifier has been badly designed with regard to its slew-rate capability. Such possibilities may then be looked into in detail. On the other hand, if both amplifiers give inaudible, or very unobtrusive, distortion, it is worth testing one amplifier in the Fig. 1 circuit with the frequency-response and phase-balancing values adopted for the other amplifier in place. Then, if there is a noticeable difference in quality when only S_1 or only S_2 is closed, the mid-frequency gains having been set to precise equality, it is likely to be because of the slightly different frequency responses — in particular, the response below the audio spectrum may be important in influencing the amount of rumble or other sub-audio-frequency signal reaching the loudspeaker, where it may cause large cone movements and thereby affect the loudspeaker distortion.
- By using an oscilloscope with the Fig. 1 set-up, much can be learnt about the relationship between the type of distortion waveform observed and the corresponding subjective nature of the distortion. The system also has the great virtue, when used with tone input, that the true waveform of the amplifier distortion is displayed, unaffected by oscillator distortion or by slight harmonic phase shifts contributed by the notch filter that would normally have to be used.

The Fig. 1 type of arrangement can also be made the basis for an accurate and very satisfactory technique for harmonic and intermodulation distortion measurement, which has the advantage of not demanding a high degree of oscillator waveform purity.

Some conclusions

One of the conclusions to be drawn from tests such as those just outlined is that amplifiers do tend to differ somewhat in the degree of unpleasantness of the distortion they produce when allowed to overload, but, apart from this I feel sure that nobody who has actually himself used these largely subjective investigational techniques could possibly continue to believe that all amplifiers sound different or that the subjectively perfect amplifier has yet to be designed. This is why Quad have been prepared to stake their reputation and say without reservation that they would be prepared to accept a challenge to have their 303 or 405 amplifiers compared effectively, using the Fig. 1 type of set-up, with what they have called a "straight wire with gain"[10]. Provided certain quite reasonable test conditions are satisfied, their claim is simply that no-one will genuinely be able to detect the slightest difference in sound quality on any programme input derived from normal sources.

The unconvinced may well say "if subjective perfection has already been achieved, then why are amplifier manufacturers still devoting a lot of research and development effort to making better amplifiers?". The cynical reply might be "to produce even more impressive-looking figures for reviews"! But in fact the enlightened designer is probably spending most of his time struggling with far more difficult problems, such as how to achieve greater reliability, how to simplify the design and hence reduce the manufacturing costs, how to eliminate the need for preset adjustments, how to increase the maximum available output, how to improve the ability of the amplifier to cope with a wider range of load impedances, how to eliminate "switch-on plonks" etc. None of these problems directly involves the concept of subjective listening quality.

It is when problems such as those just mentioned are considered that the true nature of the enormous advances made in audio-amplifier technology becomes evident. In 1938, a British 14-watt high-quality amplifier sold for about £19, yielding a figure of 0.74 watt per £1. A recent 200-watt stereo amplifier, of smaller size and weight, sells at £115 and gives 1.7 watts per £1. Allowing for inflation, it is clear that the true cost per watt using modern solid-state techniques is down by a factor of the order of ten on what could be achieved in the valve era[2]. This is undoubtedly a great engineering achievement.

As a designer of audio amplifiers and other equipment, of which some is currently in use in BBC studios and elsewhere, I must have spent many thousands of hours inventing, thinking about and experimenting with audio amplifier circuits, but I cannot recollect ever having carried out subjective quality-assessment tests as a direct part of the design and development process. Subjective tests have been done separately from the design work and for the purpose of helping to establish criteria which need to be satisfied by the equipment designed.

Without knowledge of such subjectively-derived criteria, it is natural to "play for safety" and make the performance far better than it actually needs to be. This is particularly the case with preamplifier or control-unit design, where the non-linearity distortion is usually of the simple smooth-curvature type, which does not need to be reduced anything like as far as it is possible to reduce it in order to become quite inaudible. To elaborate the design, with consequent increase in cost, to the point where the distortion is, say, a hundred times, or more, below the subjective detection limit — which it is quite possible to do — is surely not in the true interests of the customer. Needless to say, very great care indeed must nevertheless be taken with things that really do matter, such as leaving sufficient "headroom" to accommodate all pickup sensitivities[2], achieving very low hum and interference susceptibility, etc.

Once the designer has freed himself from various quite irrational and unfounded beliefs, e.g. that there is an inherent subtle difference between valve and transistor sound, that transformers always produce detectable subjective distortion, that class B amplifiers can never sound quite as clean as class A ones, that feedback should only be used in small amounts, etc., he can then proceed in a proper scientific manner to develop designs of good economy and reliability, and immaculate subjective performance. He will appreciate that there are countless ways of designing equally good-sounding amplifiers, and concentrate his efforts largely on seeking the optimum engineering solution.

Amplifier reviews

The belief that all amplifiers sound different seems to be even more deeply rooted with the popular hi-fi press and their reviewing teams than it is with designers. I feel that a great disservice is being done both to the buying public and to some manufacturers by reports on amplifiers and control units of the type which have appeared, for example, in "*Hi Fi for Pleasure*"[11,12]. The reviewers claim to have been able to detect by ear specific deficiencies in virtually all units submitted to them, including differences between "cancel" and "tone controls flat" in all cases where such a comparison was possible. But ones incredulity is surely stretched beyond the limit when one finds a well-known control unit, widely adopted by discriminating professional users, described as having a mid-range that is forward yet lacking in detail, with some compression of peaks and an unstable image, and a top end performance that is thin and rounded off, but with a splashy character imparted on cymbals, and similar explosive sounds, the overall performance being summarized as dull, with a great loss of presence and ambience and "seeming to make the music sound amateur"! Enquiries revealed that the unit in question was subsequently retested by the manufacturers and found to be in perfect order. When descriptions such as the above, which could only properly apply to equipment with quite gross faults, are used in relation to items known to be first-rate, it is clear that either something was wrong with the test set-up or that the reviewers — not to question their sincerity — had fallen prey to their own imaginations.

Since the belief that all amplifiers sound different has become so widely accepted, it is natural for people to want to find technical explanations for it. Since little correlation with performance as ordinarily measured can be found, the notion has built up that something extremely subtle and elusive is involved. To explain these supposed subtleties, those with more imagination than scientific understanding proceed to evolve a series of wilder and yet wilder pseudo-scientific hypotheses. New jargon is created — "musicality", "loss of information", etc. An article of French origin which has recently appeared in *Hi-Fi News*[13] – accompanied, however, by an expression of editorial neutrality and non-commitment – says the quality of copper used in loudspeaker leads influences the quality of the information transmission, the best wires having a purity as high as 99.99995%. The alternating magnetic field generated by a loudspeaker cable is said to represent a significant loss of information. Even in the wiring of electric-bell circuits, the use of Litz wire is claimed to give "tintinabular superiority". How silly can we get? All this sort of thing, which seems to be encouraged by some of the hi-fi magazines, for whom it no doubt provides easy material for filling their pages, is surely not good for the future of the audio industry, being liable to bring it to a state of disrepute with intelligent people.

Admittedly the subtleties and difficulties of many aspects of good sound reproduction are enormous, but it seems a pity that an atmosphere of quite irrational mysticism should be encouraged to invade even those parts of the field where things are properly understood and quite straightforward.

Finally, lest some readers may feel that the views here expressed are representative only of an engineering outlook, it may, perhaps, be relevant to add that I have a passionate interest in music, that I frequently go to concerts, do a good deal of recording of live music, and that much music making, some professional, goes on in my household.

The next article will discuss some detailed technical matters relating to amplifier design.

References

1. Walker, P. J., Current dumping audio amplifier, *Wireless World*, Dec. 1975, pp. 560-562.
2. Baxandall, P. J., High-fidelity amplifiers, Radio, TV & Audio Technical Reference Book, Chapter 14 (Newnes-Butterworths, 1977).
3. Jones, D. K., A subjective investigation into preferred microphone balances, BBC Eng. Mono. No. 68, July 1967.
4. Ogden, F., dbx, *Hi-Fi News*, Oct. 1976, pp. 92-94.
5. Blakely, L., dbx for disc, *Studio Sound*, Sept. 1976, pp. 32-34.
6. Olson, H. F., Elements of acoustical engineering, 2nd. Ed., pp. 469-471 (Van Nostrand, 1947).
7. Beranek, L. L., Acoustics, pp. 404-406 (McGraw-Hill, 1954).
8. Jones, F., Dynamic testing of audio amplifiers, *Hi-Fi News*, Nov. 1970, pp. 1655-1657.
9. Collins, A. R., Testing amplifiers with a bridge, *Audio*, March 1972.
10. Walker, P. J., Rational amplifier testing, *Hi-Fi News*, July 1977, pk. 135.
11. Reviews of 17 power amplifiers, *Hi Fi for Pleasure*, March 1976, pp. 56-63.
12. Reviews of 11 preamplifiers, *Hi Fi for Pleasure*, June 1977, pp. 86-107.
13. Hiraga, J., Can we hear connecting wires?, *Hi-Fi News*, August 1977, pp. 35-41.

Harold W. Barnard

Many people in the electronics industry will be saddened to hear of the death of Harold W. Barnard, editor of *Wireless World* from 1965 to 1973. Although he held this post for only eight years he had in fact given a lifetime of devoted service to the journal. Starting in 1925 as an assistant to the production manager, he transferred in 1936 to the news side of the (then weekly) journal to become what was known as a "leg-man" – getting news the hard way without the assistance of today's information services and publicity organizations – and eventually took complete charge of the news section. During the 1939-45 war he was a member of a small team that kept the journal going under extremely difficult conditions. In 1959 he was appointed assistant editor, a fitting tribute to his journalistic abilities.

When he retired in 1973 we wrote this of him: "Kindness, courtesy and dedication are three qualities not very much in evidence in the modern industrial scene. They are the three qualities which one would most likely pick if one were asked to characterize in a few words the retiring Editor of *Wireless World*, Harold W. Barnard. Readers may wonder what such things have to do with technical journalism: they don't seem to be relevant to the business of turning out good articles and news on radio and electronics. But technical journalism, like many other professional and industrial activities, runs on the fuel of human contacts. What is printed in each issue is the final result of much talking, listening, letter writing, discussion, argument, persuasion, joking, threatening, criticizing, and praising. All these are necessary functions, but it is the personal qualities an editor brings to exercising them that makes all the difference. It would not be fanciful to claim that kindness, courtesy and dedication have been significant factors in the making of *Wireless World* during the eight years of Harold Barnard's editorship."

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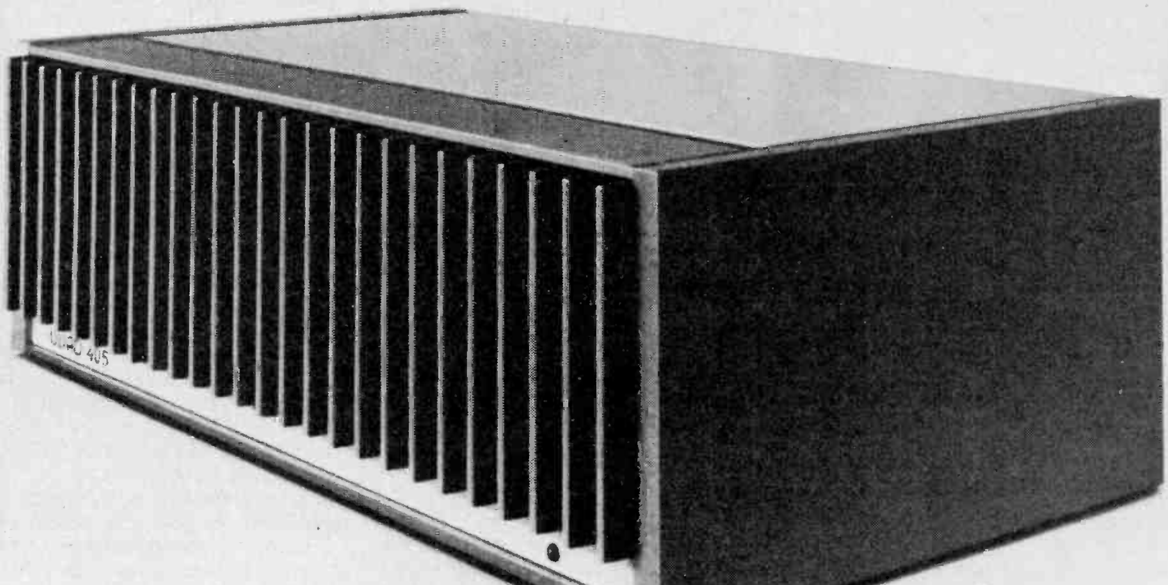

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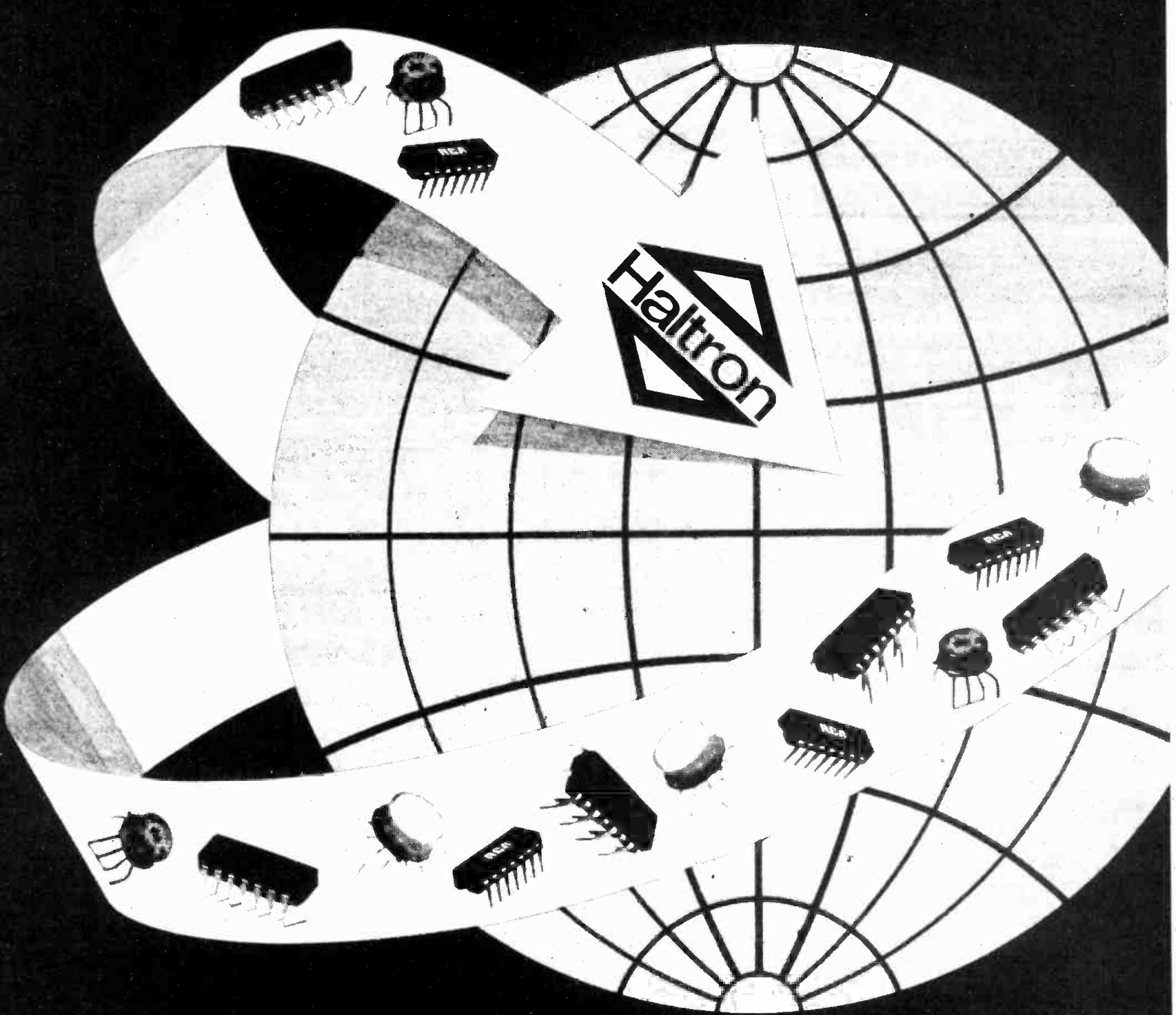

Haltron

Microwave voice link — 2

10GHz unit uses Gunn oscillator

by M. W. Hosking, M.Sc., M.I.E.E., *British Aircraft Corporation*

This low-power communication link uses a similar type of receiver to that in the domestic intruder alarm circuit described in the July and August issues. This article completes constructional details of a 10GHz pulse-modulated voice link, including waveguide and horn antenna and a simple calibration procedure.

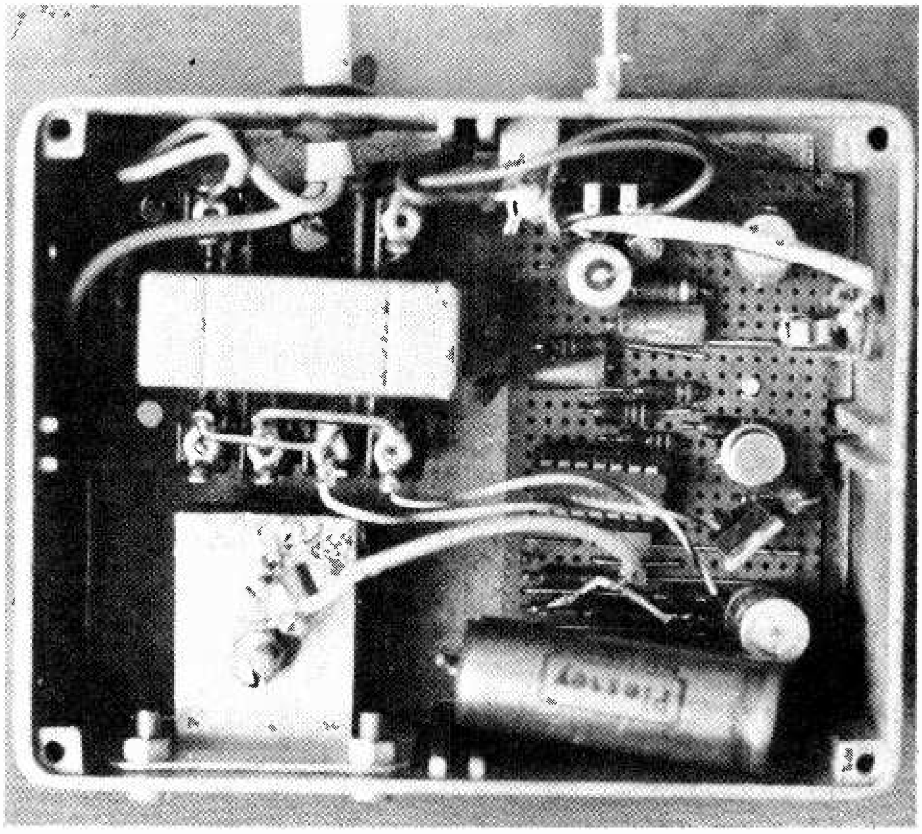


Fig. 10. Complete modulator and transmitter packaged in a standard die-cast box showing the general interconnections, as described in the October issue.

The receiver is in two parts: a microwave detector as the front end, followed by a combined filter and amplifier circuit. The detector is a Schottky-barrier diode in a waveguide assembly similar to the transmitter. The operation of this and other types of microwave diode were described in Realm of Microwaves, part 5, August 1973 issue. For use as a straightforward video detector, as opposed to a mixer, it is necessary to provide a small, forward d.c. bias of about 40μA to start efficient rectification. With this applied, the output impedance of the diode is about 800 ohm.

The rectified output from the detector, which consists of the 50kHz position-modulated pulse train is fed directly into the filter/amplifier circuit of Fig. 11. To keep the noise level to a minimum, the first section up to the base of Tr_1 is a low pass filter which starts to roll-off at 50kHz. Transistor Tr_1 has a fairly low noise figure of about 4dB and, together with IC_1, gives a stage voltage gain of about 1000.

The first stages of the inverting and non-inverting inputs to the op-amp are bypassed, Fig. 11. These stages impose a relatively slow response on the amplifier and the present circuit provides a cheap means of obtaining both fast response and high gain. The normally low noise figure is maintained with Tr_1.

In similar fashion, the second stage can also provide a voltage amplification of up to 1000, but this can be varied with R_{28}. In practice, amplification of a few hundred only has been possible before the onset of self-oscillation. As mentioned earlier, no high power stage is provided, the output from IC_2 going directly to a pair of high-impedance (4kΩ) headphones. Current drain is quite low at about 5mA per rail and thus the receiver can be operated quite conveniently from a pair of PP3 dry batteries.

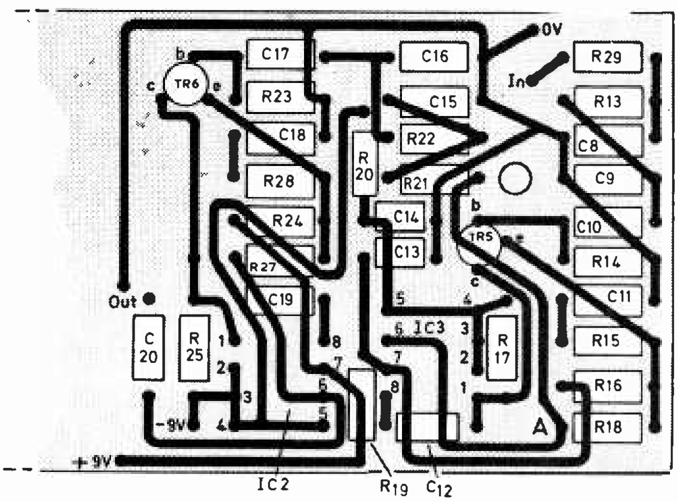


Fig. 9. Component and track layout for the receiver printed circuit board. (Extra component spaces were originally for the intruder detector circuitry.)

Receiver construction

The microwave detector is mounted in a waveguide circuit constructed in the same manner and to the same dimensions as the transmitter. Positioning is not quite so critical as with

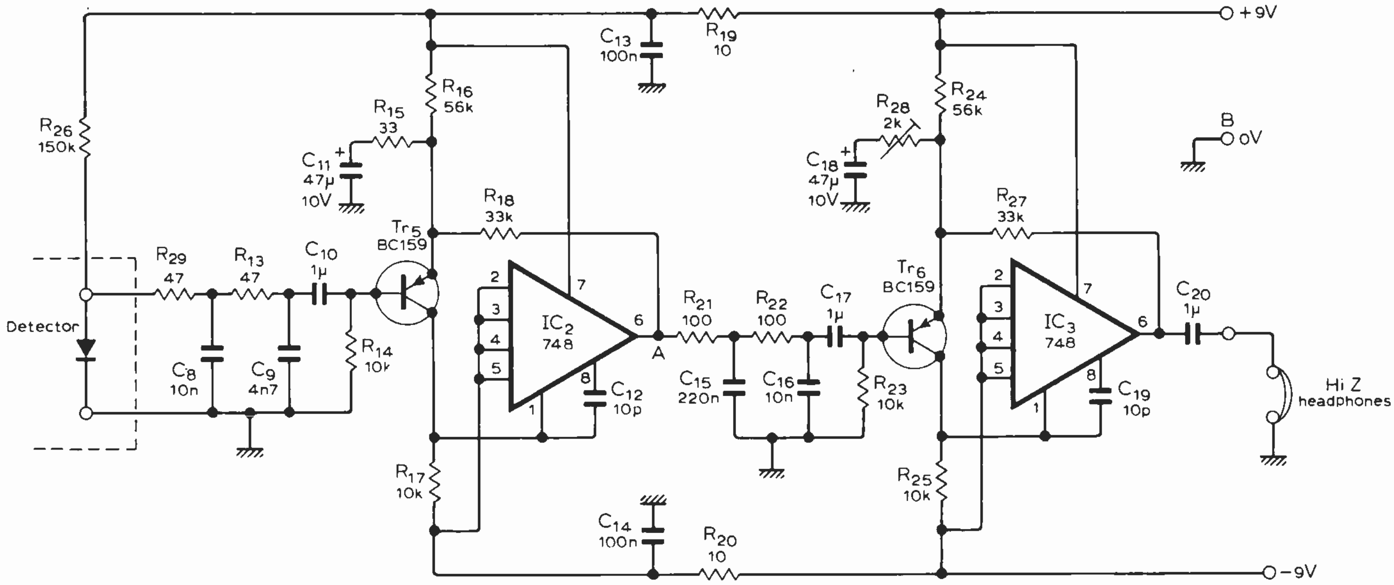


Fig. 11. Receiver/demodulator consists of a two-stage amplifier with two low-pass filtering sections. Output can be fed directly to high-impedance headphones or to an audio power amplifier for loudspeaker reception. Resistors are ⅛-watt, 5% types, capacitors 10% tolerance, except electrolytics.

the Gunn device and, as shown in Fig. 12, the tuning screw has been omitted. If you wish to experiment for optimum performance you can include this and also vary the position of the short circuit.

Remove the collet from the diode, taking care not to exert too much torque on the ceramic-to-metal joints, and solder a lead to the base, then insert the collet through the waveguide wall and bond into position with a bead of Araldite. It is important that a good electrical contact is maintained between the collet and the guide, so take care to ensure that no adhesive seeps between the two. In similar fashion to the transmitter, r.f. shielding is provided at the other end of the diode by forming a bypass capacitor from a layer of foil and adhesive tape. Ensure that the foil does not short out the diode

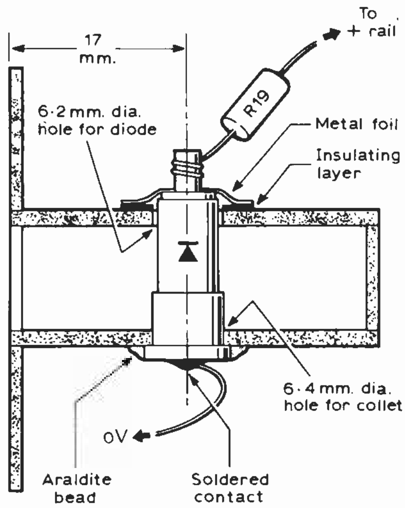
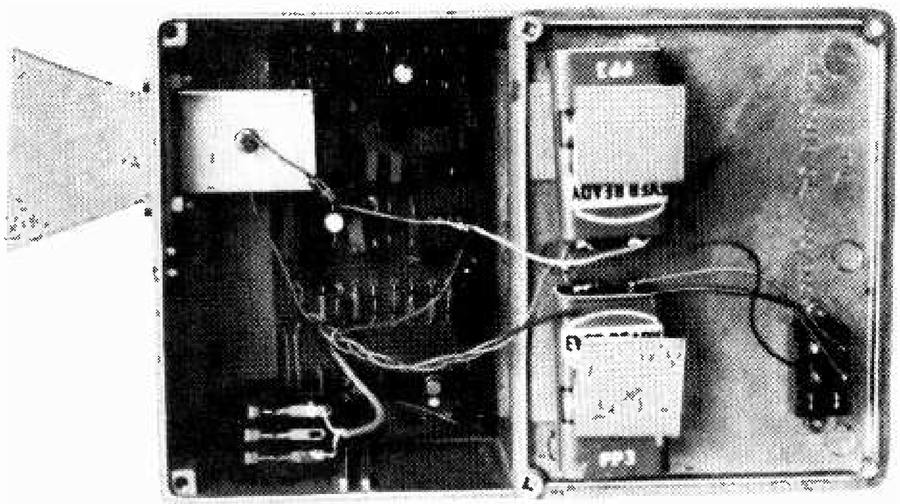


Fig. 12. Final assembly details of the microwave detector in a similar cavity to the transmitter. Metal foil, insulated from the guide, acts as microwave choke and helps screen the diode from external interference.

Fig. 13. General layout of the receiver system in standard die-cast box showing internal lid-mounted batteries.



directly to the mount. The detector diode junction is easily damaged by voltage spikes, so it should not be touched with the soldering iron. *Forward biasing with a multimeter when checking resistance will probably burn it out.*

A printed circuit board has been produced for the main receiver and the component layout is shown in Fig. 9. All parts of the receiver system have again been designed to fit into a 4¾ × 3¾ × 2in (150 × 120 × 50mm) die-cast box, the complete assembly being shown in Fig. 13. Additional mounting details are given in Fig. 14.

Antenna

Open-ended X-band waveguide, such as used for the transmitter and detector, has an acceptable impedance match when radiating into free space and a gain of about 4.5dB. However, the receiver signal-to-noise ratio can be greatly increased by using more directive antennas. The prototype used two pyramidal horns with a design aim of 20dB gain; measurement showed that 19.3dB had been achieved. The prototype horn was constructed from 0.013in (0.3mm) thick aluminium sheet, but this is not critical and may be varied up to the limits of easy fabrication. Fig. 15(a) presents the folded-out dimensions of the horn and Fig. 15(b) shows the final assembly. Flange size and circular hole positions are as given in Fig. 4(d) but the rectangular hole is slightly smaller, as indicated.

Hold a rigid straight-edge along the fold lines of the horn and carefully bend the aluminium into shape, trying to achieve as sharp and even a corner as possible. With the mating edges held together, run a bead of Araldite down the join, first ensuring that the metal is clean, dry and free from fingerprints. Bond the flange in place and heat-cure the adhesive. It is worth taking trouble to ensure that the narrow end of the horn matches exactly the rectangular

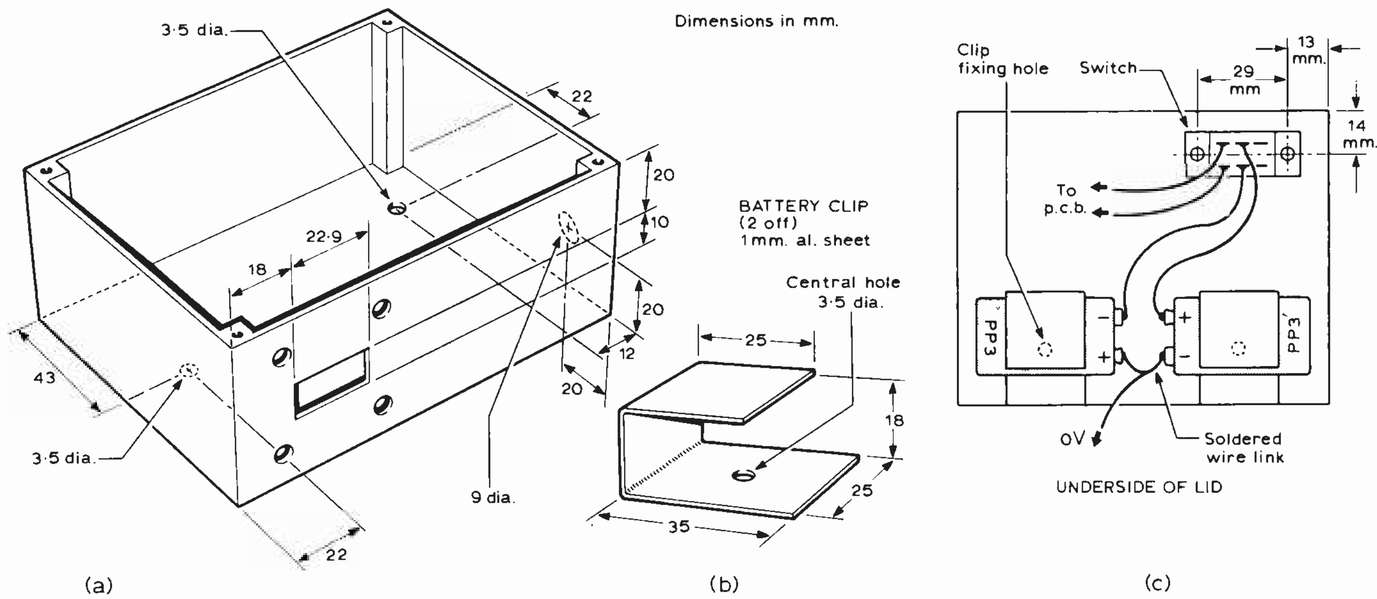


Fig. 14. Hole positions on the receiver box, together with battery mounting details.

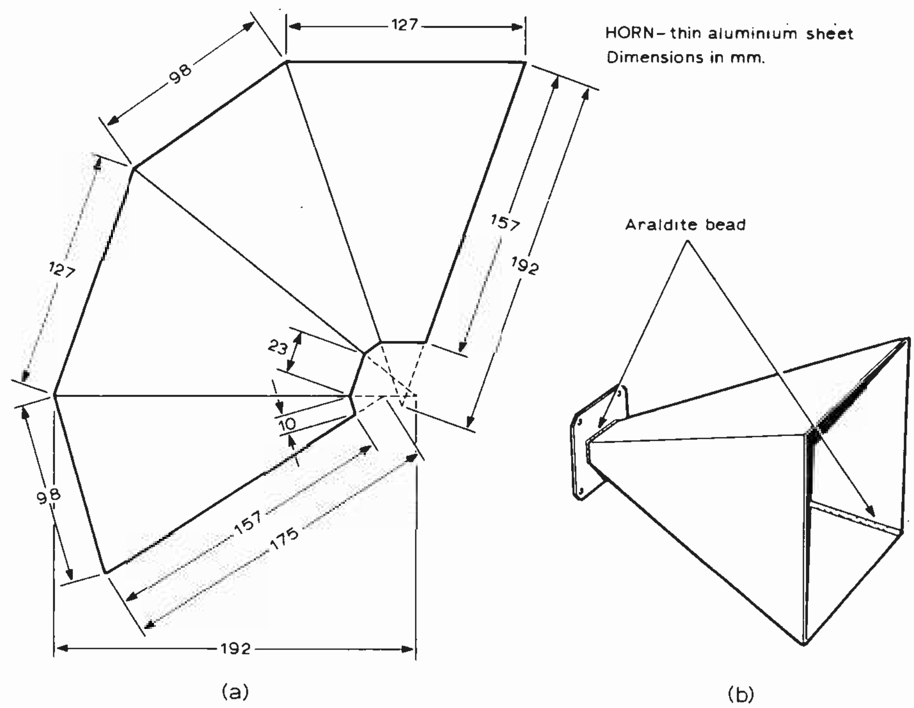


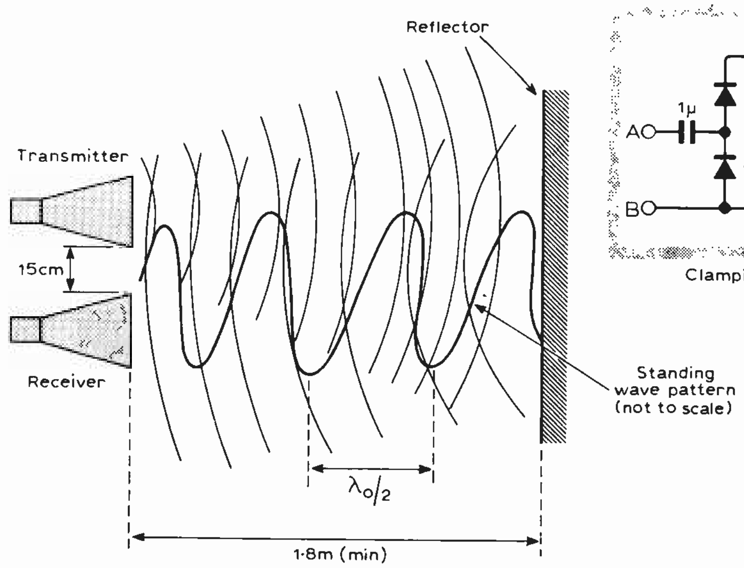
Fig. 15. Antennas are constructed from thin (0.3mm) aluminium sheet bent to the dimensions shown and give gain of about 19dB.

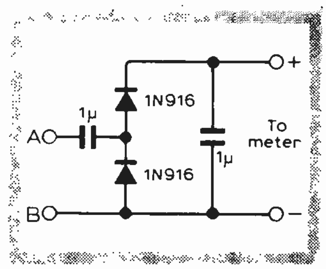
waveguide. Any overlap will have the properties of an inductance or capacitance, depending on which plane it's in and will affect the resonant frequency of the transmitter.

Frequency calibration

The Home Office transmission regulations require that a speech link with this particular modulation be operated within the frequency band 10.050 to 10.450GHz. Few readers will possess or have access to microwave frequency-measuring equipment and so the following technique is suggested.

When electromagnetic radiation is reflected from an object, the incident and reflected waves will combine with a phase difference dependant on the reactance of the object. This sets up a standing wave pattern having sharp nulls and smooth peaks, repeating every half-wavelength. Thus, a measurement of the standing wave pattern will yield the frequency. As indicated schematically in Fig. 16, place the transmitter and receiver side by side about 6in (15cm) apart and at least 6ft (1.8m) from the reflecting object. A convenient arrangement is to support the horns on a box on the floor of a room and pin a sheet of aluminium foil onto the wall. A constant amplitude signal is required for the test and this can be obtained by connecting the input to the diode





Clamping circuit

Fig. 16. Experimental arrangement for measuring transmitter frequency by the free-space standing wave pattern produced by reflecting screen.

continued on page 92

Logic design — 9

More shift registers — ring counters and maximum-length sequence generators

by B. Holdsworth* and D. Zissos†

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The simplest type of shift register counter is the ring counter where feedback is provided from the last stage and feeds the inputs of the first stage as shown in Fig. 8(a). In this circuit there are ten stages: it can be used as a decimal ring counter, since the number of stages is equal to the number of counter states. The information contained in each stage is shifted to the next stage on the receipt of a clock pulse and the counter circulates a 1 which is initially preset in the first stage, all other stages being simultaneously cleared to 0. The counting sequence of the register is shown in Fig. 8(b).

The circuit of Fig. 8(a) can be modified so that it becomes self-starting as shown in Fig. 8(c). The input $J_A = \bar{A}\bar{B}\bar{C}\bar{D}\bar{E}\bar{F}\bar{G}\bar{H}\bar{I}$ and this can only be a 1 providing $A = B = C = D = E = F = G = H = I = 0$. Clearly if any section of the counter except the last one contains a 1, $J_A = 0$, and the counter will now enter the required sequence within a maximum of ten clock pulses.

The ten outputs of this counter can be used directly to drive a decimal display without the need of decoding networks or alternatively it can be used to enable a group of circuits sequentially, as the 1 moves through the various stages of the shift register. The number of stages required in the latter case will be equal to the number of circuits that have to be enabled.

An obvious advantage of the decimal ring counter is its simplicity and since it requires no feedback logic or decoding circuits it uses fewer components. It does, though, have the disadvantage of not having a binary readout, and its counting sequence is radically changed if circuit misoperation occurs, as for example when a section other than that containing the counting 1 is, due to

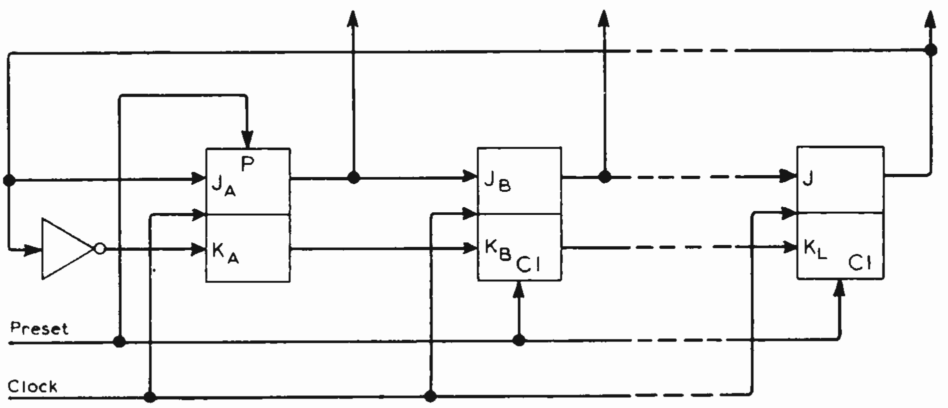


Fig 8(a)

Clock pulse	L	I	H	G	F	E	D	C	B	A
0	0	0	0	0	0	0	0	0	0	1
1	0	0	0	0	0	0	0	0	1	0
2	0	0	0	0	0	0	0	1	0	0
3	0	0	0	0	0	0	1	0	0	0
4	0	0	0	0	0	1	0	0	0	0
5	0	0	0	0	1	0	0	0	0	0
6	0	0	0	1	0	0	0	0	0	0
7	0	0	1	0	0	0	0	0	0	0
8	0	1	0	0	0	0	0	0	0	0
9	1	0	0	0	0	0	0	0	0	0

Fig 8(b)

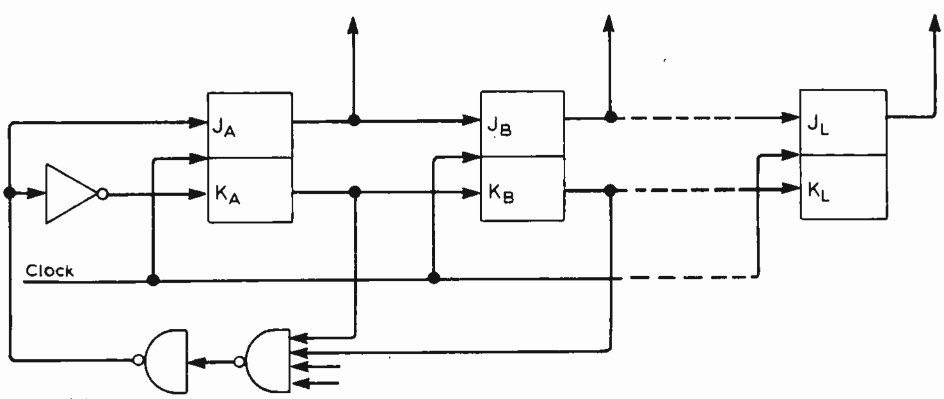


Fig 8(c)

Fig. 8. A basic ring counter (a) and the counting sequence for a decimal type. The two gates in (c) facilitate self starting and the circuit in (d) detects the presence of superfluous '1' states caused by malfunctions. The lack of a '1' in any stage is detected by the circuit at (e).

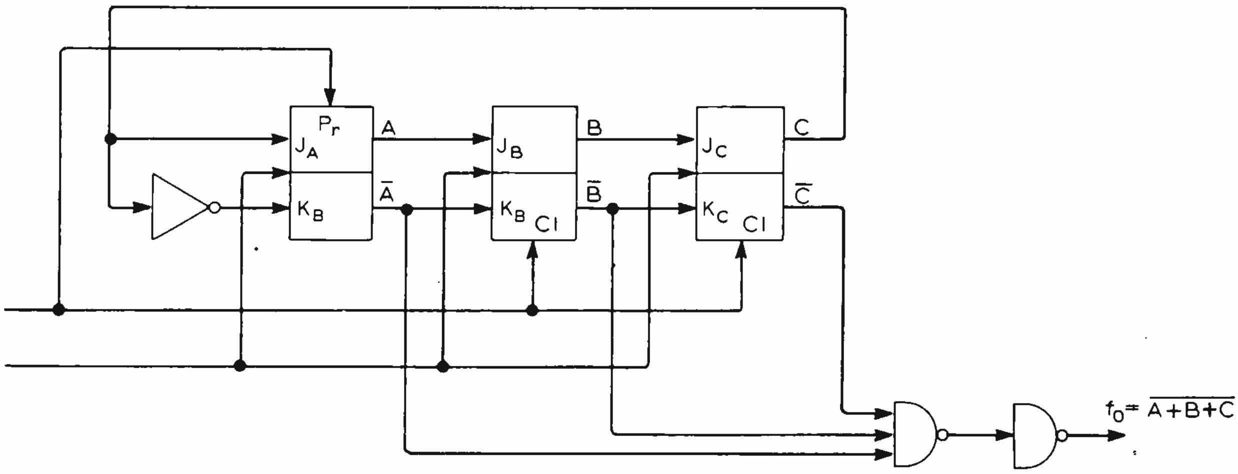


Fig 8(d)

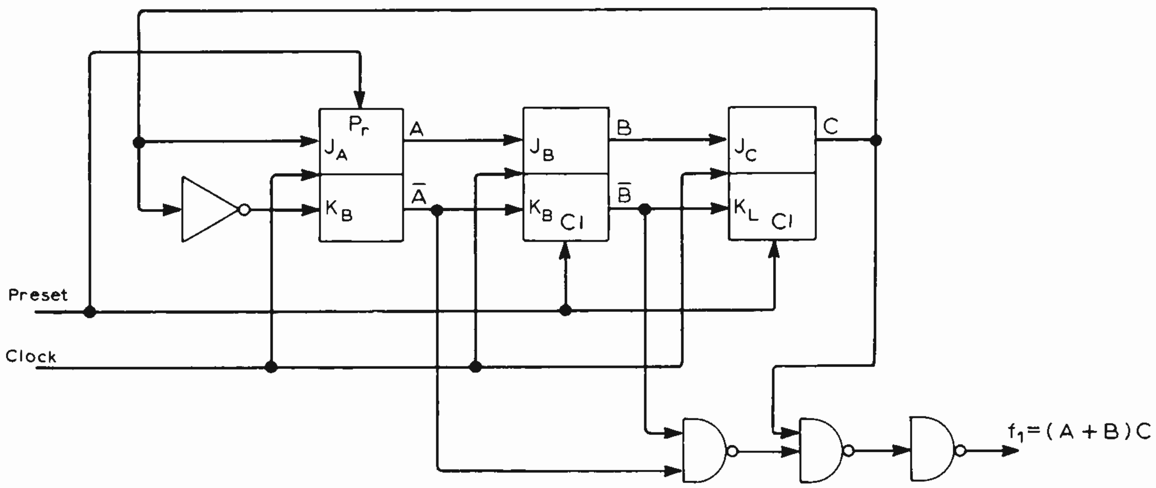


Fig 8(e)

some circuit fault also set to 1, or alternatively when the counting 1 is accidentally set to 0. However, it is not difficult to introduce simple logical networks which detect the presence of additional 1's. A three-stage ring counter having this facility is shown in Fig. 8(d). Similarly, it is not difficult to introduce a network which will indicate whether all sections of the shift register contain 0's. A circuit which will provide this facility is shown in Fig. 8(e).

The function required for the detection of additional 1's in the three stage circuit is $f_1 = (A+B)C$, and the function for indicating that all stages of the same circuit contains 0's is $f_0 = \overline{A+B+C}$.

Twisted ring or Johnson counter

As the name implies, the difference between the twisted ring counter and the ordinary ring counter is that the feedback connexions are reversed and in this case the complementary output of the last stage is connected to the J input of the first stage, whilst the inverted form of this signal is fed to the K input. If all the flip-flops are initially preset to the same state, either 0 or 1, then the number of different states of the counter is equal to twice the number of stages in the shift register. Hence a decade counter can be constructed from a five-stage shift register as illustrated in Fig. 9(a). The counting sequence of the circuit, assuming that initially all the flip-flops are cleared to zero is given in Fig. 9(b).

This is a ten-state sequence which could have been selected from the universal state diagram of a five-state shift register. The feedback logic could have been developed by first tabulating the required value of the feedback function in the column headed '*f*' in the table of Fig. 9(b) and then plotting this function in conjunction with the unused states on a Karnaugh map as shown in Fig. 9(c). Simplifying, using the normal techniques, gives $f = J_A = \bar{E}$.

For this circuit, decoding logic is required to obtain a decimal count. This logic is obtained from a five-variable Karnaugh map on which the decimal equivalent for each of the states in the counting cycle has been marked as shown in Fig. 9(d). The unmarked states on this map represent the unused states. The simplifying adjacencies for decimal 0 and 1 have also been marked on the map and if the reader cares to continue the process of simplification he will find that it is always possible to combine seven unused states with each decimal entry.

There are also three other undesired and independent count sequences for this counter. They are:

(1) $S_2—S_5—S_{11}—S_{23}—S_{14}—S_{29}—S_{26}—S_{20}—S_8—S_{17}—S_2$
(2) $S_4—S_9—S_{19}—S_6—S_{13}—S_{27}—S_{22}—S_{12}—S_{25}—S_{18}—S_4$
(3) $S_{10}—S_{21}—S_{10}$

If the counter should enter any one of these sequences, due to circuit misoperation, it will remain in that sequence unless arrangements are made to return the counter to the required sequence. This could be done by using the logic of the unused states to clear all stages of the counter and if required the same logic could be used to raise an alarm and stop the counter. It is left to the reader to show that the Boolean function that represents the unused states is:

$$f_u = \bar{A}D\bar{E} + \bar{A}B\bar{C} + \bar{A}C\bar{D} + A\bar{B}C + A\bar{D}E + AC\bar{D}$$

If it is required to make the counter self-starting it is only necessary to choose three adjacent states on the Karnaugh map, such as S_6, S_{14} and S_{10}, each of these states being from one of the unwanted sequences. If the Boolean function that represents these three states, $f = \bar{A}BD\bar{E} + \bar{A}BC\bar{E}$, is used to clear the five stages of the counter then within a maximum of ten clock pulses it will return to the desired sequence.

The Johnson counter has an even-numbered cycle length of $2n$, where n is the number of stages in the register. However, with a suitable modification of the feedback it is possible to achieve an odd-numbered cycle length of $2n-1$. For example, if the 00000 state is omitted the counting cycle becomes that shown in the table of Fig. 10(a) and the value of the new feedback function required to produce this sequence is tabulated in the column headed f. Plotting this function in conjunction with the unused states on the Karnaugh map of Fig. 10(b) and minimizing leads to the revised feedback function $f = \bar{D} + \bar{E}$. Similarly, if the 11111 state is omitted rather than the 00000 state the revised feedback function can be shown to be $f = \bar{D}\bar{E}$.

Shift registers with exclusive-OR fedback

The four-stage shift register shown in Fig. 11(a) has exclusive-OR feedback from stages C and D such that the input to the first stage $J_A = C \oplus D$. To determine the sequence of states for the register it is assumed that initially the shift register is in the state D = 0, C = 0, B = 0 and A = 1 in which case $J_A = 0 \oplus 0$, and on receipt of the next clock pulse the register enters the state D = 0, C = 0, B = 1 and A = 0. The complete sequence of states for the register is shown in Fig. 11(b), the value of the feedback function for each state being tabulated in the column headed f.

In all there are fifteen states and this is the maximum number of states a four-state register can have, so this sequence is termed the maximum length sequence. The S_0 = 0000 state is not included in the sequence since this is a 'lock-in' state. If the register enters this state $J_A = 0 \oplus 0 = 0$, so that the register is unable to leave this state when the next and subsequent clock pulses arrive. In general the maximum length sequence for such a circuit is given by the expression $p_{max} = 2^n - 1$, where n is the number of stages in the shift register.

Not all exclusive-OR connexions result in a maximum length sequence. The table in Fig. 12 gives the feedback functions which will give the maximum length sequence for values of n up to and including $n = 10$.

Clearly the circuit shown in Fig. 11(a) can be used as a binary sequence generator, the output sequence being taken directly from the output of one of the flip-flops in the register. In this case the binary sequence appearing at the output of flip-flop D is

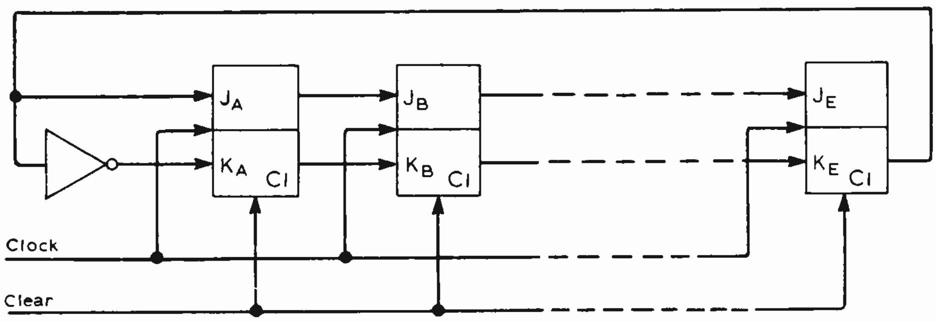


Fig 9(a)

Fig. 9. Twisted-ring decade counter (a) and its counting sequence (b). Maps at (c) indicate the method of determining the feedback function and at (d) the logic to decode the counter states for decimal indication.
Decode logic for outputs 0-9 is $\bar{A}\bar{E}$, $A\bar{B}$, $B\bar{C}$, $C\bar{D}$, $D\bar{E}$, AE, $\bar{A}B$, $\bar{B}C$, $\bar{C}D$, $\bar{D}E$.

Clock pulse	E	D	C	B	A	f
0	0	0	0	0	0	1
1	0	0	0	0	1	1
2	0	0	0	1	1	1
3	0	0	1	1	1	1
4	0	1	1	1	1	1
5	1	1	1	1	1	0
6	1	1	1	1	0	0
7	1	1	1	0	0	0
8	1	1	0	0	0	0
9	1	0	0	0	0	0

Fig 9(b)

ED \ CB	00	01	11	10
00	1	d	d	d
01	d	d	d	d
11		d		
10		d	d	d

$\bar{A}$

ED \ CB	00	01	11	10
00	1	1	1	d
01	d	d	1	d
11	d	d		d
10	d	d	d	d

A

Fig 9(c)

ED \ CB	00	01	11	10
00	0			
01				
11	8		6	7
10	9			

$\bar{A}$

ED \ CB	00	01	11	10
00	1	2	3	
01			4	
11			5	
10				

A

Fig 9(d)

E	D	C	B	A	f
0	0	0	0	1	1
0	0	0	1	1	1
0	0	1	1	1	1
0	1	1	1	1	1
1	1	1	1	1	0
1	1	1	1	0	0
1	1	1	0	0	0
1	1	0	0	0	0
1	0	0	0	0	1

Fig 10(a)

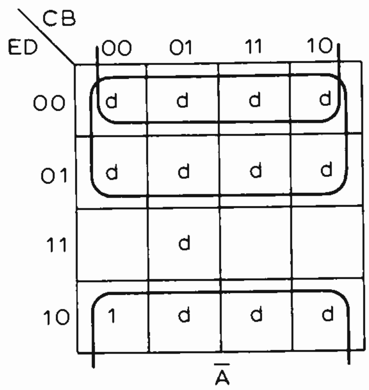


Fig 10(b)

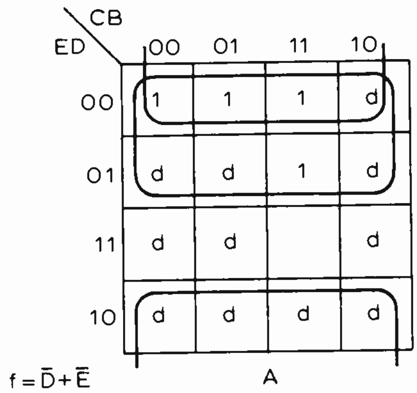


Fig 10(c)

Fig. 10. Counting sequence of an odd-numbered cycle-length ring counter and the determination of its feedback function.

Fig. 11. Maximum-length four-stage register with exclusive-OR feedback ($f = J_A = C \oplus D$).

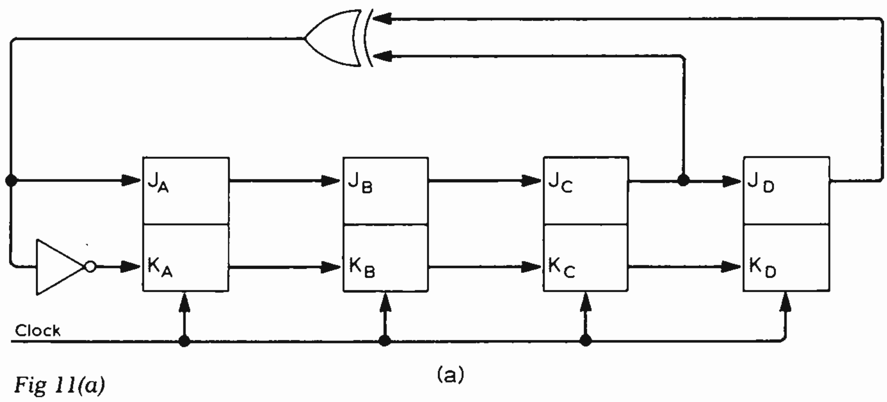


Fig 11(a)

0-0-0-1-0-0-1-1-0-1-0-1-1-1-1.

Non-maximum length sequences can be generated with the register shown in Fig. 11(a) if some other exclusive-OR function is used as the feedback. For example, if the feedback function is B$\oplus$D, one of the following sequences, tabulated in Fig. 13, will be generated. The sequence generated will depend upon the initial state of the register.

Generation of long register sequences

For values of n greater than five it is difficult to develop the de Bruijn diagram and hence the problem of designing a generator having more than thirty-one states using this diagram becomes quite complicated. A possible method of approach is to start with a maximum-length sequence generator using exclusive-OR feedback and then, if it is required, reduce the length of the sequence with additional feedback. The method will be described for a four-stage shift register, but it can also be used for shift registers having a number of stages in excess of four.

It will be assumed that a maximum length sequence generator having four stages is in the state D=0, C=0, B=1 and A=1.

Hence:

$$S = A \times 2^0 + B \times 2^1 + C \times 2^2 + D \times 2^3$$
$$= 1 \times 2^0 + 1 \times 2^1 + 0 \times 2^2 + 0 \times 2^3$$
$$= 3 = S_3$$

If when the generator is in this state, the feedback is a 0 then the next state of the generator is D=0, C=1, B=1 and A=0.

Then:

$$S = 0 \times 2^0 + 1 \times 2^1 + 1 \times 2^2 + 0 \times 2^3$$
$$= 6 = S_6$$

Alternatively, if the feedback had been 1 then the next stage of the generator would have been D=0, C=1, B=1 and A=1.

Hence:

$$S = 1 \times 2^0 + 1 \times 2^1 + 1 \times 2^2 + 0 \times 2^3$$
$$= 7 = S_7$$

Examination of the table for a four-stage maximum length sequence generator, given in Fig. 11(b), shows that the feedback $D \oplus C = 0$ when in the state S_3 and the next state is therefore S_6. However, if the feedback is modified so that it is 1 then the next state is S_7.

The state diagram for the maximum length sequence generator having four stages is shown in Fig. 14(a) and it can be seen that by modifying the feedback the states S_6, S_{13}, S_{10}, S_5 and S_{11} will be omitted from the sequence thus reducing its length from fifteen to ten states.

The modified sequence for the generator is shown in Fig. 14(b) and the modified value of the feedback function for state S_3 is encircled. The feedback function in conjunction with the unused states S_6, S_{13}, S_{10}, S_5 and S_{11} and the 'lock-in' state S_0 are plotted on the Karnaugh map and simplified in the normal way as shown Fig. 14(c). This gives a modified feedback function of:

$$f_m = C \oplus D + AB\bar{D} + \bar{A}\bar{B}\bar{D}$$

The complexities of designing a generator to produce a long binary sequence without computing aids are obviously formidable. However, a computer programme has been developed for shift registers using exclusive-OR feedback to give the maximum length sequence, which gives the following information:

— the present state of the generator,
— the next state of the generator,
— the jump state,
— the number of states excluded by the jump,
— the length of the modified sequence.

The designer has merely to scan the computer print-out to locate the length of sequence required and all the other

S	D	C	B	A	f
S_1	0	0	0	1	0
S_2	0	0	1	0	0
S_4	0	1	0	0	1
S_9	1	0	0	1	1
S_3	0	0	1	1	0
S_6	0	1	1	0	1
S_{13}	1	1	0	1	0
S_{10}	1	0	1	0	1
S_5	0	1	0	1	1
S_{11}	1	0	1	1	1
S_7	0	1	1	1	1
S_{15}	1	1	1	1	0
S_{14}	1	1	1	0	0
S_{12}	1	1	0	0	0
S_8	1	0	0	0	1

Fig 11(b) (b)

n	f	n	f
1	A	6	E⊕F
2	A⊕B	7	F⊕G
3	B⊕C	8	D⊕E⊕F⊕H
4	C⊕D	9	E⊕I
5	C⊕E	10	H⊕L

Fig 12

Fig. 12. Feedback function for maximum length sequences.

Fig. 13. A different feedback function (f = B ⊕ D) results in non-maximum-length sequence.

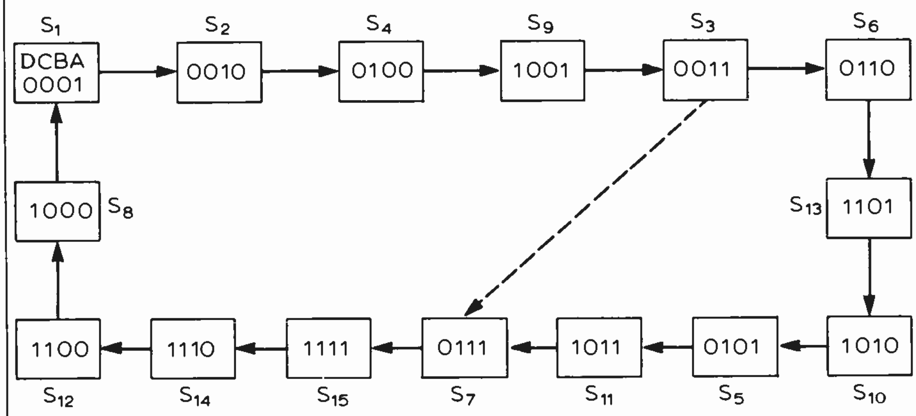
Fig. 14. State diagram of a 4-stage register with modified feedback, showing the jump.

S	D	C	B	A	f
S_1	0	0	0	1	0
S_2	0	0	1	0	1
S_5	0	1	0	1	0
S_{10}	1	0	1	0	0
S_4	0	1	0	0	0
S_8	1	0	0	0	1

S	D	C	B	A	f
S_3	0	0	1	1	1
S_7	0	1	1	1	1
S_{15}	1	1	1	1	0
S_{14}	1	1	1	0	0
S_{12}	1	1	0	0	1
S_9	1	0	0	1	1

S	D	C	B	A	f
S_6	0	1	1	0	1
S_{13}	1	1	0	1	1
S_{11}	1	0	1	1	0

Fig 13



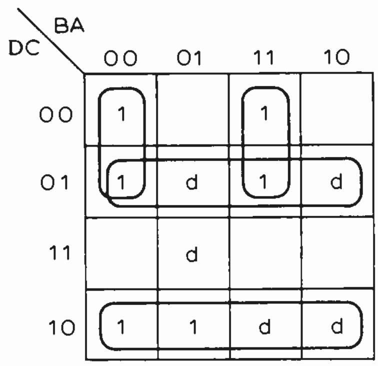
(a)

Fig 14(a)

S	D	C	B	A	f
S_1	0	0	0	1	0
S_2	0	0	1	0	0
S_4	0	1	0	0	1
S_9	1	0	0	1	1
S_3	0	0	1	1	1
S_7	0	1	1	1	1
S_{15}	1	1	1	1	0
S_{14}	1	1	1	0	0
S_{12}	1	1	0	0	0
S_8	1	0	0	0	1

(b)

Fig 14(b)



(c)

Fig 14(c)

information is immediately available. Finally it is necessary to develop the combinational logic which will provide the modification to the exclusive-OR feedback logic required to produce the desired jump.

Further reading

For further information on this subject the reader is referred to the following texts:

Digital Engineering. G. K. Kostopolous. Wiley 1975.
Shift Register Sequences. S. W. Golomb. Holden-Day 1967.
Digital Logic and Switching Circuits. J. C. Boyce. Prentice-Hall 1975.
Electronic Counters. R. M. M. Oberman. Macmillan 1973.
Design of Digital Systems. J. B. Peatman. McGraw-Hill 1972.

Literature Received

A catalogue of general electronic chassis hardware from Verospeed, the distributor company of the Vero group, is now available. New this time are metal-glaze resistors, trimmer pots, indicators and switches. Verospeed, 10 Barton Park Industrial Estate, Eastleigh, Hants. WW401

The Medilog electro-cardiogram analysis system is described in a 6-page brochure. The system provides hard copy of irregularities and variations from recorded data. Brochures can be obtained from Oxford Electronic Instruments Ltd, Ashville Industrial Park, Nuffield Way, Abingdon, Oxon OX14 1BZ WW402

A catalogue giving full electrical and mechanical details of the Roband range of power supplies and regulators for both bench use and for use in equipment is obtainable from Roband Electronics Ltd, Charlwood, Horley, Surrey RH6 0BU WW403

A booklet describing the use of Marconi instruments to measure automatically the quality of television systems by means of insertion test signals is produced by M.I. The booklet describes the use of TF2914A analyzer and monitor TF2915, which will provide limits comparison, auto scanning and control. For remote operation, data selector TK2917 is used and is also described. Marconi Instruments Ltd., Longacres, St Albans, Herts AL4 0JN WW404

The British Standards Institution has just published BS5373, which is concerned with the electrical safety aspect of room aerials for radio and television. It can be obtained from BSI Sales Department, 101 Pentonville Road, London N1 9ND at £1.20.

Projex Distribution hold ranges of components by Bulgin, ITT (semicondutors), Lorlin (switches and capacitors), Multimech (switches) and Richco printed circuit hardware. A shortform catalogue has been produced and is obtainable from 303 Morland Road, Croydon CR0 6HF WW406

High quality book-shelf speaker

The author has informed us that some dimensions in the parts list were incorrect. These have been amended below.

Front grille mounting frame
4 off 18½ × ½ × ¼in.
4 off 12 × ½ × ¼in.

Front grille
4 off 10⁷⁄₁₆ × ½ × ½in. hardwd square sec.
4 off 17⁷⁄₁₆ × ½ × ½in. hardwd square sec.
4 off 10⁷⁄₁₆ × ½ × ½in. triangular section.
4 off 17⁷⁄₁₆ × ½ × ½in. hardwd triang sec.

In Fig 9(c) the vertical dimension shown as 9in should be 9¾in. Dimensions for the two pieces of BAF wadding are 54 × 12in.

We understand that the T15 high frequency unit is no longer in production. Wilmslow Audio, 10 Swan Street, Wilmslow, Cheshire SK9 1HF, have informed us that they still have a quantity of these devices and are able to supply them ex stock.

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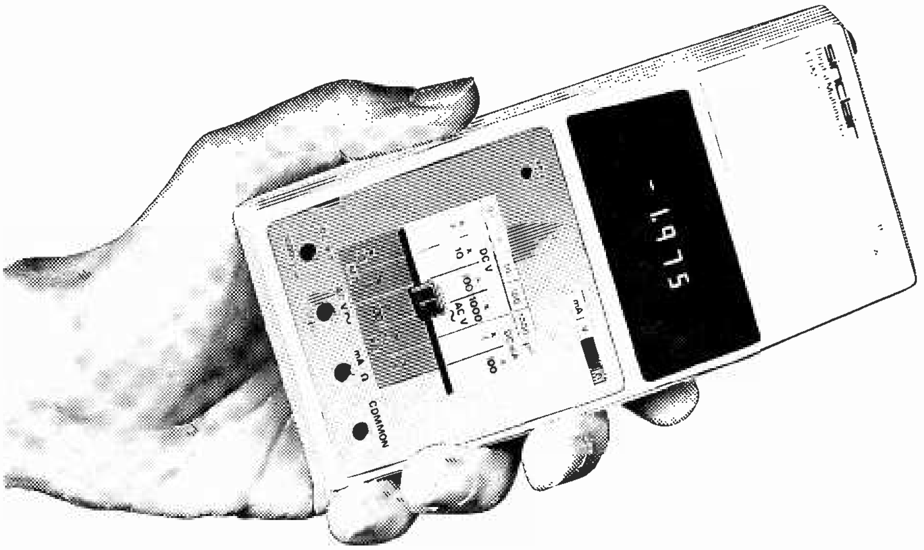

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Range: 1 mV to 1000 V.
Accuracy of reading 1.0% ± 1 count.
Note: 10 MΩ input impedance.
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Accuracy of reading: 1.0% ± 2 counts.
DC Current (6 ranges)
Range: 1 nA to 200 mA.
Accuracy of reading: 1.0% ± 1 count.
Note: Max. resolution 0.1 nA.
Resistance (5 ranges)
Range: 1Ω to 20 MΩ.
Accuracy of reading: 1.5% ± 1 count.
Note: Also provides 5 junction-test ranges.
Dimensions: 6 in x 3 in x 1½ in.
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AC adaptor for 240 V 50 Hz power @ £3.00 (inc VAT) ☐

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(indicate total order value), made payable to Sinclair Radionics Ltd.

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I understand that if I am not completely satisfied with my PDM35 in every way, I may return it within ten days for a full cash refund.

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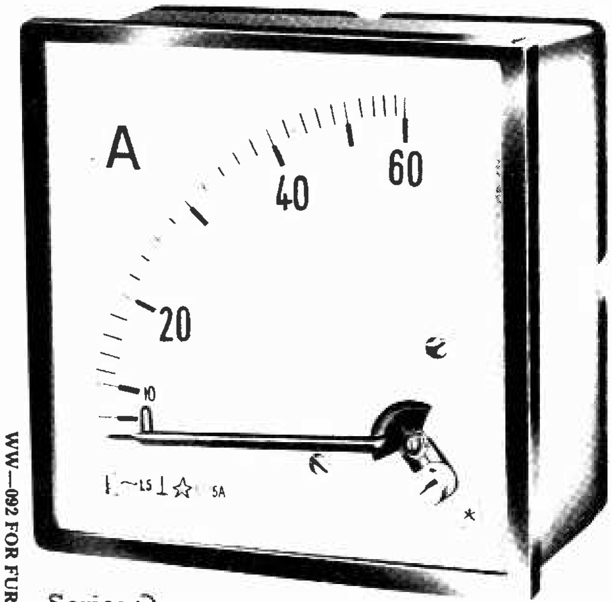
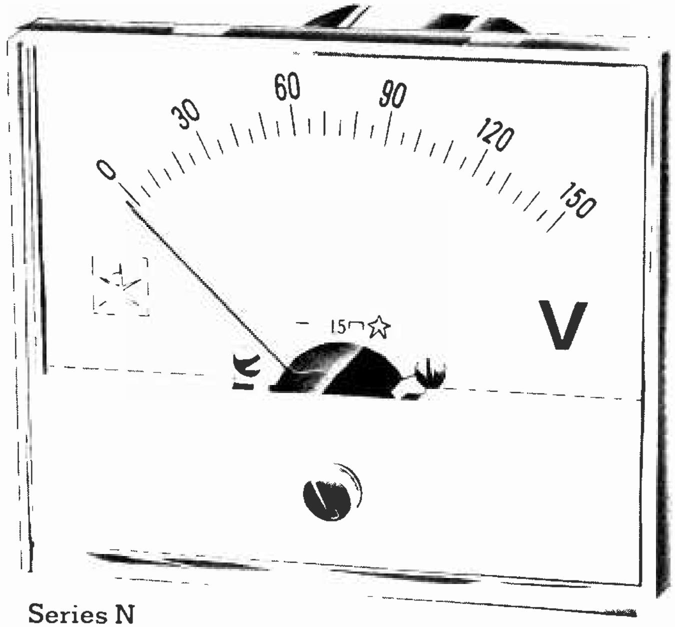


Series Q



Series N

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Series O

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WW—092 FOR FURTHER DETAILS

A check on Fourier

With some sidelights on the controversy about phase shifts

by M. G. Scroggie

One of the things we are all taught is that there is no kind of repetitive waveform which cannot be constructed by adding together pure sine waves. This is known as the Fourier principle. The frequencies of the component sine waves are all whole-number multiples of the basic or fundamental frequency of the waveform concerned (although a sine wave of that frequency is not necessarily present), these multiples being the harmonic frequencies.

This idea is not hard to accept when the wave has a smooth flowing shape. It is easy to see that the result of adding together the fundamental and third harmonic shown separately in Fig. 1 (a) is the rather peaky distortion of a sine wave shown at (b), and that therefore waveform (b) can be truly said to consist of the two sine waves (a). The degree of peakiness in (b) is obviously determined by the amplitude of the harmonic relative to that of the fundamental.

Note that even if the harmonic has the same relative amplitude, but a different phase relationship to the fundamental (c), the resulting waveform is quite different (d). This example shows the opposite kind of distortion – flattening of the peaks, such as could be caused by an amplifier with an input/output (or transfer) characteristic like Fig. 2 (a), compared with the perfect linear characteristic, (b).

But what about the sort of waveforms in television and radar? Fig. 3 shows a few typical ones. Is it really believable that such shapes can be made up of sine waves and nothing else?

A long time ago, when I was teaching students the elements of radar, I found that it was rare for anyone to question what was taught. In the Forces, at least, it was generally accepted that such awkwardness could only lead to trouble. It was prudent to keep one's head down. The teacher, on the other hand, could arrive at the alternative explanation that only the exceptional trainee had sufficient intelligence to ask a perceptive question. A more than usually perceptive one led ultimately to an article in the December 1945 issue of *Wireless World*. Current discussion on the subject of phase, sparked off by the controversy on "linear phase" loudspeakers, suggested to me that certain diagrams in that article might be worth repeating for present readers, many of whom would not even have been born in 1945.

The question, quite awkward when first put without notice, but welcome as evidence that intelligently inquiring minds had not become extinct, was something like this: "Sir; you know you

Fig 1

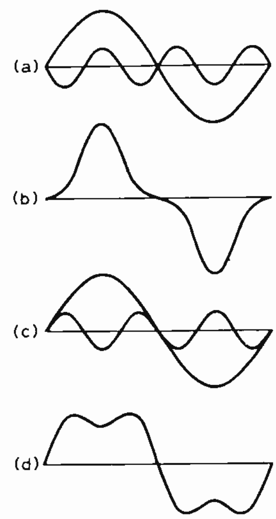


Fig. 1 (a) shows a fundamental sine wave and third harmonic, and in (b) they are added together. (c) is the same as (a) except that the harmonic has been phase-shifted, and (d) shows how this changes the combined waveform.

Fig 2

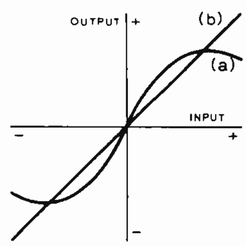


Fig. 2 (a) is the sort of transfer characteristic that would distort a sine wave as in Fig. 1 (d), compared with the linear characteristic (b).

Fig 3

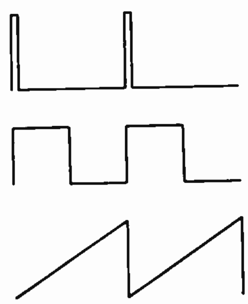


Fig. 3 Typical sharp-cornered waveforms as used in television, etc. Can these too be made from sinewaves only?

Fig 4

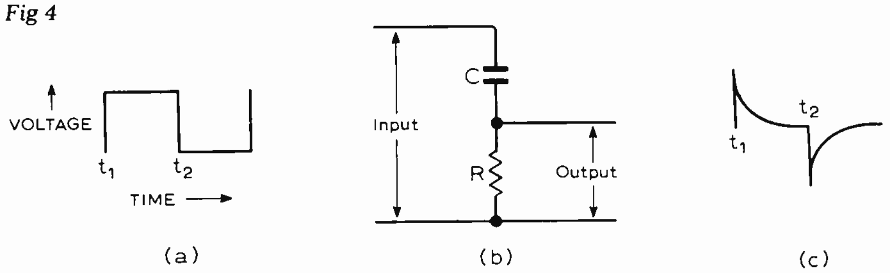


Fig. 4 When square waves, of which a sample is shown at (a), are applied to the input of a CR circuit (b) having a shortish time constant, the output is a peaked wave (c). This conclusion is arrived at by an unusual route in the diagrams that follow.

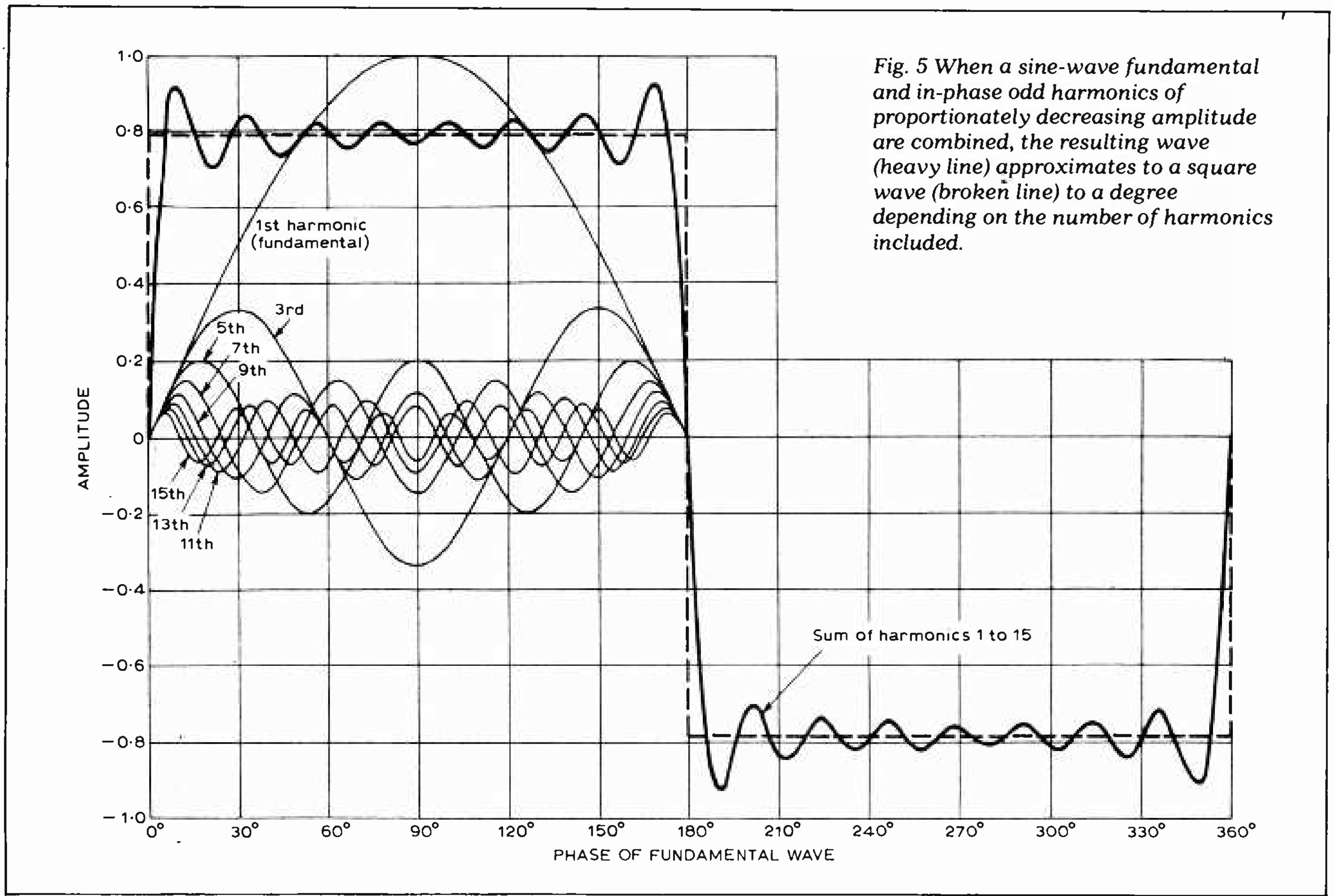


Fig. 5 When a sine-wave fundamental and in-phase odd harmonics of proportionately decreasing amplitude are combined, the resulting wave (heavy line) approximates to a square wave (broken line) to a degree depending on the number of harmonics included.

told us that all waveforms can be made up of sine waves? Well, how does that fit in with the way square waves are used to make pulses by passing them through short-time-constant circuits?" The technique to which he was referring can be seen in Fig. 4. The usual explanation of the process says nothing about the sine waves of which (a) is alleged to be composed. If these sine waves are followed separately through (b) will the results add up to the same as (c)?

The normal classroom treatment might say that at time t_1 in the cycle of the perfect square wave (Fig. 4 (a)) the circuit (b) instantaneously receives a certain positive voltage. It is impossible for a capacitor to acquire a new voltage instantaneously through a resistor, as it needs time to charge; and therefore the whole of the applied voltage momentarily appears across R, as shown at (c), causing a current to start flowing through R into C, charging it in the well-known exponential manner. The smaller *R* is, the greater the current; and the smaller C is, the quicker a given current will charge it; therefore if $C \times R$ is small the voltage across C will rise rapidly. Because the applied voltage is constant, that part of it which is across R will correspondingly die away, as shown by the exponential curve in (c) between t_1 and t_2. Such a circuit in which *CR* is small is described as having a short time constant; the time constant being the time during which the capacitor charges to 63% of the constant applied voltage. It is numerically equal to *CR*. At t_2 the process is repeated in the negative direction. And so on for successive cycles.

Now for the synthetic method. The sine waves needed for constructing certain definite waveforms, such as those in Fig. 3, can be defined by a simple formula or prescription for each shape. The set of harmonics so defined is called a Fourier series. For a perfect square wave it consists of the fundamental and odd-numbered harmonics only – *all* of them; to infinity – the amplitude of each harmonic being inversely proportional to the number of the harmonic. Each starts off from scratch, with no phase delay. It is this mass start of an infinite number of sine waves that adds up to make the infinitely steep front of the square wave.

Expressed mathematically, and assuming for simplicity that the peak amplitude of the fundamental sine wave is 1, the series is therefore

$$\sin \omega t + \frac{\sin 3\omega t}{3} + \frac{\sin 5\omega t}{5} + \frac{\sin 7\omega t}{7} + \ldots \text{ to infinity}$$

where ω is 2π times the frequency of the square wave and *t* is time. As tables of sines are in terms of angles, it is more convenient to express the series as

$$\sin \theta + \frac{\sin 3\theta}{3} + \text{ etc.}$$

each whole cycle of the square wave, or fundamental, being divided into 2π radians or 360 degrees. Fig. 5 shows the series plotted up to and including the 15th harmonic, for half a cycle. Adding up the ordinates at frequent intervals along the half-cycle gives the waveform drawn in heavy line. It is obvious from the way the harmonics come into phase again at the end of the half-cycle that if they were continued for the second half-cycle they would make the same pattern, but inverted; and so the complete waveform has been repeated upside-down to complete the cycle. You will see that it fits fairly closely around a square wave drawn in heavy broken line with amplitude $\pi/4$ (nearly 0.8) times that of the fundamental sine wave. The frequency of the superimposed ripple is the same as that of the highest harmonic included. You can either take my word for it that the difference between the ripply waveform and the perfect square wave is due solely to the limited number of component sine waves I had the patience to draw and add up (and that was quite a lot of patience), or else keep on drawing more of them yourself until belief sets in.

Incidentally, the diagram shows the amount of distortion that would be suffered by a perfect square wave in passing through a low-pass system having a sharp cut-off just above 15 times the frequency of the square wave.

Since each harmonic in the series is reduced in scale from the fundamental by the same factor in both horizontal and vertical dimensions, it has the same

Fig 6

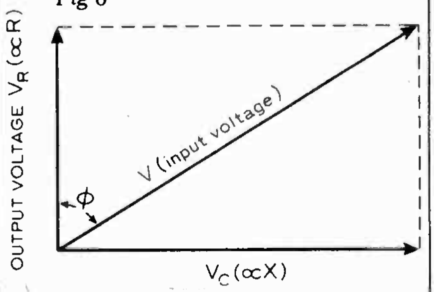


Fig 8

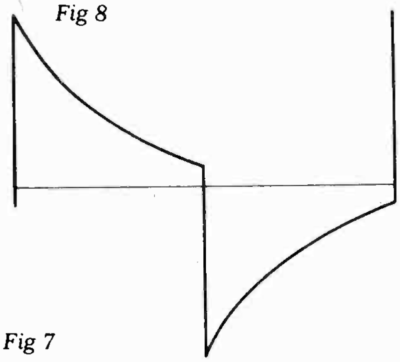


Fig. 6 Familiar graphical method for determining relative amplitudes and phase angles of output and input sine waves.

Fig. 8 A CR circuit that attenuates the fundamental of a square wave by only 1dB is accompanied by a phase shift that distorts the square wave as shown here.

Fig. 7 (below) Recombining the separate harmonics at the output gives a waveform (heavy line) approximating to that (broken line) obtained by the usual method (or by including all the harmonics to infinity).

slope as the fundamental and the other harmonics at all corresponding parts of their cycles. The 1,000,001th harmonic starts off just as steeply as the fundamental, and as all start together the slope of the combined wave is infinitely great. It is only at half-cycle intervals that all the harmonics come into phase to form the vertical parts of the square wave; everywhere else the increasing values of some harmonics are offset by decreasing values of others, and the total remains constant to form the flats of the square wave.

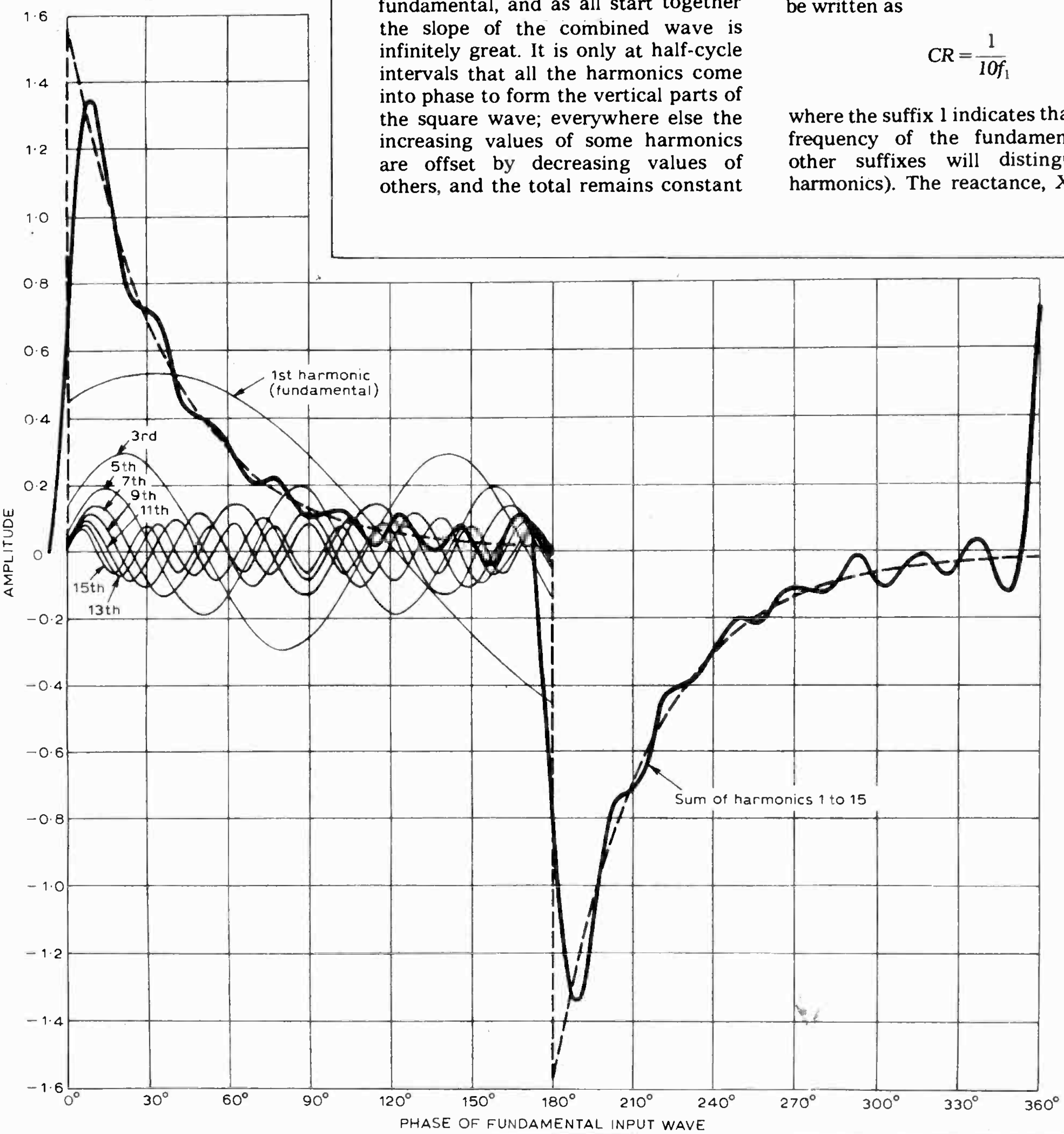
Having pondered this sufficiently for the manufacture of sharp corners using only smoothly curved ingredients to look less like a confidence trick, one can turn to consider the simple device through which it is proposed to pass the mixture: the short-time-constant circuit, Fig. 4 (b). Again there is absolutely no deception; only well-understood basic principles of simple sine-wave a.c. are to be used.

There are several methods for finding the amplitude and phase of the voltage at the output of this circuit, relative to the input. In all of them it is necessary to know the ratio of the capacitor's reactance, X, to the resistance, R; and this is derived from the time constant. For the sake of a nicely proportioned diagram and simple numbers I have chosen a time constant equal to one tenth of a cycle of the fundamental. As the duration of a cycle is the reciprocal of the frequency, this relationship can be written as

$$CR = \frac{1}{10f_1}$$

where the suffix 1 indicates that f_1 is the frequency of the fundamental (and other suffixes will distinguish the harmonics). The reactance, X_1, of the

Fig 7



capacitor at the fundamental frequency is

$$X_1 = \frac{1}{2\pi f_1 C}$$

which, from the foregoing,

$$= \frac{10R}{2\pi} = 1.6R \text{ (very nearly)}$$

Similarly

$$X_3 = \frac{1.6R}{3}, \quad X_5 = \frac{1.6R}{5},$$

and so on.

A graphical method for deriving the output phase and amplitude for each harmonic is shown in Fig. 6. The lengths of V and V_R respectively represent to the same scale the input and output voltages, and ϕ is the angle by which the phase of the output is advanced by the circuit. For the fundamental, V_C is drawn 1.6 times as long as V_R (that is to say, in proportion to X_1 and R respectively) and at right angles to it; and, if the drawing is accurate, the amplitude ratio, V_{R1}/V_1, is found to be 0.53, and ϕ is 58°. For the third harmonic, V_C is drawn one-third as long, so ϕ_3 is much less and V_{R3} (third harmonic voltage across R) is more nearly equal to V_3. But it is really V_{R3}/V_1 (ratio of third-harmonic output to *fundamental*) that we want for plotting, and of course this is one-third as much. Similarly the phase shift in terms of the fundamental cycle is one-third of ϕ_3.

The graphical method necessitates an accurate large-scale drawing, and as ϕ_n is the angle whose tangent is X_n/R_1, and V_{Rn}/V_1 is $\cos\phi_n/n$ it is easier to get them from tan and cos tables. Here are the results tabulated up to the 15th harmonic:

n	X_n/R	ϕ_n	ϕ_n/n	$\cos\phi_n$	$\cos\phi_n/n$
1	1.600	58°	58°	0.53	0.53
3	0.5333	28	9.33	0.88	0.29
5	0.3200	17.6	3.52	0.95	0.19
7	0.2285	12.9	1.84	0.975	0.14
9	0.1777	10.1	1.12	0.985	0.11
11	0.1455	8.3	0.75	0.989	0.09
13	0.1230	7.0	0.54	0.99	0.076
15	0.1067	6.0	0.40	0.995	0.066

Columns 4 and 6 give the data by which each harmonic that emerges from the "peaker" was plotted in Fig. 7. Reassembling these mangled bits by adding ordinates again, we get the heavy-line curve. Comparing this with the heavy broken line, which is the exponential curve obtained by the "classroom" method, one must admit that the resemblance is too close to be dismissed as (in the film sense) "purely coincidental". In the geometrical sense it would actually coincide if all the (infinite number of) harmonics were included.

Some of us, oppressed by experience of our own fallibility, are never very confident about the correctness of our calculations, be they financial or scientific, unless the same result is arrived at by at least two entirely different routes. So the recognizably similar results achieved by such diverse approaches as the exponential charging of a capacitor, and Fourier analysis and synthesis combined with plain a.c. theory, should enhance confidence in both these methods.

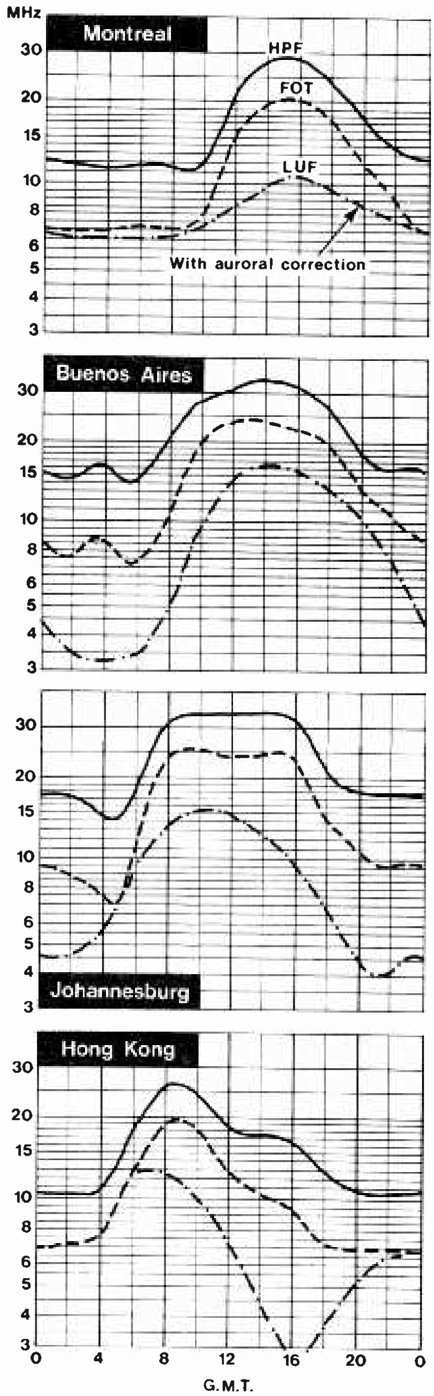
Some may consider all this to be merely academic, or even antiquarian. But now that the audio world is a battlefield between the forces of the establishment who contend that phase distortion, however drastic to the eye (compare (b) and (d) in Fig. 1), is imperceptible to the ear, and the revolutionaries who challenge this easy option for audio designers and claim that "linear phase" loudspeakers make all the difference to the discriminating listener, any sidelights on phase may be helpful. I don't intend to be caught in the crossfire, nor of course do I suggest that the gross distortion in Fig. 7 has any close connection with hi-fi, but one or two facts emerge in passing.

Phase shifts are inevitable in the audio chain, and, as James Moir has emphasized more than once, phase distortion can only be avoided if they are confined overall to equal *time* shifts at all frequencies. This condition is fulfilled in the direct sound path between loudspeakers and ears (but not necessarily in indirect paths) and in general it tends not to be fulfilled by electrical and mechanical circuits. This is exemplified in the fourth column of the table. True, this is an exaggerated case. But it also illustrates another fact, that even when what used to be called frequency distortion is kept within acceptable limits the accompanying phase distortion is much larger – numerically, that is to say; I refrain from assessing its impact, if any, on the listener!

For example, a CR circuit that reduces amplitude at a certain frequency by only 1dB causes a phase shift of 27°; enough to distort the waveform visually more than might be expected. Working on the same lines as with Fig. 7, but making $R = 2X$ (which gives 1dB loss of fundamental), we find that what the circuit does to a square wave input turns out as Fig. 8. And this assumes perfect representation of all frequencies above the fundamental. In practice there is bound to be a fall-off from some higher frequency upwards (as in Fig. 7, heavy line) with inevitable further distortion. And Fig. 8 is based on the assumption that the 1dB fundamental loss is due to one CR circuit; in practice it is likely to be split up among several of them in the audio system. With only two CR circuits, each causing 0.5dB loss, the total phase shift is more than 38°, which would make Fig. 8 look even less like a square wave. And so on for more CR circuits. There are countermeasures, of course; but it makes one think, perhaps.

HF predictions

Circuit reliability is the product of the probability of ionospheric reflection and the probability of achieving a desired signal to noise ratio and is thus at a maximum somewhere between FOT and LUF. The term FOT, which is the French equivalent of OWF (optimum working frequency), is thus a misnomer since it relates only to skywave probability. However since LUF is dependent on many factors which cannot be generalised it is found satisfactory in practice to take FOT as being what it says it is.



World of Amateur Radio

Russian amateur-radio satellites

The long-rumoured Russian intention of setting up an amateur satellite system ("RS") has now been confirmed with the registration by the USSR of details with the ITU. RS will be based on three or four satellites carrying active transponders (up-link 145.8-145.9MHz, down-link 29.3-29.4MHz) with "maximum" communication distances of 6000km. The intended orbit has an inclination of 82° and will be circular at about 950km height with a period of 102 minutes. 144MHz transmissions should be possible with powers of about 10-15 watts to aerials of 10-12dB gain. The system is due in 1977-78 and the first launch could be as early as October.

The next Amsat-Oscar launch may be February 23, 1978. The ARRL has recently introduced a "DXCC" award for Oscar operation. Pat Gowen, G3IOR, with over 90 countries worked through Oscar, appears nearest to qualifying.

"A. J. Alan", G2ST

Pre-war radio listeners will remember "A. J. Alan" as arguably the most polished radio storyteller of all time, who combined the writer's craft of a "Saki" (H. R. Munro) with an entirely original grasp of broadcasting techniques.

When he died, in December 1941, his true identity — Leslie Harrison Lambert — was at last revealed and he was said to have been a senior civil servant. He was also known as the holder, since the early 1920s, of the amateur call-sign G2ST.

In a recent radio tribute to A. J. Alan, Tony Bilbow, aided by the researches of Norman Duret of Bristol, filled in a number of missing details — for instance his early career as a professional entertainer — but curiously failed to follow up the clues that suggest Lambert's real occupation throughout the inter-war years.

The programme noted that in 1915 Lambert was at the Admiralty's secret radio interception station at Hunstanton. This was one of the network of receiving stations set up by Commander R. Bayntun Hippersley (HLX, later G2CW), a prominent Somerset landowner, after he and E. Russell Clarke (THX), a barrister, had proved to the Admiralty that experimental amateurs were able to receive, in the UK, German navy traffic at ranges much greater than had been supposed. This in turn led directly to the setting up of the Room 40 code-breaking unit at the Old Admiralty Building in Whitehall, with its many triumphs under Sir Reginald Hall, and working jointly with the early d.f. stations built by H. J. Round of Marconi's.

It would seem Lambert stayed with this organisation as a signals expert when in 1919 it was renamed as a "Code and Cypher School" and again later in 1926 when it came under MI6 and moved to that organisation's headquarters near St James's Park. Yet Tony Bilbow, misled by the "cover name", described this as "Certainly no longer secret work"! In 1939, as GCCS, the codebreakers moved to Bletchley Park and became what has been called "possibly the most crucial factor in enabling the Allies to defeat Germany" as a result of cracking the Enigma and other German codes. The cryptographers included Alastair Denniston, Alfred Dilwyn Knox and the still largely unrecognised genius of the tragic Alan Turing, whose dream of a "universal machine" led directly to the first electronic computers, such as "Colossus" built by T. H. Flowers of Post Office Research and used for codebreaking from about 1943.

"A. J. Alan" may thus, throughout the time he was a highly popular radio "star", have been not only G2ST, but also — without the BBC knowing it — a key figure in the most successful department of the British secret intelligence service!

In the air

The GB3LER beacon station on Lerwick, The Shetlands, has been re-activated after an interval of many years; it transmits on 145.965MHz with a power of 10 watts to two aerials, beaming south and north-east. The new 10GHz beacon on Alderney, Channel Islands (Gunn oscillator with 15dB horn aerial) has been heard by amateurs along the south and south-east coast of England at distances up to 170km. 144.2MHz c.w. signals from TU2EF (Ivory Coast, West Africa) were heard in Sao Paulo, Brazil by PY2OB during June, possibly the first Atlantic crossing for two-metre signals.

From January 14 to 22, 1978, a special event station, KM1CC, will mark the 75th anniversary of the first two-way radio transmission by Marconi between the USA and England. KMICC will operate on all h.f. bands from the original site of station "CC" (later MCC and WCC) in the Cape Cod National Sheashore Park in South Wellfleet, Mass, although part of the site is now submerged in the Atlantic Ocean due to soil erosion. It will be permitted to use A2 c.w. to reproduce the sound of the old 240Hz rotary spark gap. The Cornish Radio Club will similarly operate a special station at Poldhu, Cornwall. A message from President Carter will be transmitted from KM1CC.

Mercury, the journal of the Royal Signals Amateur Radio Society, has published what may be the first account of the use of a 725Hz transversal filter (based on 741 op-amp all-pass filters) to provide coherent addition of amateur c.w. signals, while filtering out non-coherent static and electrical interference without the "ringing" of conventional sharp filters. One model, described by F. J. H. Charman, G6CJ, uses four all-pass-filter sections, with each section introducing 180° phase shift with outputs added in a different amplifier and with a bandpass filter to reduce side lobes.

Reg Patrick, G2BBX, acting on the advice of W. B. Whalley of California, author of the paper "Radio-frequency eradication of tumours" (IEE's *Electronics & Power*, May 1977) recently successfully treated one of his geese, using a few watts of 14MHz r.f. power. This improved technique for r.f. diathermy uses electric-field coupling rather than the conventional electromagnetic field coils used over many years for r.f. diathermy.

The sixth National Amateur Radio Exhibition, organised by the Amateur Radio Retailers' Association, is being held at the Granby Halls, Leicester, on October 27, 28 and 29 (10a.m. to 6p.m. daily).

In brief

The RSGB has set up an ad hoc committee to consider the geographical coverage, frequencies, modes, times and contents of the GB2RS weekly news broadcasts . . . The FCC has postponed for the time being the introduction in the United States of a phone-only "communicator licence" for the 220 and 420 MHz bands which would not have required a Morse test . . . The ten-metre beacon station GB3SX has changed frequency to 28.215MHz. . . The IEE's recent "Report on the use of the radio spectrum" comments that "the allocations of frequency spectrum for the use of amateur communicators and experimenters should be preserved in view of their significant contribution to the radio art". The report also notes that "interference from non-conforming broadcast stations has rendered some amateur h.f. allocations almost unusable" . . . . The ARRL is to have a full-time staff lobbyist at Washington, DC.

PAT HAWKER, G3VA

Synthesized f.m. transceiver—1

A simple 40-channel, two-metre design

by T. D. Forrester, G8GIW

This article describes the design and construction of a two-metre (145 to 146MHz) f.m. transceiver. The two main design considerations for the unit were ease of mobile operation and low power consumption for portable operation. To comply with the former criterion, channelized operation was chosen, the appropriate channel being selected by means of thumbweel switches.

Standard and well-proven circuitry is used in the receiver section of the transceiver and it requires little alignment to achieve maximum performance. The selectivity of the receiver is determined by the bandwidth of the 10.7MHz crystal filter. In the prototype a 25kHz filter was used to accommodate some of the wider n.b.f.m. stations, again to minimize i.f. alignment.

The transmitter section uses conventional Class C frequency multipliers and, to obtain maximum efficiency, the driver and p.a. stages are also run in the Class C mode. The transmitter, which is a modified Mullard design, has been used by the author for several years in various applications and should present no difficulties in alignment.

Operation

The operation of any radio equipment while mobile is hazardous, so in an attempt to lessen the danger, all controls are kept simple and easy to operate.

The synthesizer has only two controls; mode and channel selection. The mode switch selects normal transceiver operation, repeater opera-

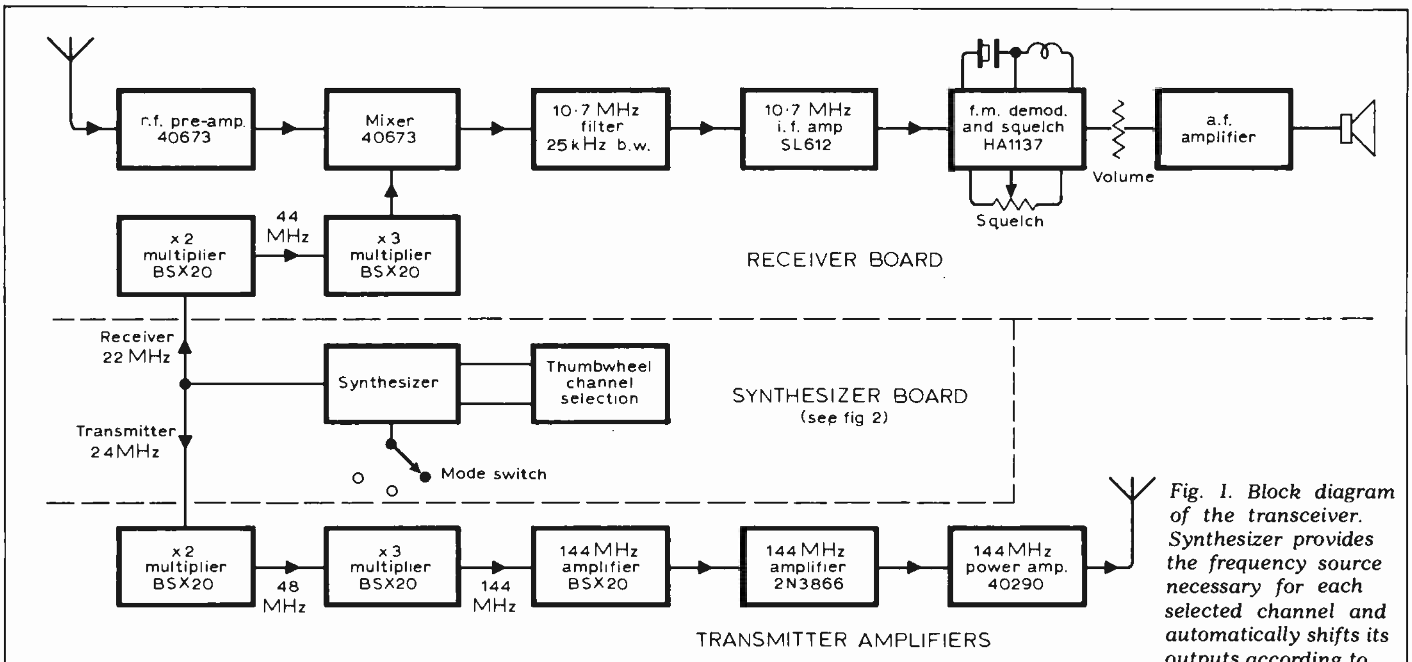


Fig. 1. Block diagram of the transceiver. Synthesizer provides the frequency source necessary for each selected channel and automatically shifts its outputs according to the mode and transmit/receive switching.

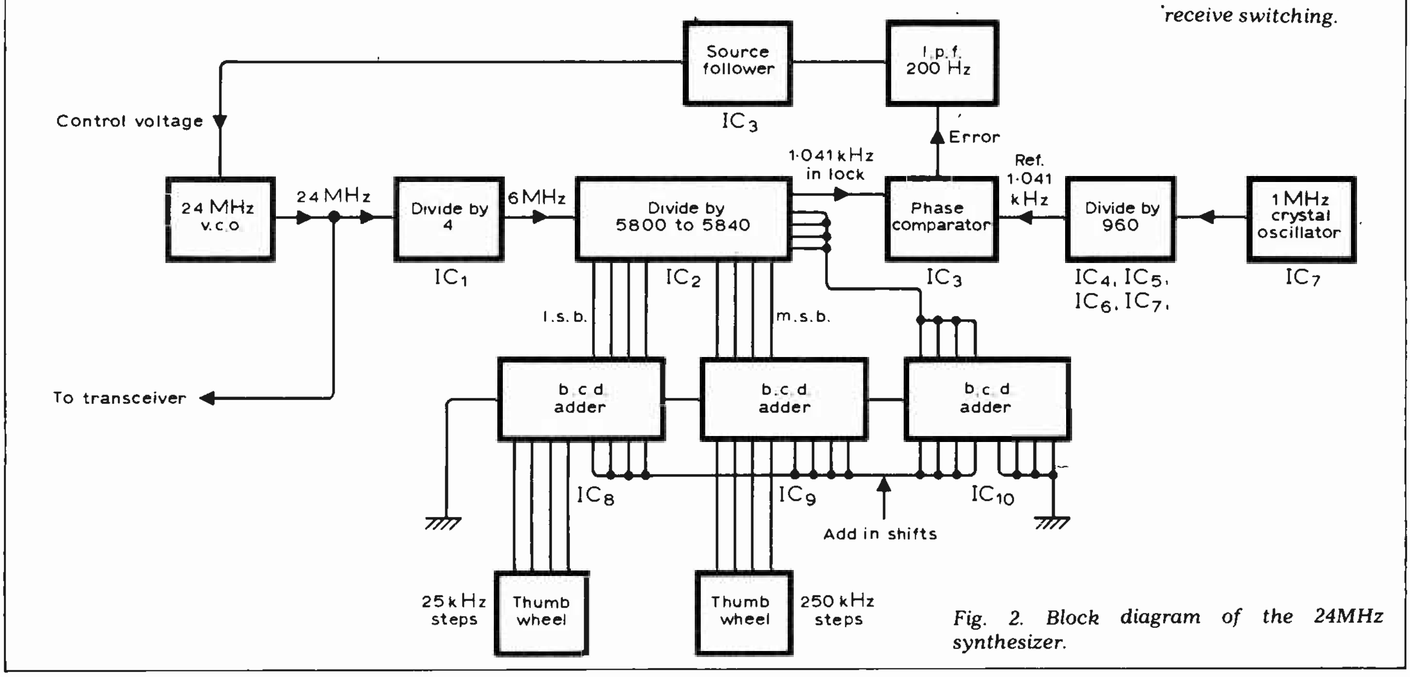


Fig. 2. Block diagram of the 24MHz synthesizer.

tion (where the transmitter operates 600kHz below the selected channel), or inverse repeater operation (where the receiver operates 600kHz below the selected channel).

Two thumbwheel switches are used to select any channel between 00 and 40; channel 00 corresponds to S0 (145MHz), channel 20 corresponds to S20 (145.500MHz), and so on, enabling easy channel identification. See Fig. 2.

The receiver has a volume control and a squelch control. The squelch control serves its normal function of muting the receiver in the absence of a signal. It may be adjusted once for one channel and then left, requiring no further adjustment for any other channel.

The volume control requires little comment, as it serves its usual purpose of controlling the audio output power, in this case up to a maximum of 200mW. This audio level may seem rather low, but it has been found to be sufficient under all but the noisiest of environments.

The transmitter has only a deviation control, which may also be preset so that it requires no adjustment when changing channels or switching on or off.

The synthesizer

To avoid using a costly v.h.f. prescaler, a 24MHz generation system was chosen for the synthesizer. The 25kHz channel spacing in the 145MHz band then becomes 4.1666kHz with respect to 24MHz. Also, by employing a generation frequency of 24MHz on transmit and 22MHz on receive, as in Fig. 1, it enables the synthesizer to be used separately with most commercial transceivers with little or no modification.

The heart of the synthesizer is the integrated circuit (IC_2), which is a programmable five-stage divider type

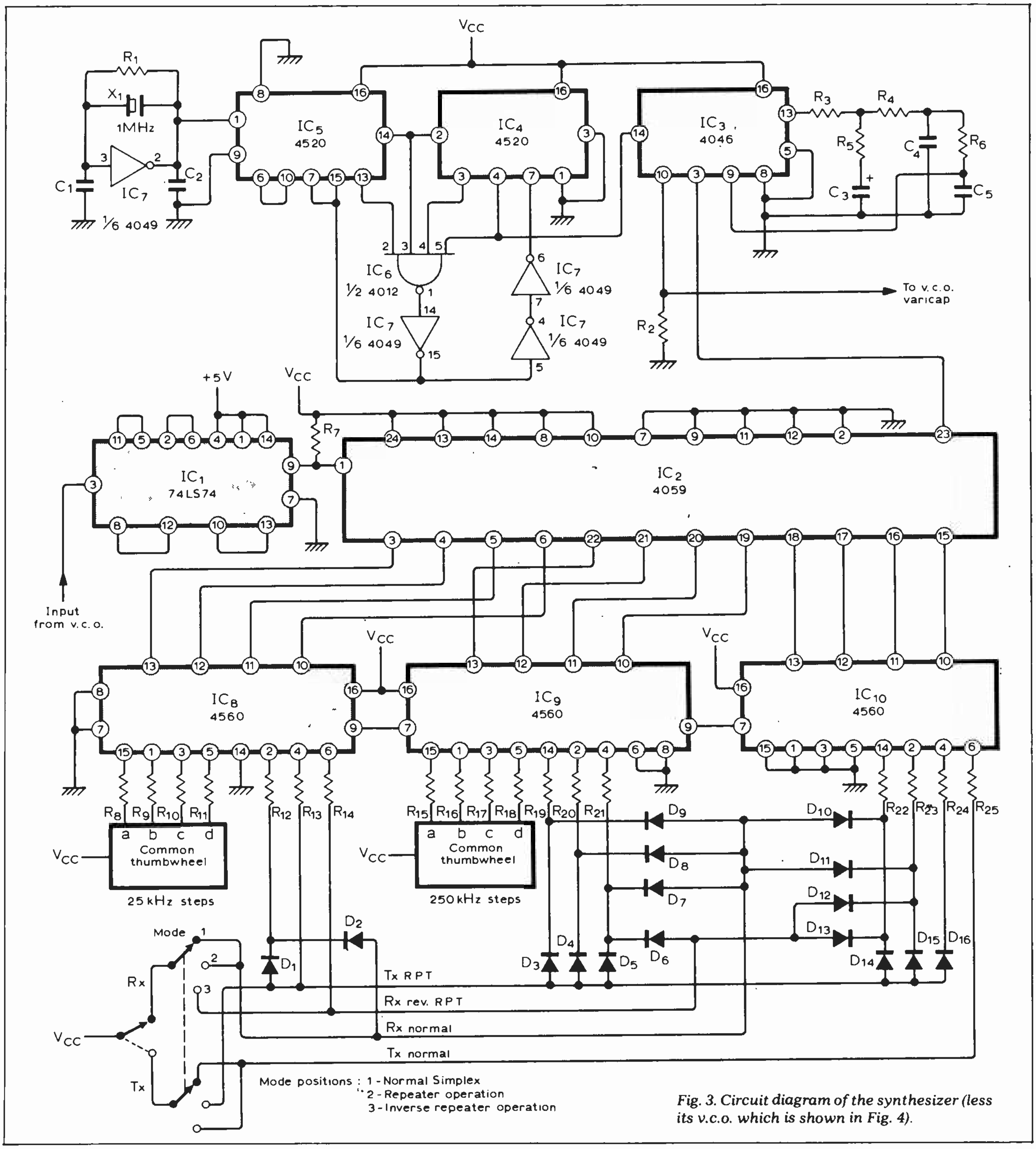


Fig. 3. Circuit diagram of the synthesizer (less its v.c.o. which is shown in Fig. 4).

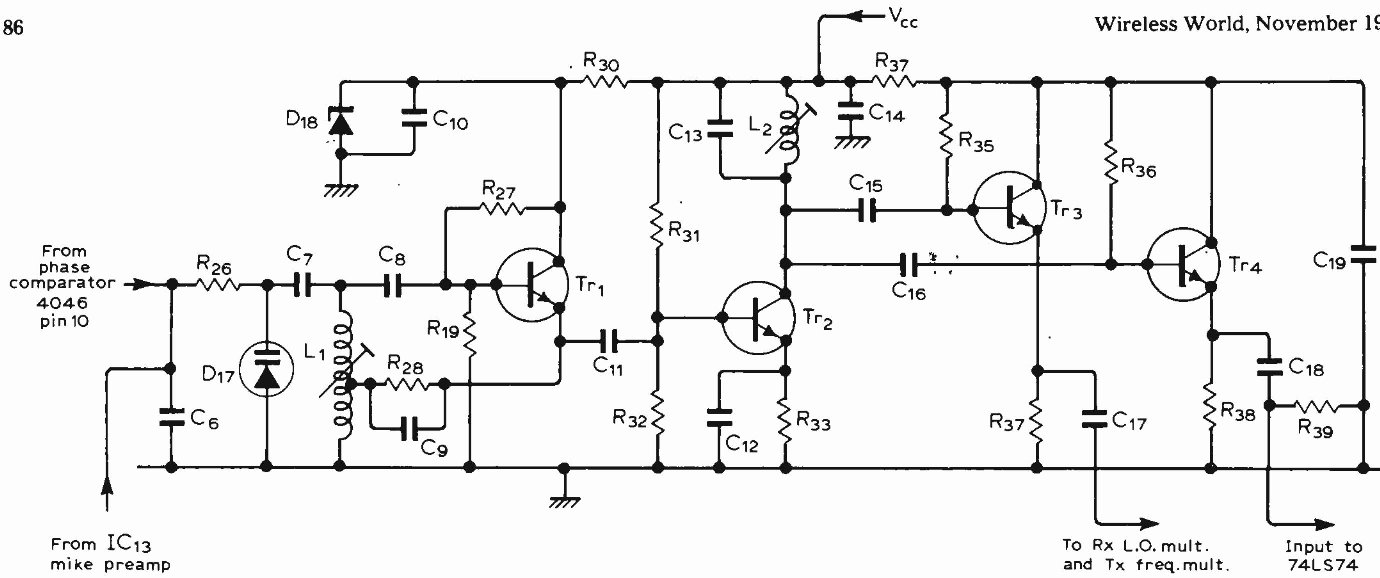


Fig. 4. Circuit diagram of the voltage controlled oscillator which is controlled by the synthesizer phase lock loop.

4059. However, only four of these stages are used. Unfortunately, because the 4059 is a c.m.o.s. device, it has a maximum frequency of 6MHz, so a divide-by-four prescaler is required to accommodate the 24MHz generation frequency. This function is achieved by a 74LS74 dual-D-type flip flop.

This further division of four reduces the channel spacing to 1.041666kHz at 6MHz, and also sets the phase-comparison frequency at 1.041666kHz.

The 1.041666kHz reference frequency is derived by dividing a 1MHz crystal oscillator by 960. This division is accomplished by IC_4, IC_5, IC_6 and IC_7. IC_7 also functions as the 1MHz oscillator, as shown in Fig. 3.

For the synthesizer to generate the appropriate frequencies, for channel 00 operation for example, the divide-by-N divider (IC_2) must divide by 5800 for normal transmit, 5372 for normal receive, 5776 for repeater transmit, and 5348 for inverse repeater receive.

Since the 5 is common to all of the above, this is hardwired on the 4059. The '800, '372, '776 and '348 are added to the selected channel in IC_8, IC_9 and IC_{10}, which are four-bit binary-coded-decimal (b.c.d.) adders.

Consider the normal tranmit case above, where the 4059 must divide by 5800 to generate 145MHz. In the 24MHz region, 145MHz is represented by 24.1666MHz, and for this to be phase locked to 1.041666kHz it must be divided by 23,200. As the 4059 is preceded by a divide-by-four prescaler, it has only to divide by 23,200/4, which is 5800.

If channel 21 (145.525MHz) is selected, this number is added in b.c.d. form to the appropriate shift in the b.c.d. adders. Therefore, on transmit, the 4059 would be programmed to divide by 5821, and so on.

The 4046 (IC_3) serves as the phase comparator and source follower, which then feeds the error signal to the v.c.o., (see Fig. 4). The low pass filter is needed to remove the 1.041666kHz ripple from the phase comparator and is formed by the RC network associated with the 4046. The v.c.o. used conventional transistor circuitry and operates between approximately 22 and 24.5MHz, depending upon which mode and channel is selected.

(to be continued)

Components list

Resistors (all 10% ¼W unless otherwise stated)

1	1M	49	82
2	18k	50	120
3	1k	51	10
4	2.7k	52	3.9k
5	4.7k	53	10k
6	2.2k	54	3.3k
7	2.2k	55	1k
8 to 25	220k	56	33k
26	12k	57	100
27	5.6k	58	1k
28	680	59	47
29	3.9k	60	100
30	220	61	100
31	5.6k	62	390
32	3.9k	63	1
33	330	64	1
34	100	65	18 to 47
35	39k		(see text)
36	39k	66	120k
37	470	67	10
38	470	68	470
39	3.3k	69	1.8k
40	39k	70	3.3k
41	47k	71	180
42	220	72	47
43	100	73	10k
44	10k	74	150
45	3.3k	75	10
46	470	76	100k
47	680	77	1k
48	470	78	27k
		79	220

Crystals

1	1MHz
2	10.7MHz

Coils

1 10 turns 30 s.w.g., tapped 2 turns from earth, 4mm int. dia.
2 15 turns 30 s.w.g., tapped 2 turns from earth, 4mm int. dia.
3 5 turns 20 s.w.g. ¼in int. dia. ½in long
4 As L3
5 As L3
6 470μH choke
7 7 turns 32 s.w.g. 4mm int. dia.
8 As L3
9 As L7
10 As L3
11 4 turns 20 s.w.g. ¼in. int. dia. ⅝in. long
12 As L3
13 3 turns 20 s.w.g. ¼in int. dia. ½in. long
14 As L13

All r.f.cs use three turns of 32 s.w.g. wire, on a FX1115 ferrite bead.

Variable resistors

80	25k linear
81	25k log.
82	100k linear preset

Capacitors (μF unless otherwise stated)

1	56p	30	100n
2	22p	31	2.2n
3	1,35V tant	32	10n
4	220n	33	10n
5	220n	34	100
6	2.2n disc	35	100n
7	68p	36	100n
8	15p	37	1n disc
9	2.2n disc	38	33p
10	2.2n disc	39	1n disc
11	2.2n disc	40	10p
12	2.2n disc	41	1n disc
13	10p	42	1n disc
14	2.2n disc	43	470, 16V
15	15p	44	220, 16V
16	15p	45	1,35V tant
17	2.2n disc	46	1n disc
18	2.2n disc	47	2.2n
19	2.2n disc	48	2.2n
20	1n disc	49	15p
21	1n disc	50 to 58	1n disc
22	1n disc	59	10
23	10n	60	4.7n
24	10n	61	2.2
25	2.2n	62	50
26	56p	63	100n
27	10p	64 to 73	3.3p
28	2.2n		trimmers
29	10n	74	1000p

Transistors

1 to 4	2N3707	11	2N3707
5	40673	12	BSX20
6	40673	13	BSX20
7	2N3707	14	BSX20
8	BFR79	15	2N3866
9	BFR39	16	40290
10	BSX20		

Diodes

1 to 16	1N914	20	7.5V zener
17	BA121	21	OA200
18	8.2V zener	22	6.1V zener
19	1N914		

Integrated circuits

1	74LS74	8	4560
2	4059	9	4560
3	4046	10	4560
4	4520	11	SL612
5	4520	12	HA1137
6	4012	13	SL622
7	4049		

Pc.bs

A full set of p.c.bs will be available from M. R. Sagin. Further details will be given in part 2.

Antennas for mobile communications via satellite

Design considerations for aircraft and ships

by D. I. Spooner B.Sc. *British Aircraft Corporation Limited*

This article is concerned with the design of antennas for use on aircraft and ships for communication to shore stations via satellites. Some of the problems encountered in these applications are discussed, and solutions are described for a range of gain level options.

Although the basic principles relating to a particular antenna design remain the same for both aircraft and ships, much of the design and installation differs considerably.

Antenna polarisation

Antennas can be designed for either linear polarisation (horizontal or vertical) or circular polarisation (left-handed or right-handed). In reality the radiation from an antenna is elliptically polarised, the ratio of the major-to-minor axes giving an indication of the polarisation purity or ellipticity. When an electromagnetic wave passes through the various regions of the ionosphere, its plane of polarisation rotates. This is known as Faraday rotation.

When circularly polarised radiation passes through the ionosphere, the worst-case polarisation degradation that could occur is from circular to linear. When this signal is received on earth by a circularly polarised antenna (of either hand) the signal loss resulting from this worst-case polarisation degradation is 3dB. However, if a linearly polarised antenna is used to receive the radiation, it is possible that the signal arriving at the antenna will be linear but orthogonal to the plane of polarisation of the receiving antenna. In this situation the loss would be enormous and in theory no signal would be received. It is for this reason that extensive use is made of circular polarisation in satellite communications. Where two-way communication is required with an object within or beyond the ionosphere, circular polarisation is used at both ends of the link. However, where one-way communication is required, for example telemetry transmission from a satellite or missile to a ground station, linear polarisation is used on the satellite or missile and circular polarisation at the ground station. In fact, many ground stations have the ability to select any polarisation they require, circular or linear, in order to optimise the communications link. However, this is a luxury not normally available on mobile stations such as aircraft or ships.

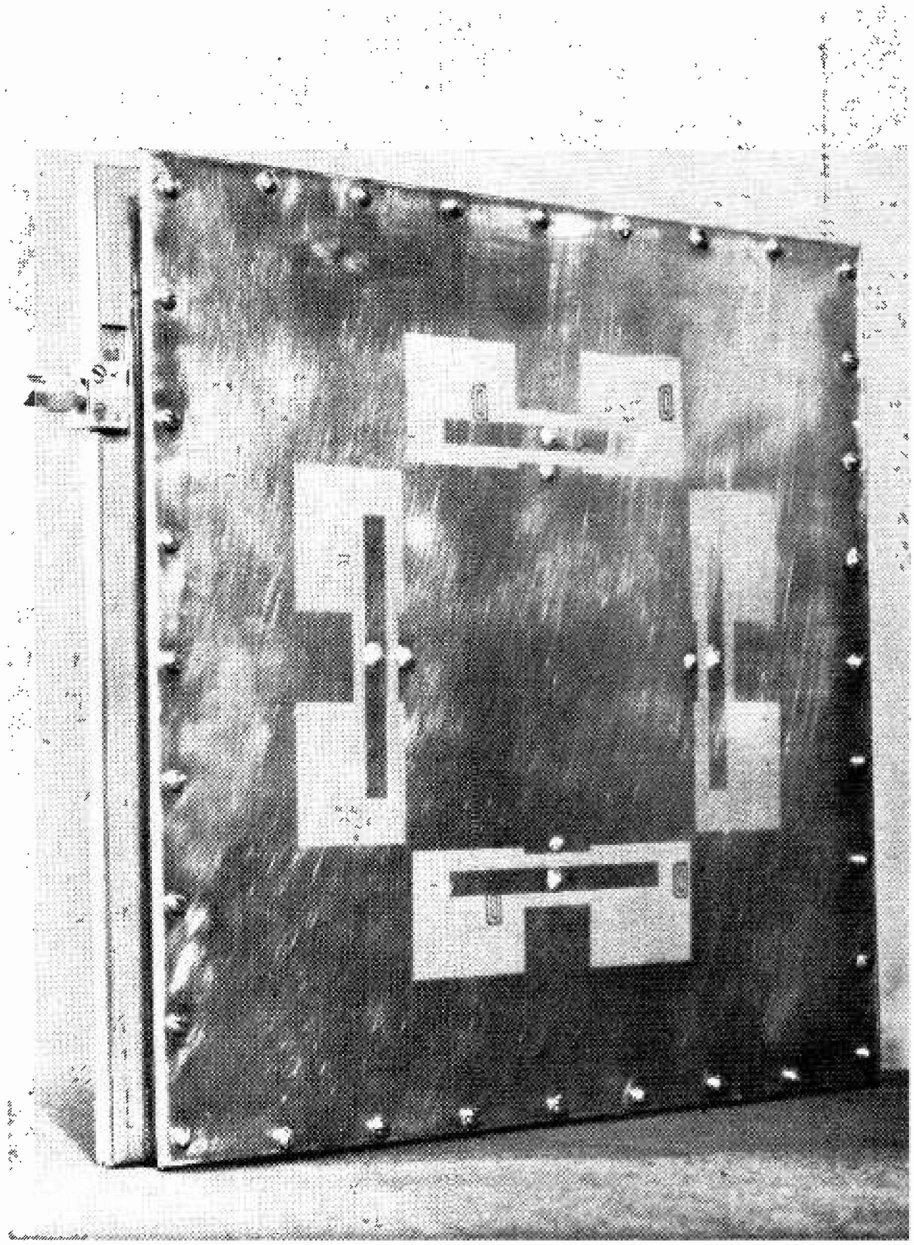


Fig. 1. Prototype circularly-polarised Quadslot antenna, designed for 1600MHz, consisting of four folded slots which are inductively loaded at each end and are spaced one half-wavelength apart. The slots are photo-etched from a single-sided, copper laminate board.

One of the many differences between a mobile and a fixed ground station is that the former has three axes of possible rotation, and that in many cases there is extensive divergence from the straight and level in operation. For example, civil aircraft and container vessels can have roll angles of ± 30 degrees. Consequently, the mobile satellite-communications antenna should provide circular polarisation over a wide angle. It is this requirement that presents such a problem. Even if the coverage/ellipticity requirement could be met by the antenna in isolation, the installation of the antenna on an irregular shaped body, such as an aircraft, can produce different antenna radiation characteristics from those that are predicted. This problem does not exist to the same extent on maritime installations. However, there are other problems that serve to tax the antenna designer's ingenuity and these will be discussed later.

Printed circuit techniques

The manufacture of antennas using printed circuit techniques allows quantity production of complex antennas and their associated feed networks, cheaply and with great accuracy. The printed-circuit type of antenna, which is often used for aerospace applications, has the advantages of being lightweight and of rugged construction, because the radiating elements and feed lines are in intimate contact with the board material (a substrate), so eliminating soldered connections. The resulting antenna normally has a small cross section allowing, for example, the antenna to be packaged between spacecraft structural members, or mounted externally on an aircraft fuselage without the penalty of excessive drag.

The choice of a suitable board material is a compromise between the requirements of good electrical and mechanical characteristics. Since the antenna is normally required to work over a wide temperature range, typically −65°C to +95°C, the material should not creep or warp over this range. For most applications the material must also be machine workable. In addition, its electrical loss must be low and the peel strength of the copper, bonded to the board, must be high over the whole temperature range. Typical materials used in microwave antennas are p.t.f.e. – fibreglass laminates (Fluorglas and RT-Duroid), a cross-linked styrene copolymer (Rexolite), and for prototype use, a high density polyolefin laminate (Polyguide).

Fig. 1 shows the Quadslot[1], a circularly polarised antenna designed for a frequency of 1600 MHz, in prototype form. It consists of four folded slots which are inductively loaded at each end and are spaced one half wavelength apart. The slots are mounted above a shallow cavity and are photo-etched from a single-sided copper laminate board; the board material being p.t.f.e.-impregnated fibreglass. They are fed from a stripline phasing network mounted at the rear of the cavity, which produces a phase progression of 90 degrees from one slot to another. The Quadslot has a peak gain (relative to an isotropic radiator) of 9dBi, and an ellipticity of better than 3dB over a beamwidth of 70 degrees.

The use of printed circuit antennas allows active circuits to be integrated with antennas on a common substrate. This is of particular value in phased array antennas because distributed amplifiers can be constructed. In this concept, every antenna element in an array, which may have thousands of elements, has its own miniature amplifier and phase shifter, resulting in a high, total radiated power without the problems associated with high-power microwave sources. In addition, circuit losses are reduced to a minimum. This gives improved efficiency and greatly increases system reliability.

Satellite communication antennas for aircraft

The problems involved in designing an antenna for use on an aircraft are severe and extensive. There is a growing demand for antennas that are, at best, to be flush mounted on an aircraft or, at worst, of low profile in order that the resultant aerodynamic drag is minimised. Aircraft manufacturers and operators require antennas that are suitable for retro-fitting, are lightweight, require little modification of the aircraft fuselage, are simple to install and maintain, resulting in a minimum "down time" of the aircraft, and yet are, of course, cheap.

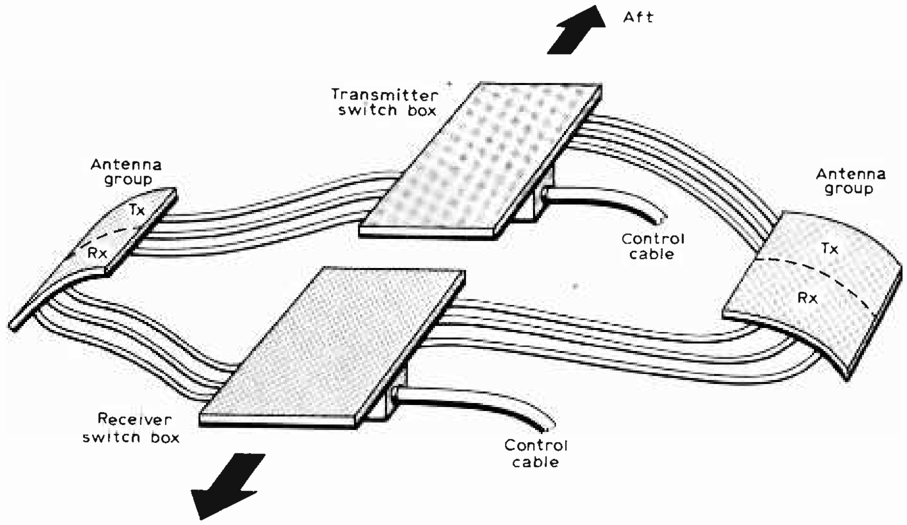


Fig. 2. Schematic of an aircraft antenna installation for use with the Aerosat communications satellite. It consists of two antenna groups, each mounted on a shoulder of the aircraft (see Fig. 3). Each antenna group consists of two arrays of three antenna elements, one transmit array and one receive array (see text).

Electrically the antenna must have a low v.s.w.r. over the operating band (1.3:1 or less), good circularity (better than 3dB over a large proportion of the coverage), adequate gain over the complete upper hemisphere and good multipath rejection.

An aircraft flying over a reflecting surface, for example the sea, will receive a direct signal from the satellite, and a reflected signal. If the path length of the reflected signal is such that it arrives 180 degrees out of phase with the direct signal, then cancellation will occur. This results in a significant drop in the received signal quality and possibly a complete break in communications. In addition, at low angles of incidence with a reflecting surface, a circularly polarised signal is reflected with the opposite hand of polarisation to the incident wave. One can see from these comments that in order to minimise multipath effects the aircraft antenna should have low level sidelobes, good circularity at low elevation angles and a sharp cut-off below the horizontal plane.

For many years the subject of an aeronautical satellite (Aerostat) has been a controversial one. During the discussions on such a satellite system, various gain levels for the aircraft terminal antenna have been proposed, ranging from the low-gain 4dBi solution to the high-gain 10dBi solution.

If virtually complete coverage of the upper hemisphere is required, with a gain level of 4dBi or above, a single antenna will not comply. Accordingly, antenna designers have proposed solutions that utilise a phased array concept. By taking a number of low gain antennas and feeding them with the correct phase and amplitude, one can control the position and, to a lesser extent, the shape of the resulting beam. If the phase relationship between one antenna and another is varied, the beams can be steered to almost any point in space. As the gain of the array is increased, the beamwidth becomes

1. Patent applied for.

progressively narrower, requiring a greater degree of accuracy in beam-pointing. This in turn leads to the need for a larger beam steering computer. A compromise is therefore needed between the costs and reliability of a large satellite and the need to keep the aircraft terminal as small and as cheap as possible.

Fig. 2 shows a schematic of a system designed and developed by the British Aircraft Corporation in conjunction with the Royal Aircraft Establishment, Farnborough. This system has been designed for use with the Aerosat communications satellite. It consists of two antenna groups, each mounted on a shoulder of an aircraft, fed by two switch units. Each switch unit is linked to the antennas by a set of three phase-matched cables. Each antenna group consists of two arrays of three antenna elements, one transmit array and one receive array. The antenna element is a cavity-backed, slot-dipole having a folded dipole within and in the plane of a slot. Since the dipole and slot are complementary (Babinet's principle) their radiation patterns are identical but with orthoganol polarisation. From this it can be seen that, with suitable phasing between the slot and the dipole, the antenna element inherently has circularly polarised radiation having good ellipticity over a large solid angle.

Separate transmit and receive arrays are used to allow optimisation of pattern and ellipticity over the respective frequency bands. Also, the use of separate arrays provides additional isolation between the transmitter and the receiver. Each antenna group of six elements is printed on a flexible double-sided, copper laminate board. This board is bolted to an aluminium casting, which forms the backbone of the antenna and also provides the cavity for each element. This casting is curved to the radius of the aircraft fuselage. A p.t.f.e. fibreglass radome covers the group of elements. The completed antenna group is ¾in thick, 15in long and 7in wide.

Fig. 3 shows a production antenna group fitted to an RAE Comet aircraft, used for experimental purposes. The antenna is designed for mounting on a blister, as shown, or flush with the aircraft skin. Each antenna group provides coverage of one half of the hemisphere, the beam being steered to one of three overlapping positions. By using three elements in each array, the system gain level is maintained at or above the minimum requirement of 4dBi over the complete hemisphere.

This antenna system was used in an extensive series of experiments sponsored by the European Space Research Organisation (ESRO), which is now the European Space Agency (ESA), with the satellite ATS-6 in the spring of 1975. The tests proved the reliability and performance of the antenna system, with an aircraft-satellite voice link to America of a standard well in excess of land-line sound quality.

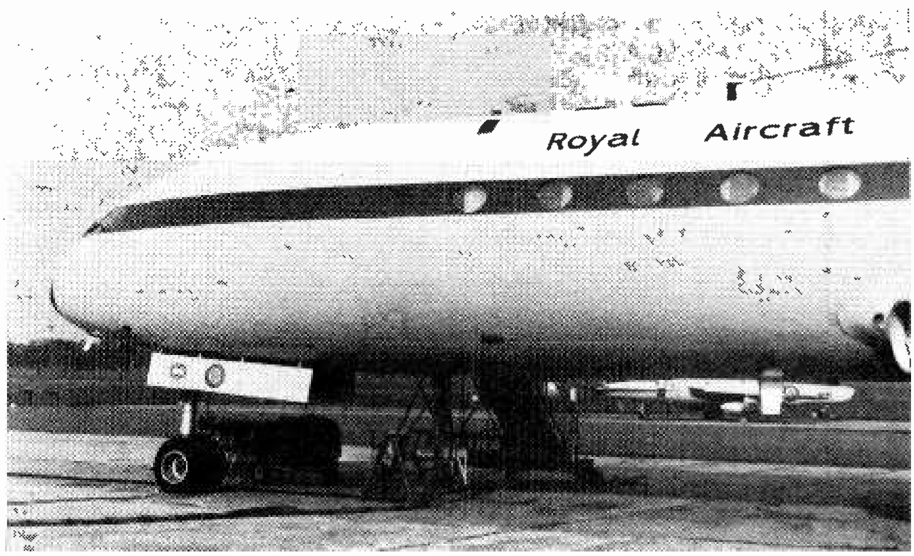


Fig. 3. Picture shows an Aerosat antenna group (see Fig. 2) mounted on the shoulder of an RAE Comet. Only the left-hand group can be seen (the rectangular plate above the foremost window), the second group is located at the other side of the aircraft's vane.

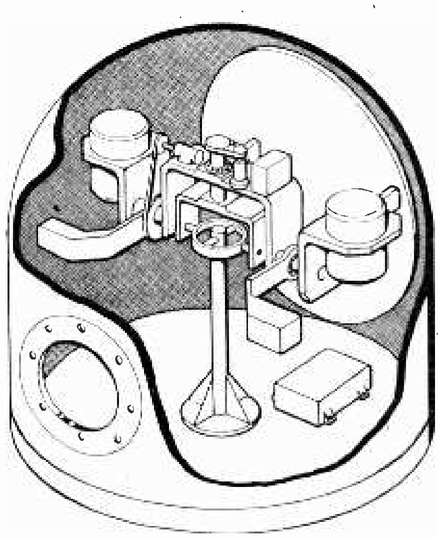


Fig. 4. Illustration of a maritime dish antenna (for a Marisat/Marots ship terminal) which, when mounted on a ship at sea, uses a double momentum wheel to stabilise its platform in the roll and pitch axes. The elements have been modified to show general constructional features (see text).

A possible development of this type of antenna is to integrate the phasing circuits into a common printed circuit board with the antenna, so providing a solution having a smaller profile and an increased efficiency. However, at the present time, it is unlikely that the required input power of 200W c.w. could be handled, due to power dissipation within the circuit board itself.

Satellite communication antennas for ships

A satellite, dedicated to marine communications, is expected to be launched early in 1976. This event has prompted the design and development of many shipborne terminals. The various antenna options that have been considered fall into two broad categories; those using parabolic dishes, and those based on multiple phased elements.

Although the motion of a ship at sea is extremely complex, the antenna is required to be accurately pointed towards the satellite at all times. Not only must the terminal cope with the motion of the ship but also the change in elevation of the satellite as the ship moves in latitude, because the satellite is in geostationary orbit over the equator.

The first generation of satellites will have a low radiated power and will require a shipborne antenna having a gain of 23dBi. Since the cost of a phased array having this gain is high, solutions have been proposed which use a parabolic dish as the antenna. In this situation the design of the antenna is straightforward and either a crossed dipole or a spiral is used as the dish feed. The problem lies in the design of the stabilised platform that the dish is to be mounted on. The conventional solution is to use a servo-driven platform, designed to compensate for movement in roll and pitch by minimising error signals generated by gyroscopes and accelerometers. Movement in azimuth is compensated for by slaving the platform to the ship's compass.

Alternatively, compensation can be obtained by using a pendulum attached to the platform. However, a simple pendulum gives damping problems due to the complex motions involved. This can be overcome by using a double momentum wheel[2], in place of the

2. Patent applied for.

simple pendulum, to stabilise the platform in the roll and pitch axes. This technique has the advantage of eliminating the precision rate sensors and associated servo control electronics and torque motors. This in turn makes it a highly reliable system. Fig. 4 shows a diagrammatic representation of this system. The severe environment necessitates the use of a dielectric cover over the dish, its stabilised platform and the above deck electronics. Warm air heaters can be used to control the temperature within the cover and to prevent the formation of ice, which can lead to an unacceptable loss in signal quality.

If a parabolic dish having a gain of 23dBi is used, at least one voice channel and one teletype channel can be received aboard the vessel. For smaller ships, requiring only teletype facilities, or for the second generation of satellites having a higher radiated power, it is feasible to use ship terminals of lower gain.

With the present state of technology, phased arrays having gain levels of 15dB or less become a possible alternative to parabolic dishes. Fig. 5 shows the prototype of a ship terminal based on a planar array, which does not require a stabilised platform. The array has twelve crossed-dipole elements printed on a single-sided copper, laminate board which is bonded to a low-dielectric foam block, rigidly positioning the elements above a ground plane. The beam formed by the array is scanned electronically in elevation, with overhead coverage provided by the Quadslot, described earlier. Rotation in azimuth is achieved by mounting the array on a turntable driven by a stepping motor. The use of electronic scanning in a single plane only, considerably simplifies the beam-steering computer and lowers production costs, since fewer phase shifters are required. This terminal, which has a peak gain of 12dBi, eliminates the need for mechanical stabilisation and provides circularly polarised coverage over a section larger than a hemisphere.

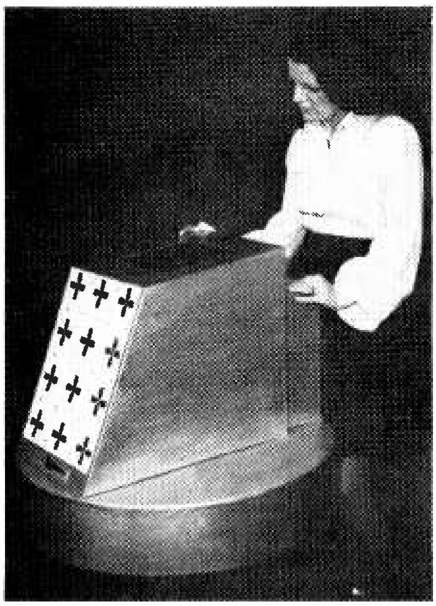


Fig. 5. Prototype phased-array maritime terminal. This unit does not require a stabilised platform, instead it scans electronically in elevation and provides overhead coverage by using a Quadslot.

A lower gain solution has been proposed which uses a vertical stack of horizontal crossed dipoles mounted on a simple stabilised platform. This solution removes the need to slave the antenna to the ship's compass since it radiates omnidirectionally in azimuth. By varying the phase difference between the crossed dipoles, the toroid of radiation is steered in elevation, resulting in a cone-shaped radiation pattern. This type of antenna, which requires a stabilised platform with its accompanied servos and gyros, suffers the disadvantage of poor circularity, particularly at low elevation angles. It has a peak gain of nearly 10dB.

Acknowledgements

My thanks go to Mr R. A. Burberry for his help and advice and to the British Aircraft Corporation for allowing this article to be published. The aircraft antennas described were developed under contract to the Royal Aircraft Establishment, Farnborough.

Microwave voice link

continued from page 71

clamping circuit of Fig. 16 to points A and B of Fig. 11, thus tapping the 50kHz square wave before it is filtered out. The voltage output from this circuit can then be monitored with a meter, the reading being proportional to the amplitude of the microwave input signal.

Even though the p.p.m. function of the transmitter is not being used, it is necessary in this and all other instances to keep the input to the modulator on load, so plug in the microphone. Having done this, it should also be muffled, as noise will cause a variation in the meter reading. Alternatively a 1kΩ resistor can be connected across the microphone input. When all is set up and a meter reading obtained, carefully and slowly slide the transmitter/receiver away from the reflector and observe the meter. This will fluctuate in reading as the receiver moves through the free-space standing wave pattern. It is easier to locate the position of a null than it is a peak of this pattern so by counting a large number of nulls, of half wavelengths (at least 40 is recommended) and measuring the total distance moved, a sufficiently good estimate of the frequency can be made. Adjustment should be aimed for the mid-band value of 10.250GHz, a wavelength of 29.27mm.

A movement through 40 nulls of the standing wave pattern will be a distance of 585.4mm. Assuming that this can be measured to an accuracy of 2mm, then the transmitter frequency can be determined to an accuracy of 35MHz: a value well within the allocated band.

Transmission regulations

In common with the regulations governing other frequency bands, the operation of a speech link at these microwave frequencies requires an amateur radio licence. Annual fee is £3, subject to passing an examination and further details can be obtained from:
Home Office,
Radio Regulatory Department,
Licensing Branch (Amateur and Special),
Waterloo Bridge House,
Waterloo Road,
London SE1 8UA.

Components

Mullard microwave devices CXY11A and BAV46 with collet are obtainable from Townsend-Coates Ltd, Loneford Road, Leicester LE5 0HH. IC_1, Fairchild type μA715DC, is obtainable from Macro Marketing Ltd, 396 Bath Road, Slough, Bucks Sl1 6JD. Printed boards for modulator and receiver are available from M. R. Sagin, 23 Keynes Road, London NW2 costing £4 inclusive.

Appendix — range performance

The power density at a range R from a transmitter radiating power P_t from an antenna of gain G_t is $P_tG_t/4\pi R^2$. A receiving antenna at R having an effective area A_r will capture some of this power, leading to a received level, P_r. Antenna gain and effective area are related by $A_r = \lambda^2 G_r/4\pi$ where λ is the wavelength. Thus, the received power is $P_r = P_tG_tG_r\lambda^2 / (4\pi R)^2$. The ability of the receiver to detect a signal is governed largely by the sensitivity of the detector diode. A subjectively measured parameter called the tangential sensitivity is used, which roughly corresponds to a level 4dB higher than the minimum detectable signal. For this particular system, after allowing 3dB loss in the input filter, the minimum detectable signal is about 5×10^{-9} watt. Gains G_t and G_r are both equal at the measured 19.3dB and λ = 2.93cm, P_t can be taken as 5mW.

Inserting these values into the above equation gives a theoretical range of about 400m. This is for a s/n ratio of unity and would not be expected in practice without more elaborate signal processing. The prototype gave a very satisfactory performance over 100m range with the transmitter and receiver being hand-held. A more stable alignment of the antennas would be expected to improve this.

Economical time-mark generator

Simple time and frequency comparator

by S. Roberts

In any establishment where oscilloscopes are in use, a time-mark generator can be a valuable tool when assessing time-base accuracy. Unfortunately, commercially-produced generators are usually too expensive for small workshops, laboratories and enthusiasts. The device to be described combines modest cost with accuracy, and may be easily constructed using readily available parts. Although described here as a complete unit, the generator could well be incorporated into a digital frequency counter, where the clock oscillator and decade divider chain would already be available, or even into an oscilloscope as part of the calibrator function.

A time-mark generator is essentially a pulse generator where the time between pulses has been accurately specified. The pulse width is made sufficiently small compared to the spacing between pulses that when looking at the output on an oscilloscope, only a single vertical line for each pulse is evident. Thus, the time-base frequency may be adjusted until the pulses are coincident with the appropriate graticule lines.

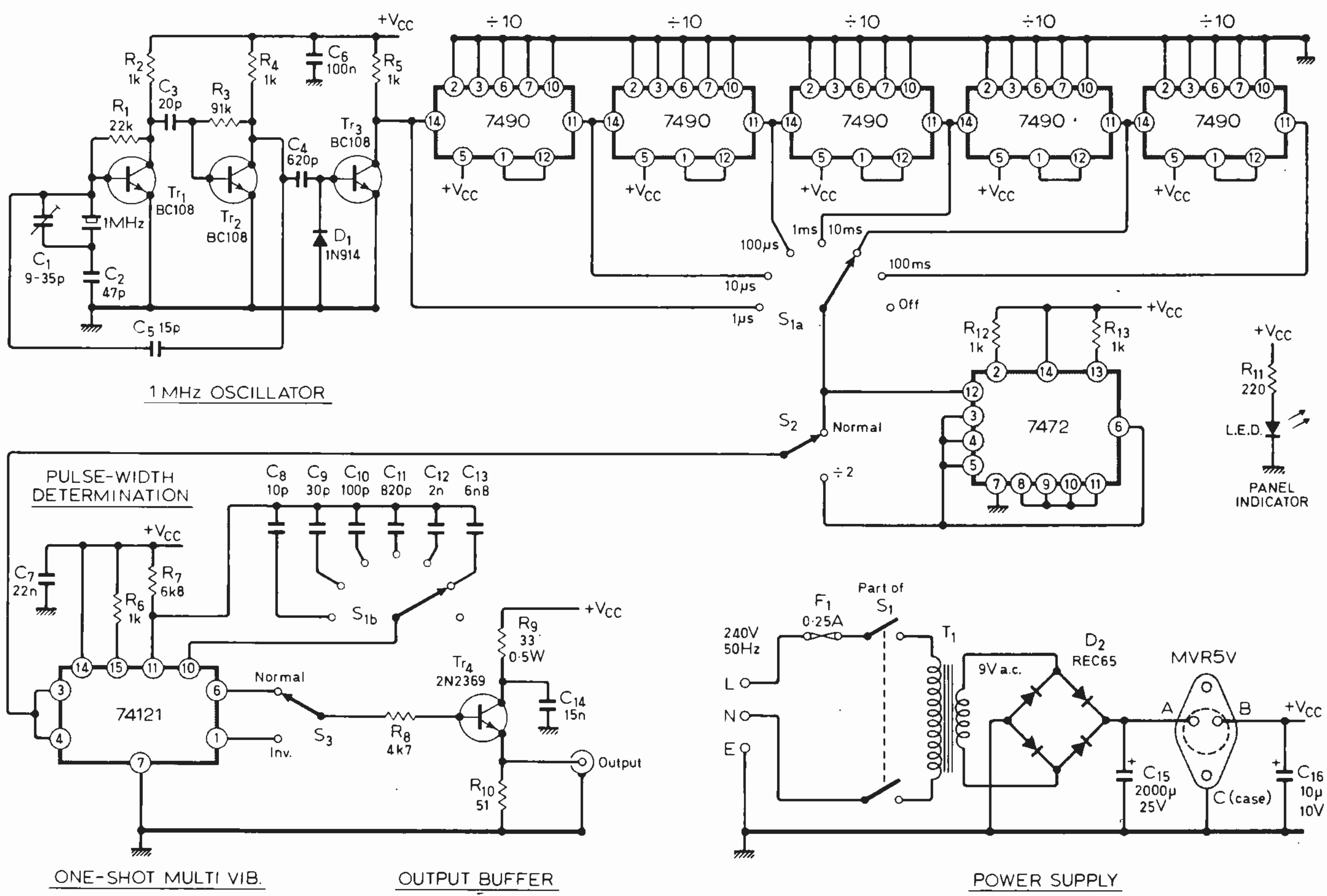
Circuit description

A 1MHz crystal-controlled oscillator, Tr_1 and Tr_2, provides an accurate frequency source. Transistor Tr_3 acts as an output buffer and its collector switches between 0V and 5V at a 1MHz rate. This is connected directly to the input of a series of SN7490 decade dividers, IC_1–IC_7, whose outputs will be 100kHz, 10kHz, 1kHz, 100Hz and 10Hz respectively.

The desired frequency, and hence time-mark interval, is selected by means of S_{1a}, and fed to IC_7 either directly or via IC_6. The SN7472, IC_6, provides further frequency division if selected by means of S_2, so doubling the number of time-mark intervals available.

It was found during experimentation that for the output marker pulses to be sufficiently narrow to ensure that accuracy was not degraded, yet wide enough that the pulses were easily

Fig. 1. Time mark generator circuit diagram.



visible, different pulse widths were necessary for different mark intervals. The optimum pulse widths, derived experimentally, range from 50ns to 35μs, as may be seen from Table 1.

Table 1

Range	Frequency	Pulse width
1 μs	1 MHz	50 ns
2 μs	500 kHz	
10 μs	100 kHz	150 ns
20 μs	50 kHz	
100 μs	10 kHz	500 ns
200 μs	5 kHz	
1 ms	1 kHz	4 μs
2 ms	500 Hz	
10 ms	100 Hz	10 μs
20 ms	50 Hz	
100 ms	10 Hz	35 μs
200 ms	5 Hz	

The various widths are determined by IC_7, which is a monostable multivibrator. The "Q" output at pin 6 goes high when the input (pins 3, 4) changes from high to low. The length of time for which it remains high is dependent upon the values of the timing components R_7 and the capacitor selected by means of S_{1b}.

The values of the timing capacitors are calculated from the formula:–

$t_{p(out)} = C_T R_T \log_e 2$

where $t_{p(out)}$ = output pulse width in ms

C_T = timing capacitor in μF

R_T = timing resistor in kΩ ($R_7 = 6.8k\Omega$)

$\log_e 2 = 0.7$

Pin 1 of IC_7 is the "$\overline{Q}$" output and will be the inverse of the "Q" output. One of the two possible outputs is selected by means of S_3 ("NORM/INV") and taken to the output buffer, Tr_4, which serves to isolate the output from IC_7 and to provide a low impedance source. The resistor R_9 is included to limit the current should the output be shorted.

The R.S. Components MVR5V voltage regulator has been used for the power supply, which simplifies construction. Other regulators such as the LM309 could of course be used, or a supply using discrete components could be constructed. About 500mA at 5V is required. Any low-voltage transformer with a secondary of around 9V at a sufficient current rating is suitable, such as the R.S. Components Type 633.

Construction

The layout of the generator is not critical, although adequate decoupling of the supply lines and good earthing is essential for a clean output pulse. The prototype was constructed with the ubiquitous Veroboard, and no problems were encountered with stray capacitance. For switch S_1, a Doram miniature Maka switch was used, with two 1-pole 12-way wafers. The mechanical stop was adjusted to limit the movement to seven positions, the extra position being used to control a mains switch also mounted on the spindle. If desired, a separate mains switch could be used, in which case a single 2-pole 6-way wafer would suffice for S_1 since only six positions would then be necessary.

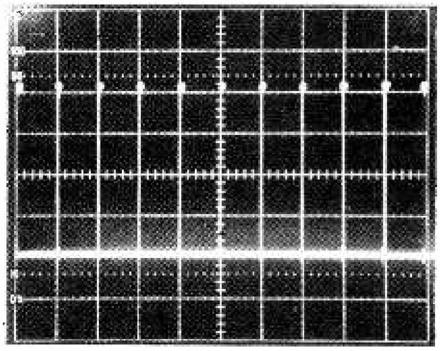


Fig. 2. Time and linearity checking of an oscilloscope sweep.

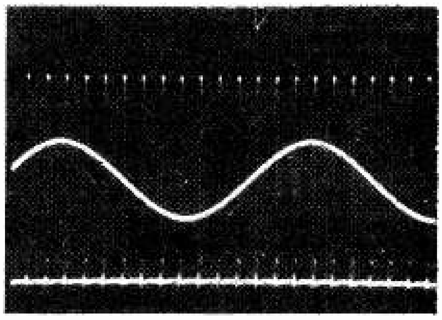
When constructing the oscillator portion, some adjustment of R_3 may be necessary to ensure that the oscillator remains reliably locked to the crystal frequency. If desired, a 10MHz oscillator could be constructed, which, in conjunction with an additional divider stage, would provide 100ns and 200ns markers.

Applications

Figure 2 is a photograph of the output on an oscilloscope screen. By adjusting the oscilloscope sweep speed, the markers can be made to coincide with the vertical graticule lines with each setting of the time-base switch. The markers then serve to show the accuracy of the time-base and the horizontal linearity. Selection of a suitable marker pulse will permit the vertical geometry to be checked – the pulse should be parallel with the vertical graticule lines.

With dual-trace oscilloscopes, the generator provides a quick and accurate means of checking the oscilloscope internal calibrator frequency – usually 1kHz if not derived from the a.c. mains. A 1ms time-mark is displayed on the upper trace, the calibrator on the lower trace, and with the oscilloscope time-base synchronised with the generator, the calibrator frequency may be adjusted until the lower trace is stationary on the screen. Other oscillators may be calibrated by the same method.

Fig. 3. Measuring frequency by means of the time-pulses.



An unknown frequency may be measured on an oscilloscope with a non-linear or uncalibrated time-base by displaying the frequency and time-marks simultaneously, and counting the number of time-mark intervals in one cycle. Figure 3 demonstrates this possibility. In this case, the time-mark generator was set for 1μs pulses. 13.3 time-mark periods can be seen over the duration of one cycle, indicating a frequency of:–

$$f = \frac{1}{P} = \frac{1}{13.3 \times 10^6} = 75.2\text{kHz}$$

In this application, the time markers may be considered to be an "electronic graticule".

These ideas represent the more obvious uses of a time-mark generator – other applications may well occur to the ingenious user.

It should be borne in mind that this design is probably the simplest possible. There is therefore scope for improvements, further facilities or modifications to suit the requirements of individual users. In its present form, however, the generator is a most useful device and sufficient for most purposes.

Sixty Years Ago

It was difficult to persuade Senatore Guglielmo Marconi to write for publication, but our November 1917 issue contained an interview given to the editor of *The Wireless Age* in America. His remarks were intended for American amateurs, and strike a very odd note indeed to a 1977 reader. It is worth bearing in mind, though, that we had been at war three years by this time.

" . . . The most striking features of my observation since I have been on this official visit to the United States is the surprising ignorance of your wireless men concerning the conditions in the fighting zone abroad. It has required a readjustment of viewpoint for me to appreciate the fact that so much of the scientific development of the wireless art has been kept secret for military reasons; naturally the United States cannot know of things which to us have seemingly become elementary.

. . . It can be readily seen . . . that the Allies faced some serious problems in supplying the right sort of men for this duty, and, in fact in supplying the armies with sufficient wireless men for their needs. We were far better equipped, however, than the Americans, because of the fact that the European nations had large standing armies with men well trained for their soldierly duties. It was simpler for us to take soldiers and train them as operators, and this we did. We had very little choice in the matter, however, because we had no great body of amateurs to call upon as you have in this country.

New Products

Tantalum capacitors

A family of resin-coated, solid tantalum capacitors has been introduced by Sprague for the low-cost, domestic equipment market. The components are in six case sizes with a variety of lead shapes for several different printed-board spacings. Values are in the 20% tolerance decade values between 0.1μF and 680μF and work at voltages from 3V d.c. to 50V d.c. up to 85°C. Sprague Electric (UK) Ltd, 159 High Street, Yiewsley, West Drayton, Middlesex.
WW 301

Spectrum analyser

A 50MHz spectrum analyser from Parametron is intended for general and field operation in addition to work in the laboratory. Centre frequencies of 200kHz to 50MHz are continuously tuned at dispersions of 100kHz to 50MHz and sweep speed is 20ms to 10s. Spurious responses are said to be −66dB and intermodulation products are at −50dB. The tuning range can be extended to 350MHz by means of a converter. Wessex Electronics Ltd, Stover Trading Estate, Yate, Bristol BS17 5QP.
WW 302

Thumbwheel switches

Plessey's Series 33 thumbwheel switches are said to have up to ten switching positions and mount from either the front or rear of a panel. Black with white legends, they have a number of switching codes. Extended printed circuit boards can be provided to mount extra components, and the switch can be illuminated by a 5V 60mA lamp. The contacts are rated at 100mA at 50V d.c. with a temperature range from -20°C to 70°C. G.E. Electronics (London) Ltd, Eardley House, 182 to 184 Campden Hill Road, Kensington, London W8 7AS.
WW 303

Opto-couplers

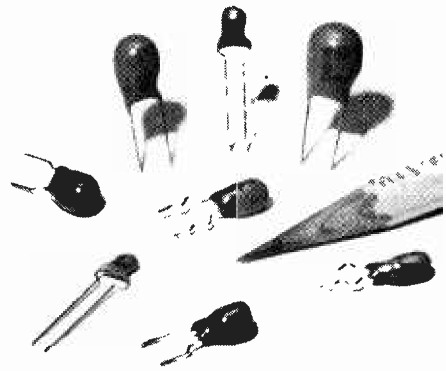
A range of photo-couplers, from National Semiconductors Ltd, utilize gallium phosphide l.e.ds and fast-responding cadmium-selenide photocell detectors. The couplers, in the 5S range, are a.c.-compatible and enable emitter-to-detector isolation voltages of up to 10kV to be achieved. They are rated up to 320V with 250mW dissipation and an l.e.d. current of 25mA, giving maximum on, and minimum dark resistances of 2kΩ and 100MΩ respectively. The devices are available in either four-pin TO-5 size cans, 0.625in long by 0.32in diameter cylindrical packages, or in 0.75in square modules. National Semiconductors Limited, Stamford House, Stamford New Road, Altrincham, Cheshire WA 141DR.
WW 304

Plastic solder

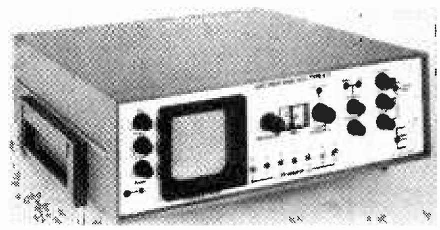
Eccobond Solder 56C is a plastic adhesive which, when cured, has an extremely low electrical resistance (its volume resistivity is typically 2×10^{-4} ohm-cm). It can be cured at temperatures as low as 49°C in 2h, or in a few minutes at much higher temperatures. The adhesive, which is supplied in paste form, bonds to metal, glass, ceramic and plastics. It may be used for making electrical connections where hot soldering is impractical, for example, to nichrome wire or conductive plastics, and at locations which cannot be subject to high temperatures. Other specifications include a lap shear strength of 56Kg/sq.cm., flexural strength 857Kg/sq.cm. and thermal expansion 36×10^{-6} per degree Centigrade. Emerson and Cuming (UK) Limited, Colville Road, Acton, London W3.
WW 305

Magnetic film recorders

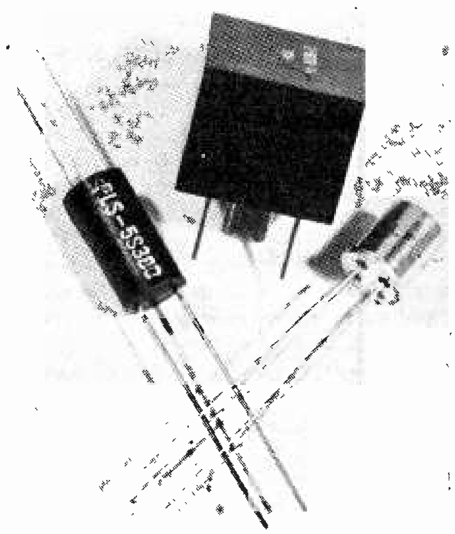
Sondor Libra M03a magnetic film recorders have been designed to handle acetate or polyester films. They have straight-line lacing paths, small size and combination pinch-wheels and sprocket-drives. Models available range from simple single-channel replay only types to three-channel record/replay types. The machines are pre-wired to take extra amplifiers and can therefore be converted to the full three-channel record/replay specification. Type M03a uses the standard Sondor method of synchronization and can therefore easily be locked to projectors, telecine machines and time-code interlock equipment. This machine is also available in a video version containing a holoscope prism system. Hayden Laboratories Limited, Hayden House, Churchfield Road, Chalfont St. Peter, Bucks., SL9 9EW.
WW 306



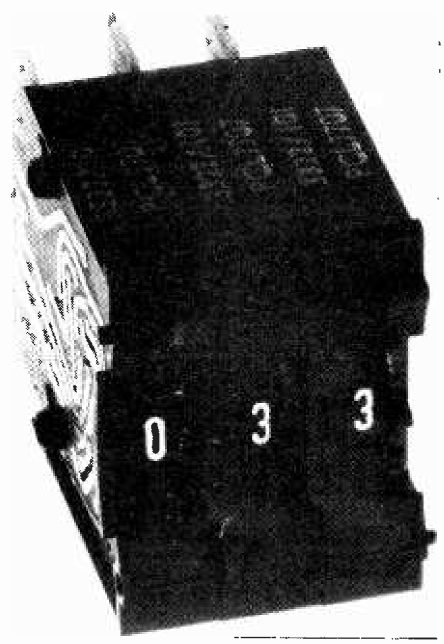
WW 301



WW 302



WW 304



WW 303

A.m. transmitters and receivers

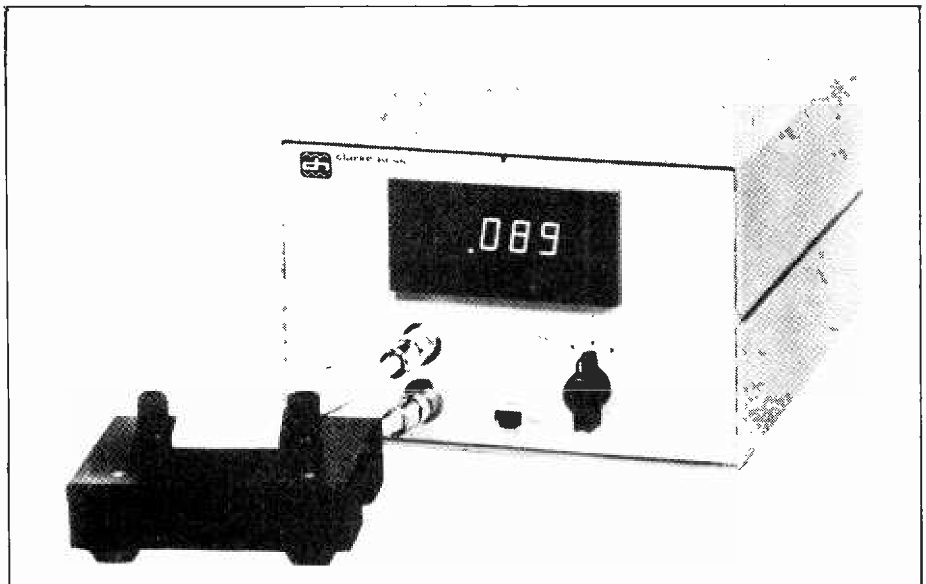
A range of fixed-station amplitude modulated transmitters and receivers have been introduced by Pye Telecommunications Ltd. The transmitters, type T401, are 25W solid-state modular designs suitable for simplex or duplex operation in the frequency range 68 to 174MHz. They have been designed using low intermodulation products specifically to make them usable on multiple transmitter sites, and they may also be fitted with tone-lock encoder (c.t.c.s.s. — continuous tone controlled sub-audio squelch) devices to ensure that only mobiles fitted with the appropriate decoder receive the message.

The receivers, type R401, use phase-lock-loop synchronous detectors so that they can receive high modulation signals with low distortion. To reduce spurious responses the receivers are based on a single-conversion design, which also results in simpler, more-reliable circuits. Helical resonators and f.e.ts in the r.f. section give the receivers high selectivities (typically 0.5μV p.d. input for 1W min. output and 30% modulation with 1kHz tone), with a signal-to-noise performance of 12dB SINAD at 0.5μV p.d. signal input (at 60% mod. with 1kHz tone). Blocking and intermodulation figures, measured to MPT1302, are in excess of 100dB and 60dB respectively. Both units can be supplied for standard 19in rack mounting and operate on a.c. or 24V d.c. supplies. Pye Telecommunications Limited, Newmarket Road, Cambridge CB5 8PD.
WW 307

WW 307

ESR meter

Equivalent series resistance of capacitors is indicated digitally by the Clarke-Hess 273A meter. Capacitors in the range 5000pF to over 1F can be tested and subjected to less than 10mV d.c. and 100mV r.m.s. at 100kHz. Resolution of the e.s.r. measurement is 0.1 milliohm up to 200 milliohms, 1 milliohm up to 2 ohms and 10 milliohms up to 20 ohms. Measurement time is normally 0.5s, but when externally clocked this is reduced to as little as 20ms, a b.c.d. output being provided for automatic test. The instrument is available in the UK from Lyons Instruments, Hoddesdon, Herts.
WW 308



WW 308

Multiplier

An eight bit multiplier from Monolithic Memories Inc is claimed to generate a 16-bit product in around 100ns. Two versions of the multiplier are available, the 67558, suited to signal processing in radar, fast Fourier transforms, sonar, speech processing, and speed multiplication in brain and body scanners, and a military version, the 57588 which extends the 67558's temperature range from between 0 and 70°C to between −55°C to 125°C. Memory Devices, Central Avenue, East Molesey, Surrey KT8 0SN.
WW 309

Power transistors

Two complementary power transistors, types BD135 and BD136, are silicon n-p-n/p-n-p devices having the following absolute maximum ratings: the total power dissipation for a 70°C case temperature is 8W, the collector current is 1A and the collector-emitter voltage is 45V. These transistors show a gain bandwidth product of 50MHz, a d.c. forward current transfer ratio voltage of 40 to 250 and a collector-emitter saturation voltage of 500mV. The devices are packaged in a TO126 case. Norbain Semiconductor Division, Norbain House, 2 Arkwright Road, Reading, Berks.
WW 310

Sequence timer

The RST rotary timer from Appliance Components has been extended with the introduction of a new unit which is capable of taking twenty switches of either the rotary wafer or the cam-operated microswitch variety or a combination of both. A common shaft drives all the switches and is operated by a synchronous motor. The rotary switches consist of a wiper and silver contacts and the cams can be shaped to provide up to 24 microswitch operations per revolution. Appliance Components Ltd, Cordwallis Street, Maidenhead, Berks SL6 7BQ.
WW 311

Cam switches

Rotary cam switches, in a modular form for assembly by the user, are available from Entrelec. Up to twelve contacts can be operated on a single shaft, which can be 90° or 45° indexed, key-operated, spring return, limited rotation and front or rear mounted. Switches in this V range are rated at up to 55A and are said to be suitable for motor control and as isolator switches. The units can be obtained from Triscott Electrical Ltd, 23 Wansford Way, Felpham, Sussex PO22 7N6.
WW 312

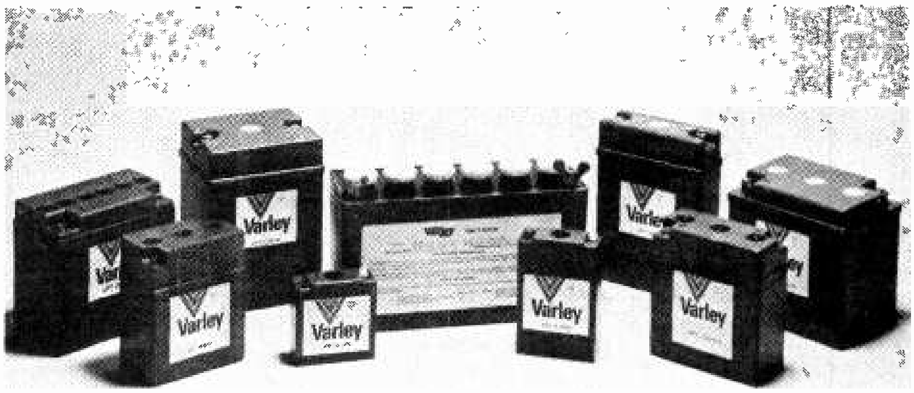
Frequency synthesizer

A fully-programmable frequency synthesizer, the Model 601, has a frequency range from 10kHz to 180MHz with a resolution of 1Hz. Built-in modulation facilities are a.m. up to 99% and f.m. in two ranges to 9.9kHz and 99kHz at modulation rates to 100kHz. The signal output level is 2V (e.m.f.) from 50Ω. A built-in step attenuator has a range from 0 to 139.9dB in 0.1dB steps and a sweep facility, having a maximum range of ±1MHz, is available as an option. The frequency reference is a 5MHz crystal oscillator with a daily ageing rate of less than one part in 10^{-9} and a long-term stability of one part in 10^{-7} over a period of six months. All functions are b.c.d.-programmable via multiway connectors on the rear panel. Sayrosa Engineers Limited, Wey River House, High Street, Alton, Hants.
WW 313

WW 313

Rechargeable batteries

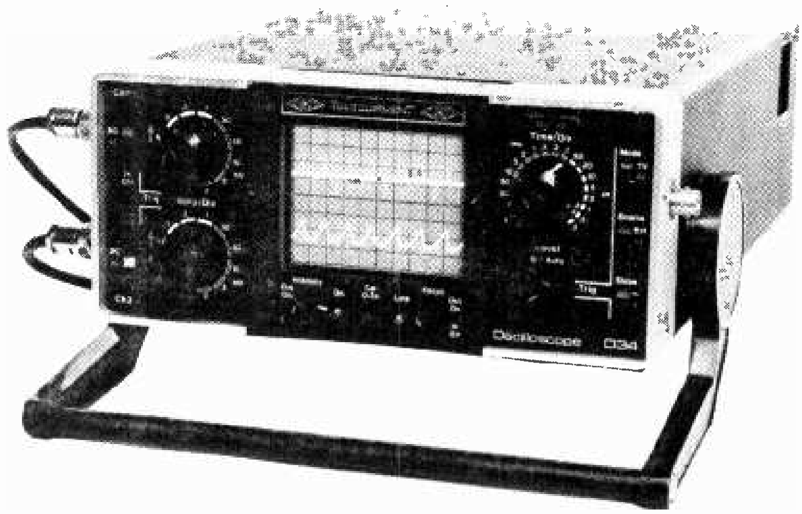
Lead-acid batteries in the Varley range, stocked by Electroplan Ltd, are low-cost and offer high power-to-weight ratio and safe spill-proof operation. These batteries are available in 2V cells and 6 and 12V packs, in capacities from 4.5 to 90Ah. They are constructed from compressed layers of highly-absorbent separator material and thin lead plates. This construction enables high capacities to be achieved in a small volume and also removes the risk of plate material becoming detached and bridging between plates. Since the electrolyte is completely absorbed by the porous separators, the batteries can be charged and used in any position without spillage, and will need topping up less often than a conventional free-acid battery. Electroplan Limited, P.O. Box 19, Orchard Road, Royston, Herts., SG8 5HH.
WW 314



WW 314

15MHz battery oscilloscope

The D34 dual-trace portable oscilloscope, from Telequipment, has all the features of the model D32, but it has been given a greater bandwidth and a higher sensitivity (the maximum deflection sensitivity has been raised to 2mV/division up to 15MHz). To match this increased performance, the maximum switch speed is now 0.2µs/division, and a signal delay has been included to facilitate the observation of fast leading edges. This oscilloscope may also be used on a mains supply. Electroplan Limited, P.O. Box 19, Orchard Road, Royston, Herts SG8 5HH.
WW 315



WW 315

Sidebands

by mixer

Wall of words

Why is it, I wonder, that the average bank clerk, boiler maker or mole exterminator is so quick to claim total and passionate ignorance of anything electronic? Mention, in passing, the fact that you work in electronic engineering and see his face register the "Well, how interesting! But of course all that sort of thing is above my head" expression. But talk to him about his car and he will instantly be away into a discussion of steering geometry, carburation and the advantages of limited-slip differentials.

Next time the company chairman is wheeled round the lab on his annual tour of inspection, just watch the pent-up surge of indifference glaze his eyes as you explain to him what you've been about during the last year. This is not to say he's a fool — anyone who gets to be chairman of a company has to have something upstairs — but it does seem that many such, otherwise rational, people experience this automatic switch off at the mere mention of electronics. I think most of the blame lies with electronic engineers themselves: we have built up this carefully-guarded mystique over the years by cloaking even the most straightforward statements in the most grotesque jargon ever heard outside a marketing and advertising office. We talk about large-scale integrated t.t.l., ceemoss bucket brigades, intelligent terminals and jungle chips without a thought for the hapless individual with a head full of nothing more complicated than running a £1m-a-year company. No wonder they all think we're too way out to be taken seriously.

A breath of fresh air

He has a good aim with a bucket of icy water, has Peter Baxandall. If, as is only proper, you turned to this page first, I insist that you must now read his article on fog-dispersal. He doesn't call it that, of course, because it would look peculiar in the index, but that's what it is about.

The writings of some of those who describe audio equipment for magazines has ascended (or descended, according to your point of view) to the level of the argot used by art and music critics. But while there are reasons for not being able to describe a painting by Lowry or a concerto by Vivaldi in precise language, there can be no excuse for disguising a lack of information in a flurry of adjectives such as "chesty", "forward", "relaxed" or, as in a recent review, "boring". Critics don't, as a rule, talk about indefinable agencies at work in paintings or music; indeed, they are usually only too willing to explain in detail just what it is about the brushwork or the violinists' fingers that gives a work its character. Perhaps now, after Baxandall, we can drop all this pseudo science about amplifiers and stop believing in fairies.

PR pidgin

a breakthrough .... the same as all the others except it uses i.cs.
years of research .... three days looking through the competition's catalogues.
professional .... has a lot of knobs and it's too dear for most people.
sophisticated .... expensive. A recent favourite – "sophisticated genuine wood."
computerised .... has a transistor in it.
symposium .... marketing managers' jamboree.
new low price .... cheaper than it could be, dearer than it should be.
indispensable .... dispensable.
high-density ABS .... plastic.
the ultimate ... oh! come now.

Not cricket

We get some funny letters to these offices. They cover the field from "My radio has gone wrong; can you tell me how to mend it, please?" to requests for an explanation of the workings of computers "... if you could spare a few minutes of your time". We had a man who used to write in and say that beings from space were following him around and could we let him have a circuit to jam their 'detection beams', and the number of people who have invented stereoscopic television displays must be well into the double figures.

But we have now received the classic communication. A letter came from an official who is responsible in some way for the welfare of inmates of H.M. prisons, wanting to know the value of a certain type of radio receiver. It appears that the governing body of the chokey in question are being given the runaround by one of their flock who, much to his indignation, has had his radio stolen!

Now, this will not do. It is quite definitely the sort of thing that gives dishonesty a bad name, and if you can't leave things lying around in a government establishment, well, it's no wonder the country's going to the dogs. Apart from which, there's the question of honour among ... er ... wealth redistribution operatives – is there no sense of shame among these people?

What I can't work out – where on earth have they hidden it?

Sound control

I suppose the knobs, switches, meters and assorted decorations are built on to audio equipment because the makers have found that their customers want them. The nearer in appearance to mission control, the better for the image, so to speak. Indeed, there is even a demand for a "military look" in some portable radios and a "laboratory look" in much recent high-fidelity sound gear. All these controls and indicators presumably have a function, but one wonders whether they are ever used.

I must point out that I'm not being patronising, because I have some equipment like that myself, although the gimmicks did come with the performance, which was why I bought it. It has a loudness button, which serves to ruin the frequency response, no less than three "on"switches and a separate "off" switch, a useless signal level meter, a scratch filter and a rumble filter, neither of which has ever been used in anger, and any amount of satin chrome. It all looks very technical and my wife won't touch it. I think she's a bit puzzled about the red pilot light, which only comes on with certain programmes.

I dare say she isn't alone, either — the days when you could "turn on the wireless" with one flick of the wrist are long gone. There must be thousands of middle-aged and elderly people who are as fastidious about sound quality as anyone else, but who simply do not want to know about bass and treble boost and cut, balance, loudness contours, tape bias and equalisation, noise-reduction controls and peak-programme meters. And yet only one NAIM springs to mind. There may be others (QUAD equipment is not excessively self-conscious) which do not attempt to impress except by way of performance, but most gear that you buy seems to have the young and technically-minded at heart rather than the person who wants to hear music without being reminded that it's all very clever.

Would it not be possible and desirable to market very high quality units with a minimum of controls, especially for people who aren't able, for any reason, to use them to best advantage?

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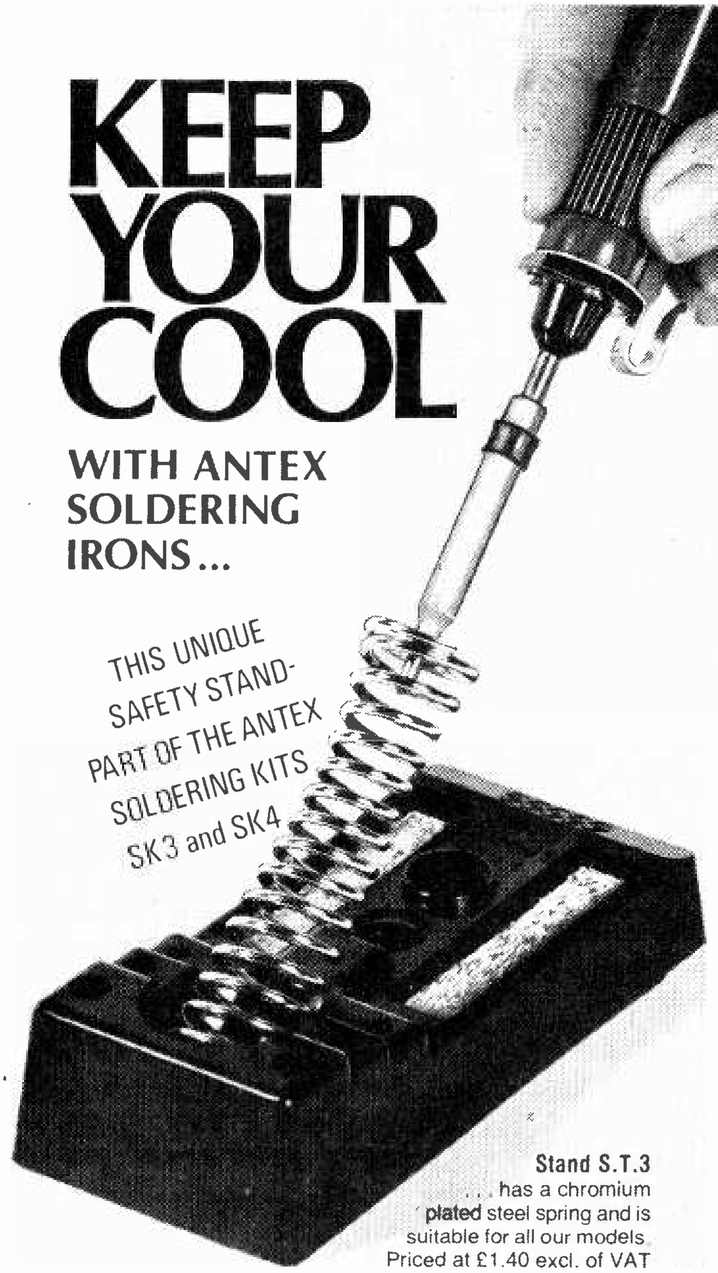


THIS UNIQUE SAFETY STAND- PART OF THE ANTEX SOLDERING KITS SK3 and SK4

Stand S.T.3
... has a chromium plated steel spring and is suitable for all our models. Priced at £1.40 excl. of VAT

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.

This sturdy plastic stand is a useful addition to any household or workshop. The SK3 and SK4 kits comprise of a full instruction card mounted with either the CX miniature soldering iron or the larger X25 general purpose iron. Included in both of these kits is the safety stand.

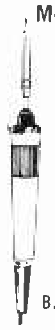
All the range of Antex soldering irons are made on the principle of putting the heating element inside a shaft, then the desired bit is eased over the shaft, giving maximum heat transference, this is why so often a small Antex iron can do the job of a larger conventional iron. The precision made slide on bits are slit to make them easily interchangeable.

Our comprehensive range is sure to meet your need.

Model CX-17 watts

... a miniature iron with the element enclosed first in a ceramic shaft, then in stainless steel. Virtually leak-free. Only 7½" long. Fitted with a 3/32" bit £3.40 excl. of VAT. Range of 5 other bits available from ¼" down to 3/64"

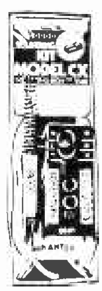
Model X25-25 watts



A general purpose iron also with a ceramic and steel shaft to give you toughness combined with near-perfect insulation. Fitted with ⅛" bit and priced at £3 40 excl. of VAT. Range of 4 other bits available.

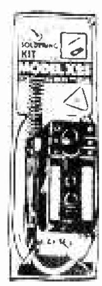
B.E.A.B.-APPROVED.

Model SK3 KIT



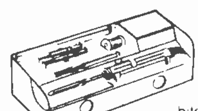
Contains both the model CX soldering iron and the stand S T 3 Priced at £4 80 excl of VAT it makes an excellent present for the radio amateur modelmaker or hobbyist

Model SK4 KIT



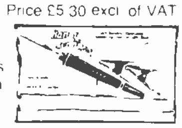
With the model X25 general purpose iron and the ST3 stand and its B.E.A.B. safety label, this kit is a must for every toolkit in the home.

Model SK1 KIT



This kit contains a 15 watt miniature soldering iron, complete with 2 spare bits a coil of solder a heat sink and a booklet How to solder Price £5 30 excl of VAT

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 £3 95 excl of VAT

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NRDC-AMBISONIC 45J

SURROUND SOUND DECODER

The **first ever** kit specially produced by Integrex for this British NRDC backed surround sound system which is the result of 7 years' research by the Ambisonic team. W.W. July, Aug. and Sept. '77.
The unit is designed to decode not only 45J but virtually all other 'quadrophonic' systems (Not CD4), including the new BBC Matrix H.10 input selections.
The decoder is linear throughout and does not rely on listener fatiguing logic enhancement techniques. Both 2 or 3 input signals and 4 or 6 output signals are provided in this most versatile unit. Complete with mains power, wooden cabinet, panel, knobs, etc.

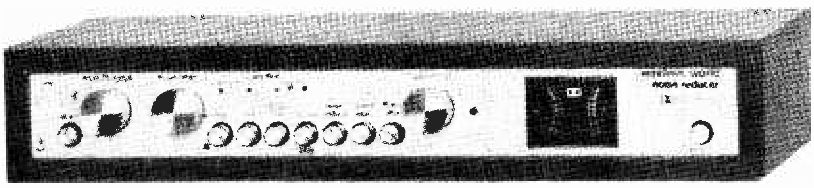
Complete kit, including licence fee £45.00 + VAT

INTRUDER 1 RADAR ALARM

With Home Office Type approval.
As in this issue of "Wireless World", designed by Mike Hosking, 240V ac mains operated and disguised as a hardbacked book. Detection range up to 30 feet. Complete kit. Exclusive designer approved kit £46.00 + VAT, all ready built and tested £54.00 + VAT.

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

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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)

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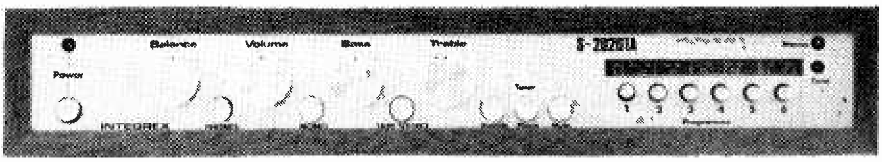
S-2020TA STEREO TUNER/AMPLIFIER KIT

SOLID MAHOGANY CABINET



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

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

PRICE: £58.95+VAT

NELSON-JONES STEREO FM TUNER KIT

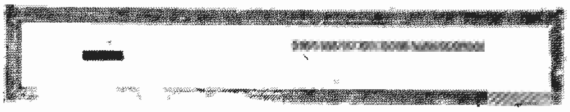
A very high performance tuner with dual gate MOSFET RF and Mixer front end, triple gang varicap tuning, and dual ceramic filter/dual IC IF amp.

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

Compare this spec. with tuners costing twice the price.

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

STEREO MODULE TUNER KIT



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

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

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A SEMICONDUCTOR POWERHOUSE
TRAMPUS ELECTRONICS LTD., 58-60 GROVE ROAD, WINDSOR, BERKS. SL4 1HS. (Trade, Export & Retail)
Tel. WINDSOR (07535) 54525. Callers welcome Mon.-Sat., 9 a.m.-5 p.m.

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Fast service on ex-stock products Same day despatch normally Quality devices manufacturers specifications, lowest prices Barclaycard & Access by post or telephone, £5 minimum VAT Add 8% to prices marked * add 12½% VAT to all other prices Post & Packing 20p U K Send CWO, except Govt Depts etc Money back if not satisfied Catalogue sale list free Send SAE

I.C.'s **All price each**
555 DIL 8 TIMER **37p***
723 TO99 REG **47p***
723 DIL 14 PIN **69p***
741 DIL 8 PIN OP AMP **25p***
741 DIL 14 or TO99 **36p***
747 DUAL 741 **89p***
748 DIL 14 PIN **29p***
748 DIL 8 PIN **49p***
7805 PLASTIC or TO3 **£1.00***
7812 or 15 PLASTIC **£1.50***
76013 or 76023 **£1.69**
8038 SIG GEN **£5.00***
AY51224 CLOCK **£2.50***
LM340 **50p***
LM301 DIL 14 PIN **29p***
LM301 DIL 8 PIN **59p***
LM309K TO3 5V **£1.00***
LM318 70V US **£2.25***
LM380N 2W AF **£1.00**
LM3900 QUAD OPA **75p***
MC1310 YES ONLY **75p***
NE555 TIMER **37p***
NE556 2 x 555 **£1.00***
SN76611 & 60IF **£1.25**
TBA810 7W AF **£1.00**

LEDS ¼" & .2" DIA
RED, NO CLIP **11p***
2" RED & CLIP **15p***
COLOUR LEDS **29p***

DISPLAYS (RED LED)
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0.3" DL707/2 **65p***
0 6" DL747/2 **£1.00***
TGS308 GAS DETECTOR **£5.00***
309pf MED/SHORT TUNER **£1.00***
AUDIBLE WARNING BLEEPER 12V 100mA **£1.49***
DALO PCB PEN 2 TIPS **74p***
SRBP 6" x 4" **80p***
FEC **£1.00***
PCB ETCHING KIT **£2.00***

DIODES
OA81/91 **5p**
IN4148 & IN914 SILICON **4p***
IN4001 **5p*** IN4004 **7p***
B2788 ZENERS 400mW **10p***
BRIDGE 1A 50V **25p*** 6A **£1.00***

TRANSISTORS
BC107 108 or 109 ALL **9p***
BC107B **15p***
BC108B or C **15p***
BC109B or C **15p***
BC147/8/9 **12p**
BC167/8/9 **10p**
BC177/8 9 **20p***
BC182/3/4 A or L **10p**
BC212/3/4 A or L **14p**
BCY70/71/72 **20p***
BD131 or 132, ea **39p***
BFY50, 51 or 52 **20p***
MJ2955 (PNP3055) **£1.50***
MJE2955 **£1.40***
MJE3055 **55p***
ORP12 **50p***
TIP29, 30 31, 32C **60p***
TIP41A OR 42A **65p***
TIP41C or 42C **£1.00***
TIP2955 **65p***
TIP3055 **55p***
TIP43 UJT **30p**
2N2646 UJT **50p***
2N2904 ORS **30p***
2N2926 YG **15p***
2N3053 **24p***
2N3055 115W **45p***
2N3442 120V 3055 **£1.50***
2N3702/3/5/6 **10p**
2N3704 **9p**
2N3819E or 23E **18p**
2N3904/5/6 **20p**
2N5457 FET **50p**
INS BUSH SETS, EA **10p***
MATCHING ADD **20p***

FULL SPEC. PAKS
PAK A 10 x LEDS **£1.00***
PAK B 4 x 741G **£1.00***
PAK C 3 x 2N3055 **£1.00***
PAK H 6 x 2N3819E **£1.00***
PAK K 40 x 1N914 **£1.00***
PAK N 25 x OA81/91 **£1.00***
PAK M 3 x 2 AMP, PNP/NPN PAIRS 60 VOLT (TOTAL 6) **£1.00***
PAK W 20 x MIXED 10V ELECTROLYTIC 2—100uf **£1.00**
MORE PAKS IN FREE LISTS

SCR & TRIACS: ST2 **25p***
BR100 **40p***
C106 4A 400V **55p***
1A 400V **50p*** 1A 600V **69p***
DISCO TRIAC 10A 400V **80p***
VERO. All stocked 0 1"
2½" x 3¾" **42p*** 3¾" x 5" **56p***
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6" x 4" DIL BREADBOARD **£2.44***
POTS **25p.** PRESETS **9p.** RESISTORS **2p. CAPACITORS:** CERAMIC **5p.** ELECTROLYTIC, 1uf-100uf **7p.**
HEATSINKS TO18/TO5 **5p***
TO3 **29p***
SOLDER DISPENSER 18SWG **35p***
SOLDERCON 100 **45p***
1000 **£4***
DIL SOCKETS 8 or 14 or 16 **15p***
CMOS: Many stocked i e
4001 or 2 **23p***
4009/10 **59p***
4011 **20p*** 4049 or 69 **23p***

TTL 7400N SERIES
7400 **14p*** 7490 **49p***
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7404 **20p*** 7493/5 **50p***
7408/9 **10p*** 74107 **20p***
7413 **39p*** 74121 **33p***
7417/20 **29p*** 74123 **39p***
7430 **8p*** 74141 **60p***
7440 **15p*** 74157 **50p***
7441 **79p*** 74193 **50p***
7447 **84p***
7448 **60p***
7470/72 **29p***
7473/74 **35p***
7475 **40p***
7476 **39p***
7480/2/3 **10p***
7485/86 **10p***

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Better instruments. Better service.

We have established a nationwide network of approved service organisations to deal with the repair and maintenance of our instruments. Every repair is backed by a full 12 month guarantee. Here's where to find them.

ENGLAND London Instrument Repair Centre, Acton Lane, Chiswick, London W4 5HJ Trade Reception. Cunnington Street Tel: 01-995 9212
London Instrument Repair Centre, Archcliffe Road, Dover, Kent Tel: Dover (0304) 202620
Farnell International Instruments Ltd., Sandbeck Way, Wetherby, West Yorkshire LS22 4DH. Tel Wetherby (0937) 3541
T.E.R Instrumemnts Ltd, Peel Lane, Astley, Manchester M29 7JH. Tel: Atherton (05234) 2275 or 5611
Midlands Instrument Repair Centre, Thorn Automation Ltd., Armitage Road, Rugeley, Staffs Tel: Rugeley (08894) 5151

SCOTLAND Falcon Electronics, 92 High Street, Johnstone, Scotland Tel: Johnstone (0505) 23377

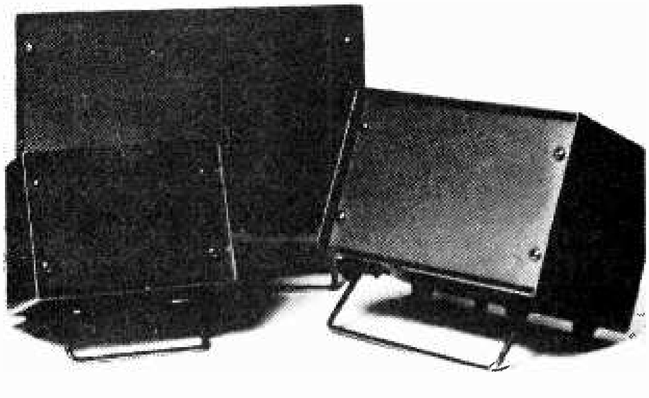
WALES Electro Services, 25 Chepstow Road, Newport, Gwent NPT 8BX Tel: Newport (0633) 211243

LIRC LONDON INSTRUMENT REPAIR CENTRE

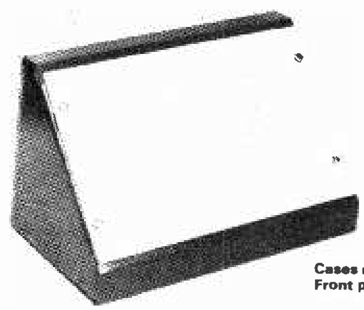
The manufacturers' joint service organisation.

WW—040 FOR FURTHER DETAILS

OLSON MINICASES



Type	Overall Dimension Width	Height	Depth	Case no vents	Case with vents	Chrome leg
21	6½''	4½''	4½''	—	4.75	1.00
22	8½''	5½''	5½''	—	5.35	1.00
23	10½''	6½''	6½''	—	6.35	1.05
24	12½''	7½''	7½''	—	6.95	1.05
25A	6½''	4½''	4½''	4.60	5.15	1.05
25B	6½''	4½''	6¼''	4.85	5.40	1.05
26A	8¾''	5¾''	6¼''	6.50	7.05	1.05
26B	8¾''	5¾''	8¼''	6.83	7.38	1.05
27A	12¼''	7½''	5½''	7.10	7.75	1.05
27B	12¼''	7½''	8''	7.70	8.35	1.05
28A	14''	10½''	6½''	8.40	9.05	—
28B	14''	10½''	8½''	9.13	9.78	—
29A	10''	4''	6''	5.88	6.43	1.05
29B	10''	4''	8''	6.20	6.75	1.05
30A	12''	5''	6''	6.40	7.05	1.05
30B	12''	5''	8''	6.70	7.35	1.05
31A	14''	6''	6''	7.00	7.65	1.05
31B	14''	6''	8''	7.35	8.00	1.05
61	15½''	7½''	9½''	—	10.60	—
62	17½''	8½''	9½''	—	12.35	—
63	16½''	9½''	9½''	—	12.35	—
64	15½''	7½''	12½''	—	12.35	—
65	17½''	8½''	12½''	—	14.00	—
66	16½''	9½''	12½''	—	14.00	—

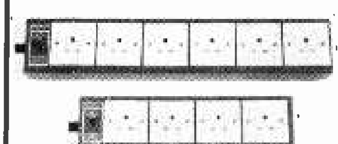


NEW OLSON SLOPING CASES

Cases made from 20G steel
Front panels made from 20G aluminium

Type	Panel Dim	Depth	Height	Price
1	150 m/m x 100 m/m	95 m/m	95 m/m	£1.95p
2	200 m/m x 100 m/m	95 m/m	95 m/m	£2.25p
3	250 m/m x 100 m/m	95 m/m	95 m/m	£2.75p

PORTABLE POWER DISTRIBUTION FOR INSTANT MAINS!



COMPLETE WITH 6FT. CABLE AND 13 AMP FUSED PLUG

4 sockets 13A £9.75
6 sockets 13A £11.50
4 sockets 13A switched ... £11.25
6 sockets 13A switched ... £12.50

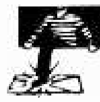
ALL DISTRIBUTION PANELS ARE FITTED WITH MK SOCKETS & PLUG

Send for details of complete range

OLSON ELECTRONICS LTD., FACTORY NO. 8, 5-7 LONG ST., LONDON E2 8HJ TEL: 01-739 2343

WW — 083 FOR FURTHER DETAILS

SWITCH TRIGGER MATS



So thin is undetectable under carpet but will switch on with slightest pressure For burglar alarms, shop doors, etc 24in × 18in **£2.33.** Post and VAT 60p 13in × 10in **£1.85.** Post and VAT 50p

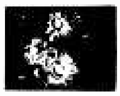
DRILL CONTROLLER

Electronically changes speed from approximately 10 revs to maximum Full power at all speeds by finger-tip control. Kit includes all parts, case, everything and full instructions. **£3.45** including post and VAT Made-up model **£1** extra.

MAINS TRANSISTOR PACK

Designed to operate transistor sets and amplifiers Adjustable output 6V, 9V, 12V for up to 500mA (class D working). Takes the places of any of the following batteries· PP1, PP3, PP4, PP6, PP7, PP9 and others Kit comprises main transformer rectifier, smoothing and load resistor condensers and instructions Real snip at only **£1.50.** VAT and postage 50p

SOUND TO LIGHT UNIT

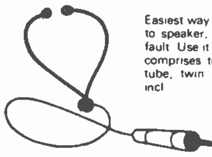


Add colour or white light to your amplifier. Will operate 1, 2 or 3 lamps (maximum 450W). Unit in box all ready to work **£7.95** plus 95p VAT and postage

MICRO SWITCH BARGAINS

Rated at 5 amps 250V. ideal to make a switch panel for a calculator and for dozens of other applications Parcel of 10 for **£1.** VAT and post paid

RADIO STETHOSCOPE



Easiest way to fault find, traces, signal from aerial to speaker, when signal stops you've found the fault Use it on Radio, TV, amplifier, anything Kit comprises transistors and parts including probe tube, twin stetho-set **£3.95** VAT and postage incl

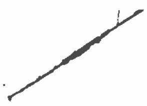
MULTISPEED MOTORS

Six speeds are available 500, 850 and 1,100 r.p.m and 7,000, 9,000 and 11,000 r.p m Shaft is ⅜ in diameter and approximately 1 in long 230/240V Its speed may be further controlled with the use of our Thyristor controller Very powerful and useful motor size approx 2 in dia × 5 in long Price **£2** including post and VAT

MAINS RELAYS

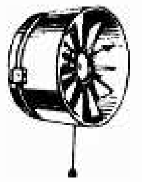
With triple 10 amp changeover contacts — operating coil wound for 230V a c, chassis mounting, one screw fixing, ex unused equipment **60p** each, 10 for **£5** post and VAT paid

TELESCOPIC AERIALS



for portable car radio or transmitter. Chrome plated — six sections, extends from 7½ to 47in **50p** + 15p post and VAT K LEO MODEL FOR F M **80p** + 17p post and VAT

EXTRACTOR FAN



Cleans the air at the rate of 10,000 cubic feet per hour Suitable for kitchens, bathrooms, factories, changing rooms, etc It s so quiet it can hardly be heard Compact, 5½in casing comprises motor, fan blades, sheet-steel casing, pull switch, mains connector and fixing brackets **£5.25** including post and VAT.
Monthly list available free. send long stamped envelope

BLACK LIGHT

As used in discos and stage effects etc — virtually no white light appears until rays impinge on white collars and cuffs, etc — we offer mains B L lamps, 175 watts plugs into any lamp holder requires no choke or control gear price **£7** + 95p post and VAT or for glamorising rock specimens, looking for watermarks, etc , a 9in 6 watt tube with starter, choke lamp holds, etc , all for **£4.50** post and VAT paid.

NEED A SPECIAL SWITCH

Double lead contact Very slight pressure, closes both contacts **12p** each . . Plastic push-rod supplied for operating **10p** each, 10 for **85p.**

HUMIDITY SWITCH

American made by Ranco, their type No J11. The action of this device depends upon the dampness causing a membrane to stretch and trigger a sensitive microswitch adjustable by a screw, quite sensitive — breathing on it for instance will switch it on Micro 3 amp at 250V a c. Overall size of the device approx 3⅜in long 1in wide and 1⅜in deep. **65p.**

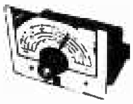
PP3/PP9 REPLACEMENT

Japanese made in plastic container with leads size 2in × 1½in × 1½in, this is ideal to power a calculator or radio, it has a full wave rectifier and smoothed output of 9V suitable for loading of up to 100m A **£2.53.**

MULLARD UNILEX

A mains operated 4 + 4 stereo system. Rated one of the finest performers in the stereo field this would make a wonderful gift for almost any one in easy-to-assemble modular form and complete with a pair of Plessey speakers this should sell at about £30 — but due to a special bulk buy and as an incentive for you to buy this month we offer the system complete at only **£14** including VAT and postage

SHORTWAVE CRYSTAL SET



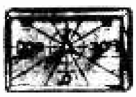
Although this uses no battery it gives really amazing results. You will receive an amazing assortment of stations over the 19, 25, 29, 31 metre bands Kit contains chassis front panel and all the parts **£1.90** — crystal earphone **55p** including VAT and postage.

DISTRIBUTION PANELS

Just what you need for work bench or lab 4 × 13 amp sockets in metal box to take standard 13-amp fused plugs and on/off switch with neon warning light Supplied complete with 6 feet of flex cable Wired up ready to work **£2.75**, VAT and postage 85p

25A ELECTRIC PROGRAMMER

Learn in your sleep Have radio playing and kettle boiling as you wake — switch on lights to ward off intruders — have a warm house to come home to All these and many other things you can do if you invest in an electrical programmer Clock by famous maker with 15 amp on/off switch Switch-on time can be set anywhere to stay on up to 6 hours Independent 60 minute memory jogger



A beautiful unit Price **£2.95.** VAT and postage 60p, or with glass front, chrome bezel **£1.50** extra

WINDSCREEN WIPER CONTROL

Vary speed of your wiper to suit conditions All parts and instructions to make **£3.75** post and VAT paid

THIS MONTH'S SNIP

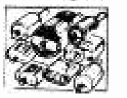
Breakdown Parcel — four unused, made for computon units containing most useful computers and these computers like those from most computer panels have wire end and of usable length The transistors for instance have leads over 1in long — the diodes have ½in leads

List of the major components is as follows 17 assorted transistors, 38 assorted diodes, 60 assorted resistors and condensers, 4 gold plated plugs in units which can serve as multipin plugs or as hook up boards for experimental or quickly changed circuits (note we can supply the socket boards which were made to receive these units) The price of this four units parcel is **£1** including VAT and post (considerably less than value of the transistor or diodes alone) DON'T MISS THIS SPLENDID OFFER

MOTORISED DISCO SWITCH

With six 10 amp changeover switches Multi adjustable switches are rated at 10 amp each so a total of 200W can be controlled and this would provide a magnificent display For mains operating **£4.25** post and VAT paid Ditto 9 switch **£4.95** post and VAT paid Ditto but 12 switch **£5.75** post and VAT paid

8 POWERFUL BATTERY MOTORS



For models Meccanos drills remote control planes, boats, etc., **£2.**

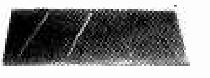
ROTARY PUMP

Self priming, portable, fits drill or electric motor, pumps up to 200 gallons per hour depending upon revs Virtually uncorrodable, use to suck water, oil, petrol fertiliser, chemicals anything liquid Hose connectors each end **£2** post paid.

MERCURY BATTERIES

Bank of 7 Mercury cells type 625 which are approx ⅝in dimeter by ⅞in thick in plastic tube giving a total of 10 7V
Being in a plastic tube it is very easy to break up the battery into separate cells and use these for radio control and similar equipment Carton of 25 batteries **£1.60**

RECTANGULAR HOT PLATE



Aluminium panel with ridged top and angled underneath to strength en it This is approx 10" × 4½" of flat plate Beneath please is 100w element and sensor switch which will maintain the surface of the plate just too hot to touch With leads and tags This is ideal if you are making up a food warmer or for an airing cupboard etc **Price £1.03.**

TERMS:
Cash with order — under **£6** must add 50p to offset packing etc BULK ENQUIRIES INVITED. Tel 01-688 1833

J. BULL (ELECTRICAL) LTD.
(Dept. WW), 103 TAMWORTH ROAD CROYDON CR9 1SG

IT'S FREE
Our monthly Advance Advertising Bargains List gives details of bargains arriving or just arrived — often bargains which sell out before our advertisement can appear — it's an interesting list and it's free — just send S.A.E. Below are a few of the Bargains still available from previous lines.

Rigonda "Party Time" Stereo Record Players. A further batch has just arrived, but we have a lot of outstanding orders and so we urge you if you want one, to call in or post your order right away As with the first batch all are 'returns under guarantee' or service room rejects,'' but we guarantee them to be repairable, and will exchange any not so Price is only **£5.95** + 75p. Carriage £2 00 + 25p, this is of course less than the price of a turntable, so they are a very popular item, hence the urgency for ordering quickly
Spares; for Party Times. Circuit diagrams — **50p,** Cartridges **£2.25,** Record mats **85p,** Mains transformers **£3.00,** Amplifiers **£2.50,** Gram motors **£3.00.** Ask about any other spares you require — and when you have it working o.k we can supply the proper Party Time speakers. **£9.50** a pair All prices include post and V A T
This Month's Special Offer: All our stocks of 7.029 cable with earth wire have now been sold, but we still have some of the twin left — we are offering this at about half its trade price, namely **£8.50** + 72p for 100 metres, also as an ~~extra inducement~~ to buy, during August and September, with every coil we will give free 100 metres of single 1 5mm which you can use as the earth wire If not collecting, please add £3.00 carriage
250-watt Mains Transformer. 40v secondary, made up of four 10v sections, all the ends of which are brought out to the tag panel, so they can be separated if required — also the 10v coils are all a very heavy gauge wire, thick enough to take 25 amps, so any one of these coils can be loaded up to the full 250 watts, or this wattage can be spread over two or more coils We can recommend this transformer for heavy/duty battery charging — high-power amplifier — plastic sealing — soil heating — light welding and dozens of other jobs Price, ~~still~~ only **£4.50** + 36p. Post ~~£1.50~~ + 12p
Flex Bargain. 3 core of ~~14/0 006~~, modern coloured cores White circular p v.c outer A standard flex for appliances using up to 6 amps or for extensions, leads, etc. Special purchase enables us to offer this at **£8.50** for 100mm coils (+ 68p) Post £1 50 + 12p
Save Yourself A Fortune. ~~Build~~ your own rechargeable batteries, using our ex-Home Office ~~nickel~~ cadmium cells — these cells are German made, ref NCB 22M, which ~~we understand are ½ amp hour~~ rating Normally, these cells retail at about £1 00 each, but a special purchase enables us to offer them at only **30p** each, or four for **£1.08.** Post 30p + 3p **Free Gift:** All who purchase ~~12 cells~~, will receive free of charge, a mains operator ni cad charger unit DON'T miss this offer
Self Repairing Fuses. Not exactly, but our magnetic circuit breakers do the same job and are a boon for the test bench, saving valuable time In the event of a short, they trip almost instantly, before the fuse can blow They are rated at 1 5 amps (enough for the average repair bench) Simply wire it in parallel with your bench switch — you would then use the circuit breaker to switch bench supply on, but keep your normal switch for loads over 1 5 amps — a real bargain @ **£1.00** + 8p
9v-0-9v Mains Transformer. "C" core construction, ½ amp continuous rating Very compact, but there is still room to add a few extra turns for an extra winding, or to change the voltage to, say, 20v In fact, the transformer uses a separate bobbin for the secondary — it s not varnished so if you want a special voltage transformer quickly, then this could be the answer Price **£1.50** + 12p Post 20p + 2p
6.5v-0-6.5v Mains Transformer. Continental make, but has standard 230/40v50hz primary and is upright mounting, and is rated at 0 75A Price **£1.75** + 14p. Post 20p + 2p.
15 Core Flex Cables. Coloured coded cores, rated at 3 amp, with circular p.v c outer — suitable for module inter-connections, etc 10-metre coil **£1.00** + 8p
Vacuum Relay. American made (EIMEC), ref no V S 2. This has a change over action and looks suitable for aerial switching and similar applications Price **£2.50** + 20p Post £0 60 + 5p Operation is by coil over one arm — we do not include the coil, nor do we have any in stock, but they are promised, watch future Newsletters for details
Rotary Switch. Heavy duty — made for switching d c , these will make and break really high a c currents We guess these at 30 or more amp — we have type (A) cover engraved on/off Price **£1.00** — (B) cover engraved 'on,' 'high,' 'off,' 'low" Six wires can be brought to the switch and would be joined as follows· 1 to 5 and 6 to 2 and in the other position, 1 to 3 and 2 to 4 Prices. (A) **£1.00** + 8p (B) **£1.50** + 12p
Motor with Fan Blades, mains operated, nicely made motor with long bearing for quiet operation and good quality set of fan blades, made by Smiths (air moving division) It is a simple matter to make a stand out of 14 gauge (clothes line) wire, you then have a simple but efficient desk fan Or if you fit this behind a heating element, in a box, you have a fan heater Price of motor and fan, **£2.50** + 32p. Post 50p + 6p.
Mains Driven Blowers: all have square or oblong outlets for easy fitting to cabinet or trunking. We have a small one, outlet size approximately 2" square, made by Woods This is a centrifugal type of blower Price **£4.00** + 50p Post 20p + 3p We also have a larger unit, made by Smiths, outlet size 3" x 3½" Actually it is a simple matter to stand this on a shelf or counter, put a few paper streamers to the outlet and you start feeling cooler at once. The motor and blades are out of harm s way inside the casing. Price **£5.75** + 46p. Post 80p + 6p
Industrial Size Centrifugal Fan, in a pressed steel housing, the motor for this is approximately 1/10 h p so it does give a very considerable air flow, but with little noise The outlet measures 10½" × 4" and this moves enough air for a large house, or medium sized office block A simple trunking connecting various rooms to this can either extract the old air or bring in fresh air, depending on how you fix it Price **£12.50** + £1 00 Carriage £2 00 + 60p
Solenoid Valves, for controlling water spraying, etc These have hose connectors on outlets and inlets. Price **£2.50** + 20p
Louvre or Ventilator Opening and Closing Motor. This is a mains motor with gearbox coupled to lever which travels through approximately 300° It has limit switches at both ends of travel Intended for the automatic control of air conditioning louvres or ventilators, made by Satchwell, technically known as ZPM modulation motor Price **£25.00** + £2 00 Post £0 60 + 5p
This Month's Special Lighting Snips — camping or emergency lights, all made up ready to join to your 12v car battery Two models — 21" 13w Price **£3.00** + 24p. Post 60p + 5p, and 12", 8w. Price **£2.75** + 22p. Post 50p + 4p
Once Only Hi-Fi Offer. The "Intermezzo 3-unit audio — a really top-class outfit which will please even the most discerning hi-fi enthusiast Most important is the record deck, this is a belt-driven transcription type, semi-automatic with manual override facility and a 5½lb turntable. Three speeds, with variable vernier speed control and illuminated stroboscope for 33 r p m It has a tubular pick-up arm with variable weight and adjustable bias controls It also has a magnetic pick-up cartridge with dimaond styli
The Speakers — wooden enclosures each with 7½" bass unit and a 4" mid range/tweeter unit, acoustically padded with cross over network incorporated
The Amplifiers are fully transistorised and have maximum output power of 10 watt per channel, overall frequency response within 60-18000 Hz ÷ 2dB Sensitivity on gram, 5 m v and on aux 250 m v and on radio, 25 m v. Power supply 240-220-127-110 volts A C 50 Hz Price **£69.50,** which is a real bargain V.A T £8 68
We are not quoting a price for carriage as we hope purchasers will call and collect — ten only available . so call on us now
Large Panel Mounting Moving Coil Meter. Size 5" × 4" 200 -0- 200 uA It has a plain scale also it is a fairly easy job to reset the pointer to the left hand zero position and thus obtain a 0/400 uA movement. Made by Sangamo Weston. Price **£3.95** + 32p Post 25p + 2p
Galvanometer 7-0-7 uA f.s.d. Moving coil precision laboratory instrument of extremely high sensitivity (0 3 uA per division) Size approx 6½" × 2½" × 2" Price **£7.50** + 60p
Acos 'G' Meters. For use with transducers and accerometers These are precision instruments. They measure G in three steps 0-10, 0-100 and 0-1000 directly on a large scale 0-1 Two models are available An inbuilt circuit with relays to trip the external circuit (trip level) is adjustable by a control which is virtually linear with the meter scale The trip load may be up to 2A Once the circuit has been tripped, it can be re-set by use of a reset button Price **£10.00** + 80p.
0-1 mA Panel Meter, ~~clear plastic front, Approx~~ 1½" square Price **£2.50** + 20p
Panel Meter 0-250 uA — British make — 3" square bakelite case flush mounting. Price **£2.50** each
0-100 Micro Amp Meter. Large oblong full vision front Size 4¼" × 3¼" approx Good quality Japanese made, moving coil meter Price **£4.50** + 36p
Balance Meter. 100 uA Centre zero Edgewise mounting. Price **£1.50** + 12p

BI-PAK

High quality modules for stereo, mono and other audio equipment.

NEW

PUSH-BUTTON STEREO FM TUNER

Fitted with Phase Lock-loop Decoder

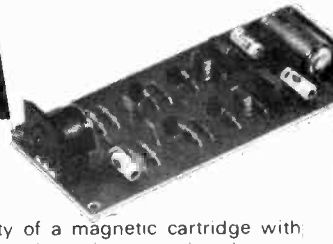
OUR PRICE ONLY
£20.45

The 450 Tuner provides instant program selection at the touch of a button ensuring accurate tuning of 4 pre-selected stations, any of which may be altered as often as you choose, by simply changing the settings of the pre-set controls.
Used with your existing audio equipment or with the BI-KITS **STEREO 30** or the **MK60** Kit etc. Alternatively the **PS12** can be used if no suitable supply is available, together with the Transformer **T538**.
The S450 is supplied fully built, tested and aligned. The unit is easily installed using the simple instructions supplied.

★ FET Input Stage
★ VARI-CAP diode tuning
★ Switched AFC
★ Multi turn pre-sets
★ LED Stereo Indicator

Typical Specification:
Sensitivity 3μ volts
Stereo separation 30db
Supply required 20-30v at 90 Ma max.

MPA 30



Enjoy the quality of a magnetic cartridge with your existing ceramic equipment using the new M.P.A. 30, a high quality pre-amplifier enabling magnetic cartridges to be used where facilities exist for the use of ceramic cartridges only.
It is provided with a standard DIN input socket for ease of connection. Full instructions supplied.

£2.85

VAT ADD 12½%

POSTAGE & PACKING
Postage & Packing add 25p unless otherwise shown. Add extra for airmail. Min. £1.00

STEREO PRE-AMPLIFIER PA100

OUR PRICE £13.75

A top quality stereo pre-amplifier and tone control unit. The six push-button selector switch provides a choice of inputs together with two really effective filters for high and low frequencies, plus tape output.

Frequency Response + 1dB 20Hz 20KHz. Sensitivity of inputs
1. Tape Input 100mV into 100K ohms
2. Radio Tuner 100mV into 100K ohms
3. Magnetic P.U. 3mV into 50K ohms

P.U. Input equalises to R1AA curve with 1dB from 20Hz to 20KHz
Supply — 20-35V at 20mA
Dimensions — 299mm x 89mm x 35mm.

MK. 60 AUDIO KIT: Comprising 2 x AL60's. 1 x SPM80. 1 x BTM80. 1 x PA100. 1 front panel and knobs. 1 Kit of parts to include on/off switch, neon indicator, stereo headphone sockets plus instruction booklet. **COMPLETE PRICE £34.90** plus 85p postage.

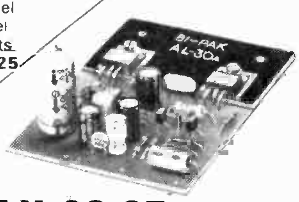
TEAK 60 AUDIO KIT:
Comprising: Teak veneered cabinet size 16¾"x11½"x3¾", other parts include aluminium chassis, heatsink and front panel bracket plus back panel and appropriate sockets etc. **KIT PRICE £13.25** plus 85p postage.

NEW AL30A

10w R.M.S. AUDIO AMPLIFIER MODULE

The AL30A is a high quality audio amplifier module replacing our AL20 & 30. The versatility of its design makes it ideal for record players, tape recorders, stereo amps, cassette and cartridge players. A power supply is available comprising a PS12 together with a transformer T538, also for stereo, the pre-amp PA12.

SPECIFICATION:
● Output Power 10w. R.M.S.
● Supply 22 to 32 volts.
● Load Impedance 8 to 6ohms.
● Input Impedance 50K.
● Sensitivity 90mv for full output.
● Total Harmonic Distortion Less than .5% (Typically .3%).
● Frequency Response 60Hz to 25KHz ± 2db.
● Max. Heat Sink Temp 80°c.
● Dimensions 90 x 64 x 27mm



ONLY £3.65

STEREO 30

COMPLETE AUDIO

7+7 WATTS R.M.S.

P & P 45p

£16.25

The Stereo 30 comprises a complete stereo pre-amplifier, power amplifiers and power supply. This, with only the addition of a transformer or overwind will produce a high quality audio unit suitable for use with a wide range of inputs i.e. high quality ceramic pick-up, stereo tuner, stereo tape deck etc. Simple to install, capable of producing really first class results, this unit is supplied with full instructions, black front panel knobs, main switch, fuse and fuse holder and universal mounting brackets enabling it to be installed in a record plinth, cabinets of your own construction or the cabinet available. Ideal for the beginner or the advanced constructor who requires Hi-Fi performance with a minimum of installation difficulty (can be installed in 30 mins).

TRANSFORMER £3.25 plus 50p p & p
TEAK CASE £5.45 plus 70p p & p

AL 60 25 Watts (RMS)

★ Max Heat Sink temp 90C. ★ Frequency response 20Hz to 100KHz ★ Distortion better than 0.1 at 1KHz ★ Supply voltage 15-50v ★ Thermal Feedback ★ Latest Design Improvements ★ Load — 3,4,8, or 16 ohms ★ Signal to noise ratio 80db ★ Overall size 63mm. 105mm. 13mm.

Especially designed to a strict specification. Only the finest components have been used and the latest solid-state circuitry incorporated in this powerful little amplifier which should satisfy the most critical A.F. enthusiast.

£4.35

NEW PA12

NEW PA12 Stereo Pre-Amplifier completely redesigned for use with AL30A Amplifier Modules. Features include on/off volume. Balance, Bass and Treble controls. Complete with tape output.

Frequency Response 20Hz-20KHz (—3dB). Bass and Treble range 12dB. Input Impedence 1 meg ohm. Input Sensitivity 300mV. Supply requirements 24V.5mA. Size 152mm x 84mm x 33mm.

£6.70

PS12

Power supply for **AL30A, PA12, SA450,** etc.

Input voltage 15-20v A.C. Output voltage 22-30v D.C. Output current 800 mA Max. Size 60mm x 43mm x 26mm.
Transformer T538 £3.20

OUR PRICE £1.30

Stabilised Power Supply Type SPM80

SPM80 is especially designed to power 2 of the AL60 Amplifiers, up to 15 watts (R.M.S.) per channel simultaneously. With the addition of the Mains Transformer **BMT80,** the unit will provide outputs of up to 1.5A at 35V. Size: 63mm. 105mm. 30mm. Incorporating short circuit protection.
Transformer BMT80
£5.30 + 86p postage

£3.75

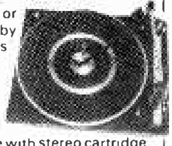
BI-PAK

P.O. BOX 6, WARE, HERTS.

SHOP AT 18 BALDOCK ST., WARE, HERTS
OPEN 9 to 5.30 Mon./Sat.

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

BSR HI-FI AUTOCHANGER
STEREO AND MONO £17.50 Post 75p



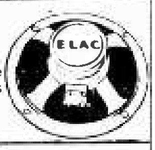
Plays 12", 10" or 7" records Auto or Manual A high quality unit backed by BSR reliability with 12 months guarantee A C 200/250V
Size 13½-11¼in 3 speeds
Above motor board 3¾in
Below motor board 2½in
with STEREO and MONO CARTRIDGE
B S R SINGLE PLAYER similar to above with stereo cartridge and cueing device, large turntable **£13.50**
B.S.R. P128 with magnetic cartridge Balanced arm Cueing device Bias Compensator **£24.50.** Post £1

PORTABLE PLAYER CABINET
Modern design. Rexine covered
Vynair front grille Chrome fittings
Size 17 x 15 x 8in. approx **£4.50** Post 75p
Motor board cut for BSR or Garrard deck

HEAVY METAL PLINTHS
With P V C Cover Cut out for most B S R or Garrard decks. Silver grey finish **£6.50** Post £1 50
Model A Size 12½ x 14¾ x 7½in
Model B Size 16 x 13¾ x 7in **£7.50**
Extra large plinth & cover teak wood base Size 20"x17½"x9" **£19.50.** Callers only

COMPLETE STEREO SYSTEM
Two full size loudspeakers 13¾ x 10 x 3¾in Player unit clips to loudspeakers making it extremely compact, overall size only 13¾ x 10 x 8½in, 3 watts per channel, plays all records 33 r p m, 45 r p m Separate volume and tone controls Attractive Teak finish 240V a c mains **£22.50** £1 carriage

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 15 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 and fully guaranteed

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

R.C.S. "MINOR" 10 watt AMPLIFIER KIT
This kit is suitable for record players, guitars, tape playback, electronic instruments or small P A systems Two versions available Mono. **£11.25;** Stereo. **£18.** Post 45p Specification 10W per channel; input 100mV. size 9½ x 3 x 2in approx S.A.E details. Full instructions supplied. AC mains powered

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

80 Ohm Coax 8p yd.
FRINGE LOW LOSS **15p** yd.
Ideal 625 and colour
PLUGS **10p.** SOCKETS **10p.**
LINE SOCKETS **18p.**
OUTLET BOXES **50p.**

ELAC 9 x 5in HI-FI SPEAKER TYPE 59RM £3.45 Post 35p
This famous unit now available 10 watts. 8 ohm

E.M.I. 13½ x 8in. SPEAKER SALE!

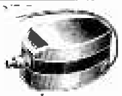
With tweeter and crossover 10 watt State 3 or 8 ohm As illustrated **£7.95** Post 45p

Ditto 15 watts. 8 ohm **£10.50** Post 65p

With tweeter and crossover. 20 watts Bass res 25 c p s Flux = 11,000 gauss 4 or 8 or 15 ohm. 20 to 20,000 c p s **£11.50** Post 75p

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

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



R.C.S. SOUND TO LIGHT KIT. £14
Kit of parts to build a 3 channel sound to light unit 1,000 watts per channel. Post 35p
Easy to build Full instructions supplied Cabinet **£3.**

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

R.C.S. POWER PACK KIT £3.35
12 VOLT. 750mA. Complete with printed circuit board and assembly instructions Post 30p
12 VOLT 300mA KIT. **£3.15.** 9 VOLT 1 AMP KIT. **£3.35.**

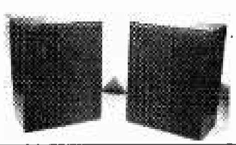
R.C.S. GENERAL PURPOSE TRANSISTOR PRE-AMPLIFIER — BRITISH MADE
Ideal for Mike, Tape, P U. Guitar, etc Can be used with battery 9-12V or H T line 200-300V d c operation Size 1¾ x 1¼ x ⅝in Response 25 c/s to 25 kc/s 26 dB gain
For use with valve or transistor equipment. **£1.45**
Full instructions supplied Details S A E Post 30p

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

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

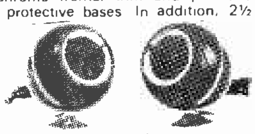
MAINS TRANSFORMERS ALL POST 50p 250-0-250V 70mA. 6.5V. 2A **£3.45.** 250-0-250V 80mA. 6 3V 3.5A. 6 3V 1A or 5V 2A **£4.60.** 350-0-350V 80mA. 6 3V 3 5A. 6 3V 1A or 5V 2A **£5.80.** 300-0-300V 120mA. 2×6 3V 2A C T. 5V 2A **£8.50.** 220V 45mA. 6 3V 2A **£1.75.** HEATED TRANS. 6 3V ½ amp **£1;** 3 amp **£1.40.** GENERAL PURPOSE LOW VOLTAGE Tapped outputs at 2 amp 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 25 and 30V **£5.30.** 1 amp 6, 8, 10, 12, 16, 18 20, 24, 30, 36, 40, 48, 60 **£5.30.** 2 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30 36, 40, 48, 60 **£8.50.** 3 amp 6, 8, 10, 12, 16, 18 20, 24 30, 36, 40, 48, 60 **£11.00.** 5 amp 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40 48, 60 **£14.50.** 12V 100mA **£1,** 9V 1 amp **£1,** 12V 300mA. **£1,** 12V 750mA. **£1,** 10V, 30V, 40V, 2 amp.. **£2.75,** 20V, 3 amp. **£2.45,** 40V, 2 amp., **£2.95,** 30V 5A and 34V 2ACT **£3.45,** 0, 5, 8 10, 16V, ½ amp, **£1.95,** 20V ½ amp. **£1.75,** 20V, 1 amp. **£2.20,** 20V 3 amp.. **£2.50,** 20-0-20V 1 amp, **£2.95,** 30V 1½ amp, **£2.75;** 20V, 40V, 60V or 20-0-20V, 1 amp. **£3.50.** 30-0-30V 3 amp **£7.** 2 × 18V 6 amp **£11.00.**
AUTO TRANSFORMERS 115V to 230V or 230V to 115V 150W **£5;** 250W **£6;** 400W **£7;** 500W **£8.** FULL WAVE BRIDGE CHARGER RECTIFIERS 6 or 12V outputs. 1½ amp **40p;** 2 amp **55p;** 4 amp **85p.** CHARGER TRANSFORMERS 1½ amp **£2.75;** 4 amp **£4.60.** 12V 1½A HALF WAVE Selenium Rectifier, **25p.**

R.C.S. BOOKSHELF SPEAKERS



13 × 10 × 6in
50 to 14 000 cps
8 watts rms 4, 8 or 16 ohms
£16 pair Post £1 30

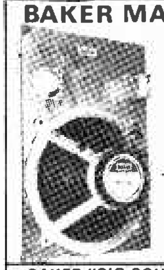
GLOBAL SPEAKERS £4.95 ea.
These little marvels of modern sound reproduction are ideally suited for today's domestic audio set-up. Two of these smart spheres, each with 5 watt deep throated ceramic magnets, will produce superb stereo reproduction.
The globe shaped cases in high gloss mouldings of red and 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.
Frequency Response: 100-20,000 Hz
Impedance: 8 ohms
Power Capacity 5 watts



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

SHORT WAVE 100pF air spaced gangable tuner, **95p.**
TRIMMERS 10pF, 30pF 50pF, **5p.** 100pF 150pF, **15p.**
CERAMIC, 1pF to 0 01mF, **5p.** Silver Mica 2 to 5000pF, **5p.**
PAPER 350V-0 1 **7p;** 0 5 **13p;** 1mF 150V **20p;** 2mF 150V **20p;** 500V-0 001 to 0 05 **5p;** 0 1 **10p;** 0 25 **13p;** 0 47 **25p.**
MICRO SWITCH SINGLE POLE CHANGEOVER 20p.
SUB-MIN MICRO SWITCH, 25p. Single pole change over
TWIN GANG, 385 + 385pF **50p;** 500pF standard **75p;** 365 + 365 + 25 + 25pF Slow motion drive **65p.**
120pF **TWIN GANG, 50p;** 365pF **TWIN GANG, 50p.**
NEON PANEL INDICATORS 250V. Amber or red **30p.**
RESISTORS. ¼W, ½W, 1W, 20% **2p;** 2W, **10p;** 10Ω to 10M
HIGH STABILITY. ½W 2% 10 ohms to 6 meg, **12p.**
Ditto 5% Preferred values 10 ohms to 10 meg, **5p.**
WIRE-WOUND RESISTORS 5 watt, 10 watt 15 watt, 10 ohms to 100K **12p** each

BAKER MAJOR 12" £15.00
Post £1 00



30-14,500 c/s 12in double cone woofer and tweeter cone together with a BAKER ceramic magnet assembly having a flux density of 14,000 gauss and a total flux of 145,000 Maxwells Bass resonance 40 c/s Rated 25W NOTE 4 or 8 or 16 ohms must be stated
Module kit 30-17 000 c/s with tweeter crossover baffle and instructions **£19.00** Post £1 60 each
Please state 4 or 8 or 16 ohms

BAKER "BIG-SOUND" SPEAKERS. Post £1 00 each

'Group 25'	'Group 35'	'Group 50/15'
12in 30W **£12.00** 4 or 8 or 16 ohm	12in 40W **£14.00** 4 or 8 or 16 ohm	15in 75W **£26.00** 8 or 16 ohm

BAKER LOUDSPEAKER, 12 INCH. 60 WATT. GROUP 50/12, 4 OR 8 OR 16 OHM HIGH POWER
FULL RANGE PROFESSIONAL QUALITY
RESPONSE 30-16 000 CPS **£21.00**
MASSIVE CERAMIC MAGNET WITH Post £1 60
ALUMINIUM PRESENCE CENTRE DOME

TEAK VENEERED HI-FI SPEAKERS AND CABINETS
For 12in or 10in speaker 20x13x12in **£14.50** Post £2
For 13x8in or 8in speaker **£8.50** Post £1
For 6½in speaker and tweeter 12x8x6in **£5.80** Post 75p
Many other cabinets in stock Phone your requirements
SPEAKER COVERING MATERIALS. Samples Large S A E
LOUDSPEAKER CABINET WADDING 18in wide **20p** ft

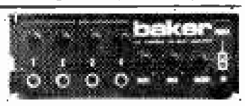
R.C.S. 100 watt VALVE AMPLIFIER CHASSIS

Four inputs Four way mixing, master volume, treble and bass controls Suits all speakers This professional quality amplifier chassis is suitable for all groups disco, P A, where high quality power is required 5 speaker outputs A/C mains operated Slave output socket Produced by demand for a quality valve amplifier. 100V line output to order Send for leaflet
Suitable carrying cab **£16.50** Price **£94** carr £2 50

Horn Tweeters 2 16kc/s. 10W 8 ohm or 16 ohm **£3.60**
De Luxe Horn Tweeters 3-18kc/s, 30W, 8 ohm, **£7.50.**
CROSSOVERS. TWO-WAY 3000 c/s 3 or 8 or 15 ohm **£1.90.** 3-way 950 cps/3000 cps, **£2.20.**
LOUDSPEAKERS P.M. 3 OHM 7x4in, **£1.50;** 6½in, **£1.80;** 8x5in, **£1.90;** 8in **£1.95.**
SPECIAL OFFER: 80 ohm 2¼in 2¾in, 35 ohm, 3in, 25 ohm, 2½in, 3in, 5x3in 7x4in, 8 ohm, 2½in, 3in, 3½in 5in 15 ohm, 3½in dia. 6x4in, 7x4in, 5x3in 3 ohm, 2⅝in, 3½in, 5in dia **£1.50** each
PHILIPS LOUDSPEAKER, 8in, 4 ohms 4 watts, **£1.95**
RICHARD ALLAN TWIN CONE LOUDSPEAKERS
8in diameter 4W **£2.50.** 10in diameter 5W **£2.95;** 12in diameter 6W **£3.50.** 3/8/15 ohms, please state
PIEZO ELECTRIC HORN TWEETER. Handles up to 100 watts No crossover required **£7.95.**

Tweeter Volume Control 15 ohms 10W with one inch long threaded bush for wood panel mounting ¼in spindle **65p.**

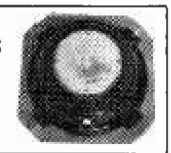
BAKER 150 WATT PROFESSIONAL MIXER AMPLIFIER



All purpose transistorised
Ideal for Groups Disco and P A 4 inputs speech and music 4 way mixing Output 4 8/16 ohms a c Mains Separate treble and bass controls Master volume control
Guaranteed Details S A E **£72** £1 50 carr

100 WATT DISCO AMPLIFIER
volume treble bass controls 500 M V or 1 volt input Four loudspeaker outputs 4 to 16 ohm All transistor **£59**

GOODMANS COMPACT 12-INCH BASS WOOFER



Standard 12in diameter fixing with cut sides 10⅜ square 14 000 Gauss magnet 30 watts R M S 4 ohm imp
Bass resonance = 30 cps
Frequency response 30-8000 c p s
£10.95 each Post £1

ALUMINIUM HEAT SINKS. FINNED TYPE.
Sizes 6½" × 4½" × 2¼" **95p.** 6½" × 2" × 2¼" **65p.**
BALANCED TWIN RIBBON FEEDER 300 ohms. 5p yd.
JACK SOCKET Std. open-circuit 20p, closed circuit 25p;
Chrome Lead-Socket 45p. Mono or Stereo.
Phono Plugs 8p. Phono Socket 8p.
JACK PLUGS Std. Chrome 30p; Plastic 25p; 3.5mm 15p.
STEREO JACK PLUG 30p. SOCKET 25p.
DIN SOCKETS Chassis 3-pin 10p. 5-pin 10p.
DIN SOCKETS FREE 3-pin 25p; 5-pin 25p. DIN PLUGS 3-pin 25p; 5-pin 25p. VALVE HOLDERS, 10p; CANS 10p.
TV CONVERGENCE POTS 15p each
Values = 5 7 10 20, 50 100, 200 250, 470, 2000 ohms

ELECTRO MAGNETIC PENDULUM MECHANISM
1.5V d c operation over 300 hours continuous on SP2 battery fully adjustable swing and speed Ideal displays, teaching electro magnetism or for metronome strobe etc **95p** Post 30p

★★★ SPECIAL OFFER ★★★
PERIOD LOUDSPEAKER CABINETS. Two styles available, Regency and Queen Anne. Size approximately 34 x 19 x 16in. These cabinets are slightly soiled and are priced from £10 each. Callers only.

BLANK ALUMINIUM CHASSIS. 6 x 4—**70p;** 8 x 6—**90p,** 10 x 7—**£1.15;** 12 x 8—**£1.35;** 14 x 9—**£1.50;** 16 x 6 **£1.45;** 16 x 10—**£1.70. ANGLE ALI.** 6 x ¾ x ¾in.—**15p.**
ALUMINIUM PANELS. 6 x 4—**17p;** 8 x 6—**24p;** 14 x 3—**25p;** 10 x 7—**35p;** 12 x 8—**43p;** 12 x 5—**30p;** 16 x 6—**43p;** 14 x 9—**52p;** 12 x 12—**68p;** 16 x 10—**75p.**
MANY ALI BOXES IN STOCK. MANY SIZES
VARICAP FM TUNER HEAD with circuit & connections **£4.95.**
TAG STRIP 28-way **12p.**
TAPE OSCILLATOR COIL. Valve type. **35p.**
BRIDGE RECTIFIER 200V PIV ½ amp **50p.**
TOGGLE SWITCHES S P **30p.** D P S T **40p.** D.P D T **50p.**
MANY OTHER TOGGLES IN STOCK
PICK-UP CARTRIDGES ACOS GP91 **£1.50.** GP93 **£2.50.**
SONOTONE stereo **£2.00. SHURE** M75 ECS **£8.**

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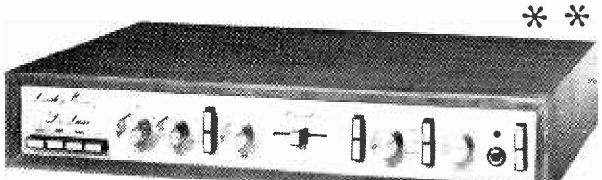
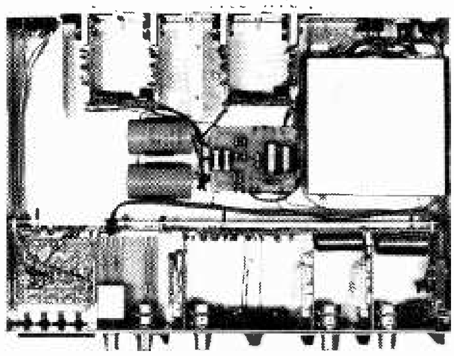
POWERTRAN AUDIO KIT SUPPLIERS TO THE WORLD

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



Available as Separate Packs

Details in Free Catalogue



Internal view of De Luxe Kit

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 for a very modest cost (just look at prices for comparable high quality high power ready-built units!) 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

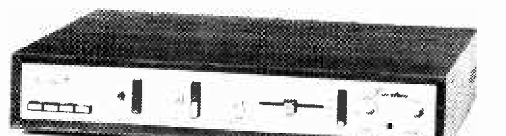
Our new De Luxe model uses 14 boards which interconnect with gold plated contacts and have the potentiometers and switches fitted to them There are 3 boards for each power amplifier 1 board for the power supply and 7 boards for the stereo pre amplifier This system almost eliminates internal wiring making construction 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 latest circuit improvements generously sized heatsinks 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	£10.95
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 (free with complete kit)	£0.30
16. Teak cabinet 18.3" x 12.7" x 3.1"	£10.70

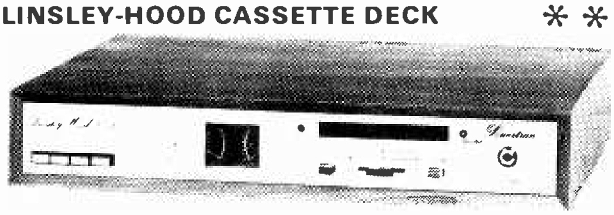
2 each of packs 1-7 inclusive are required for complete stereo amplifier. Total cost of individually purchased packs ... £90.80

STANDARD LINSLEY-HOOD 75W AMPLIFIER



SPECIAL PRICE FOR COMPLETE KIT £79.80

LINSLEY-HOOD CASSETTE DECK



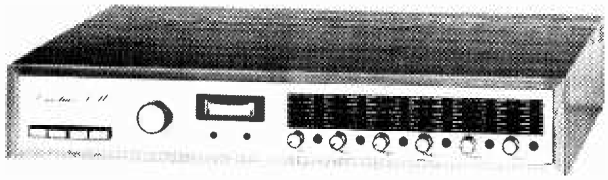
SPECIAL PRICE FOR COMPLETE KIT £79.60

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 for power supply (Powertran design)	£2.80
11. Set of miscellaneous parts. including sockets. fuse holder. fuses. interconnecting wire. etc	£3.40
12. Set of metalwork including silk screened fascia panel. internal screen. fixing parts. etc	£7.10
13. Construction notes	£0.25
14. Teak cabinet 18.3" x 12.7" x 3.1"	£10.70

One each of packs 1-14 inclusive are required for complete stereo cassette deck. Total cost of individually purchased packs £83.80

Published in Wireless World (May, June, August 1976) by Mr Linsley-Hood this design, although straightforward and relatively low cost nevertheless provides a very high standard of performance To permit circuit optimization separate record and replay amplifiers are used, the latter using a discrete component front-end designed such that the noise level is below that of the tape background. 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

WIRELESS WORLD FM TUNER



SPECIAL PRICE FOR COMPLETE KIT £70.20

Pack	Price
1. Fibreglass printed board for front end IF strip. demodulator, AFC and mute circuits	£2.15
2. Set of metal oxide resistors. thermistor. capacitors. cermet preset for mounting on Pack 1	£4.80
3. Set of transistors. diodes. LED. integrated circuits for mounting on Pack 1	£5.25
4. Pre-aligned front end module. cell assembly. three section ceramic filter	£8.50
5. Fibreglass printed circuit board for stereo decoder	£1.10
6. Set of metal oxide resistors. capacitors. cermet preset for decoder	£2.60
7. Set of transistors LED. integrated circuit for decoder	£2.90
8. Set of components for channel selector switch module including fibreglass printed circuit board. push-button switches. knobs. LEDs. preset adjusters, etc.	£9.40
9. Function switch. 10 turn tuning potentiometer. knobs	£5.80
10. Frequency meter. meter drive components. fibreglass printed circuit board	£10.35
11. Toroidal transformer with electrostatic screen. Primary: 0-117V 234V	£4.90
12. Set of capacitors. rectifiers. voltage regulator for power supply	£2.10
13. Set of miscellaneous parts. including sockets. fuse holder. fuses. inter-connecting wire. etc	£2.05
14. Set of metalwork parts including silk screen printed fascia panel. acrylic silk screen printed tuning indicator panel insert. internal screen. fixing parts. etc.	£8.30
15. Construction notes (free with complete kit)	£0.25
16. Teak cabinet 18.3" x 12.7" x 3.1"	£10.70

One each of packs 1-16 inclusive are required for complete stereo FM tuner. Total cost of individually purchased packs £81.15

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

EXPORT A SPECIALITY!

Our Export Department can readily despatch orders of any size to any country in the world Some of the countries to which we sent kits last year are shown in this advertisement To assist in estimating postal costs our catalogue gives the weights of all packs and kits This will be sent free on request, by airmail, together with our 'Export Postal Guide' which gives current postage prices

EXPORT ORDERS No minimum order charge! Prices same as for U K customers but no Value Added Tax charged Postage charged at actual cost plus 50p documentation and handling Please send payment with order by Bank Draft, Postal Order, International Money Order or cheque drawn on an account in the U K Alternatively for orders over £500 we will accept Irrevocable Letter of Credit payable at sight in London

OUR CATALOGUE IS FREE

JUST SEND YOUR NAME AND ADDRESS TO RECEIVE YOURS

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T20+20 AND T30+30 20W, 30W AMPLIFIERS

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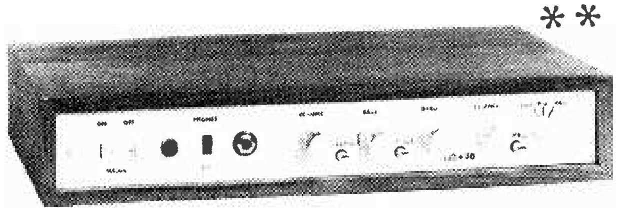

Designed by Texas engineers and described in Practical Wireless, the Texan was an immediate success. Now developed further in our laboratories to include a Toroidal transformer and additional improvements, the slimline T2D+20 delivers 20W rms per channel of true Hi-Fi at exceptionally low cost The easy to build design is based on a single F/Glass PCB and features all the normal facilities found on quality amplifiers including scratch and fumble filters, adaptable input selector and headphones socket In a follow-up article in Practical Wireless further modifications were suggested and these have been incorporated into the T30+30 These include RF interference filters and a tape monitor facility Power output of this model is 30W rms per channel

Pack	T20	T30
1. Set of low noise resistors ...	£1.60	£1.70
2. Set of small capacitors	£2.60	£3.40
3. Set of power supply capacitors	£2.20	£2.50
4. Set of miscellaneous parts ...	£3.50	£3.50
5. Set of slide. mains. P.B. switches	£1.50	£1.50
6. Set of pots., selector switch .	£2.80	£2.80
7. Set of semiconductors. ICs. skts.	£7.25	£7.75
8. Toroidal transformer—240V prim. e.s. screen	£5.60	£7.20

Pack	T20	T30
9. Fibreglass PCB	£3.50	£3.90
10. Set of metalwork. fixing parts	£5.20	£6.20
11. Set of cables. mains lead	£0.40	£0.40
12. Handbook (free with complete kit)	£0.25	£0.25
13. Teak cabinet 15.4" x 6.7" x 2.8"	£4.50	£4.50

One each of Pack 1-13 are required for complete stereo amplifier. Total cost of individually purchased packs T20+20 £40.90. T30+30 £45.60.

SPECIAL PRICES FOR COMPLETE KITS

T20+20 KIT PRICE £33.10   **T30+30 KIT PRICE £38.40**

WWII TUNER

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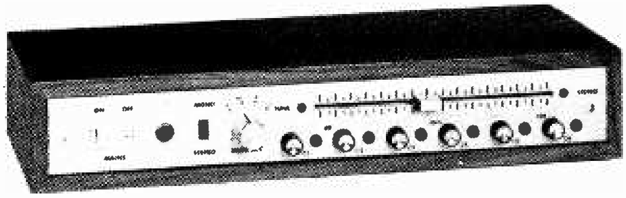

Following the success of our **Wireless World FM Tuner Kit** this cost reduced model was designed to complement the **T20+20** and **T30+30** amplifiers and the cabinet size, front panel format and electrical characteristics make this tuner compatible with either. The frequency meter of the more advanced model has been omitted and the mechanics simplified, however the circuitry is identical and this kit offers most outstanding value for money. Facilities included are switchable afc, adjustable, switchable muting, LED tuning indication and both continuous and push-button channel selection (readily adjusted by controls on the front panel)

SPECIAL PRICE FOR COMPLETE KIT £47.70 AVAILABLE AS SEPARATE PACKS – PRICES IN OUR FREE CATALOGUE

POWERTRAN S.F.M.T. TUNER

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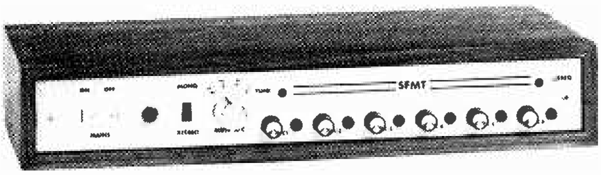

The requirement was a simple, low cost design which could be constructed easily without special alignment equipment but which still gives a first class output suitable for feeding any of our very popular amplifiers or any other high quality audio equipment Not finding a suitable published circuit, the requirement was met by design and development work in our own laboratories and this tuner, which uses a pre-aligned front end module can be set up with the aid of nothing more sophisticated than a multi-meter. A phase-locked-loop is used for stereo decoding and controls include switchable afc, switchable muting and push-button channel selection (adjustable by controls on the front panel). This unit matches well with the T20+20 and T30+30 amplifiers

PRICE FOR COMPLETE KIT £35.90 AVAILABLE AS COMPLETE KIT ONLY

Wireless World Amplifier Designs. Full kits are not available for these projects but component packs and PCBs are stocked for the highly regarded Bailey and 20W class AB Linsley-Hood designs together with an efficient regulated power supply of our own design Suitable for driving these amplifiers is the Bailey Burrows pre-amplifier and our circuit board, for the stereo version of it features 6 inputs, scratch and fumble filters and wide range tone controls, which may be either rotary or slider operating For tape systems a set of three PCBs have been prepared for the integrated circuit based, high performance stereo Stuart design Details of component packs are in our free Catalogue

30W Bailey Amplifier	
BAIL Pk 1 F/Glass PCB	£1.00
BAIL Pk 2 Resistors, Capacitors Potentiometer set	£2.35
BAIL Pk 3 Semiconductor set	£4.70
20W Linsley-Hood Class AB	
LHAB Pk 1 F/Glass PCB	£1.05
LHAB Pk 2 Resistor Capacitor Potentiometer set	£3.20
LHAB Pk 3 Semiconductor set	£3.35
Regulator Power Supply	
60VS Pk 1 F/Glass PCB	£0.85
60VS Pk 2 Resistor Capacitor set	£2.20
60VS Pk 3 Semiconductor set	£3.10
60VS Pk 6A Toroidal transformer (for use with Bailey)	£8.80
60VS Pk 6B Toroidal transformer (for use with 20W LH)	£7.25
Bailey Burrows Stereo Pre-Amp	
BBPA Pk 1 F/Glass PCB (stereo)	£2.80
BBPA Pk 2 Resistor Capacitor Semiconductor set (stereo)	£6.70
BBPA Pk 3R Rotary Potentiometer set (stereo)	£2.85
BBPA Pk 3S Slider Potentiometer set with knobs (stereo)	£3.10
Stuart Tape Recorder	
TRRP Pk 1 Replay Amp F/Glass PCB (stereo)	£1.30
TRRC Pk 1 Record Amp F/Glass PCB (stereo)	£1.70
TROS Pk 1 Bias Erase/Stabilizer F/Glass PCB (stereo)	£1.20

SQ QUADRAPHONIC DECODERS

These state-of-the-art circuits described by CBS are offered as kits of superior quality with close tolerance capacitors metal oxide resistors and Fibreglass PCBs designed for edge connector insertion Further information on these kits is given in our FREE CATALOGUE

M1 Basic matrix decoder	£5.90
L1 Full logic decoder	£17.20
L2A Full logic decoder with variable blend	£22.60
L3A As L2A but with high performance discrete component front end	£30.10
(or with carbon film resistors)	£25.90
SQM1 30 Decoder complete with 30W rear channel amplifiers Complete kit matches T30+30 amplifier	£40.75

Value Added Tax not included in prices
UK Carriage FREE

PRICE STABILITY: Order with confidence! Irrespective of any price changes we will honour all prices in this advertisement until December 31st, 1977, if this month's advertisement is mentioned with your order Errors and VAT rate changes excluded

U.K. ORDERS: Subject to 12½% * surcharge for VAT (i e add ⅛ to the price). No charge is made for carriage. *or at current rate if changed

SECURICOR DELIVERY: For this optional service (U K mainland only) add £2 50 (VAT inclusive) per kit

SALES COUNTER: If you prefer to collect your kit from the factory call at Sales Counter (at rear of factory) Open 1 p m-4 30 p m Monday-Thursday

SEMICONDUCTORS as used in our range of quality audio equipment

2N699	£0.20	BC107	£0.10	BF257	£0.40	MPSA05	£0.25	TIP30C	£0.60
2N3055	£0.45	BC108	£0.10	BF259	£0.47	MPSA12	£0.35	TIP41A	£0.70
2N3442	£1.20	BC109	£0.10	BFR39	£0.30	MPSA55	£0.25	TIP42A	£0.80
2N3711	£0.09	BC109C	£0.12	BFR79	£0.30	MPSA65	£0.35	TIP41B	£0.75
2N3904	£0.17	BC125	£0.15	BFY51	£0.20	MPSA66	£0.40	TIP42B	£0.80
2N3906	£0.20	BC126	£0.15	BFY52	£0.20	MPSU05	£0.50	1N914	£0.07
2N5087	£0.25	BC182	£0.10	CA3046	£0.70	SBA750A	£1.90	1N916	£0.07
2N5089	£0.25	BC212	£0.12	LM301AN	£0.55	SL301	£1.30	1S920	£0.10
2H5457	£0.45	BC182L	£0.10	LP1186	£6.50	SL3045	£1.20		
2N5459	£0.45	BC184L	£0.11	MC1310	£2.20	SN72741P	£0.40		
2N5460	£0.50	BC212L	£0.12	MC1351	£1.05	SN72748P	£0.40		
2N5461	£0.50	BC214L	0.14	MC1741CG	£0.65	STCR53	£2.40		
2N5830	£0.35	BCY72	£0.13	MFC4010	£0.95	TIL209	£0.20		
40361	£0.40	BD529	£0.65	MJ481	£1.20	TIP29A	£0.40	**FILTERS**	
40362	£0.45	BD530	£0.55	MJ491	£1.45	TIP30A	£0.45	FM4	£1.00
74004	£0.35	BDY56	£1.60	MJE521	£0.60	TIP29C	£0.55	SFJ10 7MA	£1.50

NEW PROJECTS

LINSLEY-HOOD LOW DISTORTION OSCILLATOR

A Wien bridge audio oscillator (10Hz-100KHz) with sine or square wave output (1mV-1V) published in Wireless World September, October 1977

Pack 1 Fibreglass PCB	£2.65
Pack 2 Capacitors, 2% metal oxide resistors	£2.60
Pack 3 Transistors, IC, IC socket, thermistor	£3.90
Pack 4 Potentiometers and switches	£2.80

ERIC F. TAYLOR PRE-AMPLIFIER

A low noise, low distortion (0 005%) stereo pre-amplifier for use with magnetic pick-up (RIAA equalization)

Pack 1 Fibreglass PCB (Stereo)	£1.45
Pack 2 Metal oxide resistors, capacitors (Stereo)	£3.20
Pack 3 Transistors, ICs, IC sockets, zeners (Stereo)	£4.20

For further details of these please ask for our NEW PROJECTS LIST

QUALITY: All components are brand new first grade full specification guaranteed devices All resistors (except where stated as metal oxide) are low noise carbon film types All printed circuit boards are fibreglass, drilled roller tinned and supplied with circuit diagrams and construction layouts

AFTER-SALES BACK-UP: Servicing facilities (very rarely required for our kits) are available for all ** complete kits Further details will be sent on request

FOR FURTHER INFORMATION PLEASE WRITE OR TELEPHONE FOR OUR FREE CATALOGUE

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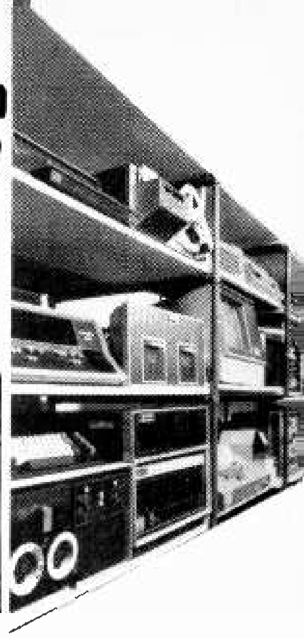

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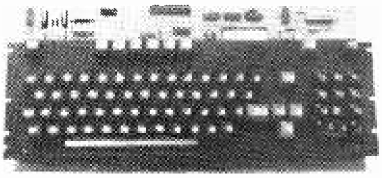

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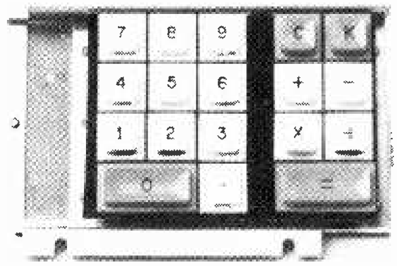

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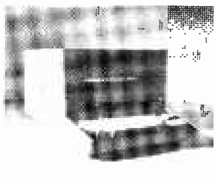

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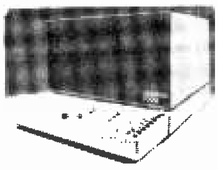

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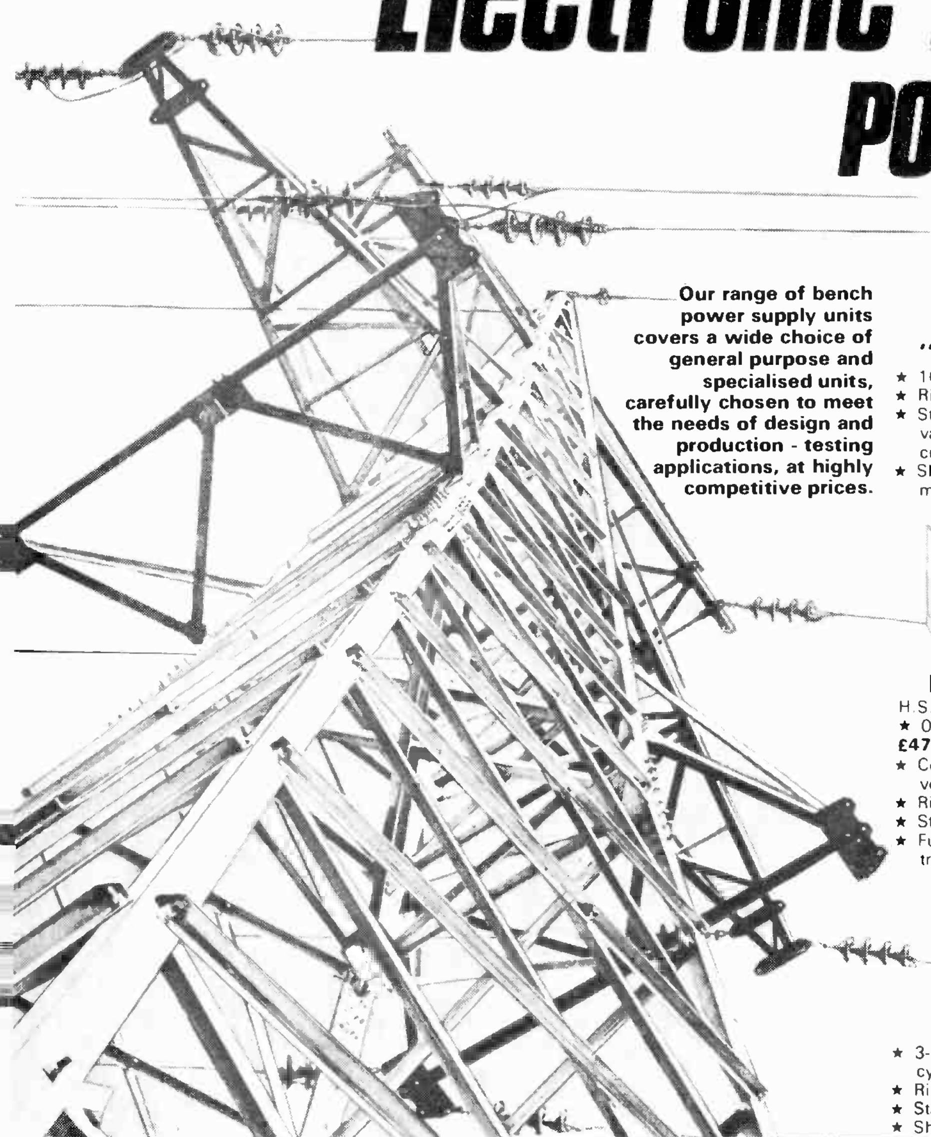

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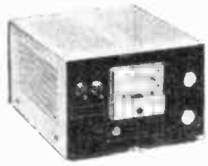

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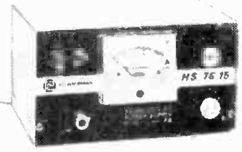

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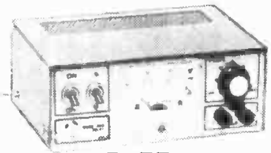

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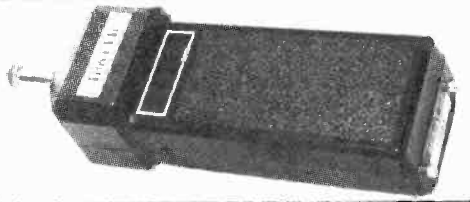

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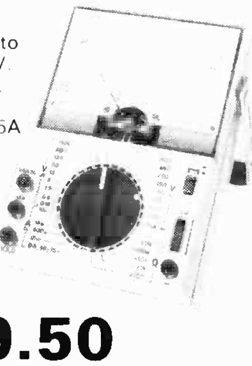


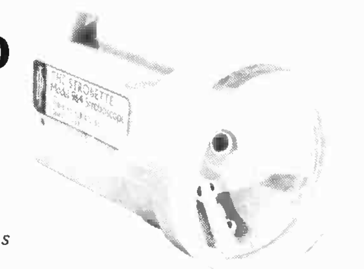
- ★ D.C. Volts, 150mV to 1500V f.s.d. at 100KΩ/V.
- ★ A.C. Volts, 1.5 to 1500V. f.s.d. at 31.6KΩ/V.
- ★ D.C. Current, 10μA to 15A f.s.d.
- ★ A.C. Current, 15A.
- ★ Mirror-scale, rugged taut-band suspension, dB scale, diode and fuse protection.
- ★ Supplied complete with test leads and leather carrying-case.

£39.50

"STROBETTE" STROBOSCOPE TACHOMETER MODEL 964

- ★ 200-6000 flashes/minute
- ★ Directly calibrated in r.p.m.
- ★ Xenon lamp

£75.00



Part of our wide range of "strobes and tachos"

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0A2	0.85
0B2	0.40
0C3	0.50
0Z4	0.55
1A3	0.60
1A5GT	0.55
1A7GT	0.60
1B3GT	0.55
1C2	1.00
1D5	0.75
1G6	1.00
1H5GT	0.80
1L4	0.25
1LD5	0.70
1LN5	0.70
1N5GT	0.75
1R5	0.50
1S4	0.40
1S5	0.35
1T4	0.30
1U4	0.70
1U5	0.85
2D21	0.55
2GK5	0.75
2X2	0.70
3A4	0.55
3B7	0.55
3D6	0.40
3Q4	0.80
3Q5GT	0.70
3S4	0.45
3V4	0.80
4CB6	0.75
4GK5	0.75
5CG8	0.75
5R4GY	1.00
5T4	2.00
5U4G	1.00
5V4G	1.00
5Y3GT	0.65
5Z3	1.00
5Z4G	0.75
5Z4GT	1.00
6/30L2	0.79
6A8G	1.40
6AC7	0.55
6AG5	0.35
6AG7	0.60
6AH6	0.70
6AJ5	0.70
6AJ8	0.55
6AK5	0.45
6AK8	0.40
6AL5	0.20
6AM6	0.70
6AM8A	0.70
6AN8	0.70
6AQ5	0.68
6AQ8	0.50
6AR5	0.80
6AS7	1.00
6AT6	0.50
6AU6	0.40
6AV6	0.65
6AW8A	1.15
6AX4	0.75
6B8G	0.35
6BA6	0.40
6BC8	0.90
6BE6	0.40
6BG6G	1.00
6BH6	0.70
6BJ6	0.65
6BK7A	0.85
6BN8	1.00
6BQ5	0.41
6BQ7A	0.60
6BR7	1.00
6BR8	1.25
6BW6	1.70
6BW7	0.65
6BX6	0.29
6BY7	0.36
6BZ6	0.60
6C4	0.50
6C6	0.45
6C9	2.00
6C10	0.71
6CB6A	0.65
6C12	0.55
6CD6G	4.00
6CG8A	0.90
6CL6	0.75
6CL8A	0.95
6CM7	1.00
6CS6	0.45
6CU5	0.90
6D3	0.75
6DE7	0.90
6DT6A	0.65
6EW6	0.85
6E5	1.00
6F1	0.80
6F6G	0.60
6F12	0.70
6F14	0.90
6F15	0.85
6F16	0.75
6F18	0.60
6F23	0.65
6F24	0.80
6F25	1.00
6F26	0.36
6F28	0.74
6F32	0.70
6G6G	0.60
6GH8A	0.80
6GK5	0.75
6GK6	2.00
6GU7	0.90
6H6GT	0.30
6J5GT	0.65
6J6	0.35
6J7G	0.50
6J7M	0.65
6JU8A	0.90
6K7G	0.35
6K8G	0.50
6K8GT	0.55
6L1	2.50
6L6GC	0.85
6L7(M)	1.50
6L12	0.50
6L18	0.60
6L19	2.00
6LD12	0.40
6LD20	0.80
6N7GT	0.70
6PL12	0.40
6P15	0.41
6Q7G	0.75
6Q7GT	0.75
6Q7M	0.75
6R7G	0.70
6R7(M)	1.00
6SA7	0.55
6SC7GT	0.75
6SG7	0.55
6SH7	0.55
6SJ7	0.60
6SK7	1.00
6SK7GT	0.55
6SQ7	0.60
6U4GT	0.80
6U7G	0.55
6U8	0.50
6V6G	0.50
6V6GT	1.00
6X4	0.95
6X5GT	0.45
6Y6G	0.95
6Y7G	1.25
7A7	1.00
7B6	0.80
7B7	0.80
7D6	2.00
7F8	2.00
7H7	0.80
7R7	2.00
7V7	2.00
7Y4	0.80
7Z4	0.80
8D2	0.50
8D8	0.50
9BW6	0.90
9D7	0.70
9U8	0.45
10C2	0.70
10C14	0.50
10D1	0.65
10DE7	0.80
10F1	0.67
10F9	0.65
10F18	0.65
10L14	0.45
10LD11	0.75
10LD12	0.45
10PL12	0.55
10P13	0.80
10P14	2.50
10P18	0.54
12A6	0.65
12AC6	0.80
12AD6	0.80
12AE6	0.80
12AT6	0.45
12AT7	0.48
12AU6	0.50
12AU7	0.48
12AV6	0.60
12AX7	0.48
12BA6	0.50
12BE6	0.85
12BH7	0.55
12BY7	1.15
12E1	3.50
12J5GT	0.40
12J7GT	0.70
12K5	1.50
12K7GT	0.50
12K8	0.75
12Q7GT	0.50
12SA7GT	0.75
12SC7	0.50
12SG7	0.55
12SH7	0.50
12SJ7	0.60
12SK7	0.60
12SN7GT	0.75
12SQ7	0.80
12SQ7GT	0.80
12SR7	0.75
13D8	2.00
14H7	0.75
14S7	1.00
18	1.25
19AQ5	0.65
19BG6G	1.00
19G6	6.50
19H1	4.00
19Y3	0.40
20D1	0.70
20D4	2.50
20F2	0.85
20L1	1.20
20P1	1.00
20P3	1.00
20P4	0.84
20P5	1.50
25A6G	0.70
25L6G	0.70
25Y5	0.80
25Z4G	0.50
25Z5	0.75
25Z6G	0.80
28D7	2.00
30A5	0.75
30C1	0.80
30C15	0.77
30C17	0.77
30C18	2.25
30F5	0.70
30L1	0.39
30L15	0.75
30L17	0.70
30P4MR	0.98
30P12	0.74
30P19/	
30P4	0.90
30P16	0.37
30P18	0.50
30PL1	1.00
30PL12	0.54
30PL13	1.00
30PL14	1.29
30PL15	1.00
35A3	0.75
35C5	0.80
35D5	0.90
35L6GT	0.80
35W4	0.55
35Z3	0.80
35Z4GT	0.70
35Z5GT	0.80
50B5	0.95
50C5	0.70
50CD6G	4.00
50EH5	0.65
50L6GT	1.00
66KU	0.52
72	0.70
77	0.45
85A2	0.75
85A3	0.75
90CV	2.80
108C1	0.40
150C2	0.85
215SG	0.60
303	1.20
305	1.20
807	1.10
956	0.50
1625	2.50
1821	1.00
5702	1.20
5763	1.65
6057	1.00
6060	1.00
6067	1.00
6146	4.70
6463	2.00
7025	2.00
7193	0.60
7475	1.20
9002	0.55
9006	0.45
A1834	1.00
A3042	6.00
AC2PEN	1.00
AC2PENDD	1.00
AC6/PEN	1.00
AC/P4	1.50
AC/PEN(7)	1.20
AC/TH1	1.00
AL60	1.50
ARP3	0.60
ATP4	0.50
AZ1	0.50
AZ31	0.60
AZ41	0.50
B36	0.75
B719	0.50
B729	0.79
BL63	2.00
CL33	1.75
CV6	0.60
CV63	1.00
CV988	0.25
CY1C	1.00
CY31	0.70
D1	0.50
D63	0.30
DAC32	0.80
DAF91	0.35
DAF96	0.60
DC90	0.70
DD4	0.80
DF33	0.75
DF91	0.30
DF96	0.60
DH63	0.75
DH76	0.50
DH77	0.50
DH81	0.80
DK32	0.60
DK40	0.70
DK91	0.50
DK92	1.00
DK96	0.70
DL63	0.70
DL82	0.80
DL92	0.45
DL94	0.80
DL96	0.60
DM70	0.80
DM71	1.75
DW4/350	1.15
DY51	2.00
DY87/6	0.45
DY802	0.50
E80CC	4.75
E80CF	6.00
E80F	5.50
E83F	3.50
E88CC	1.20
E92CC	4.50
E180CC	5.00
E180F	5.50
E182CC	5.50
E188CC	4.50
E280F	12.50
E1148	0.60
EA50	0.40
EA76	1.30
EABC80	0.48
EAC91	0.55
EAF42	0.70
EAF801	0.75
EB34	0.30
EB91	0.20
EBC41	0.75
EBC81	0.60
EBC90	0.50
EBC91	0.65
EBF80	0.40
EBF83	0.45
EBF89	0.40
EBL21	2.00
EC52	1.00
EC53	1.00
EC54	1.00
EC86	0.84
EC88	0.84
EC90	0.50
EC92	0.55
EC97	0.75
ECC32	1.00
ECC33	2.00
ECC35	2.00
ECC40	0.90
ECC81	0.48
ECC82	0.48
ECC83	0.48
ECC84	0.35
ECC85	0.50
ECC86	1.25
ECC88	0.72
ECC91	0.35
ECC189	0.80
ECC804	0.79
ECC807	2.80
ECF80	0.65
ECF82	0.50
ECF86	0.80
ECH35	1.60
ECH42	0.71
ECH81	0.55
ECH83	1.00
ECH84	0.50
ECL80	0.45
ECL82	0.50
ECL83	0.74
ECL84	0.65
ECL85	0.70
ECL86	0.64
ECLL800	10.00
EF22	1.00
EF40	0.78
EF41	0.80
EF73	1.75
EF80	0.29
EF83	1.25
EF85	0.36
EF86	0.50
EF89	0.42
EF91	0.70
EF92	0.50
EF93	0.40
EF94	0.40
EF95	0.45
EF97	0.90
EF98	0.90
EF183	0.42
EF184	0.42
EF804	1.75
EH90	0.45
EK90	0.40
EL32	0.60
EL34	1.25
EL35	3.00
EL37	3.00
EL41	0.57
EL81	0.70
EL83	0.70
EL84	0.41
EL86	0.60
EL90	0.68
EL95	0.67
EL360	1.80
EL506	1.20
EL509	2.50
EM80	0.55
EM81	0.60
EM83	0.60
EM84	0.45
EM85	1.20
EM87	1.10
EMM803	2.50
EY51	0.45
EY81	0.45
EY83	0.60
EY86/7	0.37
EY88	0.55
EY91	0.50
EY500A	1.45
EZ35	0.45
EZ40	0.52
EZ41	0.52
EZ80	0.35
EZ81	0.40
EZ90	0.95
FC4	1.00
FW4/500	1.80
FW4/800	1.80
GY501	0.95
GZ30	0.75
GZ32	1.00
GZ33	2.00
GZ34	2.00
GZ37	2.00
HABC80	0.80
HL13C	0.60
HL23	0.70
HL23DD	0.68
HL41	1.00
HL41DD	1.00
HL42DD	1.00
HN309	1.70
HVR2	1.00
HVR2A	1.00
HY90	0.55
KT2	0.90
KT8	3.00
KT32	1.00
KT41	1.00
KT44	1.00
KT63	0.60
KT66	3.00
KT71	1.00
KT81	2.00
KT88	6.75
KTW61	1.50
KTW62	1.50
KTW63	1.20
L63	0.65
LN119	0.55
LN152	0.45
LN309	0.49
LZ319	0.80
LZ329	0.80
M8162	1.00
MHL4	1.00
MHLD6	0.99
MKT4	1.20
MU12/14	1.15
MX40	1.00
N150	0.57
N308	0.96
N339	1.25
N379	0.50
N709	0.41
P61	0.60
PABC80	0.45
PC86	0.62
PC88	0.62
PC92	0.55
PC95	1.00
PC97	0.75
PC900	0.40
PCC84	0.39
PCC85	0.47
PCC88	0.61
PCC89	0.49
PCC189	0.52
PCC805	0.75
PCC806	0.70
PCF80	0.80
PCF82	0.45
PCF84	0.70
PCF86	0.57
PCF87	0.77
PCF200	1.35
PCF201	1.00
PCF800	0.77
PCF801	0.49
PCF802	0.75
PCF805	2.25
PCF806	0.53
PCH200	1.00
PCL82	0.54
PCL83	0.49
PCL84	0.46
PCL86	0.65
PCL88	1.29
PCL800	1.00
PCL801	1.00
PCL805/85	0.80
PEN4DD	2.00
PEN25	1.00
PEN45	1.00
PEN45DD	1.00
PEN46	1.00
PEN453DD	2.00
PENA4	1.00
PENDD/4020	1.00
PFL200	0.90
PL33	1.00
PL36	0.60
PL81	0.49
PL81A	0.53
PL82	0.37
PL83	0.45
PL84	0.50
PL302	0.90
PI504/500	1.00
PL505	2.20
PL508	1.30
PL509	2.55
PL519	2.80
PL801	0.74
PL802	3.20
PM84	0.75
PY31	0.50
PY33/2	0.50
PY80	0.50
PY81	0.50
PY82	0.40
PY83	0.50
PY88	0.60
PY301	0.50
PY500	1.56
PY500A	1.56
PY800	0.50
PY801	0.50
PZ30	0.50
QP21	1.10
QQV03/10	2.00
QS75/20	1.00
QS95/10	1.00
QS150/15	1.80
QV03/12	1.65
QV04/7	3.00
QV06/20	4.70
R10	6.50
R11	1.00
R16	2.00
R17	1.00
R19	0.75
R20	0.60
R52	0.48
RK34	1.00
SP4	1.50
SP13C	0.75
TH4B	1.00
TH233	1.00
TP2620	1.00
TP22	1.00
TP25	1.00
UABC80	0.45
UAF42	0.70
UBC41	0.50
UBC81	0.55
UBF80	0.50
UBF89	0.39
UBL21	2.00
UC92	0.50
UCC84	0.90
UCC85	0.45
UCF80	0.80
UCH21	2.00
UCH42	0.71
UCH81	0.50
UCL82	0.55
UCL83	0.57
UF41	0.70
UF42	0.80
UF80	0.40
UF85	0.50
UF89	0.52
UL41	0.70
UL46	0.70
UL84	0.54
UM80	0.60
UR1C	1.00
UU5	1.15
UU9	0.52
UU12	0.40
UY41	0.50
UY42	0.50
UY85	0.35
U10	1.00
U12/14	1.15
U16	1.00
U17	1.00
U18/20	1.80
U19	4.00
U22	0.85
U25	0.71
U26	0.60
U31	0.50
U33	1.75
U35	1.75
U37	2.00
U45	1.20
U47	0.71
U49	0.60
U50	0.85
U52	1.00
U76	0.70
U78	0.95
U81	0.80
U150	0.52
U153	0.50
U191	0.50
U192	0.40
U193	0.50
U251	1.00
U281	0.75
U282	0.70
U291	0.50
U301	1.00
U329	1.00
U339	0.50
U381	0.35
U403	0.90
U404	0.75
U709	0.40
U801	1.00
U4020	0.75
VLS492	9.50
VP2	1.50
VP4(5)	2.00
VP13C	0.60
VP23	0.65
VP41	0.90
VR105	0.50
VR150	0.75
VT61A	0.75
VU111	1.00
VU120	1.00
VU120A	1.00
VU133	1.00
VX6020	1.00
W76	0.50
W81M	1.20
W107	0.75
W719	0.36
W729	1.20
WD709	0.40
XE3	0.60
XFY12	0.60
XH15	0.60
XSG15	1.20
X41	1.00
X61	1.60
X63	1.40
X65	1.60
X66	1.60
X76M	0.75
X119	0.50
X142	0.71
X150	0.71
X719	0.55
Z145	0.67
Z152	0.29
Z329	0.70
Z719	0.29
Z729	0.50
Z749	0.65
Z759	5.85
Transistors and Diodes	
1N1124A	0.61
1N4744A	0.16
1N4952	0.58
2N404	0.21
2N966	0.61
2N1756	0.58
2N2147	0.99
2N2297	0.26
2N2369	0.16
2N2613	0.45
2N3053	0.38
2N3121	2.90
2N3703	0.23
2N3709	0.23
2N3866	1.16
2N3988	0.58
2S323	0.58
AA119	0.18
AA120	0.18
AA129	0.18
AAZ13	0.21
AC107	0.18
AC113	0.30
AC114	0.47
AC126	0.14
AC127	0.20
AC128	0.26
AC132	0.23
AC154	0.30
AC156	0.23
AC157	0.30
AC165	0.30
AC166	0.30
AC168	0.44
AC169	0.38
AC176	0.64
AC177	0.32
ACY17	0.30
ACY18	0.23
ACY19	0.23
ACY20	0.30
ACY21	0.30
ACY22	0.18
ACY28	0.21
AD140	0.50
AD161	0.53
AD162	0.53
AF102	1.04
AF106	0.58
AF114	0.30
AF115	0.30
AF117	0.23
AF121	0.35
AF124	0.36
AF125	0.50
AF139	0.76
AF178	0.79
AF180	0.56
AF186	0.64
AF239	0.44
ASY27	0.50
ASY28	0.38
ASY29	0.58
BA102	0.53
BA115	0.16
BA116	0.21
BA129	0.14
BA130	0.12
BA148	0.20
BA153	0.18
BCY10	0.53
BCY12	0.58
BCY33	0.23
BCY34	0.26
BCY38	0.26
BC107	0.14
BC108	0.14
BC109	0.14
BC113	0.30
BC115	0.18
BC116	0.30
BC118	0.26
BF154	0.30
BF158	0.21
BF159	0.30
BF163	0.23
BF173	0.44
BF180	0.35
BF181	0.47
BF185	0.47
BFY50	0.26
BFY51	0.23
BFY52	0.23
BTX34/400	2.31
BY100	0.21
BY101	0.18
BY105	0.21
BY114	0.21
BY126	0.18
BY127	0.21
BYY23	1.16
BYZ10	0.30
BYZ11	0.30
BYZ12	0.30
BYZ13	0.30
BYZ15	2.03
CG12E	0.23
CG64H	0.23
FSY11A	0.26
FSY41A	0.26
GD4	0.38
GD5	0.32
GD6	0.32
GD8	0.23
GD9	0.23
GD11	0.23
GD12	0.23
GD14	0.58
GD15	0.47
GD16	0.23
GET119	0.30
GET573	0.44
GET587	0.50
GET872	1.11
GET873	0.18
GET882	0.58
GET887	0.26
GET889	0.26
GET896	0.26
GET897	0.26
GET898	0.26
GEX113	0.21
GEX36	0.58
GEX45	0.38
GEX55	0.87
GT3	0.30
M1	0.18
MAT100	0.45
MAT101	0.50
MAT120	0.45
OA9	0.14
OA47	0.12
OA70	0.18
OA73	0.18
OA79	0.11
OA81	0.11
OA85	0.11
OA86	0.23
OA90	0.14
OA91	0.11
OA95	0.11
OA200	0.11
OA202	0.12
OC19	1.46
OC22	0.44
OC23	0.44
OC24	0.44
OC28	0.69
OC29	0.73
OC36	1.00
OC38	0.50
OC41	0.58
OC42	0.73
OC43	1.37
OC44	0.12
OC45	0.13
OC65	1.31
OC70	0.14
OC71	0.13
OC72	0.13
OC74	0.26
OC75	0.13
OC76	0.18
OC77	0.32
OC78	0.18
OC78D	0.18
OC79	0.47
OC81	0.13
OC81D	0.13
OC82	0.13
OC82D	0.13
OC83	0.23
OC84	0.28
OC123	0.26
OC140	1.11
OC169	0.50
OC171	0.40
OC172	0.41
OC201	1.00
OC204	0.50
OC206	1.05
ORP12	0.61
SFT237	0.50
SM1036	0.58
ST1276	0.58
SX1/6	0.21
U14706	0.30
XZ30	0.30
Y543	0.21
Y728	0.21

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MATCHED TRANSISTOR SETS
LP15 (AC113, AC154, AC157, AA120), **61p** per pack.
1/OC81D and 2/OC81, **50p.**
1/OC44 and 2/OC45, **50p.**
1/OC82D and 2/OC82, **56p.** Set of 3/OC83, **76p.**
1 watt Zenners, 2.4v, 2.7v, 3v, 3.6v, 4.3v, 4.7v, 5.1v, 13v, 15v, 16v, 18v, 20v, 24v, 30v, **12p each.**

All goods are unused and subject to the manufacturers' guarantee.
Terms of business. Cash or cheque with order. Despatch charges: — Orders below £25 in value, add 50p for post and packing. Orders over £25 post and packing free of charge. All orders cleared same day. Any parcel insured against damage in transit for 5p extra per parcel. Conditions of sale available on request. Many others in stock too numerous to list. Please enclose S.A.E. for reply to any enquiries.
All prices subject to change without notice.
Special offer of EF50 valves, soiled but new and tested. £1 each.

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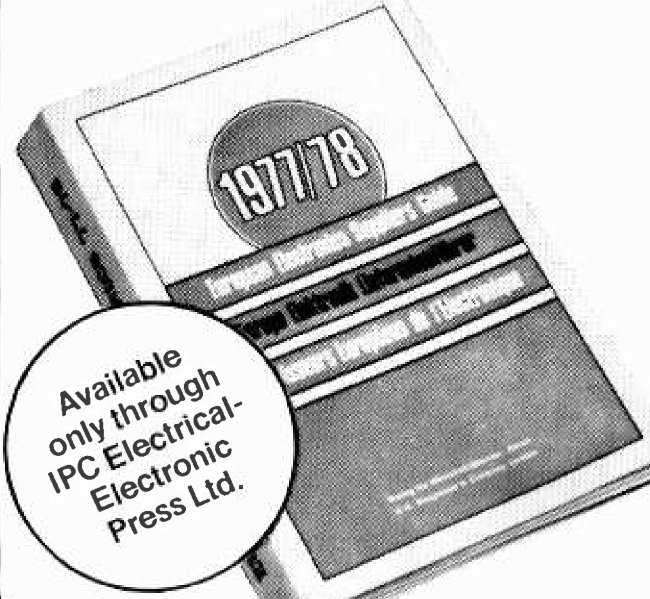

The second edition of this valuable three-language (English, French and German) directory gives details of 2,800 firms, including 130 from Eastern Europe. 880 products are grouped into 26 chapters, covering cables, components, computers, materials, production equipment and 21 fields of specialised application from aerospace to underwater engineering. Comprising 730 pages (A5 format), the new edition includes cross-referencing from products to manufacturers and—for the first time—from firms to products. Special attention has been paid to the indexing which is separate for each of the three language sections. European Electronics Suppliers Guide is published jointly by Verlag Fur Wirtschaftsliteratur GmbH (Zurich) and C. G. Wedgwood & Co. (London) and is available only through IPC Electrical-Electronic Press Ltd.

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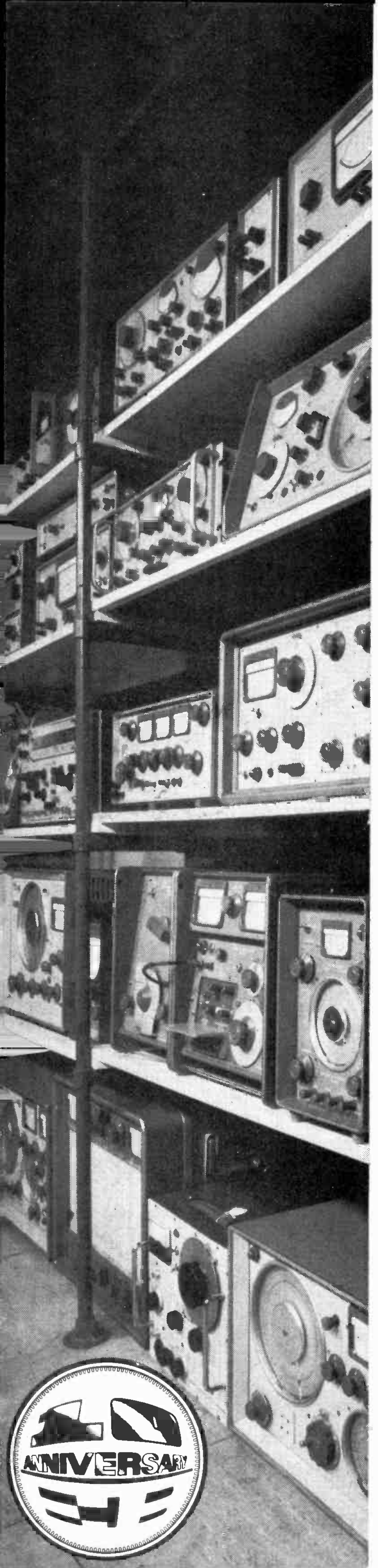


Electronic
The Test Equipment People

SIGNAL SOURCES

ADVANCE

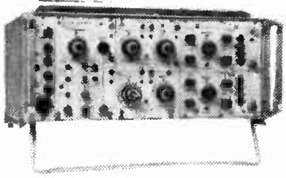
Signal Generator J4. 10Hz-100KHz 600 ohms impedance. Sine & Square Brand new condition **£150.00**

V.H.F. Square wave Generator SG21. 10 KHz-100MHz Max. o/p 2V **£50.00**

H1 Audio Signal Generator. 15Hz-50KHz Sine and Square **£35.00**

E2 R.F. Signal Generator 10KHz-100MHz **£76.00**

H1E Audio Signal Generator. Sine & Square Wave 15Hz-50KHz. 200V to 20V (Sine). Distortion 1% 1.4mV to 140V (Square). Brand new condition **£70.00**



Type PG59 Pulse Generator 2 Channel, double pulse. Functions: Frequency, Width, Rise & Fall Time, Amplitude, Offset, Delay, Prepulse & Gate. Repetition Freq. 1Hz to 10MHz (20 MHz in double pulse mode. Delay & Width 25 nsecs/1sec. Full specification on request **£625.00**

Type SG67A Wide Range Oscillator Freq. Range 1Hz-1MHz. Sine or Square. Output Amplitude up to 2.5V. Battery operated. **£95.00**

Type J1 Audio Signal Generator 15Hz-50KHz. Output 0.25V to 25V at impedance 600 ohms or 5 ohms **£50.00**

R.F. Signal Generator B4B7 30KHz-30MHz. Output Z:— 75. Int. Mod. 400Hz. 0-80%. Provision for Ext. Mod. Audio o/p 0-10V at 400 Hz. into 600Ω **£165**

AVO

R.F. Signal Generator HF134. 100KHz-240MHz 75Ω. Int. mod. 1KHz @ 30%. Ext. mod. facility **£150.00**

HEWLETT PACKARD

10515A Frequency Doubler. Extends the usable frequency range of signal generators. Operating on input frequencies 0.5MHz to 500MHz it provides a doubled output in the range of 1MHz to 1GHz. The frequency response of this 50 ohm device is very flat (< ±2dB typically) over the entire frequency range and undesired harmonics are well suppressed **£75.00**

F.M./A.M. Signal Generator 202H. F.M. A.M. C.W. & pulse coverage 54 to 216 MHz R.F. o/p 0.1μV-0.2V 50ohms Impedance **£495.00**

Audio Signal Generator 206A 20Hz-20KHz ±2% accuracy. Distortion ∠1% **£90.00**

612A-U.H.F. Signal Generator 450-1230MHz. 0.1μV-0.5V (50ohms) A.M. Internal & external. Pulse mod. facilities. SUPERB CONDITION **£1250.00**

MARCONI INSTRUMENTS

TF1060 U.H.F. Signal Generator 450-1250MHz. Sine wave and pulse a.m. **£350.00**

Signal Generator **TF867**. 15KHz-30MHz o/p 0.4μV-4V. Int. & Ext. mod. Supplied with Terminating unit **£185.00**

Solid State Generator 6058B. Freq. range 8-12.5GHz. Int. & Ext. mod. freq. Stab. 0.003%. 50Ω impedance **£530.00**

A.M. Signal Generator TF801D/1S Military version 10-485MHz **£450.00-£800.00**

R.C. Oscillator TF1370A 10Hz-10MHz Square Wave up to 100KHz High Outputs up to 31.6V **£285.00**

Phase/A.M. Signal Generator TF 2003 0.4-12MHz **£150.00**

F.M./A.M. Signal Generator TF 995A/3S. Ministry type No. CT402 1.5MHz-220MHz. R.F. o/p 2μV-200mV. Internal & External Mod. Facilities V. good condition **£385.00**

A.M. Signal Generator TF801D/1 Freq. range 10-470MHz R.F. output 0.1μ-1V Piston attenuator. 50ohms Impedance.

AM Signal Generator TF 801B/3S 12.485MHz. 0.1μV-1V **£195.00**

R.C. Oscillator TF1101. Frequency range 20HZ-200KHz. Output: Direct into 600Ω0-20V variable. Attenuator 0.6dB in 10dB steps. Impedance: 600Ω. Distortion: Via 1KHz Filter less than 0.1%. Direct or via Attenuator. Less than 0.5% 50Hz-20KHz. Less than 1% 20Hz-200KHz **£120.00-£150.00**

Signal Generator TF144H/4. Later models in super condition **£500.00 to £650.00**

MF/HF Signal Generator TF2002. 10KHz-72MHz. 100% A.M. depth Int. A.M. Variable from 20Hz to 20KHz R.F. o/p, 0.1μV to 2V Solid State **£675.00**

AM/FM Signal Generator TF995B/2 **£675.00**

MARCONI-SANDERS

Microwave Sweep Generator type 6600A c/w 6619 plug in 1.7GHz-4.2GHz **£2,900.00**

MUIRHEAD L.F. Decade Oscillator DB80A. 2-phase 0.01Hz-11.2KHz **£295.00**

Decade Oscillator DB90D. 1Hz-11.2KHz **£260.00**

PHILIPS

PM5501 Colour bar generator. Extremely light and compact instrument for mobile maintenance, 5 different test patterns for colour and black/white TV installation and service. R.F. output signal switchable. VHF, Band III and UHF Band IV. 1KHz tone for sound performance checks (sine wave) **£165.00**

50MHz Pulse Generator PM5712 **£435.00**

Pulse Generator PM5775 **£800.00**

Pulse Generator PM5776 **£900.00**

L.F. Generator PM5105. 10Hz-100KHz. Sine & Square Wave 2V(R.M.S.) Stabilised o/p. Low Distortion: <0.8% (10Hz-100KHz) **£156.00**

DIGITAL VOLTMETERS AND MULTIMETERS

AVO

Test leads **£4.00**

Multiminor Mk 4 c/w carrying case and leads **£13.50**

Model 7x **£40.00**

Heavy Duty Mk 5 (with case) **£40.00**

DYNAMCO

Digital Voltmeter DM 2023 c/w DC ranging unit C1. Scale 99999 0.001% F.S.D. DC Accuracy 10μV-1Kv DC **£450.00**

HEWLETT PACKARD

DVM type 3430A 3 digit 5 ranges 100mV to 100V. FS input resistances 10Mohms Overload protection **£145.00**

Digital Multimeter 34702A with Display 34740A. 4 digit display. 4 ranges both AC & DC plus 6 ranges of ohms. AC function covers 45Hz to 100KHz. Ohms ranges are 100ohms to 10Mohms FS LED display. New condition. A much sought-after device still in current production **£400.00**

PHILIPS

Electronic Analogue Multimeter PM2503

DC & AC Volts, 100mV-1KV f.s.d. Resistance 100 ohms-10M Ohms. DC & AC Current 1μA-1A f.s.d. **£85.00**

SIGN/ROGERS

A.F. Voltmeter AM324 **£50.00**

SOLARTRON

A.C. Converter LM1219. 30mV—300V mean reading. Freq. range 10Hz—10KH **P.O.A.**

D.C. Digital Voltmeter LM1420.2 2.5μV—1Kv in 6 ranges. ±0.05% DC accuracy **£235.00**

D.V.M. Type LM1420.2Ba. DC, true R.M.S. and mean A.C. sensing. Accurate measurement irrespective of harmonic distortion accuracy ±0.25%. Freq. 20Hz—20KHz **£350**

DVM Type LM 1440.2 10μV—2Kv DC. 5 ranges. Oven controlled zenerdiode. Accuracy ±0.033% FSD ±0.005% reading **P.O.A.**

D.V.M. LM1480.3 Autoranging version of LM 1440.3 Max reading 39999 5μV—2KV DC. Full spec. on request **P.O.A.**

D.V.M. LM 1604 DC only. 1μV sensitivity. 0.01% accuracy. Max reading 19999 1μV—1KV. Remote and Auto-ranging. 110dB series mode reject on. No common Mode error **P.O.A.**

D.M.M. 7050 (Autoranging) **£245.00**

OSCILLOSCOPES

COSSOR

£485.00

Dual Trace Scope 4000. 50MHz 7nsec Rise Time 5mV/cm sensitivity. Calibrated sweep delay. Gated trigger. X-Y display 8 × 10cm display

200μV/cm, Scope 130C. 500KHz bandwidth. Identical X and Y amps. X2 to X50 sweep mag. **£205.00**

MARCONI INSTRUMENTS

Portable Scope TF 2203. Single Beam DC—15MHz. 50mV/cm. Z mod **£150.00**

40MHz TF 2200 series supplied with 3 plug ins

V12. TM 6455 (single trace).
TM 6456 (dual trace).
TM 6457 (TV diff).

Full specs. on request. 6 MONTH WARRANTY **£265.00**

PHILIPS

PM6507 Transistor Curve Tracer. Solid State CRT — 10 × 12cm. Full spec. on request **£475.00**

PROBES

X1 Part No. 90 **£6.50**

X10 Part No. 91 **£8.50**

X1 & X10 (switchable) Part No. 95 **£10.50**

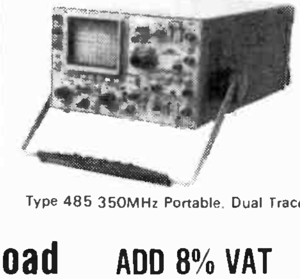
SOLARTRON

CD1740 50MHz Scope System c/w CX1741 & CX1744. Dual Trace, DC-50MHz 10 × 8cm display. Sensitivity 5mV/cm to 20V/cm. Delayed sweep, Solid State **£485.00**

Portable Scope DC-6MHz Double Beam CT436 **£105.00**

TEKTRONIX

DC30MHz Oscilloscope 545A c/w CA & L Plug-ins **£445.00**



Type 485 350MHz Portable. Dual Trace.

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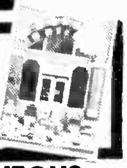


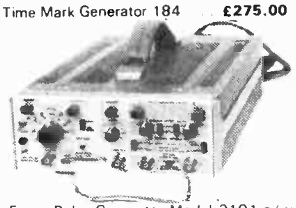
5mV/div. 1nsec/div sweep rate. Delayed sweep, Auto focus, variable trigger hold off 50 ohms internal input protection **£3,250.00**
Type 531A DC-15MHz c/w CA Plug-in — Dual Trace **£275.00**
Type 531A DC-15MHz c/w Single Trace Plug-in **£245.00**
Type 549 (Mainframe) DC-30MHz Bistable split screen storage. Automatic Erase. 5cm/µS writing speed. Calibrated sweep delay. Various plug-in units available **£750.00**
Type 551 DC-27MHz. Main frame and power supply. Various plug-in units available **£450.00**
Type 564B (Mainframe) Storage Oscilloscope. Various plug-in units available **£750.00**

TELEQUIPMENT

Rack Mounting Scope S54AR. Fitted with P7 long persistence CRT. Single trace. DC-10MHz. 10mV/cm. Unused condition **£205**

SCOPE TEST EQUIPMENT

Time Mark Generator 184 **£275.00**



5nsec Pulse Generator Model 2101 c/w loads and connectors **£575.00**
Time Mark Generator 2901 **£450.00**
Pulse Generator Model 110 **£95.00**

TRANSMISSION TEST EQUIPMENT

AIRMEC/RACAL
Wave Analyser 248A. 5-300MHz **£250.00-£300.00**
Wave Analyser 248. Freq. range 5MHz-300MHz **£145.00**
Modulation Meter 409 **£295.00**
Type 210 Modulation Meter (earlier version of 210A) **£85.00-£100.00**
Type 210A Modulation Meter. 2.5-300MHz. AM Range 0-100%. FM Range 0 to ±100KHz in 4 ranges **£185.00-£245.00**

GENERAL RADIO
Type 1900A Wave Analyser c/w Graphic Level Recorder 1521B
Spec: 1900A. 20Hz-50KHz. 3 bandwidths 3, 10 and 50Hz Tracking averages 30mV-300V F.S.D. Input impedance 1M ohm 3 meter speeds
Spec: 1521B 4.5Hz-200KHz 1 mV sensitivity. Linear dB plot of r.m.s. ac-voltage level 20, 40 or 80 dB range **£2,000.00**

HEWLETT PACKARD
Sweeping Local Oscillator 3595A Plug-in for use with 3590A Wave Analyser Freq. range 20Hz to 620KHz **£650.00**

MARCONI INSTRUMENTS
MF Transmission Test Set TF2333. Freq. range 30Hz to 550KHz. Measures response of active and passive transmission network. Full spec. on request **£600.00**
Distortion Factor Meter TF142F Fundamental Freq. Range 100Hz-8KHz. Dist. measuring ranges 0-5% 0-50%. Measures all spurious components up to 30KHz **£60.00-£80.00**
A.F. Transmission Measuring Set Model TF2332. Frequency Range 20Hz to 20KHz **£400.00**

RADIOMETER
Wave Analyser FRA 2 T3 Special version of FRA 2 with facilities for Intermodulation measurements and selective measurements of frequency responses. Freq. range 30Hz to 16KHz incremental freq. 0Hz to ±60Hz. Selectivity 3 curves with following 1dB points ±1.25Hz ±12.5Hz ±63Hz and 60dB points ±40Hz

130	350
+Hz	—Hz
150	450

Voltage range 100µV-1KV. Auxiliary Oscillator Range 0Hz to 1.6KHz and 1.5 to 1.6KHz o/p — 10V (EMF) continuously variable impedance 1 Kohms 16µF **£275.00**

BRIDGES

AVO/BPL
Type CZ457/5 Component Comparator. Used for testing or calibrating resistors, capacitors and inductors **£245.00**

MARCONI INSTRUMENTS
TF936 Impedance Bridge **£125.00**
TFT245 CCT Magn. Meter c/w Oscillator TF1246 **£685.00**

ROHDE & SCHWARZ
L.C. Bridge Type LCB BN 620. Used as Inductance Bridge 10µH to 1000H. Used as Capacitance Bridge 10nF to 1000µF **£165.00**

WAYNE KERR
COMPONENT BRIDGE B521 (CT375). Resistance 10 ranges from 1M ohm to 1000M ohm. Capacitance 10 ranges from 50kµF to 500pF. Inductance 10 ranges from 1µF to 500 KH. Capable of measuring components in situ **£105.00**
Universal Bridge B221A (CT530). 0.1% Accuracy. Measures R, G, C & L. Mains operated **£275.00**
Low Impedance Adaptor Q221A for use with above **£75.00**

FREQUENCY COUNTERS

ADVANCE
Counter TC16 5Hz-80MHz, 5 digit **£110.00**
Timer Counter TC12A 5 digit 2Hz to 15MHz Time & Period. 10mV sensitivity. Brand new condition **£160.00**
Type TC18 Time Counter Freq. measurement 10Hz-512MHz 6 digit LED display UNUSED CONDITION **£275.00**

FLUKE
Industrial Counter Totaliser 1941A. 5Hz-40MHz 40mV sensitivity R.P.M. measurement **£150.00**

VENNER
3MHz Freq. counter TSA 6674 **£80.00**

RACAL
Frequency Period Meter 5Hz-10MHz 9520. Period Average measurements **£110.00**
Universal Counter Timer 9838. Measuring functions: — Frequency. Single and multi period. Ratio and Multiple ratio. Time interval — single line and double line totalising. 10 Hz to 100 MHz Frequency 10 Hz to 5 MHz Period. 1µ S to 10' sec. Time change **£285**

VOLTMETERS

BOONTON
R.F. Voltmeter 91 C. Measurement range 1mV to 3V. Frequency range: 20 KHz to 1200 MHz (with 'T' Adaptor supplied). Supplies also with R.F. probe and tip and 50Ω termination. Weight 12 lbs. **£455**

BRUEL & KJOER
Heterodyne Voltmeter 2006. For measurements of voltage, frequency and modulation factor AM and FM. High impedance FET probe 50Ω termination and 60 dB attenuator included. Sensitivity 50ΩV — 50V F.S.D. 100 KHz to 230 MHz. Built in reference voltage and loudspeaker for identification
Electronic Voltmeter 2409. True R.M.S. Average and Peak. 2Hz to 200KHz. Sensitivity 10mV — 1kV **£250**

FLUKE
DC Differential Volymeter 891A. Input ranges, 1, 10, 100, 1000V, DC with 10% overanging. Infinite input resistance 0-1100V. Absolute accuracy ± 0.01% of input. 1 mV full scale Null Sensitivity. Reslution 1 ppm of range **£395**

GENERAL RADIO
Electronic Voltmeter 1806A AC DC 9 Resistance ± 2% accuracy. Wide frequency range — up to 1500 MHz **£175**

HEWLETT PACKARD
R.F. Millivoltmeter 411A 10mV — 10V 500 KHz — 1GHz **£185**

HEWLETT PACKARD
R.F. Voltmeter 3406A 20µV sensitivity — average response 1 mV sensitivity. 1 mV — 3V F.S. 8 ranges. 10KHz — 1.2 GHz **£485**

RHODE & SCHWARZ
Selective Microvoltmeter USVH BN 1521 10 KHz — 30 MHz 0.2 V — IV. F.s.d. of lowest range 1 V **£675**

MISCELLANEOUS

ADVANCE
Digital Panel Meters DPM 102, 103, 112P, 201, 204, 301, 302, 303, 306, 343 **Price and specs. on application**

AVANTEK
Unit Amplifier Type UF 101. Gain control modules designed for use with UA amplifier or other systems. Weight ½oz. 50Ω impedance. Frequency response 10-500MHz **£150**
Unit Amplifier Type UA 103. Frequency response 10-500MHz. 10-70dB of gain by cascading modules. 50Ω impedance **£50**
Unit Amplifier Type UA 301. Frequency 1 to 400MHz Nominal gain 7dB **£75**
Unit Amplifier UA 305 2-400MHz Response. Nominal gain 13 dB **£100**
Full specs. on the above devices available on request.

BIRD
Coaxial Resistor 8053 10W RF coaxial load resistor **£20.00**
Wattmeter Termaline 6B35 3 ranges 0-120 / 0-600 / 0-1200W 30-500MHz **£425.00**
Wattmeter Termaline 67 3 ranges 0-25 / 0-100 / 0-500W / 30-500MHz **£265.00**

BRUEL & KJAER
Random Noise Generator 1402 **£250.00**
Automatic Vibration Exciter 101B **£495.00**

CAMBRIDGE
AC/DC Resistance Box, 5 decade **£70.00**

GENERAL RADIO
Standard Frequency Multiplier 1112A. **Price & specs. on application**
Standard Frequency Multiplier 1112B **Price & specs. on application**

HEATHKIT
Distortion Meter 1M-12U **£40.00**

MARCONI INSTRUMENTS
A.F. Attenuator TF33BC **£75.00**
R.F. Power Meter TF1152/1 **£75.00**
R.F. Power Meter TF1152A/1 **£80.00**
Colour Gain and Delay Test Set TF2904 625 line **£505.00**
R.F. Power Meter TF2502 3 and 10 watt ranges DC-1GHz **£355.00**
L.F. Extension Unit. TM6448 for use with OA 1094A sereis **£200.00**

ROHDE & SCHWARZ

VHF Field Strength Meter HFV 25-300MHz in 1 band. Measurement range 100dB (µV) 50 ohm impedance **£1,750.00**
Standard Stereodecoder MSDC BN4193 **£850.00**
Polyscop I **£950.00**
Selektomat USWV **£800.00**
Frequency Indicator FKN **£475.00**
Type MSDC Standard Stereodecoder 30Hz-15KHz **£850.00**
Type MSC Stereocoder BN4192/2 **£1,250.00**

RECORD
Chart Recorder — 500 µA Movement 1in & 6in. per hour **£70.00**

WAVETEK
Programmable Phase Meter 775 **£795.00**

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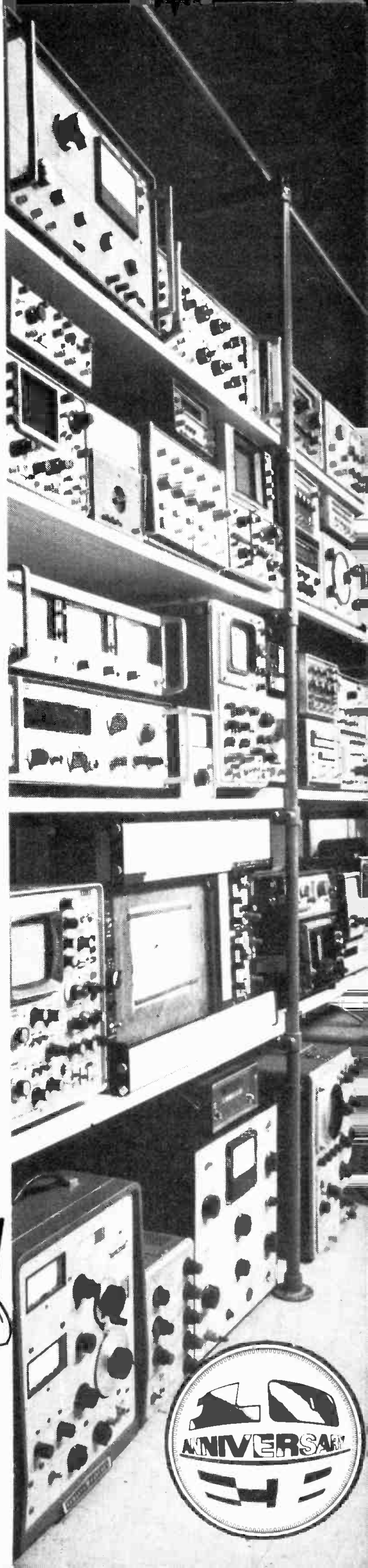

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Please note: All instruments offered are secondhand and tested and guaranteed 12 months unless otherwise stated

Hours of business: 9a.m.-5p.m. Mon.-Fri. Closed lunch 1-2p.m.

WW — 115 FOR FURTHER DETAILS

TELECOMMUNICATIONS ANTENNAS

The PU900 is a fixed station broadband antenna with a gain of 15dB over a dipole, front to back ratio average 20dB. In the lower part of the band from 400-700MHz the bandwidth is 150MHz and from 700 to 1500MHz it is 250MHz with a VSWR better than 1.5-1.0 with reference to 50 ohms. The antenna can be operated in either the horizontal or vertical mode.

We not only design and manufacture antennas, but also a wide range of structures, both guyed and self-supporting towers. This enables us to offer a complete package to customers.

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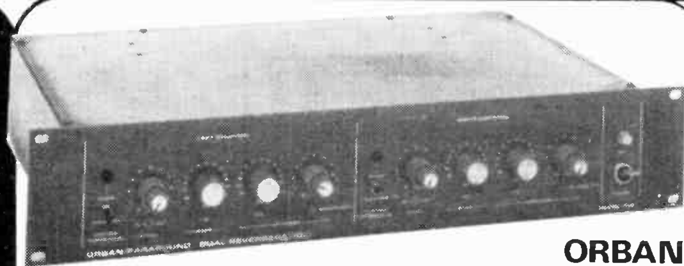
Manufacturers & Erectors of Radiotelephone Masts, Towers & Antennas

WW—102 FOR FURTHER DETAILS

NEW PRODUCTS FROM ITA



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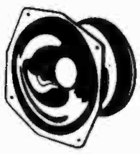

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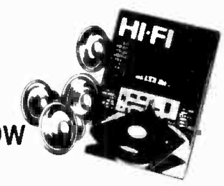

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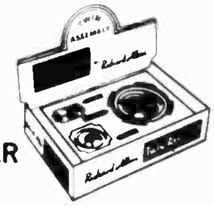

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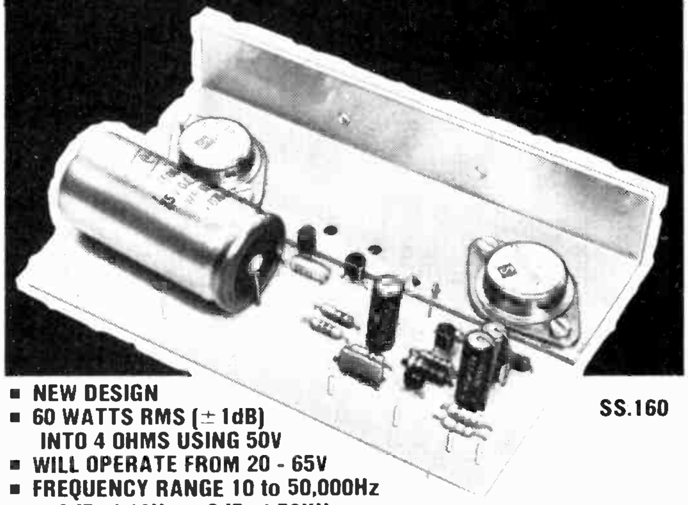

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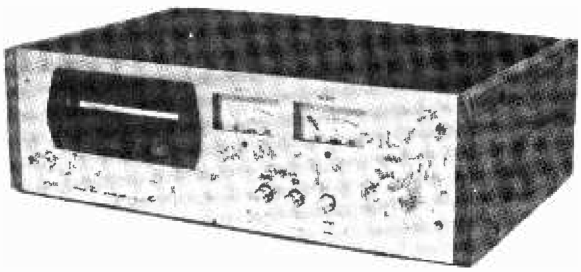

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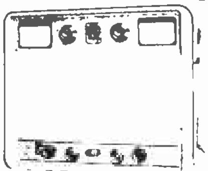

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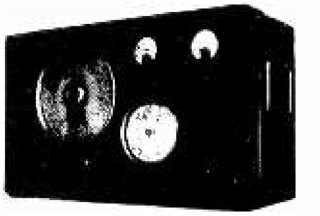

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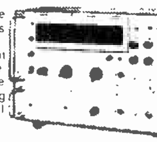

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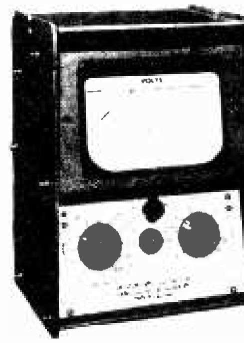

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*training and supervising technical staff

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HNC or equivalent qualification required and minimum of nine years' relevant experience.

Salary scale: £3621-£4227 (including London Weighting) plus 5% earnings supplement (minimum £2.50 per week, maximum £4 per week).

Application form from Educational Development Service, Polytechnic of North London, Holloway Road, N7 8DB.

7571

DEVON AREA HEALTH AUTHORITY
Exeter Health Care District

ROYAL DEVON AND EXETER HOSPITAL (WONFORD)

Barrack Road, Exeter EX2 5DW

MEDICAL PHYSICS TECHNICIAN IV

(Salary: £2346-£3267 p.a. plus phase 1 & 2 pay supplements)

Required for general duties in the Physics Department concerned with Radiotherapy, Radioactive Isotopes, Radiation Protection and Instrumentation.
Further information obtainable from the Principal Physicist, Mr. C. F. Walker, tel: Exeter (0392) 77833 ext. 2262.
Application form and job description obtainable from the Personnel Officer, Royal Devon and Exeter Hospital (Wonford), Barrack Road, Exeter EX2 5DW.

(7624)

REPAIR/ CALIBRATION ENGINEERS

C S L

We are looking for additional Repair/Calibration Engineers for servicing and calibrating electronic test equipment in our Repair Laboratories.
We welcome DVM, Oscilloscope and RF specialists together with others having a broader background. We would also welcome Engineers with more limited experience who wish to improve their knowledge to cover some of the other equipment that we handle.
We offer salaries in range £3,300 to £4,000 according to grade, with overtime, service awards and profit sharing bonuses in addition. Our working conditions are very good and our staff enjoy the benefit of the friendly atmosphere of a small company.
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Having told you about ourselves, why not contact us and discuss where you could fit into our Company.
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Blackwater Station Estate, Camberley, Surrey
Telephone Camberley 33922 (7635)

Closed Circuit Television (Video Workshop) Engineer

£3349 - £4910

Garnett House
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Applications are invited for this post at Garnett College which trains qualified mature students for teaching careers in Further and Higher Education. Duties will include maintenance of television equipment in use throughout the college, production work and participation in training. Applicants should be qualified and experienced in the use and maintenance of CCTV equipment.
Excellent conditions of employment. Starting salary will be dependent on qualifications and experience. Salary includes London Weighting and pay supplements for 1976 and 1977.

For further details and application forms contact the Chief Technician at the College. Tel. 01-789 6533.

GLC Mechanical & Electrical Engineering (7652)

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To assume technical and administrative control of a base workshops concerned with trouble-shooting, repair, and maintenance of tape players and associated public address equipment. A thorough knowledge of audio equipment and previous experience of the control of technical staff is essential.

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For trouble-shooting and repair of tape players and associated audio equipment. Some previous experience is essential and on the job training would be given to suitable candidates.

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Orpington
Kent BR5 3QP

(7643)

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A vacancy exists in the Electronics Section of the Department of Medical Physics. The work involves the development and manufacture of a wide range of medical and research instruments, using both digital and analogue integrated circuit techniques.

Appointment will be to Medical Physics Technician Scale IV. Scale: £3,162-£4,130 (inclusive of all allowances). Minimum qualifications are ONC or equivalent with recognised practical training.

For further details of the post contact Mr D. Ritchie, Chief Technician, Department of Medical Physics, St. George's Hospital SW17 (672-1255 ext. 4058).

Formal application and request for job descriptions should be made to: Miss H. Forsyth, Personnel Department, St. George's Hospital, Blackshaw Road SW17.

(7577)

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Salary £3,776 - £4,708 p.a. (including all allowances and according to experience). Application form from Personnel Department, Royal Free Hospital, 21 Pond Street, London, NW3 2PN. Telephone: 01-794 0431. Quote Ref. 1498.

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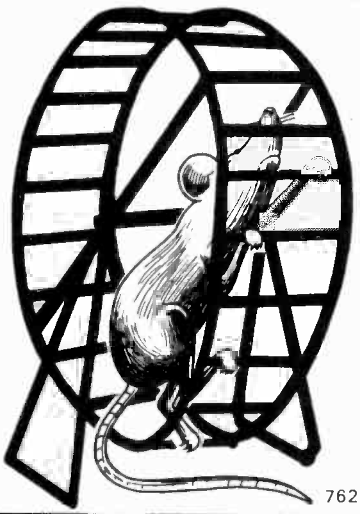

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LINK ELECTRONICS Walworth Industrial Estate, Andover, Hampshire, England Telephone: Andover (0264) 61345

(7597)

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(7637)

GCHQ Cheltenham

The Polytechnic of North London

Department of Chemistry

LABORATORY TECHNICIAN

(Grade 5)

is required in the Spectroscopy Laboratory of the Department either to operate the Mass Spectrometer or to be actively involved in the electronic and mechanical maintenance of spectroscopic instruments.

Experience at fault-finding, repair and maintenance of electronic and scientific instruments would be a special advantage.

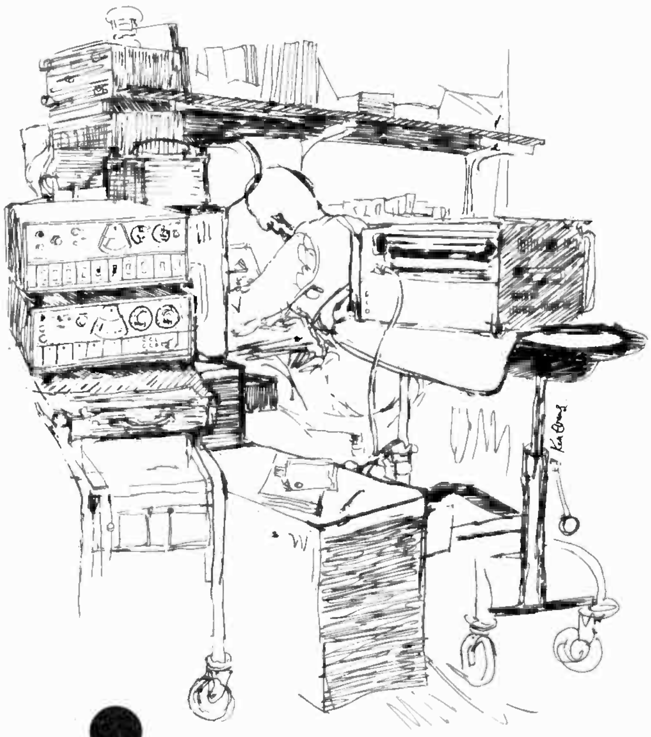
Candidates should normally hold HNC, C and G Advanced certificate and have at least 8 years' experience inclusive of the training period.

Salary scale: £3216-£3672 (inclusive of London Weighting) plus 5% earnings supplement (minimum £2.50 per week, maximum £4 per week).

Apply for further details and application form to the Head of the Department of Chemistry, The Polytechnic of North London, Holloway Road, London N7 8DB.

7572

Marconi Instruments



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The appointment will be made in our Scientific Officer grade, the scale for which is £3147 p.a. to £5047 p.a. (including supplement and London Allowance). The starting salary will be according to qualifications and experience.

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Please write or telephone for an application form to: R. E. Nolan, Personnel Officer (Research), Glaxo Research Ltd., Greenford Road, Greenford, Middlesex. Tel. 01-422 3434, quoting reference No. ZH179.

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LONDON N19 3JG, ENGLAND
Telephone: 01-272 7766

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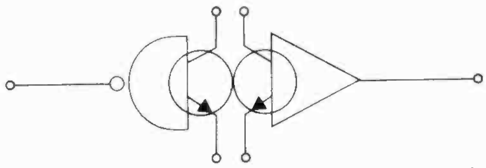
SITUATIONS VACANT

College of Higher Education
TOPS Course

Train as an Electronic Technician Engineer



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The course is based on an electronic systems approach with particular emphasis on electronic duties and signal generation, transmission, processing and display. It is intended to cover the knowledge and practical abilities for employment as an electronic technician engineer in a wide variety of functions such as development, diognostic testing, commissioning or installation of electronic equipment and systems.

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You must have been away from full time education for a total of three years and should be ideally aged 25 years or over. You should have had experience in electrical or electronic engineering in industry or the Services, but should be unemployed or willing to give up your job to take the course. You must have at least an appropriate ONC, OND or City & Guilds technician certificate.

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(7573)
HO/9

Manpower Services Commission
MSC **Training Services Agency**

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PT	72	20	21	£20.00
TL	75	22	21	£20.00
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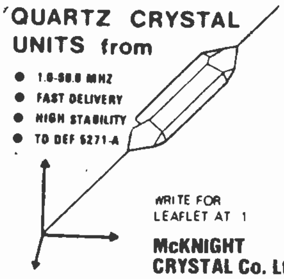

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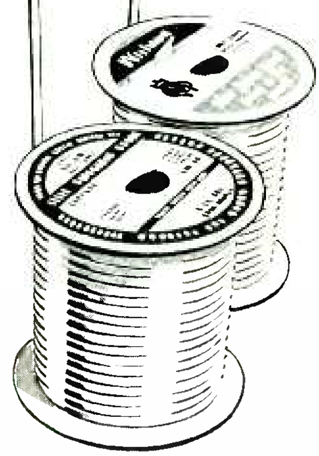

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