wireless world

Matrix H decoder

JUNE 1977 40p

Using microprocessors
Clock date display

The Queen's Silver Jubilee
Wireless World 25 years ago

A Synthesized Signal Generator from mi

£8,000? £6,000? £4,000? under £2,000?

Somehow some of our customers have been persuaded that our prices are as big as we are. Sometimes the biggest brains are the most cost-conscious brains. For example, our illustration shows a synthesized signal generator which costs £1,700 *: the new 520MHz TF2015/1 Signal Generator with its associated Synchronizer. With this combination, synthesizer operation is obtainable without any degradation of generator signal purity, performance and versatility.

Leakage specification is lower than any other available VHF/UHF source and output accuracy at low levels beats all others in the price range.

Building on the enviable reputation of the TF2015 for performance, reliability and value, we have now introduced two new a.m./f.m. versions: the TF2015/1 for narrow band mobile radio testing and TF2015/2 for telemetry and other wideband applications. The U.K. price for TF2015/2 with Synchronizer is £1,888 *. All have a frequency coverage of 10 to 520MHz with calibrated a.m. and f.m.

Tuning in 100Hz steps whilst under locked conditions provides a valuable facility for bandwidth measurements and channel stepping. Digital setting of frequency with direct readout means no waiting for counter gate times when you want high resolution, and no r.f. leakage from display holes.

*Special U.K. price

One in four

Only one in four of our customers tells us he needs the stability of a synthesizer. So the other three can save almost half the cost of the synthesizer combination by buying the analogue part alone. So, whether you require a synthesizer or a signal generator you can now obtain quality at ordinary prices.

Optional accessories include Pulse Modulator TF2169, i.f. probes for 'squelch killing', multiple calibration plates for units of output level, matching pads, attenuators, reverse power protection and carrying case.

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Electronics, Television, Radio, Audio

JUNE 1977 Vol 83 No 1498

Contents

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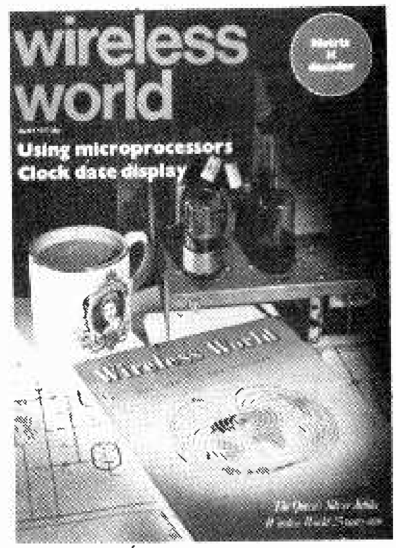


Front cover assembles a June 1952 issue of WW and other artefacts to commemorate Queen Elizabeth's Silver Jubilee (see note on page 83)

IN OUR NEXT ISSUE

Microwave intruder alarm. Constructional project using book-size Doppler radar based on 10GHz Gunn diode oscillator to detect movement in rooms or business premises.

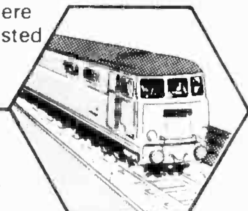
Multi-system surround-sound decoder for BMX, Matrix H, System 45J, QS/RM, and SQ using NRDC Ambisonic technology. Suitable for three-amplifier / four-speaker, four-amplifier / four-speaker, and four-amplifier / six-speaker reproduction.

Eliminating adjacent channel interference. Two methods using the fact that an a.m. signal has two symmetrical sidebands to effect mutual cancellation of unwanted signals.

ISSN 0043 6062

THE JAMES SCOTT INDUSTRIAL MICROWAVE RANGE OF EQUIPMENT

The James Scott range of Microwave equipment offers industrial users a greater choice of alternative systems in robust, industrial, cast aluminium housings, for a wide variety of applications.
The range is made up of standard sub-assemblies which can be permutated to suit individual application requirements. Here are some suggested applications for these units.



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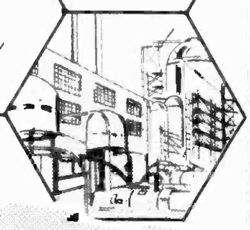

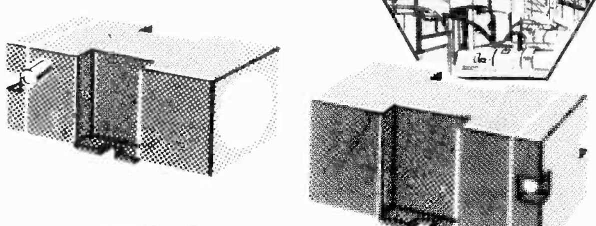

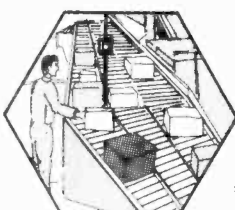

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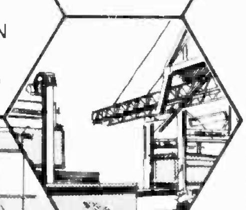

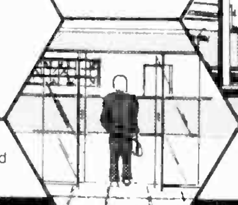

Please write or telephone for further information and technical literature to

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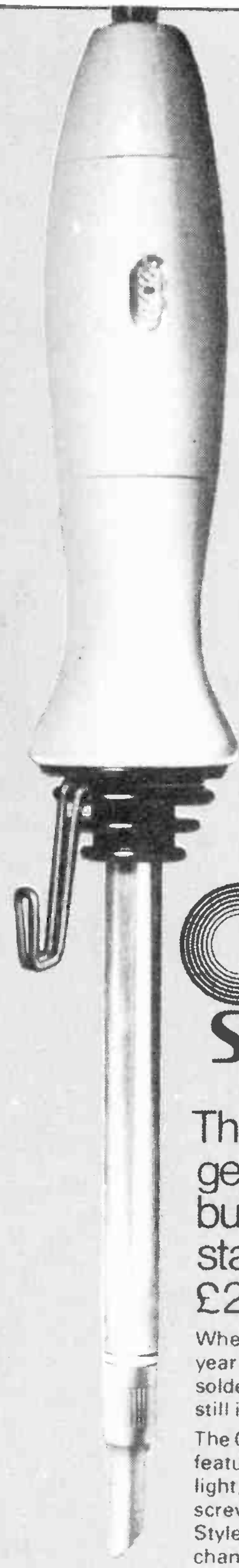

*Illustration actual size

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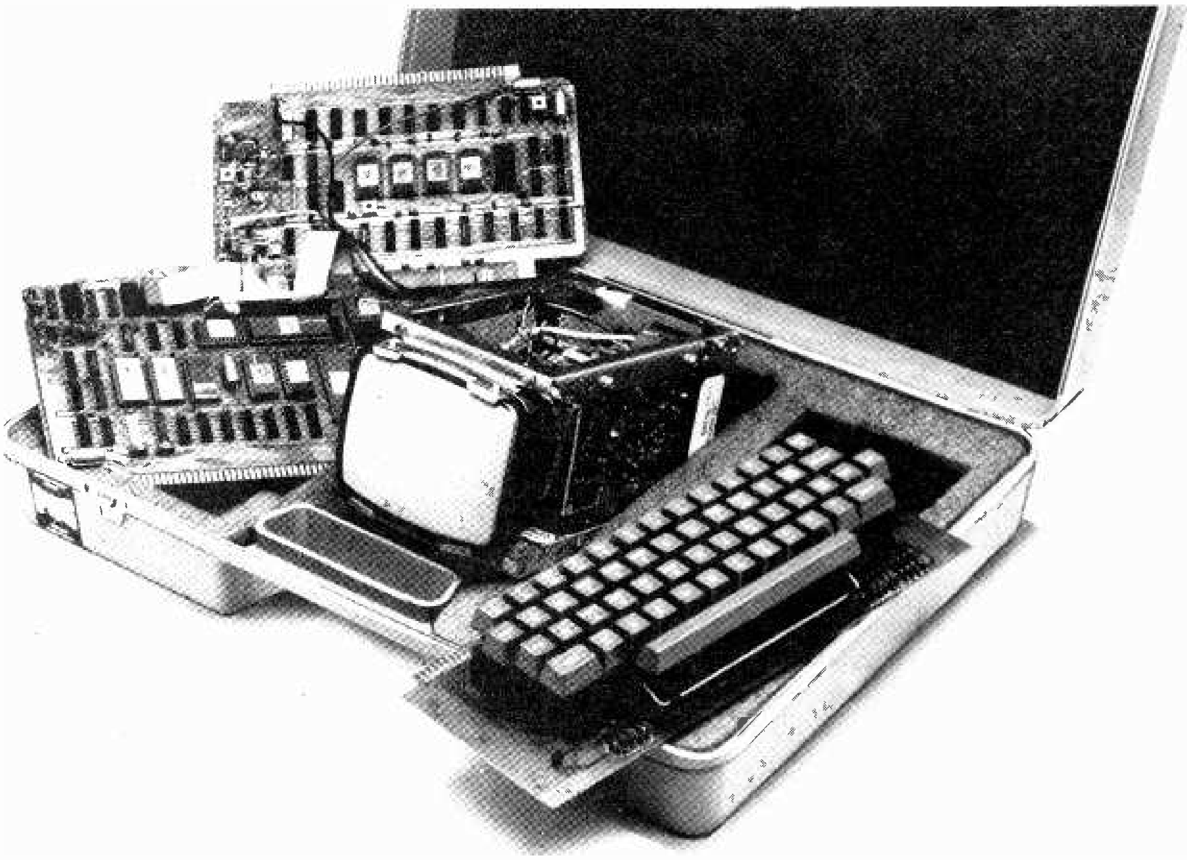

Meet the M6800 microprocessor evaluation system that works for its living.

The Motorola Polyvalent Development System (known to its friends as the Polykit) is all good news.

It's big enough to do real work in real work situations and small enough to take with you in its light-weight case. It even includes a keyboard so you can stop tying up the Teletype.

The Polykit is powerful enough to enable you to produce and prove software for most of the problems you'll come across–and if you want to work at home, there's a special interface that lets you use your own T.V. as a display monitor (black and white this year!).

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This kit not only works for a living–it pays its way too.

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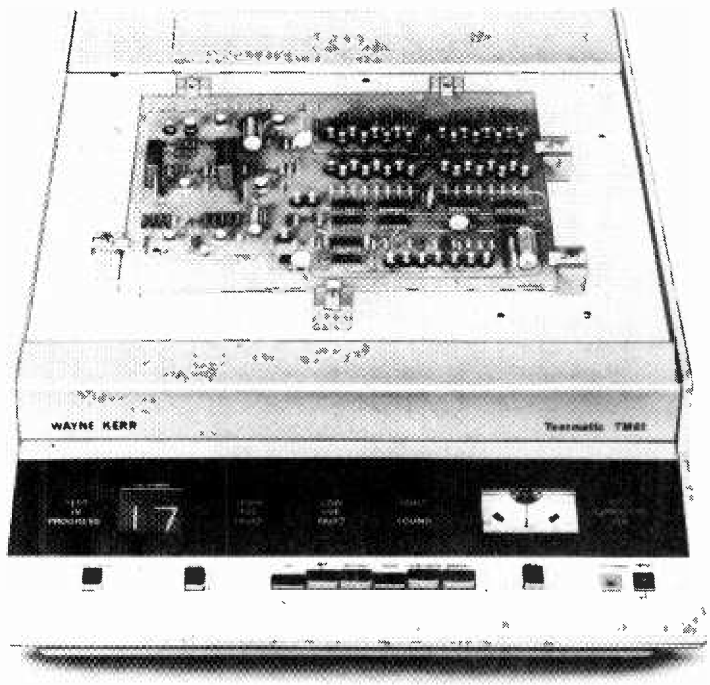

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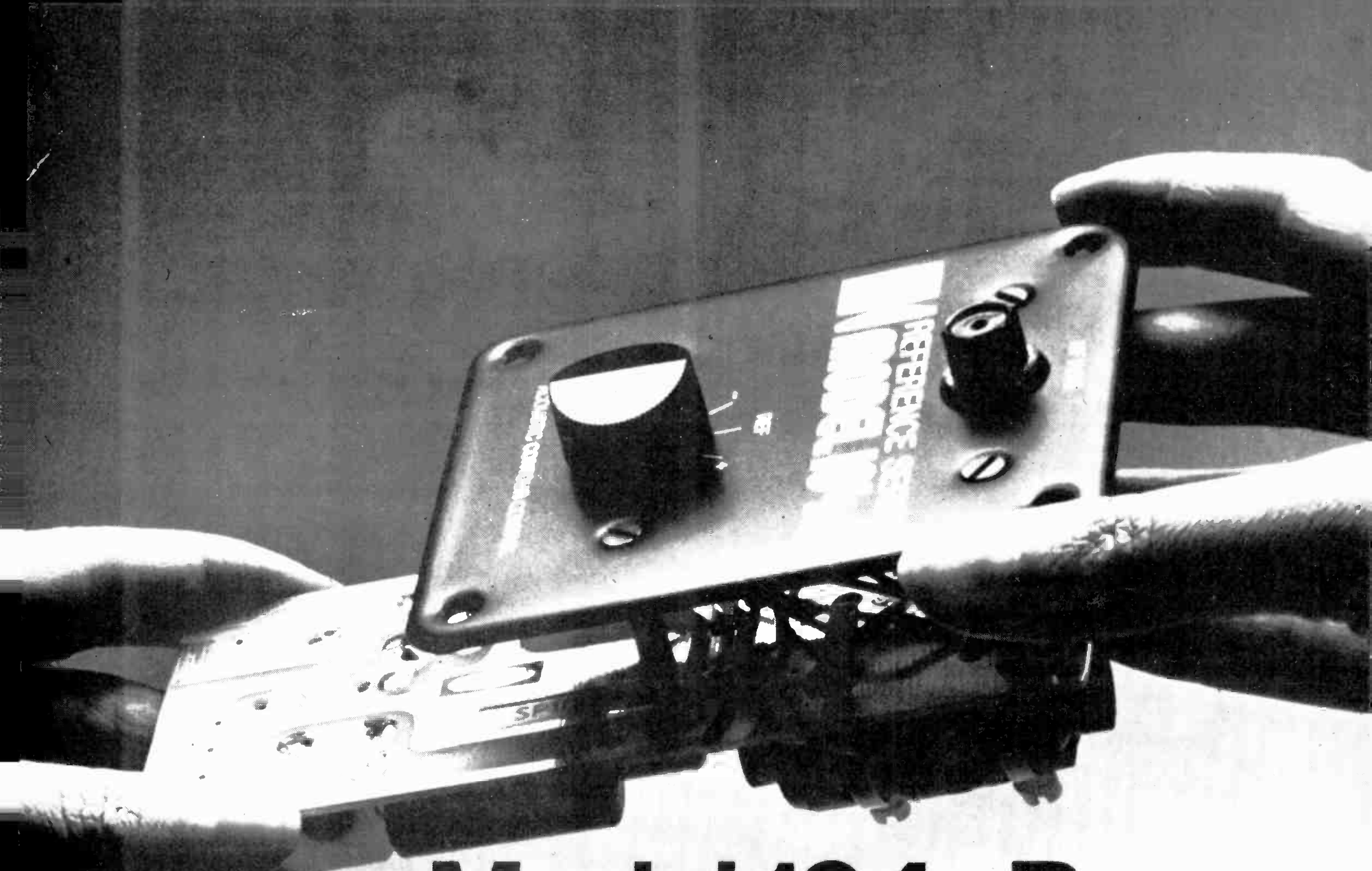
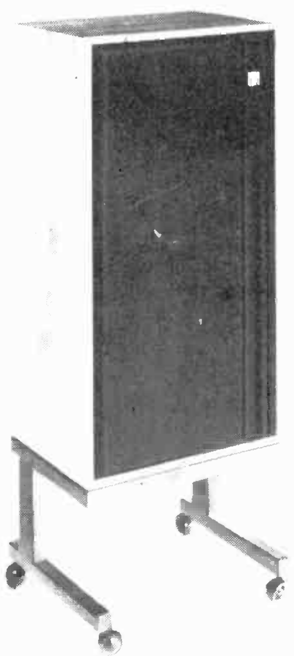


Model 104 aB.



One step nearer the reference.

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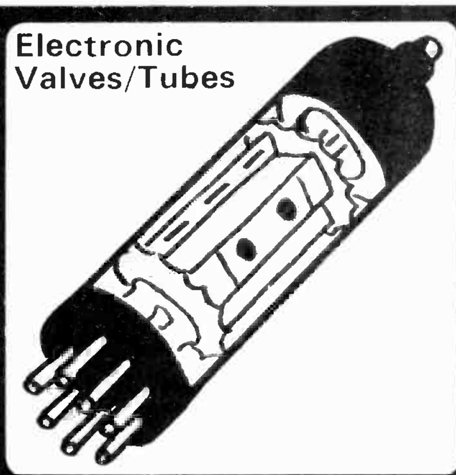

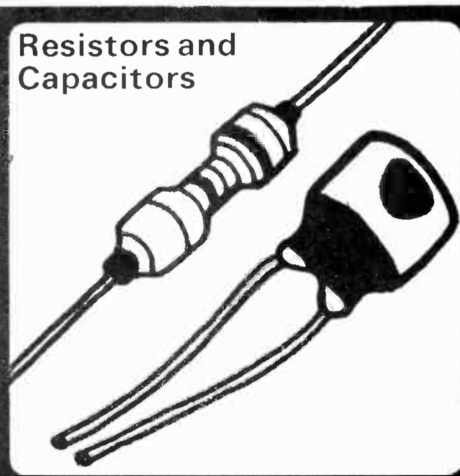

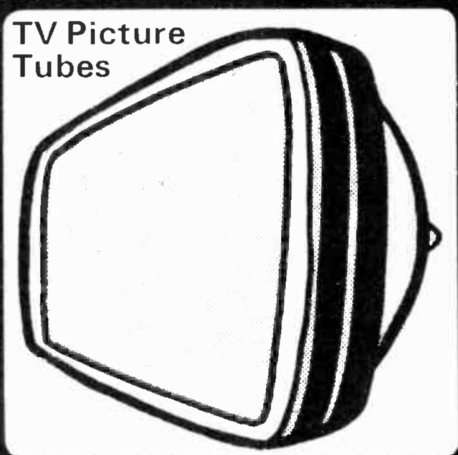

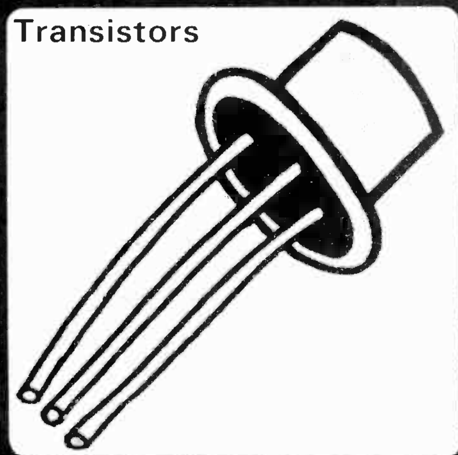

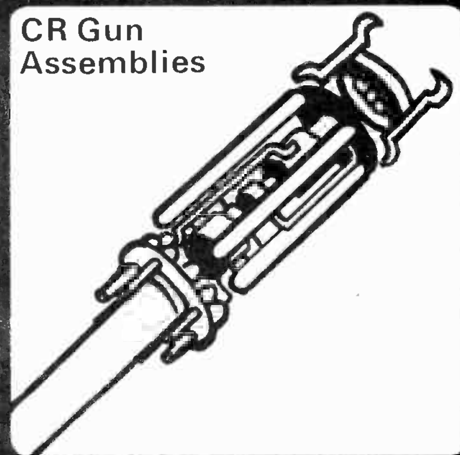

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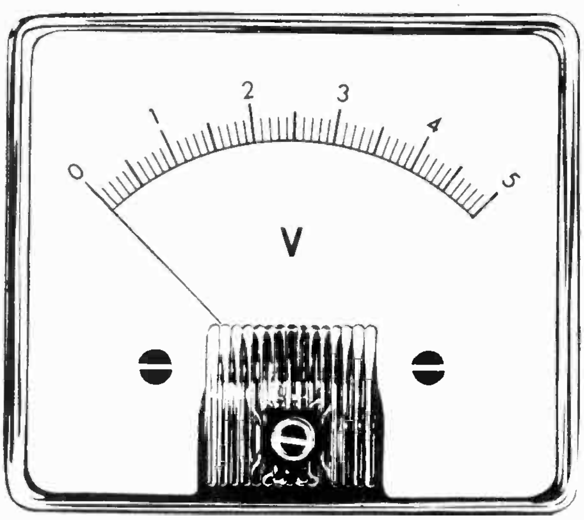

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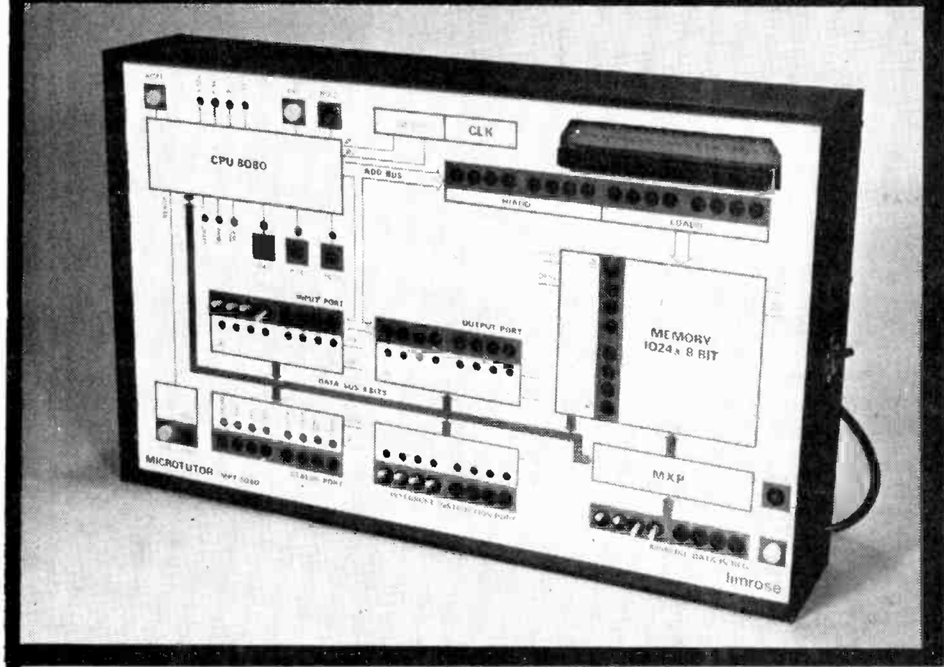
New low cost microcomputer for learning the 'how' of microprocessors ....



Now, there is a new Microcomputer to provide "hands on" experience to master and apply microprocessors – the Limrose MPT8080.

It comes ready to use. Nothing else to buy, debug or assemble. Just plug it in and you have a powerful microcomputer ready to use. No need for a Teletype, but if you have one, it can be hooked on using a plug-in card.

The comprehensive instruction manual is so straight-forward that even a person with limited technical knowledge can rapidly learn how microprocessors work.

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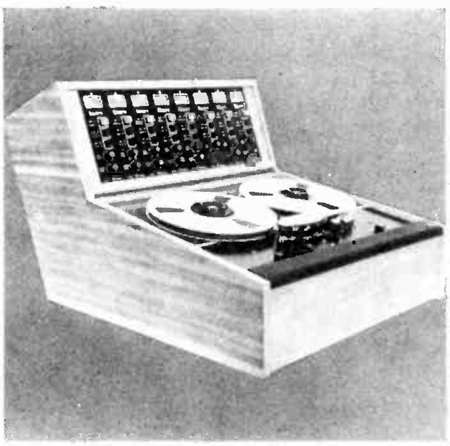
ITAM 805 (8TRACK) MASTER RECORDER



Fully modular electronics using plug-in PCB's throughout. Separate sync and replay amps give identical levels. Switchable VU's with slow decay. Individual oscillator for each channel. Dolby A switching facility. Comprehensive facilities include sync on all channels, servo controlled capstan, modular electronics, variable speed (optional), relay-solenoid operation. Compact presentation for easy portability.

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WOW!

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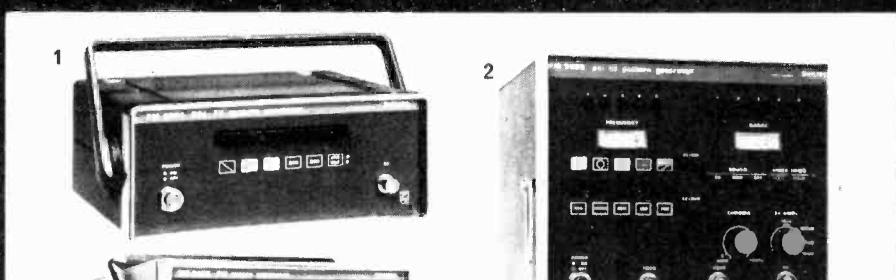

1 PM5501 PAL TV Pattern Generator Extremely light portable instrument for service in customer's home. Five different test patterns for colour and black/white installation and service.

2 PM5509 PAL TV Pattern Generator The ultimate in pattern generators. Full IF coverage: band I, III, IV & V. Electronic tuning with preset channels. 10 test patterns (colour and black/white).

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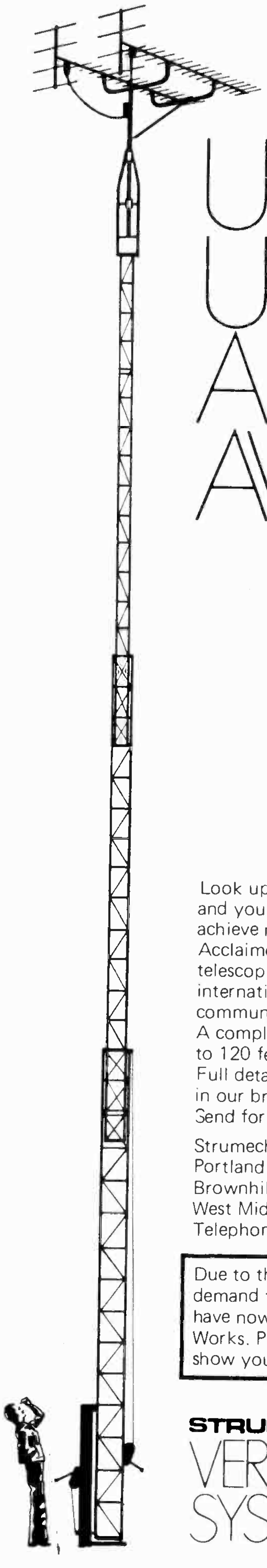

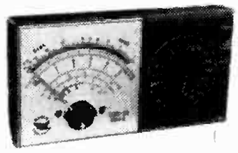

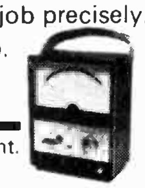

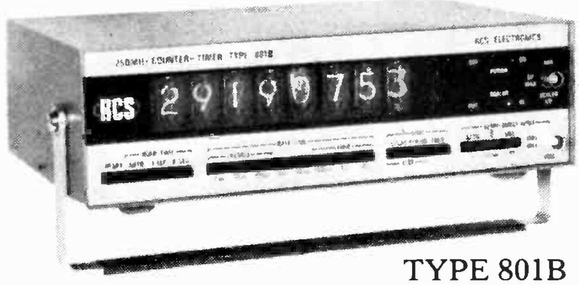
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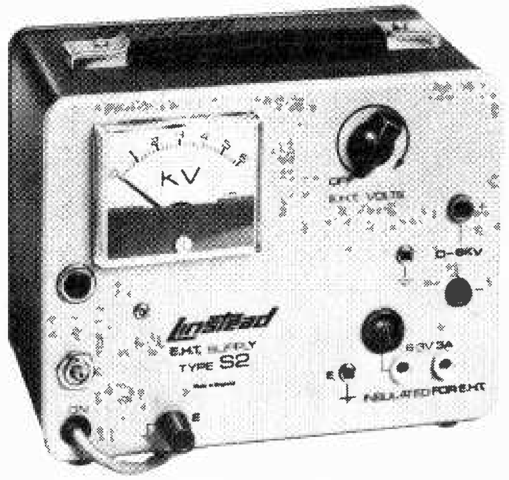
How to get high



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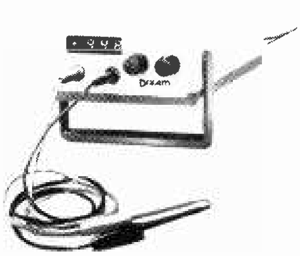

A clear, functional multimeter, featuring extremely accurate digital display, in superbly styled shatterproof carry-case. It could cost £100! But the complete Doram kit with case, printed circuit board, leads and all components is yours for just £54.50 plus £4.36 VAT.

Based on Ferranti technology with accuracy ± 0.6%, the new Doram Multimeter is an indispensable tool at a terrific saving. Measurement is indicated by a 3½ digit display updated twice per second – display flashes to indicate overload.

KEY DATA

Volts DC	200mV, 2V 20V 200V, 1000V Input impedance 4 2MΩ Maximum sensitivity 100µV
Volts AC	200mV 2V 20V 200V, 500V Input impedance 4 2MΩ Maximum sensitivity 100µV
Current AC/DC	200µA 2mA 20mA 200mA 2A
Resistance	200Ω, 2KΩ, 20KΩ 200KΩ, 2MΩ

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Doram Electronics Ltd. PO Box TR8, Wellington Road Industrial Estate, Wellington Bridge, Leeds, West Yorkshire LS12 2UF

Registered in London No 1155856 Directors R A Marler, D I Turner, F Chable

Yes, I want to save up to £40

Please send me (subject to availability) complete kit(s) for Doram DIGITAL MULTIMETER at (£54 50 + £4 36 VAT incl p & p) total **£58.86.** I understand I can return the unused kit(s) within 7 days and claim my money back if kit(s) returned undamaged in the form received and ready for re sale

Please send me complete DORAM KITS CATALOGUE(s) showing an additional 25 kits, at 25p each

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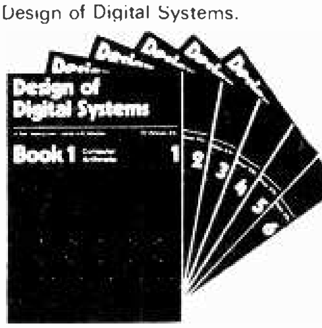

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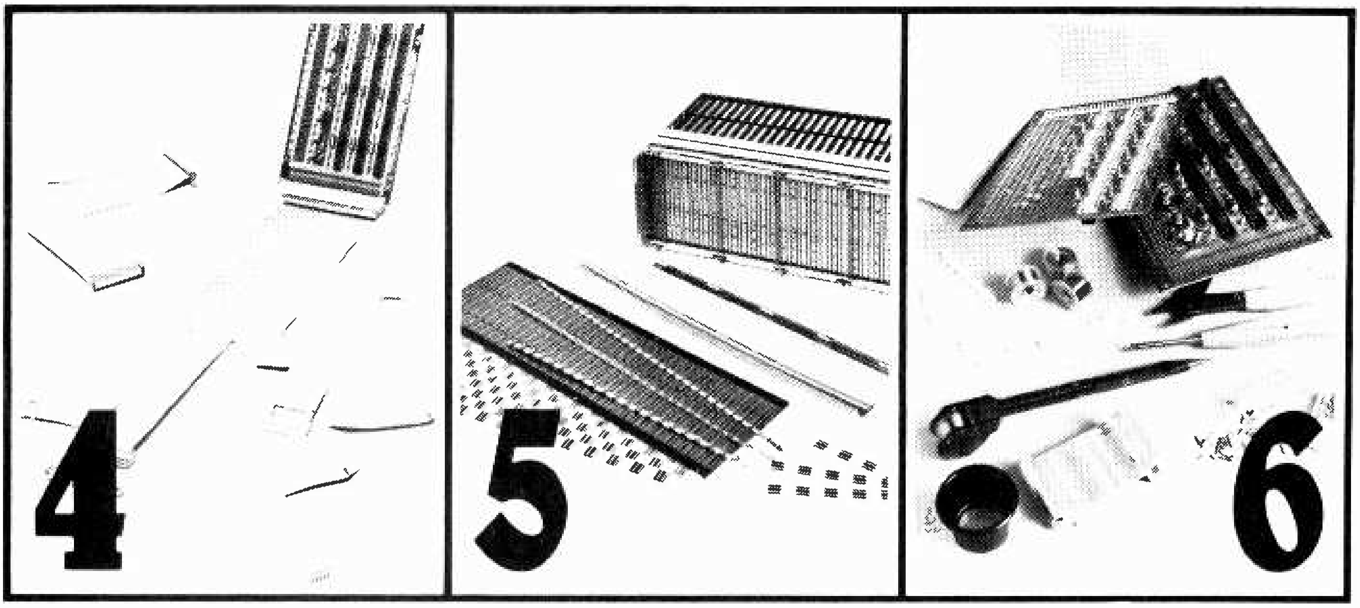

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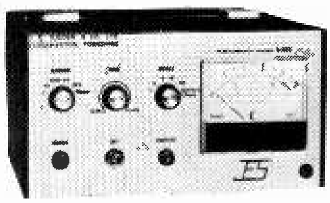

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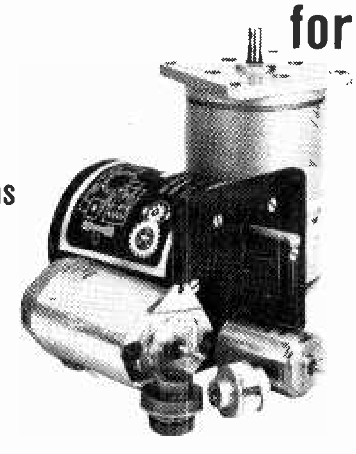

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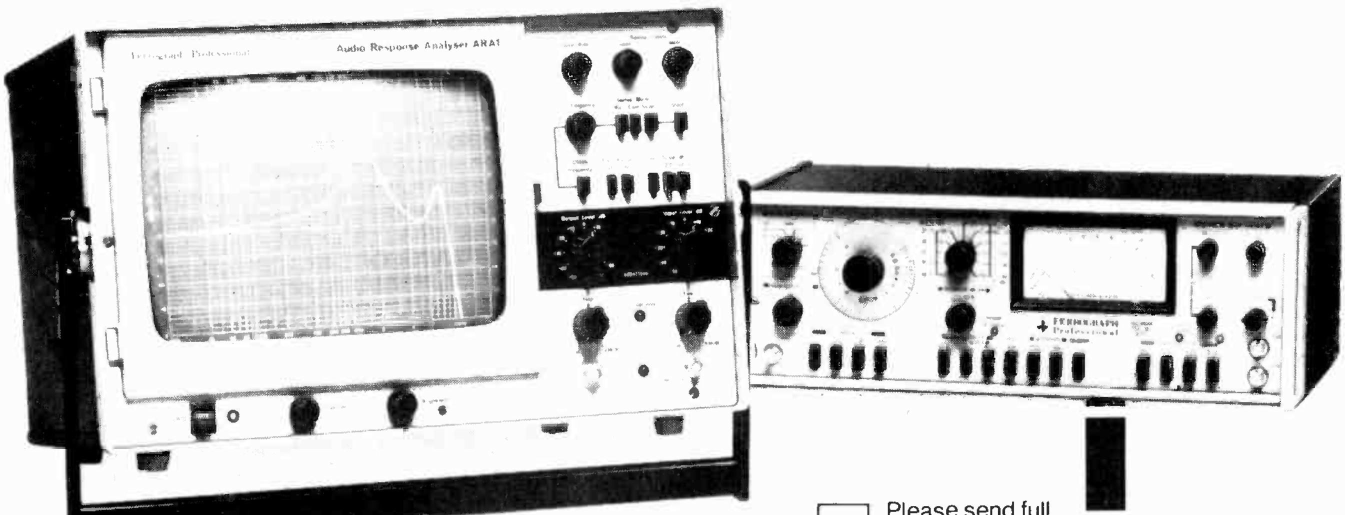

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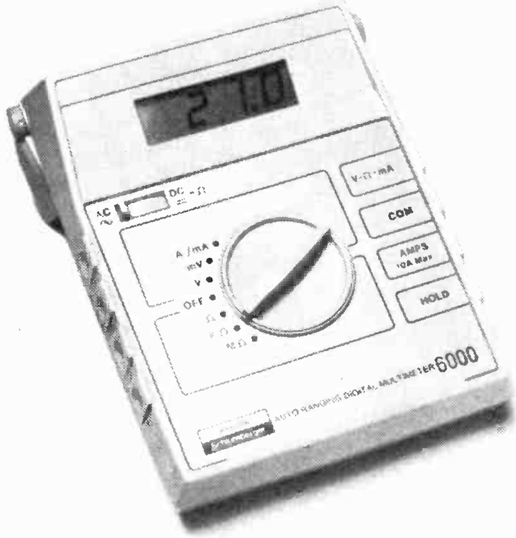

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This is an echo chamber?

Yes, and much more! It is the first N-channel Bucket Brigade Device designed with the audio engineer in mind. The SAD-1024 Serial Analog Delay will provide reverberation, echo, tremolo, vibrato and chorus effects in electronic organs and musical instruments. It will equalise speaker systems in an auditorium, or can be used in speech compression or voice scrambling systems. The SAD-1024, which contains two independent sections of 512 analog storage elements will accomplish all of these with a signal-to-noise ratio in excess of 75dB. The two sections may be used independently or they may be connected in sequence to provide 1024 clock periods of delay. The delay provided by the device can be continuously varied by the clock rate from less than one milli-second to more than one second.

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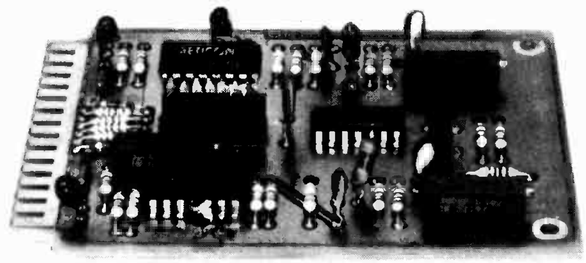
You get all these features for less than 1p per storage element in OEM quantities.

We also offer an optional complete circuit card to help you evaluate this exciting new device. Other devices for applications such as time base correction in the video bandwidth are also available.



RETICON®

The SAD-1024 and circuit card is available immediately from Reticon's sole UK distributors, Herbert Controls and Instruments Limited, Spring Road, Letchworth, Herts SG6 4AJ. Telephone: 04626-3841. Telex: 825535.

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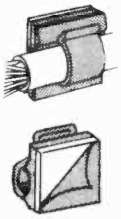
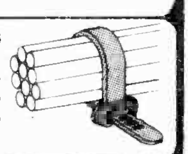
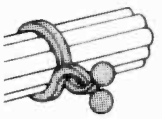
PLASTIC FASTENERS FOR ELECTRONICS



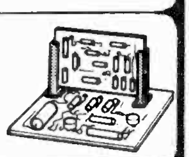
SELF-ADHESIVE CABLE CLIPS are a quick and simple means of securing cables, cords and small looms to flat surfaces. No drilling or fixing screws necessary. The peel-off backing is removed immediately before placing the clip. The coating adheres to most clean, flat surfaces and withstands a wide range of humidity and temperature. Cable clips are moulded in natural nylon and have rounded edges to prevent damage to the cables.



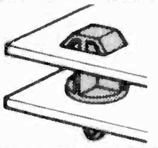
CABLE STRAPS are semi-permanent fasteners for strapping wires and cables into tight, compact looms. The ratchet fastener is adjustable and can be released by pinching-in the sides of the fastener head. Cable straps are made from black nylon.



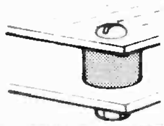
WIRE TIES are a flexible means of fastening wires and small cables into orderly, compact looms. They are quick and easy to fit and can be re-used, greatly reducing re-looming times. Wire ties are made from nylon and are available in various sizes each determined by a different colour.



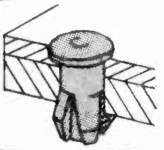
The **P.C. BOARD GUIDE** is a self-retaining edge support for printed circuit boards. It has good panel retention and grips p.c. boards firmly and securely. The guide is available in two types of material - yellow acetal or grey Noryl, for high temperature and voltage applications.



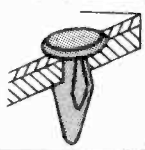
P.C. BOARD SPACERS are simple to fit, one-piece mouldings for use with p.c. boards. They have a self retaining shank for fastening into panels and a T-shaped anchor for securing p.c. boards of 0.062" thickness. They have good resistance to vibration and are suitable for board-to-board or board-tochassis use.



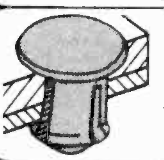
P.C. BOARD STAND-OFFS are quickly assembled, self-retaining panel supports for p.c. boards. Made from natural (off white) nylon and have good resistance to vibration. Suitable for panels up to 0.079" thickness. Stand-Offs accept a No. 4 self-tapping screw.



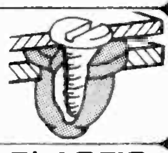
PLASTIC RIVETS fasten panels, fittings and name plates to metal plastic and wood. Resilient enough to fix into brittle materials like fibreglass, hardboard and glass. Shank, head and pin are one piece. Fixing is by driving the pin through the head into the space between the legs, gripping the work.



DRIVE FASTENERS hold two or more panels together. Easily fixed, normally by thumb pressure. No special tools required. Boat-shaped DRIVE Fasteners are for panels of thin and medium thickness and are removable. Ribbed Drive Fasteners are used in blind holes where hole length exceeds ler gth of shank.



PLASTIC HOLE PLUGS are quick, inexpensive means of plugging unwanted holes. Hole Plugs keep out dust, dirt and moisture. Attractively shaped heads give a neat finish. The snap action grip of the Hole Plug makes a vibration resistant seal. Hole Plugs are made from nylon and are non-corrosive.



LOKUT ANCHORS are used to strengthen holes by providing additional screw thread engagement in materials where self-tapping screws would be unsatisfactory. Made from high strength nylon and used in insulation, and electrical chassis work. Easily fitted by hand.

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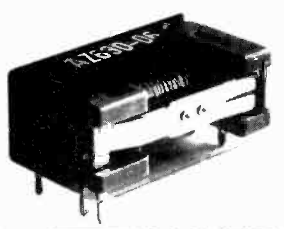

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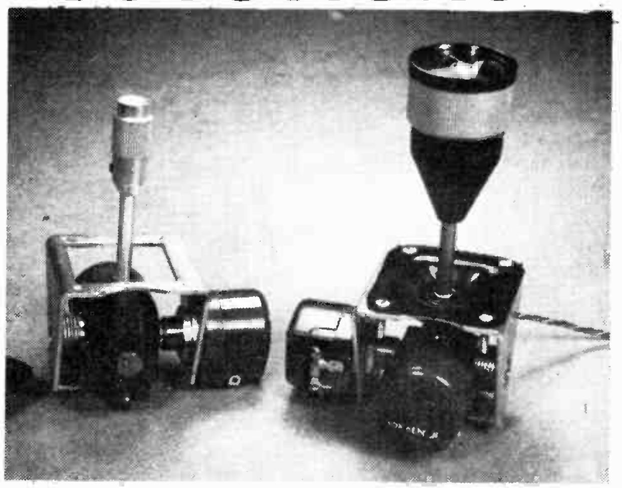

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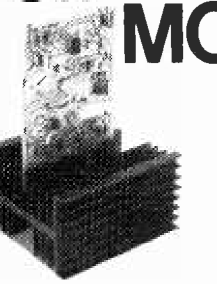

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T.H.D.	0.05% @ 1kHz	0.05% @ 1kHz	0.05% @ 1kHz
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Input Sensitivity	0dB (0.775V) 70 watts	0dB (0.775V) 110 watts	0dB (0.775V) 170 watts
Input Impedance	47k	47k	47k
Power Requirement	± 35Volts	± 45Volts	± 55 Volts
Overall Dimens.	5.8" Long x 3" Wide x 1" High.	5.8" Long x 3" Wide x 1" High	4.8" Long x 3" Wide x 1" High Heat Sink 6" x 5" x 1"

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The NEC, which has declared microwave space communication to its speciality, knows perfectly which attributes equipments must have for becoming bestsellers.
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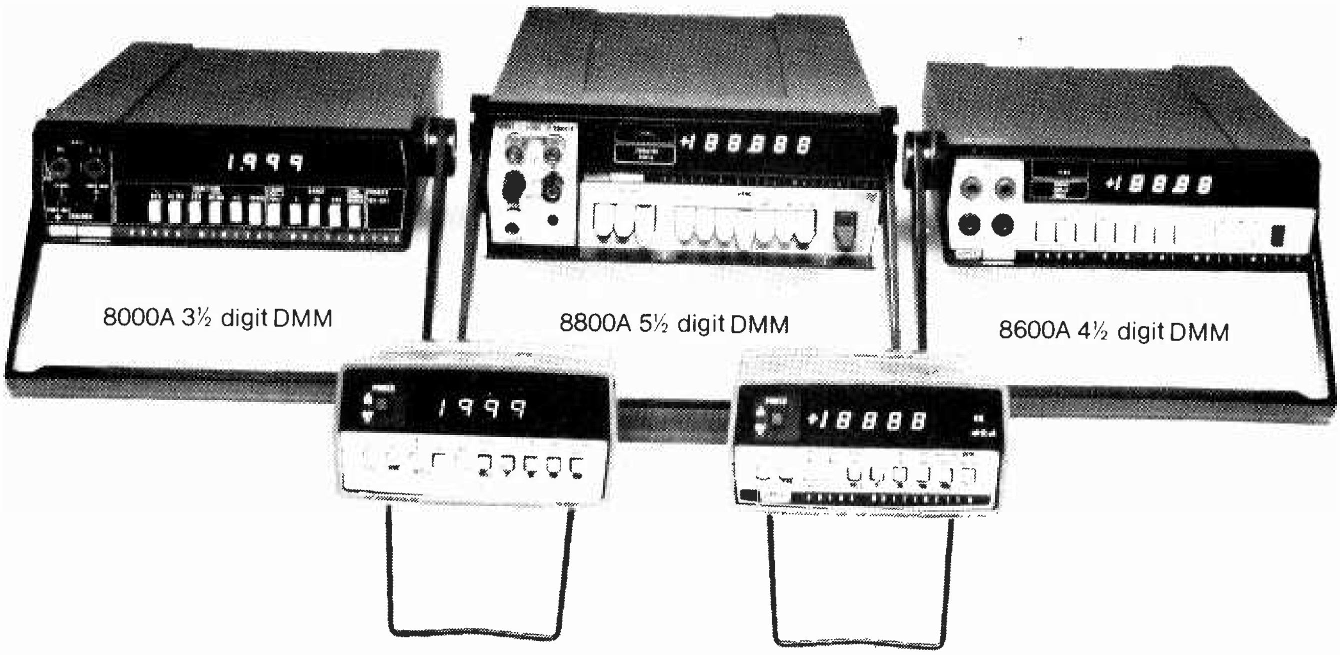

8000A 3½ digit DMM

8800A 5½ digit DMM

8600A 4½ digit DMM

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wireless world

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TOM IVALL, M.I.E.R.E.

Deputy Editor:
PHILIP DARRINGTON
Phone 01-261 8435

Technical Editor:
GEOFFREY SHORTER, B.Sc.
Phone 01-261 8443

Assistant Editors:
MIKE SAGIN
Phone 01-261 8429
RAY ASHMORE, B.Sc., G8KYY
Phone 01-261 8043
JOHN DWYER
Phone 01-261 8620

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Radio and air safety

Which is more important, entertainment or human lives? Anyone who has been able to listen to v.h.f. voice communication aboard a civil aircraft and compare it with broadcast voices on even a medium-price v.h.f. domestic receiver will be appalled at the difference in quality. Our relative values seem to be all wrong. In an airliner the safety of hundreds of lives and millions of pounds worth of aircraft hangs on the effectiveness of the radio telephone communication with the ground, especially during take-off and landing. And if one compares the engineering refinement of the two systems one cannot help but be appalled again. The air-ground voice communication technology looks relatively crude. This is not to criticise the design and manufacture of the equipment. No doubt it well fulfils the specifications laid down. The question is whether the specifications are good enough for the very critical nature of this communication task.

All this is brought into sharp focus by the worst air disaster in history – the collision between two Boeing 747 jumbo jets at Tenerife airport on March 27, which killed 577 people and lost tens of millions of pounds worth of aircraft. No doubt the blame will be laid ultimately on a human error. But it appears from tape recordings of the exchange between the control tower and the two aircraft that an important factor in this human error (if indeed it was) was that another transmission on the same frequency prevented the KLM captain from hearing in full one of the control tower messages. Now the possibility of radio interference in such a situation is serious enough in itself. But it could be argued that the pilot should have taken no action till he had queried this message. The real point is that a misunderstanding may have occurred through the medium of the v.h.f. radio telephone system. And this is not an uncommon situation, as accident reports will confirm.

The International Civil Aviation Organization should examine to what extent the effectiveness of v.h.f. voice communication is a significant factor in such mishearings and misunderstandings. Voice quality is inherently poor in an a.m. interference-prone system with an audio bandwidth of about 2700Hz. On top of this is the problem of the foreign accents of non English-speaking pilots and controllers (English being the international language for air-ground communications). Certainly the *intelligence* conveyed is the responsibility of the pilot and controller. But considering what is at stake the radio telephone system should be specified to convey sufficient speech *information* (in terms of the reproduction of phonemes and morphemes) to ensure that there is little chance of mishearing in critical situations where, because of human stress or impatience, messages are not queried or verified.

This entails not only straight electronic engineering but investigation into the psychology of speech perception in bandwidth-limited and possibly noisy channels. For example, it is a well known fact that the recognition of spoken messages in the absence of full information depends a great deal on the hearer's expectation of what is coming. As a Pan Am pilot was reported as saying in the aftermath of Tenerife, "sometimes you think you hear what you want to hear". With the problem of foreign accents, one possibility would be to explore the use of speech analysis and synthesis to reconstruct speech in a standard, universally acceptable form with audio signal characteristics matched to the existing v.h.f. channels.

The public using air transport has a right to demand the best communication engineering available to secure their safety in flight. It is up to ICAO to re-examine the standards and specifications laying down the communication requirements, which may well prove to be set too low.

Purpose-built Matrix H decoder

Modification to variable-matrixing technique

by Geoffrey Shorter

Recent work at the BBC's Engineering Research Department into decoding techniques for matrix H has centred on the variable-matrix type. Initial work on a phase-shifted Sansui Variomatrix decoder led to an improved variable matrix decoder specifically intended for matrix H. This article reports some of this recent work, gives results of BBC appraisals and includes a practical design for a decoder.

Whilst the BBC weekly surround-sound transmissions which started recently are on a pilot basis it seems unlikely that equipment manufacturers will commit themselves to producing matrix H decoder equipment in more than sample quantities. To decode these experimental transmissions into four loudspeakers, one can use decoders for other systems — with suitable modifications where necessary — or construct a purpose-built H decoder. Compatibility of H through other system's decoders can be pictured by inspection of the phase-amplitude or energy sphere, or more conveniently its side view. Diagrams in recent issues suggest, for instance, that a BMX decoder as used in Nippon Columbia UD-4 equipment (e.g. Denon UDA-100, UDA-300) would approximately decode H as it stands. A little wideband phase difference (say 20° phase lag in the right channel) between channels prior to decoding to tilt the pan-locus about the left-right axis might give an improved result. Regular Matrix or Sansui QS decoders without the Variomatrix addition could also be used given an appropriate phase shift, as indeed can the Variomatrix type, as pointed out in the May issue.

What this article is about, however, is recent BBC work on adapting the variable-matrix technique and their design given in this article is specifically intended for matrix H. It was produced by Phil Gaskell and Paul Ratliff of the Research Department, who have developed it to an extent where they say "the shortcomings of the variable-matrix technique are rarely obtrusive". They consider the limit of performance of H decoders has not yet been reached, some aspects remaining to be optimized, and they envisage further developments using more complex forms of programme-dependent decoding, or delay lines to overcome l.f. localization and transient problems. Nevertheless, a useful improvement in performance is felt to have been obtained compared with the phase-shifted Variomatrix approach.

Early laboratory model of Matrix H decoder developed at BBC

Three kinds of decoder tested by the Research Department are a fixed-coefficient H decoder based on the four-point equations given later, a Sansui Variomatrix decoder with prior wideband 60° phase-shift network in the right-channel input, and a variable matrix decoder designed specifically for H. This report starts by giving the results of the BBC appraisals, very largely in their own words.

Single-source localization tests

The fixed decoding gave good overall accuracy but images were more diffuse than those of the four-channel reference (pair-wise mixed material). Unlike most other systems the images were not unpleasant or "phasey" and were reasonably stable with head movement. Some comments of "closesness" of images were made but otherwise results were acceptable.

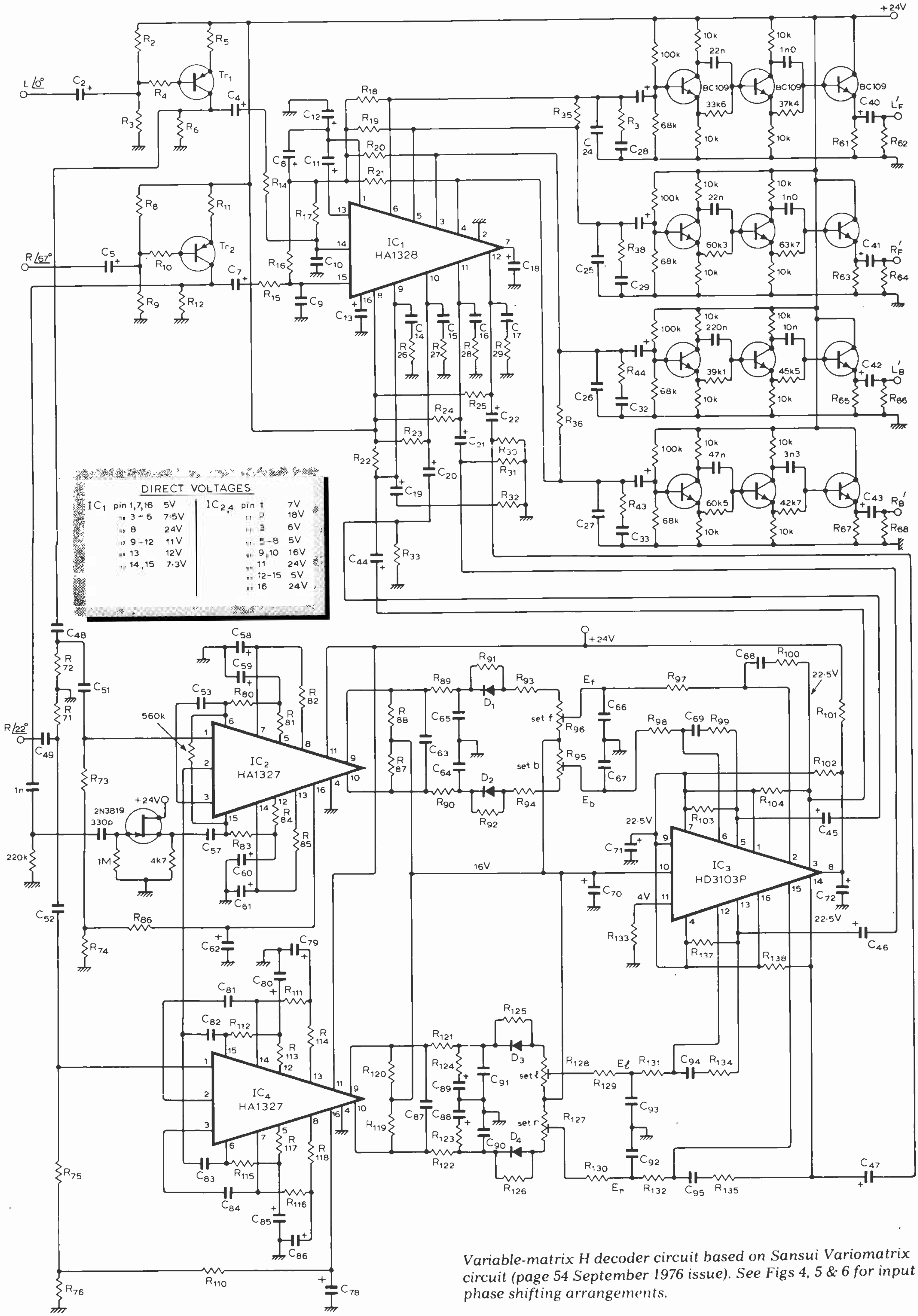
The Variomatrix decoder with phase-shifted unput gave better overall accuracy and sharper images, to the extent that results were not significantly inferior to those of the reference. The "closing-in" effect was absent but some comments were made that sibilants were localized differently to the main image, due probably to limitations in transient performance of the technique used.

The "purpose-built" H variable-matrix decoder gave a further small improvement in overall accuracy and the overall performance closely matched that of the reference. Though sibilant effects were not completely absent, they were much less noticeable.

Programme tests

The fixed decoder gave good accuracy with multi-source material and good tonal quality. It gave an overall pleasing sound sensation but was somewhat blurred and "closed-in" compared to the four-track reference. There was some instability of the sound-stage with head movement, and when the listener moved out of the central listening area the sound-stage collapsed to the nearest loudspeaker more noticeably than with the reference. Even so, a pleasing unoppressive sound was maintained, unlike most other systems decoded linearly.

With the phase-shifted Variomatrix



DIRECT VOLTAGES

IC1 pin		IC2,4 pin	
1,7,16	5V	1	7V
3 – 6	7·5V	2	18V
8	24V	3	6V
9 – 12	11V	5 – 8	5V
13	12V	9, 10	16V
14, 15	7·3V	11	24V
		12 – 15	5V
		16	24V

Variable-matrix H decoder circuit based on Sansui Variomatrix circuit (page 54 September 1976 issue). See Figs 4, 5 & 6 for input phase shifting arrangements.

decoder a much more spacious sound was produced, generally with good tonal quality. Its performance was more similar to the reference than that of the linear decoder. Occasional sibilant mislocations occurred, mainly on speech, but these were not too objectionable. However, with "serious" music the ambience was often found to be too narrow at the rear of the sound-stage, and a narrowing of the front-stage also occurred when the main body of sound was located in the centre-front region of the stage. For complex material sound images seemed to be less clearly defined than with the reference and there was an apparent excess of low-frequency energy in the centre of the stage, almost certainly due to the left/right blending at low frequencies. Some image movement was detectable, and in particular a dominant front sound-stage tended to pull forward secondary sound-images, located at the rear corners, to appear at the sides of the sound stage; but this was seldom seriously objectionable. Some secondary image wandering could occasionally be detected by experienced listeners, but none of these deficiencies appeared to be severely detrimental. This decoder was more tolerant to off-centre listening positions, but uncomfortably "phasey" effects could be detected in some locations for some image positions, largely due to the limitations of the phase-correction circuits.

The H variable-matrix decoder produced a spacious sound of good tonal quality, similar to the reference. The sound gave the impression of being significantly clearer, with a more "open" perspective than that of the Variomatrix decoder, and was judged to be very close to the reference. Ambience-spread in the rear-stage was substantially improved, and had a more natural tonal quality. Compression of the front-stage was much less obvious than with the Variomatrix decoder. Sibilant effects were hardly noticeable, although occasional image movement could still be detected. The lack of low-frequency energy in the centre-stage region, using complex source material, was preferred with this decoder, and was significant when listening for extended periods, the sound sensation being more comfortable. Tolerance to off-centre listening appeared to be particularly good, very much like the reference and previous unpleasant phasey sensations were absent.

A three-way comparison test between the phase-shifted Variomatrix decoder, the H variable-matrix decoder, with a four-channel tape as a reference was arranged after the initial assessment period. Nine studio managers from BBC Radio Broadcasting Groups were asked to assess and rate the two decoder performances on a continuous 0-100% quality scale, with the reference necessarily defined as having a 100% rating. The listeners were unaware of the decoder options being used. They listened to a 30-minute tape contining a wide selection of programme items. Overall the H decoder was rated as 77% as compared to reference, and the Variomatrix decoder was rated at 47%. However, this result pertained to tests where small differences in performance might be expected to be magnified. In some earlier tests* where the original programme material was balanced for the Matrix H system using the modified commercial decoder, a much closer match was obtained to the reference and was considerably better than that for other matrix systems tested.

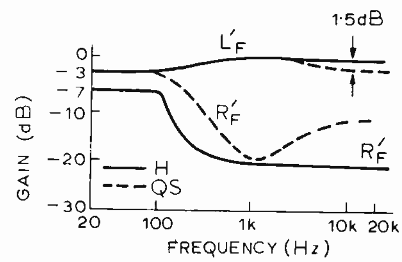


Fig. 1. Separation curves for a left-front sound, for both the QS and H variable matrix decoders, show improved high-separation band.

Variomatrix operation

In the variable matrix technique developed by Ito and Takahashi of Sansui,† the location of the dominant source in the sound stage is detected in the control circuits. To detect whether the dominant source is in the front or the back stage, the encoded signals are limited and passed to a phase detector that produces control voltages dependent on their phase difference. Left/right control signals are obtained as a result of measuring the ratio of signal levels in the two channels. To do this a phase difference of 45° is introduced, their sum and difference taken, limited and applied to a phase detector in a similar way to the front/back arrangement. Sansui claim the phase detecting system allows an input dynamic range of 1000:1.

Field-effect transistors convert the four control voltages to variable resistances, placed in such a way that the left, right, sum and difference signals are altered in gain, from zero to 1.41 or $\sqrt{2}$, with a basic matrix value of 0.41, prior to final matrixing.

The cancellations that occur can significantly reduce crosstalk for primary sound sources; however the penalty is that secondary images are less well-defined and can be incorrectly located. As a result, with the dynamic nature of programme, the secondary image can sometimes be heard to wander. The level of secondary sounds can also change, but not usually by more than 3dB (total power).

The phase detectors require a few cycles to derive the control signals and at low frequencies this is longer than the attack time; the audio signals are thus filtered with a cut-off at about 100Hz. Because the control signals may vary up to a frequency given by the attack time, audio signals below this frequency are not controlled and the variable matrix action is bypassed to prevent severe intermodulation distortion. At high frequencies control is partially bypassed to reduce separation. This frequency dependence means some correction is needed to maintain a uniform overall power response; an h.f. attenuation of 1.5dB is applied at the input and an l.f. cut of 3dB at the output. (Frequency-dependent blend circuits, included between front and rear pairs of outputs, give low frequency localization along the front/back centre line.)

*Reported in the May issue by P. A. Ratliff and D. J. Meares, pages 41-5.

†Preprint F-6 at the 42nd AES convention 1972.

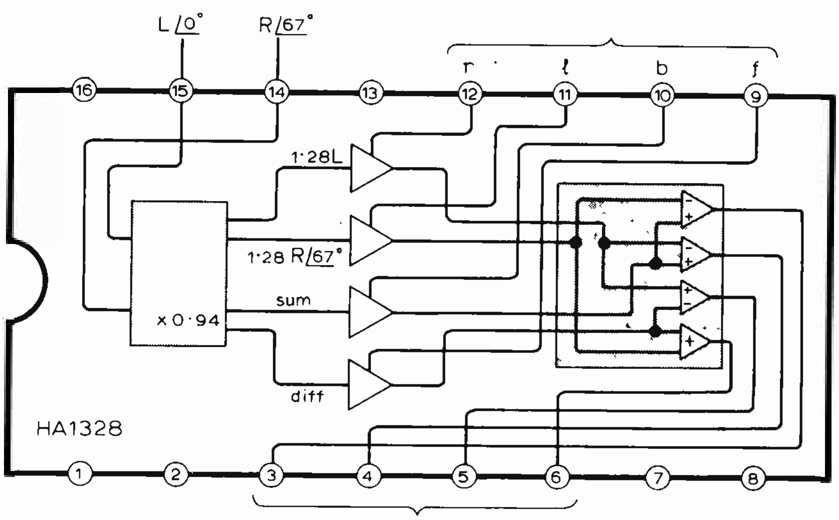


Fig. 2. Variable matrix i.c. for H decoding is same as used for QS decoding. Ratio of gains 1.28 to 0.94 is approximately that for QS (1.41 to 1) so resistors R_{30} to R_{33} can remain unaltered.

The QS Variomatrix decoding equations are

$L_F' = (1+f)(L-R) + (1+l)\sqrt{2}R$
$R_F' = -(1+f)(L-R) + (1+r)\sqrt{2}L$
$L_B' = -j(1+b)(L+R) + j(1+l)\sqrt{2}R$
$R_B' = j(1+b)(L+R) - j(1+r)\sqrt{2}L$

j indicating a wideband relative phase shift of 90°.

For Matrix H decoding with a phase shifter and QS Variomatrix, estimates of greatest separation can be deduced from the above equations by replacing the appropriate term with a phase-shifted term, e.g. $R\angle 60°$.

Matrix H variable matrix

Although performance of a modified QS Variomatrix is good, according to the Research Department, its limitations brought about a variable-matrix design for direct application to the basic H matrix.

The conjugate H decoding matrix is

$$\begin{bmatrix} L_F' \\ R_F' \\ L_B' \\ R_B' \end{bmatrix} = \begin{bmatrix} 0.94\angle{-10°} & 0.34\angle 65° \\ 0.34\angle{-65°} & 0.94\angle 10° \\ 0.94\angle 25° & 0.34\angle{-115°} \\ 0.34\angle 115° & 0.94\angle{-25°} \end{bmatrix} \begin{bmatrix} L \\ R \end{bmatrix}$$

which with a 10° reduction in front phase angles gives the following outputs from a fixed decoder

$L_F' = 0.94L\angle{-20°} + 0.34R\angle 55°$
$R_F' = 0.34L\angle{-55°} + 0.94R\angle 20°$
$L_B' = 0.94L\angle 25° + 0.34R\angle{-115°}$
$R_B' = 0.34L\angle 115° + 0.94R\angle{-25°}$

For application to variable-matrix decoding the equations are rewritten

$L_F' = [0.94f(L-R\angle 75°) + l1.28R\angle 75°]\angle{-20°}$
$R_F' = [-0.94f(L-R\angle 75°) + r1.28L]\angle{-55°}$
$L_B' = [0.94b(L+R\angle 40°) - l1.28R\angle 40°]\angle 25°$
$R_B' = [0.94b(L+R\angle 40°) - r1.28L]\angle{-65°}$

in which the −20°, −55°, etc, phase angles are to be applied at the outputs. Factors f, b, l and r are unity for basic decoding. There are five signals requiring control, $L-R\angle 75°$, $L+R\angle 40°$, $R\angle 75°$, L, and $R\angle 40°$, though six control signals are used in the prototype. Predicted separations for this decoder are "adequate", but for a corner signal the maximum front-to-back separation is 13.6dB, which may displace the image slightly.

Alteration of phase angles 75° and 40° is expected to improve this. As Matrix H gives good localization without the variable matrix treatment the l.f. blend circuits are omitted and with no audible intermodulation distortion. This allows good separation to be maintained to a lower frequency, Fig. 1, and permits a reduction in the control action, with a slight reduction in secondary image movement, whilst still maintaining adequate separation. (Control action at high frequencies is also allowed to extend higher in frequency than in the QS decoder.)

Output phase shifters accurate to 4kHz were used, with values of shift slightly different from those quoted. Unlike the input phase shift circuits, it is not necessary to hold tight tolerances at higher frequencies. In listening tests much sharper and better defined images are reported with this decoder, and slightly less image movement occurred than with the phase-shifted Variomatrix decoder. "A greater sense of openness and better overall perspective" are reported, together with a much greater tolerance to listener position.

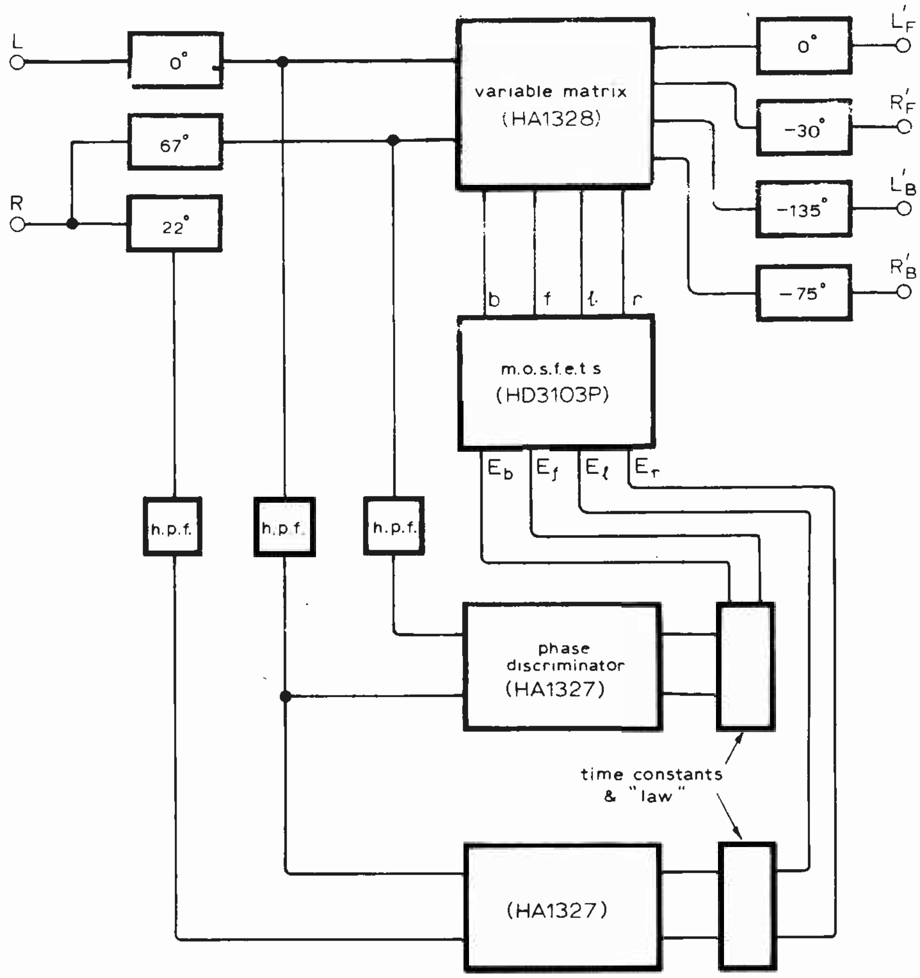
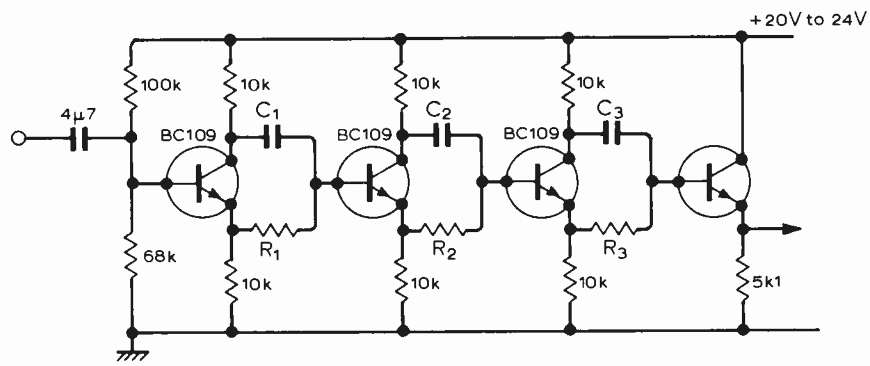


Fig. 3. Decoder arrangement uses wideband phase shift circuit to feed lower phase discriminator i.c. (left/right detector).



Phase shift	C_1	R_1	C_2	R_2	C_3	R_3
$\phi°$	150n (220n)	52k3 (35k6)	8n2	54k6	680p	51k
$(\phi+90)°$	33n (47n)	49k2 (34k5)	2n2	57k2	150p	47k9

Fig. 4. Three RC phase-shift chains use preferred values for capacitors and made-up values for resistors to give designed pole frequencies. Use 2% metal oxide or film resistors, 2% polystyrene capacitors for C_1 to C_3 or 5% polycarbonate for large values.

Practical variable-matrix decoder

One obvious way of simplifying the "two-angle" decoder design described would be to try and use the same phase angles for decoding both front and back outputs. This is possible if the decode matrix phase angles are altered a little, to give

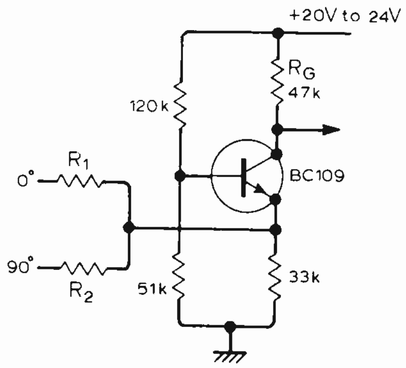
$$L_F' = [0.94f(L - R\angle 67^\circ) + l\,1.28R\angle 67^\circ]\angle -20^\circ$$
$$R_F' = [-0.94f(L - R\angle 67^\circ) + r\,1.28L]\angle -50^\circ$$
$$L_B' = [0.94b(L + R\angle 67^\circ) - l\,1.28R\angle 67^\circ]\angle 25^\circ$$
$$R_B' = [0.94b(L + R\angle 67^\circ) - r\,1.28L])\angle -95^\circ$$

where $f = b = l = r = 1$ gives the basic matrix. This uses one value of phase shift, 67°, for both front and back circuits. Separations for corner sources are also improved without significantly worsening other locations. This decoder, Fig. 2 & 3, is said to show the same favourable qualities as the "two-angle" decoder, and the results of a BBC subjective appraisal were given earlier.

The circuit is similar to the Sansui QS variable matrix, first published in the September 1976 issue of *Wireless World*. Those components that are omitted in this design are deleted from the components list and most of the components that are added have their values annotated.

Care has been taken in the design of the phase-shift circuits (Fig. 4). In these circuits, what is required are relative phase differences over a wide audio band. In the input circuits the "0°" shifter is a frequency-dependent phase shift circuit whose phase differs from that of the "90°" circuit by approximately 90° over a usefully wide band. Intermediate values of phase differences are achieved with a summing network, Fig. 5, one of which follows each of the phase-shift chains (Fig. 6).

The RC components of the chain are chosen so that the capacitors have preferred values; the resistor values are made up to give the designed pole frequencies. In making up the resistor values, generally use 2% tolerance components; but in situations where only a small percentage of the total value is being added a higher tolerance is permissible.



Φ	R1	R2
0°	47k	∞
22°	51k	120k
67°	120k	51k
45°	66k5 (use say 68k's)	66k5

Fig. 5. Summation circuit follows each of the three phase-shift chains, with R_1 and R_2 chosen to give required phase difference. For the $L\angle 0°$ chain, R_2 is open-circuit. In general use, matrix coefficients determine their values, =47k/coefficient. Adjust R_G value for overall unity gain in decoder if desired. Resistors R_1, R_2, R_G are 2% metal oxide or film types. (The 45° phase difference is not used in this decoder.)

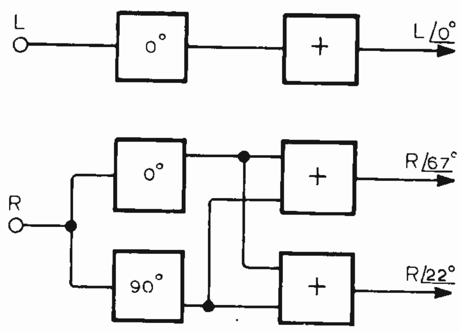


Fig. 6. Input phase difference circuit arrangement provides 67° shift and 22° for left/right phase discriminator.

Output phase shifters accurate to 4kHz were used, with values of shift slightly different from those quoted. Unlike the input phase shift circuits, it is not necessary to hold tight tolerances at higher frequencies.

They are made two-stage circuits to avoid image displacement, blurring, and possible increased audibility of wandering; the BBC feel the extra complication is easily justified. The values are slightly different from those given in "two-angle" decoding because of the different base matrix (there was little difference reported subjectively between the base matrixes).

Setting up the decoder

The phase and level differences required for setting up are as follows. Start by setting potentiometers to their mid-positions.

- Generate a centre-front sound of 1kHz, 300mV from equal-level, 48° phase difference tones (left leads right). With this input adjust *b* control for a front-back separation of about 15dB (figures can be up to 5dB more or about 3dB less).
- For a centre back sound, apply equal-level inputs of 300mV at 1kHz and a phase difference of −90°. Adjust *f* control for a front-back separation of 15dB.
- For a left-front sound (1kHz) use a level difference of 8.8dB (L/R) and +75° phase, and adjust *l* control for 16dB separation from left front to left back.
- For a right-front sound, —8.8dB and +75° difference, adjust *r* control for about 16dB separation from right front to right back.

To make this alignment procedure easier the BBC say they will produce a special test disc.

continued on page 78

Components

Resistors ¼W 10%, except those marked * which are 5%.

$R_{2,8}$	47k	R_{86}	680k
R_3	100k	$R_{87,88}$*	120k
$R_{4,10}$	1k	$R_{89,90}$	56k
$R_{5,6}$*	2.2k	$R_{91,92}$	2.2M
R_9	100k	$R_{93,94}$	470k
$R_{11,12}$*	2.2k	$R_{95,96}$	1M preset
$R_{14,15}$*	68k	$R_{97,98}$	1M
R_{16-21}*	22k	$R_{99,100}$	100k
R_{22-25}*	15k	R_{101}	4.7k
R_{26-29}	47	R_{102}*	2.7k
R_{30-33}*	1.2k	$R_{103,104}$	12k
$R_{35,36}$	120k	R_{110}	680k
$R_{37,38}$*	27k	$R_{111,112}$	330k
$R_{43,44}$*	27k	$R_{113,114}$	120k
$R_{61,63}$	4.7k	$R_{115,116}$	330k
$R_{62,64}$	100k	$R_{117-120}$*	120k
$R_{65,67}$	4.7k	$R_{121-124}$	56k
$R_{66,68}$	100k	$R_{125,126}$	1.5M
$R_{71,72}$*	220k	$R_{127,128}$	1M preset
$R_{73,75}$*	680k	$R_{129,130}$	330k
$R_{74,76}$	330k	$R_{131,132}$	1M
R_{78}	33k	R_{133}	10k
$R_{80,83}$	270k	$R_{134,135}$	100k
$R_{81,84}$	120k	$R_{137,138}$	15k
$R_{82,85}$	390k		

Capacitors: Types E are electrolytic, PC Siemens B32540 polycarbonate, PS 30V polystyrene. Those marked * should be 5% tolerance.

$C_{2,5}$	3.3µ	E	C_{78}	33µ	E
$C_{4,7}$	1µ	E	$C_{79,80}$	4.7µ	E
$C_{8,12}$	100µ	E(10V)	C_{81-84}*	1n	PC
$C_{9,10}$	100p	PS	$C_{85,86}$	4.7µ	E
$C_{11,13}$	47µ	E(10v)	C_{87}	6.8n	PC
C_{14-17}	3.3n	PC	$C_{88,89}$	1µ	E
C_{18}	47µ	E(10V)	$C_{90,91}$	5.6n	PC
C_{19-22}	10µ	E(10V)	$C_{92,93}$	33n	PC
C_{24-27}	470p	PS	$C_{94,95}$	2.2n	PC
$C_{28,29}$	33n	PC			
$C_{32,33}$	33n	PC			
C_{40-43}	1µ	E			
C_{44-47}	3.3µ	E			
$C_{48,49}$*	1n	PC			
$C_{51,52}$*	330p	PS			
$C_{53,57}$*	3.9n	PS			
C_{58-61}	4.7µ	E			
C_{62}	33µ	E			
C_{63}	6.8n	PC			
$C_{64,65}$	5.6n	PC			
$C_{66,67}$	10n	PC			
$C_{68,69}$	2.2n	PC			
$C_{70,71}$	33µ	E			
C_{72}	10µ	E			

Semiconductor devices

IC_1	HA1328	Hitachi
$IC_{2,4}$	HA1327	Hitachi
IC_3	HD3103P	Hitachi
Tr_1, Tr_2	BC214K	
Remainder	BC109, BC209A	
D_1—D_4	1N4148	

See page 78 for component suppliers for the decoder and acknowledgements.

News of the Month

Engineering enquiry "definitely on"

An enquiry into the engineering profession will be announced "shortly," possibly in a matter of weeks, according to sources in Whitehall and Westminster. Pressure for such an enquiry has been building up for more than a year, following the dispute among the members of and with the Council of Engineering Institutions (see *Wireless World*, October 1976, p.46.) As long ago as September 1975 the then Prime Minister, Harold Wilson, told the chairman of the Commons Select Committee on Science and Technology that the structure of the engineering profession needed "public attention," yet nothing has been done.

Meanwhile pressure has been building up from some of the professional institutions, (see *Wireless World*, April 1977, p.53), and the unions. At its last conference the TUC called for an enquiry and, at the end of March, Mr Eric Varley, the secretary of state for industry, received a letter from Mr Stan Davison, assistant general secretary of the Association of Scientific, Technical and Managerial Staffs, to remind him of the TUC resolution. "We are very strongly in support of the demand for the setting up of such an enquiry," the letter went on.

A week earlier Mr Varley had received a strongly-worded letter from the general secretary of the Institution of Professional Civil Servants, Mr William McCall, who said he was "dismayed" that there was no sign of any progress towards the solution of major problems affecting the engineering profession. "We have now come to the conclusion that the only method likely to lead to early progress lies through a major public enquiry, preferably by a royal commission, into all aspects of recruitment, education, training and standards and qualifications of engineers, including the question of registration." The government must "intervene decisively."

By Whitehall standards the importance of a subject is normally measured by the prestige of its scrutineers, the highest honour being a grilling at the hands of a royal commission headed by a high court judge. That is why even Arthur Palmer MP, head of the Science and Technology Select Committee, is hoping that that committee will not be the enquirer. If the profession were to learn that it rated only a Commons committee the news would deal a body blow to whatever remnants of pride the engineers had left even before it started.

Engineering circles do not expect to get their Royal Commission, but they expect an independent enquiry on which will be represented industry, the unions, academics and the institutions themselves. There is some disappointment that the industry department is still delaying, notably until after the British Association has produced a report it is preparing on the profession, but it is now considered a *sine qua non* that the terms of reference should allow a critical study of the Council of Engineering Institutions.

Local radio frequencies

The BBC are against the Annan Committee's proposal to take local radio away from them and ILR and put it in the hands of a new, separate authority (see report on Annan in this issue). Apart from their social, economic and organizational reasons already reported, the BBC disagree with Annan's contention that there are not enough frequencies for BBC and commercial local radio to compete. "Our engineers think the Annan Committee have got it wrong" declared Sir Michael Swann, the Corporation's chairman, at a press conference. There are enough medium frequencies, it is claimed, to provide 65 BBC stations in England, and for both BBC and IBA local radio to develop throughout the UK. "... The dual system of BBC local radio and commercial radio could be extended so that the BBC could operate about 85 local radio stations on low power m.f. (65 of them in England) giving coverage of about 94% of the total UK population by day, as well as the IBA taking up all 60 options it has proposed. The BBC and the IBA could each operate 45 to 55 of these stations on v.h.f. as well."

Recently the BBC said it wanted to set up an additional 45 local radio stations in England. At present 20 stations cover 74% of the population of England. The further 45, serving smaller communities, would provide a local radio service in areas not covered by these 20 stations. In March the Corporation produced a list naming 26 of the proposed new 45, and in April it named the remaining 19 possible areas. These are Blackpool, Bournemouth, Bradford, Burnley, Chester, Crawley, Doncaster, Eastbourne, Hereford, Huddersfield, Isle of Wight, Lancaster, Portsmouth, Reading, Salisbury, Sunderland, Tunbridge Wells / Tonbridge, Whitehaven and Wigan.

Howard Newby, managing director of BBC Radio, has said that three people and a secretary can run a small local radio station.

Electronic aid for road traffic

Seven European countries have signed an agreement to participate in a research project to devise a standard system of electronic road traffic aids. The project is being organized by the Committee on European Co-operation in Scientific and Technical Research (COST), of which 19 countries are members. The aim is "to develop techniques for common control and realtime management of traffic on major roads throughout the participating countries in the hope that this will result in smoother, more accident-free driving." Those who have signed so far are the UK, Belgium, Germany, France, Austria, Switzerland and Finland. Yugoslavia and Italy are expected to sign shortly.

The European commission proposed to the Council of Ministers in mid-March that the EEC should participate in aspects of the project of concern to the community. It will enable signatories to co-operate closely in research and development in their laboratories and "could result", says the Commission in a statement, "in the setting up of a European system which, suitably standardized, would guarantee that a driver enjoys the same services whatever his route, in those countries which have adopted the system."

Traffic on inter-city roads in the community in 1970 was seven times what it was in 1950. In ten years the number of vehicles crossing frontiers increased to 7½ times the initial figure.

Nine working parties have been set up in connection with COST 30, as the project is called, to co-ordinate research in various areas. Among these are the automatic or manual detection of accidents; improvements in weather forecasting; a study of relaying aural information to drivers both regionally, so that the information is available both at home and in the car, and locally, conveyed only to those drivers affected by local occurrences; a similar study for visual information, telling drivers at each junction the best directions for a given route, for example the development of variable roadside signalling techniques; and three other subjects concerned with traffic management, various road information systems and requirements, and the language used in conveying information.

The agreement comes into force once five countries have signed, and lasts three years. After two years the management committee co-ordinating the working parties will decide if there should be public trials. (See *Wireless World*, December 1976, p.47).

Cellular mobile radio going ahead

America, Japan, Tehran, Scandinavia and Germany are going ahead with cellular multiple access radio telephone systems. In the US a battle is being fought between American Radio Telephone Service Inc (ART) and Illinois Bell to win acceptance of their system as the standard, a decision which the FCC have said, in docket 18262 issued in 1971, must be reached by January 1, 1979. In the UK the Home Office is holding fire until the 1979 WARC conference nine months later, though the subject was covered in the Warden report on private land mobile radio services.

Warden outlined two possible multiple access systems. In the first, now used in one form by the Post Office, a central base station covers one area and can operate on all channels at once. The subscriber is given a choice of operating channels, but these are allocated either manually or automatically from a central point.

The cellular system uses a number of low power stations, each covering a limited area. "The area to be covered is divided into a number of cells, each cell having at its centre a fixed transmitter receiver installation, usually but not necessarily having a multichannel capability. Every fixed station is linked back to a central control point, at which is located a computer which assigns channels within each cell according to demand from the mobiles being served." Such a system saves spectrum space because a radio channel or group of channels can be used repeatedly within a given geographical area. Warden goes on to describe in detail a 52-cell system covering the London area suitable for 39,000 mobiles.

At the moment the leaders in America are ART. Illinois Bell first had their application to run an experimental system refused by the FCC and, now that the FCC have decided, on March 3, to accept it, an appeal against the application has been made by the National Association of Radiotelephone Systems (NARS), the FCC told *Wireless World*. The action will not affect Bell's plans, however, unless the court rules in favour of the appeal and takes action.

Although ART's application to run a system in the Washington, Baltimore and Northern Virginia area has been filed but not yet accepted, it probably will be accepted without a hearing. No date has been fixed for an ART hearing though Bell had to submit to one on February 28.

NARS is an association of independent common carriers who are normally in competition with the major telephone companies, like Bell. It appears that most of the opposition to the Bell application has come from those common carriers operating in the Chicago area, where Bell also operate the telephone service and now want to operate radiotelephones as well. Motorola, whose system ART will operate, are not common carriers. But ART, who operate the Washington area, took their system up.

Like all the others the ART system, called Dynamic Adaptive Total Area Coverage (Dyna TAC), is based on hexagonal cells. At first four directional aerials will each cover one hexagon, each hexagon to contain six triangles each representing an area using a different frequency, and each covered by the same directional transmitter. The transmitters of the four hexagons will be 19 miles apart, enough to allow the re-use of frequencies. ART will start with one large hexagonal cell but the size of the additional cells will be smaller to allow for differences in population density. The largest hexagons will be about 11 miles in radius, Motorola vice president Martin Cooper told *Wireless World*, and the size of the cells will then reduce to a cell made of a triangle 5½ miles on each side. The system will eventually have 32 cells of these varying sizes. After that, more growth will be possible by increasing the number of transmitters in each cell, an extra transmitter adding another 22 subscribers. Every one of the 32 cells will have 48 simultaneous channels. With 5½ mile triangles the capacity will be 32,000 subscribers.

The ART application covers 48 base stations, seven signalling stations, up to 100 portable radio units, 55 aerials and seven aerial towers. ART have signed a $2.5 million contract with Morotola for he fixed part of the system, including the $¼ million ART will have to pay the FCC during the experimental stage.

On January 1, 1979 the commercial service can begin with 1,000 units using 12.5MHz of the 40MHz the FCC has set aside for private dispatch cellular systems in the 800MHz to 900MHz region. That will be enough for the 32,000 subscribers, and the full 40MHz will be enough for 129,000. Another 75MHz has been allocated to public correspondence systems. According to the application the heart of the system is the distributed terminals using digital switching.

The Illinois Bell system, according to Motorola, does not cover portable units, needs more base units, and needs greater distance between transmitters. Channel spacing was at first 40kHz but has now been reduced to 30kHz. Motorola also use 30 kHz but have moved up from 25 kHz.

An experimental 800MHz system developed by a Japanese consortium is operating in Tokyo. The Tehran system also uses 800MHz, but the Scandinavian, and Australian systems use a 450MHz carrier. The Japanese have nearly finished their experiments and are set to sell their system abroad. One of the reasons given for holding back in the UK is that the Home Office could not make a new radio telephone system acceptable to users because of the capital cost involved, unless the Home Office were subjected to a great deal of pressure from the manufacturers.

Warden points out that, unlike in the US, these 900MHz frequencies may be used to extend the national coverage of tv broadcasting. However "we cannot see any particular magic in the use of frequencies in the 900MHz band, so that from a purely national point of view there is no reason why such systems cannot be accommodated in other bands not very far removed from those which have served land mobile radio for years."

Autodialling telephones to be given field trials

The Post Office, having successfully completed a technical evaluation of Pye TMC's autodialling telephones, has placed initial orders for 2,000 47 address Key Callmakers and 1,500 10-address Instafones to be used in field trials. The 10-address units, which are suitable for the domestic market, will be used in the field by subscribers in the Glasgow and Bristol areas for a period of about six months. These trials will start in August or September this year.

The Key Callmaker provides storage for up to 47 telephone numbers, each of up to 18 digits in length. A keypad is provided for storing these "most frequently-used numbers" and for normal dialling. Dialling any one of the stored numbers is achieved automatically by pressing one key only. A "try again" key is also fitted so that any number previously manually dialled can be recalled any number of times by pressing one key only. The Key Callmaker also has a "waiting amplifier" and loudspeaker which, in conjunction with an automatic dial tone detection facility, provides the caller with an audible signal enabling the progress of the call to be monitored, and keypad calls to be made, without lifting the handset.

A similar unit, the Multicall, has been manufactured for the overseas market. All of the autodialling telephones are built using metal-oxide-silicon l.s.i. circuits which have been purpose-built by PYE TMC.

For the overseas market, prices are expected to be about £200 for the

Multicall and about £65 for the Instafone. Post Office rentals would be about £30 per quarter for the Key Callmaker and about £7 per quarter for the Instafone, in addition to a £5 fitting charge and the normal telephone charges.

Radio communication equipment will play an important part in the Colombian Amazonas Expedition later this year. The British Army is giving logistical support to this scientific expedition and they will be taking with them six Plessey PRC320 sets (seen here), part of the British Army's Clansman system, to maintain communications between a base camp at Ara Acuara and four exploration teams. They will also provide a link through to the main base in Bogota. Plessey headquarters at Ilford, Essex, will try to keep in touch with the expedition by h.f. radio. In addition the expedition hopes to obtain a local amateur licence and in this case will be calling from the jungle on 14.25MHz. Readers may like to listen for them.

Set makers clobbered

In a speech to the Radio Industries Club at the end of March Capital Radio managing director John Whitney said that he found it "almost inconceivable" that the market in radio receivers as measured by the British Radio Equipment Manufacturers' Association had declined from 6.7 million sold into UK shops in 1973 to 3.8 million in 1976. "This is the more inexplicable since Independent Local Radio's audience surveys tell us that the highest proportion of people who listen to the radio regularly are of the younger age group — from 15 to 35 — 94% across a week, and they listen for more than 20 hours each on average." This group, he said, was likely to have a little more money to spend, and was the group more likely to own or want to buy a v.h.f. set. "The opportunities, surely, for expansion are enormous."

He quoted the remarks of "the sales director of perhaps the largest multiple chain store in the country," who "accused the set manufacturers of living in the past, of not moving with the times, or not seizing the opportunities that presented themselves, of a failure to recognize a new market trend or to back the development of a new service such as ILR." While calculators had dropped in price from an initial £80 to £4.60, and digital watches had dropped over £40 to £14 or less in two years, there was no sign of a miniaturised pencil v.h.f. radio, or a wristwatch radio. "Why, he asked, were the opportunities not being seized to take advantage of the enormous growth in radio listening?" (See "Radio in the '80s," *Wireless World*, May 1977.)

The same view was reflected in a little-noticed section of the Annan report, on reception problems. Annan cited a Consumers' Association report which found that v.h.f. sets cost between £55 and £80 at today's prices, but were difficult to tune. Both the CA and the BBC had advised greater use of pushbutton tuning. BREMA had replied that the sets would be too expensive to produce.

The committee also found that more attention needed to be paid to selectivity, meaning the capture ratio "and not least the ultralinearity of r.f. stages rather than mere insistence on sensitivity which is the principal criterion quoted by manufacturers." Annan also referred to the "melancholy statistics " showing that BREMA's estimate of the average life of a portable radio was five years, and that British firms only made 8% of the radio receivers sold in the UK. "We believe that if British manufacturers took a more aggressive stance and pressed ahead with developing adequate, easily tunable v.h.f. radio receivers for sale at acceptable prices, they might recapture a portion of what is evidently a large market."

Annan also dealt with the sound quality of tv sets. "BREMA told us that the public were not willing to pay for better quality sound", and the rental companies reported complaints from customers that television sets had "too many knobs to twiddle with". BREMA also said that adding a socket to replay tv sound through an audio system was difficult but that "new techniques were emerging" to make this easier. "They expected the practice of fitting external speaker sockets would become more common in a few years' time." Annan said nothing about the presence of outlet sockets in Japanese sets, many models having had them for years.

BREMA told *Wireless World* that the decline in the radio receiver market could be statistical, in that many radio sets were now combined with a cassette recorder or some other device. And Jack Dickman, chairman of Fidelity Radio, has launched an as yet one-man campaign to make the industry look more go-ahead. Writing in *Electrical & Electronic Trader* on April 1 he said, "After one of the bleakest periods in the history of radio manufacture, when retail sales between 1975 and 1976 dropped from 4,255,000 to 3,640,000 sets, there has been a remarkable recovery during the last three months."

In a statement he said they had made 19,000 in March last year, 38,000 this. "By keeping overheads down to an absolute minimum, by constantly improving our techniques, and by maintaining a scrupulously efficient buying department we are now proving that British companies can beat imports from Malaysia, Singapore, Taiwan and Korea ... It is a myth about the so-called supremacy of Far Eastern radio manufacturers. The truth is that they produce designs which don't take account of national preferences, they seldom include long wave . . . and whenever there's a big new demand in the United States (for citizen's band radio for instance) they immediately switch production and leave European customers out in the cold."

Whether this is technically-blinkered complacency or well-founded optimism remains to be seen, but the British makers will have to go a long way to compete with their West German counterparts, who have only had to suffer imports of 36% of sets in 1976, that an improvement of 3% on the previous year. Better news is that Dickman also warned against British companies (he didn't name them) that bought from cheap-labour countries and stuck their own labels on the products. "An increasing number of qualified electronics engineers and industrial designers are either not finding jobs or are merely acting as shopkeepers for Far Eastern goods. If this continues we won't have any good personnel two years from now; and then we'll really be at the mercy of the Far East."

World of Amateur Radio

Amateur radio at the Smithsonian

A visit to Washington, DC, gave an opportunity to see the amateur radio station, NN3SI, which forms an exhibit at the "A Nation of Nations" display at the Smithsonian Institution's National Museum of History and Technology. In a set up not unlike our own GB2SM at the Science Museum I found a volunteer operator, John Swafford, W4HU, busy chasing DX at one of the two independently operating consoles (h.f. and v.h.f.) with Collins, Drake, Yaesu and many other firms represented in the display.

Other visitors that day included a New York family with husband, wife and son all holding amateur licences, and whose car was equipped with both amateur and Citizens' Band equipment. It was interesting to find general agreement that although CB does cause problems to amateur radio it has proved a contributory factor to road safety. Indeed only that morning the New Yorker had been able to help a truck driver by telling him by radio that one of his tyres had caught fire! Broadcasters are less enthusiastic, fearing not only a significant loss of audience but also suffering considerably from harmonic interference to Channels 2 and 5. FCC are shortly to publish a handbook on television interference as it is recognised that many service engineers (including those specialising in the repair of CB equipment) and the general public have little idea of the causes and cures of tvi. Another talking point is the curious legal situation which has arisen this year and prevents the FCC from collecting any fees for amateur, CB and even broadcast licence fees.

There were also some red faces in the FCC when it was found that a novice licence examination had a circuit error that made it impossible to answer the question.

From all quarters

Novice licences have now been introduced in New Zealand with the first examinations last February including rudimentary theory, a "regulatory" paper of similar standard to the existing licences and a 6 words-per-minute Morse test. Transmitter power is limited to 10 watts d.c. input between 3525 and 3575 kHz, crystal-controlled and with both c.w. and a.m. (including s.s.b.) operation permitted.

Colloquia on amateur radio topics organised by our professional institutions are rare and it was a pity that more advance publicity was not given to the "Recent developments in amateur radio" event held by the IERE Communication Group in association with the RSGB at The Royal Institution recently. As a result only about 30 people watched the enthusiastic presentations on "Microwaves" (Dr Dain Evans, G3RPE), "Amateur Radio Satellites" (Pat Gowen, G3IOR and Martin Sweeting, G3YJO), "Image Transmission" (Grant Dixon, G8CGK) and "Repeaters and Mobiles" (R. Powers, G8CKN).

The University of Lancaster Amateur Radio Society is to hold another of its popular North-west Amateur Radio Conventions at Lancaster University on September 17-18 with lectures, trade stands, films, constructors' competition etc. (details R. J. Scott, G4EGE, c/o Physics Dept, University of Lancaster, Lancaster LA1 4YB).

A joint BATC-RSGB meeting, together with local groups from Luton and Birmingham (Macclesfield also showing interest), has discussed the question of amateur television repeaters with outputs in the 1215MHz band. Three channels, with outputs 40MHz higher than the incoming signal have been designated, although initially the Luton atv repeater may have its input frequency in the 432MHz band. The repeaters will be suitable for 625-line System I transmissions and it is intended that these particular repeaters would not be available for other modes of operation.

Beacons and bands

A new beacon station, A9XC, on 28.245MHz located at Bahrein operates between 2100 and 1300 GMT daily and should prove a valuable guide to 28MHZ conditions during the increasing sunspot activity of the next few years. Frequencies of existing 28MHz beacons are gradually being changed to above 28.2MHz to avoid interference to American novice transmissions which should be audible in Europe if the latest forecasts of a high maximum peak of sunspot cycle 21 prove well founded.

ZS5VHF at Alverstone, near Durban, is the first of a series of South African v.h.f. beacon stations; it opened recently on 144.925MHz. A beacon at Mbabane, Swaziland, 3D6AX, is operating on 144.735MHz from a site 4500ft above sea level.

The 1296MHz beacon, GB3AND, at Andover will increase power to 40 watts if authorisation is obtained. The number of operational u.h.f. repeaters in the 432 MHz band in the UK may soon reach 20.

Arthur C. Gee, G2UK, has recently taken over editorship of *Oscar News*, the journal of AMSAT UK which provides detailed information for users of the Oscar satellites. Oscar 8 (Oscar Project A-O-D) is now expected to be launched around November 11, 1977 as a piggy-back package on a Landsat weather satellite. Projected orbit is 500 to 550 miles high so that maximum range through the satellite is likely to be about 4000 miles, rather less than for Oscar 6 and 7. It will carry an American-built 145 to 29 MHz transposer and a Japanese-built 145 to 435 MHz unit. The telemetry beacons will be on 29.4 and 435.095 MHz. Maximum power needed to work through Oscar 8 should be 100 watts effective radiated power.

After an absence from the band of some years, I recently put a transmitter on the 1.8MHz ("top band") band and was surprised to find so much European activity in the evenings: Czech, Yugoslav, Dutch, German, French stations etc. in considerable numbers: a very different situation from a few years ago when most operation on this band was strictly inter-G or the valiant early morning efforts to get across to North America.

In brief

The Bromsgrove amateur radio club intends to issue a special "Silver Jubilee" award to amateurs contacting 25 of the Jubilee "GE" stations which must include the Bromsgrove club callsign GE3VCG, one other Bromsgrove club station and any 23 other "Ge" stations (details from G8KLO, with stamped addressed envelope) . . . Ulrich L. Rohde, DJ2LR, president of Rohde & Schwarz Sales Co. and well-known writer of amateur radio technical articles has recently been elected Professor of Electrical Engineering at the University of Florida (Gainesville) . . . June mobile rallies include Maidstone on June 5; Longleat and Elvaston Castle on June 12; HMS Mercury (Royal Navy amateur radio society) on June 19 . . . The RSGB's National Field Day (h.f.) is on June 11 to 12 . . . Richard Thurlow, G3WW, estimates the number of s.s.t.v. operators at about 3000, including many now using scan converters to permit display of slow-scan images on normal domestic tv sets. He points out that the new UK licence requires voice or c.w. station identification before and after each s.s.t.v. transmission and during every 15 minutes thereof . . . The Northern Mobile Rally of the Otley Radio & Electronics Society is at The Victoria Park Hall, Keighley, on May 22 . . . A fine of $1000 was imposed recently in Anchorage, Alaska for unlicensed CB operation after FCC engineers had spent some two years in investigation.

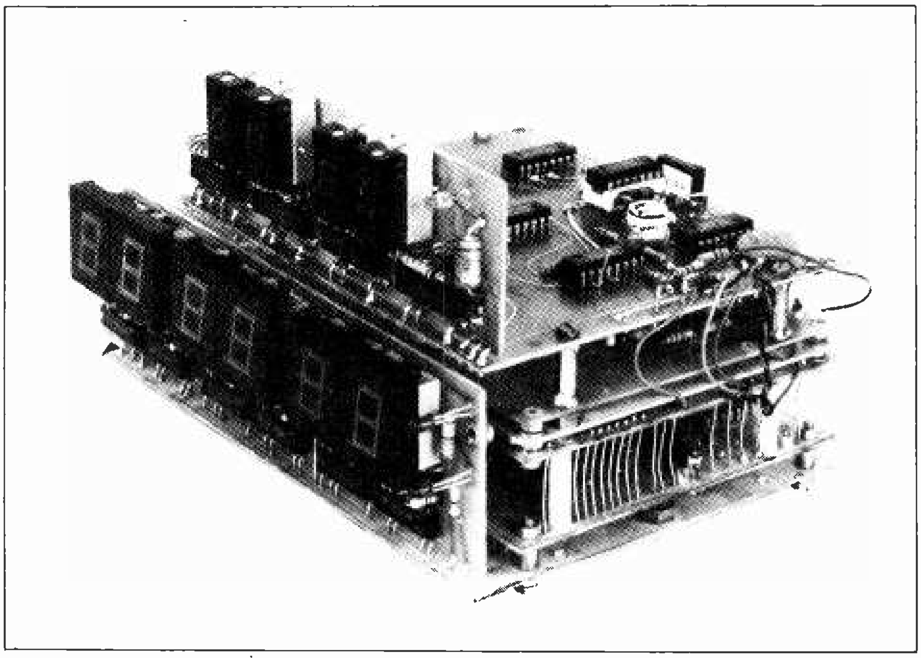
PAT HAWKER, G3VA

Date display, BST switch and alarm

Add on circuits for the time code clock

by N. C. Helsby M.A. *University of Essex*

This article describes a decoder which enables the self setting time code clock, *Wireless World* August 1976, to display the day and month and automatically switch the GMT/BST converter. A second circuit provides an alarm facility which can be programmed with thumb wheel switches. The complete design offers an alarm clock and calendar of unquestioned accuracy, 1 second in 3000 years, which never requires settting and which takes care of leap seconds, leap years and British Summer Time automatically.



The 60kHz Rugby MSF transmission now includes date information in addition to the established time of day code. A British Summer Time bit is also encoded as well as a further parity check on the date information alone. The hours and minutes are transmitted as previously and are complete 200ms after the minute edge as shown in waveform A of Fig. 1. Date information is in the same b.c.d. format and follows on with the carrier representing a 1 and no carrier a 0. A logic 1 is also transmitted in the BST slot if British Summer Time is in operation.

The wide range of c.m.o.s. integrated circuits has made their choice attractive for this part of the design. They enable power saving and interface easily with existing t.t.l. circuitry. The three input signals required are available from the edge of the existing seconds-counter p.c.b. without any dismantling. Waveforms obtained at these points when decoding takes place are shown in Fig. 1. A and F are shown in the inverted form.

Circuit description

Data arrives serially and is assembled into parallel form to drive the displays. The data is clocked into a shift register composed of IC_1 and IC_2, see Fig. 2, in a similar fashion to the time-code part of the clock. A 100Hz oscillator is required to start at the moment the time decoder

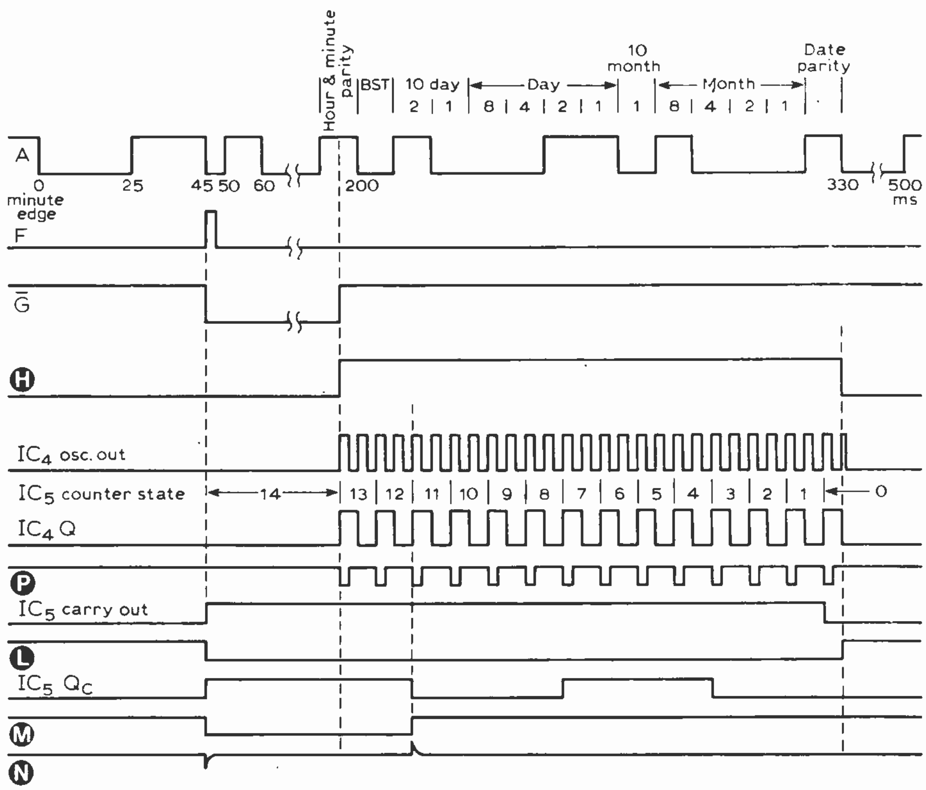


Fig. 1 Waveforms from the date decoder circuit. The three input signals are taken from the time decoder of the original clock.

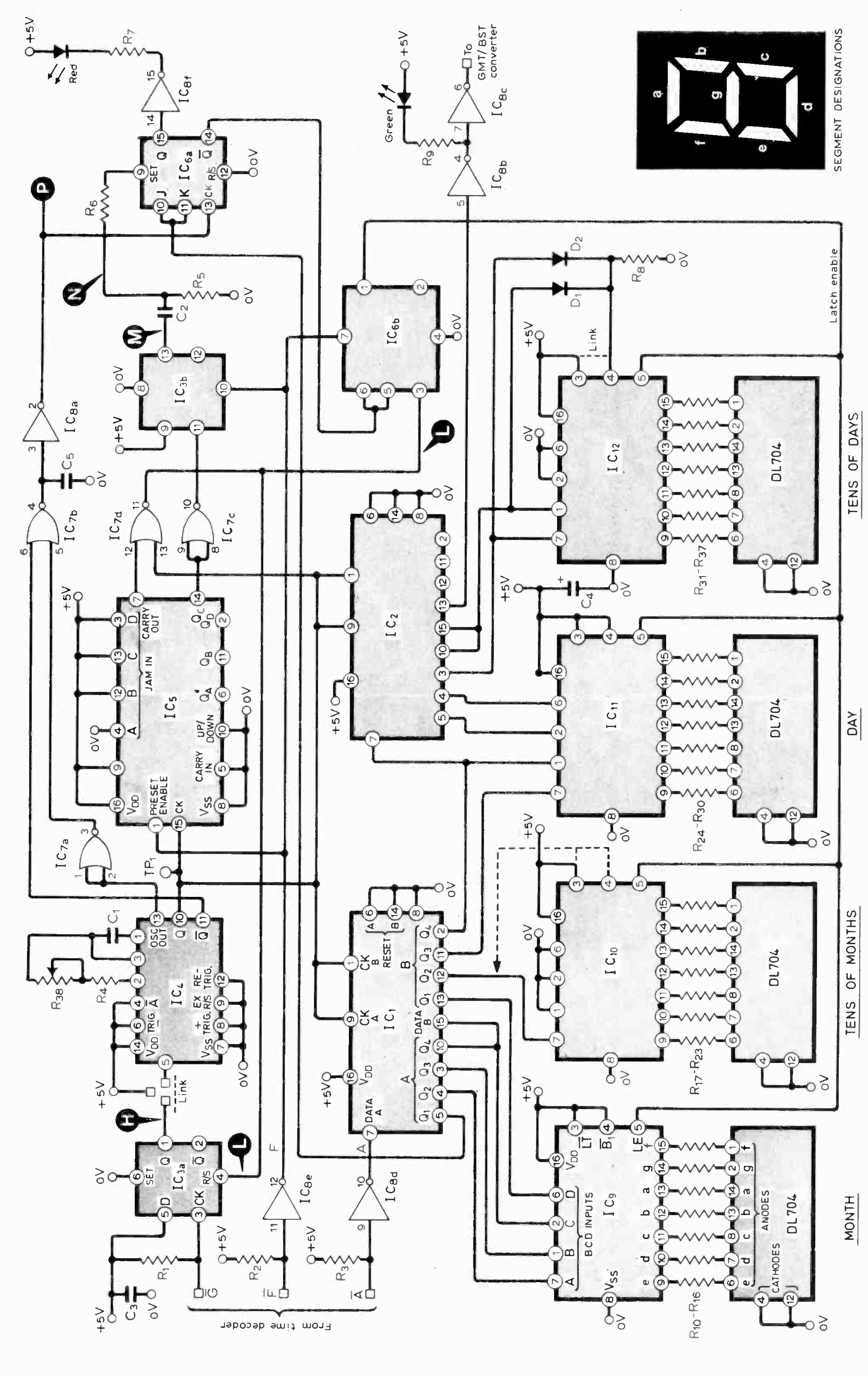


Fig. 2. Circuit diagram of the date decoder and BST switch. For normal operation pins 4 of IC_{10} and $_{12}$ are connected to +5V. If leading zero blanking is required, pin 4 of IC_{12} is connected to D_1 and D_2, and pin 4 of IC_{10} is connected to pin 7 of IC_{10}.

100Hz clock stops so, in order to avoid any modification to existing units, a separate clock generator is used. A c.m.o.s. astable multivibrator is used, which incorporates gating, provides an oscillator output, and the oscillator output divided in frequency by two. The positive edge of the waveform G, obtained from the time-decoder, represents the starting point and is used to clock a D-type flip-flop IC_3 (a) which enables astable IC_4. The resulting oscillator output is shown in Fig. 1 together with the Q output, which is the half-oscillator-frequency waveform. Gating by IC_7 (a)(b), and spare inverter IC_8(a) is used to generate the NAND function of these two waveforms to give the signal P, which has a positive edge delayed by 2.5ms for the parity checking circuit.

The positive edge of the Q output clocks data A into the shift registers and clocks a pre-settable counter IC_5. This i.c. counts down from the previously pre-set count, which is determined by the state of the "jam" inputs at the time of the preset enable signal shown as F in Fig. 1. When the counter reaches zero on the arrival of the fourteenth positive clock edge, the "carry out" terminal goes low. This signal is NOR gated with the clock Q to produce L so that when Q also goes low 5ms later, IC_3 is reset, which stops the astable. This happens 5ms after the last active clock edge, and the positive edge of L clocks the JK flip-flop IC_6(b). The purpose of this is to provide a "latch enable" signal or otherwise, for the display decoders.

Parity checking

The new parity bit refers only to the date code and does not include the BST bit. The transmitted parity bit is such that the signal always contains an odd number of 1s. Just before the arrival of the date at the minute, the signal F pre-sets the counter, resets IC_3(b), and sets IC_6(b). The D type flip-flop IC_3(b) is used to determine the start of parity checking by setting IC_6(a) when the counter output Qc first goes low as the count of 11 is reached. The positive transition of IC_3(b) is differentiated by C_2 R_5 to provide a pulse which sets the parity checking JK flip-flop IC_6(a). The Q output of this device is set high by the pulse and changes state for every 1 present at the J and K inputs which are connected to the signal A. The Q output of IC_6(a) should finish low because of the odd number of 1s. If an even number are received the Q output remains high, which is indicated by a l.e.d., and inhibits the display of the code.

When the latch enable signal is high, the display decoders store the information that was present just prior to the high. The Q output of IC_6(b), which is connected to the latch enable inputs, is set high before the entry of the new date code, and is clocked 2.5ms after the completed parity check by the positive edge of L. If an error is detected, IC_6(b)

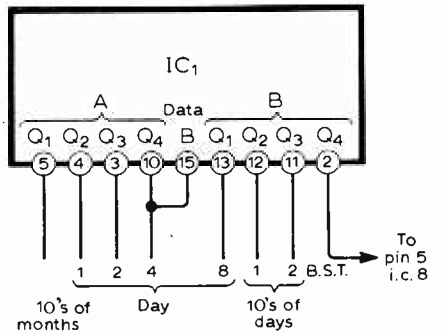


Fig. 3. Outputs of IC_1 when the simplified display is used.

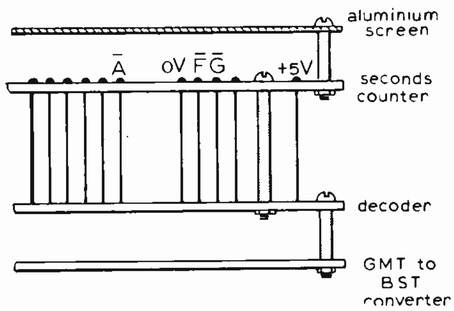


Fig. 4. Output from the original clock module. A sixth connection is made from the date decoder board to the GMT/BST converter for automatic switching.

JK inputs are low inhibiting any change on receipt of the positive edge of L. The Q output remains high until the next minute which prevents information from being displayed when a parity error is indicated. Entry of the date code at each minute does not require display blanking because the displays are latched to the stored code from the previous minute and do not display the new code until it has been validated.

To display only the day number without a parity check and register the BST information, shift register IC_2 and others parts may be omitted by simply pre-setting counter IC_5 with the binary equivalent of 9 instead of 14. A pre-set 9 requires 1001 at the "jam" inputs which is achieved by taking pins 12 and 13 of

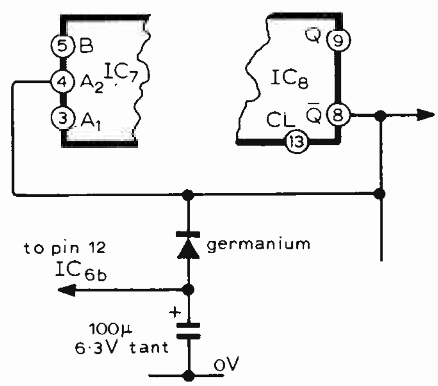


Fig. 5. Modification to the existing time-decoder circuit (Wireless World, Aug. 1976, p.49, Fig. 4). This addition prevents retriggering if the 13 bit date-code appears the same as the time-code.

the counter to 0V instead of +5V, and pin 4 to +5V instead of 0V. The day is then strobed into IC_1 and indicated by what are normally the month displays. Pin 1 of IC_{10} must be connected to pin 11 of IC_1, instead of 0V, to obtain the full code for tens of days, and segment "g" of the display does require a drive resistor in this case. The BST bit now appears on pin 2 of IC_1 which may be linked to the appropriate vacant hole for pin 13 of IC_2. Finally, the "latch enable" line is wired to the "carry out" terminal of IC_5 so that the displays do not flicker when the new information is entered into the shift register. In addition to $IC_{2, 6, 11}$ and $_{12}$, C_2, $R_{5, 6}$ and $_7$, the segment drive resistors and displays normally used for days and tens of days may all be omitted for this scheme. Fig. 3 shows the outputs obtained from IC_1.

Stability

The control range of R_{38} has been deliberately limited to about ±9% so that accurate setting may be achieved. The initial adjustment for any 4047 may vary by ±4% from the norm which leaves ±5% adjustment for capacitor and resistor tolerances. A metallized polycarbonate film capacitor is recommended which is superior to polyester film, and it is suggested that R_4 is a metal oxide type, selected on test, if sufficient control range is not available. The time-code 100Hz clock is required to be within about ±3% to synchronize with the incoming data. When the date code is used an overall accuracy of about ±1.8% is required. The 555 timer used in the time-decoder and the 4047 both have typical specifications of about 50 p.p.m./°C in this application.

Construction

The date decoder and display can be built on two printed circuit boards and mounted on top of the existing clock module as shown in the photograph. Five connections to the date decoder are taken fro. the edge of the seconds counter board as shown in Fig. 4. No interference has been observed on the receiver output as a result of this positioning but the supply leads should be short and kept away from the ferrite-rod aerial. Power required by the date decoder is determined by the number of segments illuminated and reaches a maximum at a current of about 180mA with 26 segments on. The total five-volt supply current of a complete clock with date display can reach about 900mA which is within the capabilities of the specified regulator i.c.

For setting up, the 4047 astable is allowed to run by linking pin 5 to +5V and R_{38} is adjusted for a frequency of 100.0Hz at TP1. A socket should be used for IC_4 because the 4047 has a different gate-oxide protection circuit which is only 30% as effective as the static discharge protection at other terminals.

The date information may be displayed as 08 01 for the 8th January or 8 1 with the leading zeros blanked by the dotted links in Fig. 2. The display drivers include a blanking input which may be taken low for this purpose. In the case of the tens of months digit, the code itself can provide the control directly but for tens-of-days, decoding of the zero condition is required using diodes D_1 and D_2. When the two bits of the tens-of-days code are both zero the diodes are in the non-conducting state and R_8 holds the blanking input low on the display. If either or both bits are high, either or both diodes conduct to enable normal display of the data.

Double recognition of the start code

The transmitted pattern of bits in the date code on certain dates may be interpreted as the start code at certain times on those dates. A simple addition to the time-decoder board will eliminate this possibility by "locking-out" re-triggering of the decoder until the end of the date sequence. A capacitor holds the output of IC_6(b) high for approximately 150ms after Q returns high at the end of the time code, as it charges via the input current of IC_6(b). It is discharged by IC_8(b) Q output going low. The track to pin 12 of IC_6 is cut and the pin is connected to the junction of the diode and capacitor as shown in Fig. 5. The diode is a germanium type for low forward voltage drop and the capacitor a tantalum bead type.

Components list

Integrated circuits		Resistors	
1-3	4015	1-3	8.2k
4	4047	4	200k
5	4029	5	100k
6	4027	6	10k
7	4001	7	220
8	4049	8	100k
9-12	4511	9	150
		10-37	390Ω
		38	47k cermet

Capacitors

1	0.01μF polycarbonate ±5%
2,5	1000pf ±20%
3	0.1μF disc ceramic
4	47μF 6V electrolytic

Miscellaneous

L.e.ds, 1 red, 1 green

Common cathode 0.3in displays, DL704 or equivalent

$D_{1,2}$ 1N916 if fitted.

Printed circuit boards

A set comprising two double sided boards and one single sided board for the date decoder/BST switch, display, and alarm circuit (to be described next month) is available for £8.00 inclusive from M. R. Sagin, at 23 Keyes Road, London N.W.2. The decoder board allows leading zero blanking, and the alarm board offers automatic cancelling after a preselected number of minutes. A set of five p.c.bs and special components are still available for the original time code clock as detailed in the August 1976 issue of Wireless World.

"UD-45" in principle . . .

April 12 was the date set by the UK section of Audio Engineering Society to hear of the work of the NRDC project in surround sound. At the height of speculation that Nippon Columbia were about to make an announcement about the NRDC 45J system (*News*, last issue), it turned out that, because of contractual difficulties, only an informal notice was possible. Peter Fellgett of Reading University, a partner in the NRDC-sponsored effort, said that agreement had "in principle" been reached between NRDC and Nippon Columbia to provide a kernel surround-sound system, technically designated 45J. It combines the attributes of the NRDC ambisonic psychoacoustic research with that of UD-4 technology "essentially maintaining inter-compatibility with this earlier work. Advantages of 45J are improved stereo and mono without compromising the surround performance."

The statement issued says the practical limitations of system 45J lie less with the number of available transmission channels, than with the number of loudspeakers (with appropriate amplification) which the user has available to decode it. "Permitting a hierarchy of appplications within the one system, 45J may be used where only two channels are available. But improved fidelity by reduced phase anomalies is available by using a third channel, easily available within the confines of both media, even if of restricted bandwidth. A fourth channel, where available, allows reproduction of 'height' information (periphony), or can be used for loudspeaker emphasis."

A laboratory-type Nippon Columbia decoder was shown to the meeting, with facilities for decoding 45J in its two-channel form and, with demodulation circuitry, in three and four-channel forms. Such "ambisonic" decoders feature loudspeaker layout compensation, loudspeaker-to-listener distance compensation, options for decoding through six loudspeakers (but using four amplifiers), and frequency-dependent "psychoacoustic" decoding.

Among the many points made by co-lecturer Michael Gerzon, possibly the least widely known is that for best subjective illusion with four speakers, three channels are best, a fourth degrading results in the manner of "speaker emphasis" (sound directions close to loudspeakers being pulled towards the loudspeakers). Another, now becoming more widely recognised, is of the relative poorness of the pair-wise mixing approach. "Pair wise mixing is actually a guess made in 1968 and never checked" explained Michael Gerzon.

Readers who missed the event will be able to catch up by reading Michael Gerzon's December 1974 article, the April 1977 article, and the coming universal decoder design series.

. . . Matrix H in practice

April 12 was also the date chosen by the BBC to announce a series of experimental matrix H broadcasts to the daily press. The BBC has been experimentally broadcasting programmes in surround sound since April 30. These are on the v.h.f. networks of Radios 1, 2, 3 and 4 and are being transmitted at the rate of about one per week.

Programmes are announced in *Radio Times*. The compatible quadraphonic system being used, known as matrix H, was described in our May issue (pp.41-45). To listen to the programmes you need a stereo tuner, a quadraphonic decoder designed or adapted for matrix H, four audio amplifiers (or two stereo amplifiers or one four-channel amplifier) and four loudspeakers. Some existing quadraphonic record reproducing equipment may be adaptable for listening to the broadcasts.

The BBC statement issued to the press unfortunately led one to believe the broadcasts were "entirely" compatible with stereo and mono. Douglas Muggeridge, director of radio programmes, said the BBC would not have decided to go ahead with experimental broadcasts "if the quality of the normal signal would have been in any way impaired." In advising the Home Office of their plans the BBC described matrix H as having the greatest likelihood of giving quadraphony with negligible impairment to listeners with ordinary equipment. But the Home Office say that the impairment is noticeable, though not serious. Presumably "ordinary equipment" can be taken to mean equipment on which the phase differences are not noticeable.

No regular quadraphonic broadcasting service has been planned, as the EBU are investigating a number of possible systems with the aim of agreeing on a single system for the whole of Europe, but the BBC experimental broadcasts will continue for about a year.

Readers who have not heard matrix H will be able to using one of the *Wireless World* designs. At present there are no commercial matrix H decoders on the market*, but it is possible to adapt existing quadraphonic decoders, and last month we published details of how to adapt a Sansui QS Variomatrix decoder for the matrix H broadcasts (May issue p.50). In the present issue we also give a circuit for constructing a purpose-built matrix H decoder, based on BBC Research Department development work. ■

*Sansui tell us two receiver models will be available shortly, adapted for matrix H.

Letters to the Editor

INDUCTOR STANDARDIZATION?

May I put in a plea for the humble inductor?

In various journals over the past few years I have noted with increasing despair phrases such as: " ... inductors have been avoided ...", "... coil-less design ...", "... simulated inductor ...", " ...RC active filters ..." Anyone would think you could catch rabies if you used a coil/inductor.

Maybe the root of the problem is that coils are essentially customized things, not much given to standardization in the form of resistors, capacitors etc. However, if you ever read our advertisements, you will see that we have been trying to establish the fact that we supply coils of a broadly standard nature.

Nevertheless, I wonder if your readers could be asked to provide their own ideas of a basis of standardization of the range for general purposes. I feel confident that a basic set of standards could thus be drawn up and publicised, so that designers need not have to fuss over absurdities like " 49t 0.28mm wire on a Mullard Vinkor LA1157 (260μH)".

So rather than waste time and effort rolling your own (whoever wound their own resistors from bits of resistance wire?), let's establish the humble coil as a bona fide stock component so that designers design circuits, not components.

William Poel,
Ambit International,
Brentwood,
Essex.

INTERFERENCE FROM AMATEUR STATIONS

We have noted that in your March issue the first part of the RSGB interference survey report is published in its original form. The RSGB has been represented at a number of our Interference Sub-Committee meetings, and at the last of these (when the report was considered) it was emphasised that receiver manufacturers have a very clear and sympathetic understanding of the technical and social problems involved.

As mentioned in the report, there is an established procedure for dealing with this sort of interference, and the fact that receiver manufacturers get so few complaints suggests two things. Firstly, that the amateurs concerned are taking what action they can to alleviate the situation, and this co-operation is gratefully acknowledged. Secondly, that the procedure whereby the Post Office notifies the appropriate manufacturer of an unresolved case of interference is often not being invoked.

As with any instance of interference, a balance has to be struck between conflicting aspects, but in this case the "neighbour-relations" add a particularly sensitive factor. On the one hand the amateur has the right to operate his equipment within the conditions of his licence, and on the other hand the viewer or listener also has the right to expect interference-free reception provided that his equipment is supplied with an adequate signal from an efficient aerial system.

There is no simple answer to the rejection of strong out-of-band signals; the main factors involved embrace the type and siting of the aerial, the matching of the feeder, the characteristics, internal wiring of the receiver (particularly any resonances), and extension speaker leads. The RSGB has designed a filter (which has been examined by BREMA and the Home Office) and this is a possible solution to one of these aspects, although it requires modification to meet safety requirements if it is fitted internally. Even so, to include it as standard in receivers would mean an additional cost of at least £2M per annum to be paid by the purchasing public in the UK – and it would still not clear the interference if it enters the set other than via the down-lead.

With the increasing number of strong out-of-band signals to which sets at domestic sites are now being subjected, UK receiver manufacturers have, over the last few years, been incorporating a higher degree of immunity in their sets. However, it will be some years before all the older receivers are replaced and the overall problem will, therefore, be with us for some time to come. Unfortunately, the RSGB survey does not give information on the vintage of the affected receivers.

D. P. Doo,
Technical Secretary,
The British Radio Equipment Manufacturers' Association,
London W1.

TRANSIENT INTERMODULATION DISTORTION

During the past few months you have printed several articles by various contributors, as have other magazines, on the subject of a new distortion phenomenon which has been named transient intermodulation distortion (t.i.m.). The following properties have been claimed for this form of distortion:

1. It is transient in nature, and totally undetectable with steady state signals.
2. It may be prevented by ensuring that the pre-amplifier closed loop bandwidth is less than the power amplifier open loop bandwidth.
3. It is caused by blocking of an amplifier input stage due to overloading because of delay in the feedback signal.

Taking the second point first, Professor M. Otala in making this statement[1] gives the impression that t.i.m. is a bandwidth related phenomenon, whereas in fact t.i.m. is merely a new name for the distortion caused by slew rate limiting, and t.i.m. is generated when, and only when, the input signal slew rate is sufficient to cause the power amplifier to try to exceed its maximum slewing rate.

To illustrate the error of statement 2 above, it is possible to design a power amplifier with a slew rate of only 1 volt per microsecond at the output, but with an open loop bandwidth of 100kHz. According to Prof. Otala, t.i.m. will not be generated if the input signal bandwidth is less than 100kHz, but such an amplifier as described will slew at a frequency of the order of 5kHz at an output of 60 volts peak to peak, and t.i.m. will be generated at all higher frequencies if the input is maintained constant.

The claim that t.i.m. or slew rate limiting is undetectable with sine wave signals is not true, since a rapid increase in distortion may be very clearly seen with any amplifier using single pole second stage compensation as its output slew rate is approached.

T.i.m. is said to be far more likely with amplifiers using a large feedback factor than it is with amplifiers using a small feedback factor. However, since t.i.m. is produced whenever an amplifier input slew rate is exceeded (where input slew rate is defined as the maximum slew rate of the amplifier divided by its closed loop gain), it will be produced independently of the amount of feedback used. The only time when t.i.m. will be produced in practice with most reasonably high slew rate amplifiers is when they are feeding a capacitive load such as a Quad Electrostatic loudspeaker. The reason is as follows:

If an amplifier must provide 60 volts peak to peak at 20kHz into a load consisting of 2μF in parallel with 8 ohms, it must be capable of charging the capacitor at a maximum rate of $SR = 2\pi FV_{max} = 3.77\ V/\mu s$. Unfortunately, the maximum slew rate of a sine wave occurs as it goes through zero, i.e. when the resistive load is drawing no current. Thus the amplifier must supply sufficient current to charge 2μF at a rate of 3.8 volts/μs, i.e. it must supply 7.6 amps at zero output voltage.

Since this requirement is outside the safe operating area of the power transistors in most amplifiers, the protection circuits will normally operate, causing a delay in the feedback signal and the generation of t.i.m.

To the best of my knowledge no one has ever reported that t.i.m. is worse for Quad Electrostatic loudspeakers than it is for moving coil types, despite the fact that the effect is far more serious with heavy capacitive loads than it is with any other loads, and also despite the fact that t.i.m. is claimed to be clearly audible. It, therefore, seems apparent to me that people are hearing what they want to hear rather than what is really there.

The amplifier design[1] is claimed to be completely free from t.i.m. but if loaded by 2μF at its output, it will produce t.i.m. just like any other amplifier due to high frequency clipping by the protection networks in the output stage.

In conclusion, I would like to list the following points:

- T.i.m. is produced when and only when the input signal to an amplifier exceeds its input slew rate.
- Amplifiers with very heavy feedback areno more likely to produce t.i.m. than those with low values of feedback factor, although the internal overshoots may have higher amplitudes when slew rate limiting does occur.
- T.i.m. is far more likely when an amplifier is feeding an electrostatic loudspeaker than when it is feeding a moving coil unit.

M. Rigby,
Neve Electronic Laboratories Ltd,
Royston,
Hertfordshire.

Reference

1. "An audio amplifier for ultimate quality requirements" by Jan Lohstroh and Matti Otala. *IEEE Transactions on Audio and Electroacoustics*, volume AU-21, No. 6 December 1973.

Professor Otala replies:

Although Mr Rigby's letter is not addressed to me, I feel obliged to respond to it as my name is mentioned a few times.

Mr Rigby starts by stating that "... t.i.m. is generated when, and only when, the input signal slew rate is sufficient to cause the power amplifier to try to exceed its maximum slewing rate". This statement is false because
– exceeding the slewing rate corresponds to 100% momentary intermodulation distortion
– in most cases slew rate is not an abrupt limit, but the amplifier becomes highly non-linear already far below it. It is an established experimental fact that in commercial amplifiers t.i.m. is in many cases produced already at one tenth of the slew rate[1].

Mr Rigby continues by postulating an amplifier having a $1V/\mu s$ slew rate and a 100kHz open-loop bandwidth. This is intellectual dishonesty because either his 100kHz specification is the *small-signal* bandwidth, which is irrelevant in this context, or the amplifier feedback resistor is bypassed with a capacitor, in which case the amplifier does not slew at all but has a nice, clean signal rise without any nonlinearity. Consequently, in this case t.i.m. is not produced with any input signal.

Mr Rigby goes on to state that t.i.m. is detectable with the sine wave signals. It is unclear what he means by "sine wave signals". However, it is a rigidly established experimental fact that the standardized total harmonic distortion measurement method and the SMPTE intermodulation measurement method do not reveal t.i.m.[1, 2]. There are two reasons for this:
– the SMPTE-i.m. and the low-frequency t.h.d. input signals do not drive amplifiers near the onset of t.i.m., not to mention slew rate.
– if the t.h.d. measurement is attempted at a higher frequency, the harmonics will lie outside the passband of the amplifier and will suffer considerable attentuation.[1]

After this Mr Rigby claims that t.i.m. is independent of the feedback. The trivial error in this claim is the assumption that the slew rate would be a constant for a given amplifier. Let us take an operational amplifier as an example. If the feedback is increased, the stability considerations require that the frequency compensation must be changed. Increasing the compensation capacitor proportionally to the feedback decreases the open-loop upper cut-off frequency. The slew rate o the amplifier will then be inversely proportional to the feedback factor, i.e. the higher the feedback, the smaller the slew rate. This is a simple basic relationship which leads on to the fact that t.i.m., if it is generated, is directly proportional to the feedback factor, as has been shown both theoretically[3] and experimentally[5].

There are a number of other claims that may require a short comment.
– T.i.m. may be prevented by ensuring that the pre-amplifier bandwidth is smaller than the power amplifier open-loop bandwidth[3,4]. However, this is not the only possible way and reactive feedback with pole cancelling is probably one of the best alternatives[6].
– Mr Rigby's claim that a certain amplifier[7] produces t.i.m. due to high-frequency clipping in the output stage protection networks is inconceivable, because that amplifier does not incorporate any protection networks.
– measurements showing that certain amplifiers produce gross t.i.m. when used with capacitive loads were reported by Scott Kent at the Boston Audio Society Distortion Symposium, Boston, Mass., 1976.

In brief, it has been shown that Mr Rigby's first two conclusions are false, and that his third conclusion is correct, although on other grounds than those he discusses.

Matti Otala,
Electronics Laboratory,
Technical Research Centre of Finland,
Ouli, Finland.

References

1. Leinonen, E., Otala, M., Curl, J., A method for measuring transient intermodulation distortion (t.i.m.). 55th AES Convention. New York 1976. Reprint no. 1185, 26. To be published in the *Journal of the AES*, April 1977.
2. Leinonen, E., Otala, M., Correlation of audio distortion specifications. 56th AES Convention. Paris 1977.
3. Otala, M., Leinonen, E., The theory of transient intermodulation distortion. *Monitor-Proc. IREE*, vol. 37 (1976), no, 5, pp. 53-59. To be republished in *IEEE Transactions on Acoustics, Speech and Signal Processing*, February 1977.
4. Otala, M., Circuit design modifications for minimizing transient intermodulation distortion in audio amplifiers. *Journal of the AES* vol. 20 (1972), no. 6, pp. 396-399.
5. Leinonen, E., Digital and analogue simulation of transient intermodulation distortion. Report no. 18, Electrical and Nuclear Technology Series. Technical Research Centre of Finland, 1976.
6. Leach, M., Suppression of slew rate and transient i.m. distortion in audio power amplifiers. 55th AES Convention, New York 1976. Reprint no. 1137.
7. Lohstroh, J., Otala, M., An audio power amplifier for ultimate quality requirements. *IEE Transactions on audio and electro-acoustics*, vol. AU-21 (1973), no. 6, pp. 545-551.

NEW CONCEPT FOR AMPLIFIER SPECIFICATIONS

There has been much correspondence recently about load specifications of audio amplifiers. I would like to suggest that it is possible to look at this problem from a wider point of view which might give more insight into the ways of specifying performance.

I do not think it is too outrageous to suggest that the specifications of a piece of audio equipment should define the way in which it performs audibly, since it is surely the character of the sound reproduced which is of greatest interest.

I think it would be helpful to extend our understanding of audio amplifiers by introducing a concept which I suggest should be called "loss of information" (l.o.i.). This concept will allow us to differentiate between the various mechanisms that degrade the audio signal. For example, harmonic and intermodulation distortion do not result in loss of information, while slew-rate limiting, clipping and protection activation do result in l.o.i.

Let us consider why this idea has not come to light before. When valves were in common use the parameters on which effort was expended were those of harmonic distortion and bandwidth. However, valve hi-fi amplifiers were usually designed so that slew-rate limiting and t.i.d. did not occur. This was due in part to the limited bandwidth and in part to the high frequency characteristics of valves; also protection was not required, so it is unlikely that a well-designed valve amplifier has any l.o.i. mechanisms. When transistor amplifiers first appeared, commercial pressures, not unnaturally, led designers to seek lower t.h.ds and wider bandwidths, apparently without any appreciation of the possible side effects. I would like to suggest that in fact it is the loss of information mechanisms that account for most of the variations in sound quality between one audio amplifier and another, and more particularly between a valve amplifier and a transistor amplifier.

It should be noted that crossover distortion is made up of high order odd harmonics which in themselves are not audible even at quite high levels. Crossover non-linearities, however, generally result in l.o.i. and it is this that makes the crossover distortion audibly objectionable.

A further aspect of l.o.i. occurs when the amplifier suffers from any form of latch-up – a short initial loss of information will be followed by a prolonged loss while the amplifier recovers. This will make the sound quality even less acceptable. To improve the quality of the sound it is necessary not only to try to eliminate the causes of l.o.i. but also to ensure that where l.o.i. does occur (e.g. clipping) it is limited to the shortest possible time.

It can be seen that the question of load specification is more complex than it would appear at first sight. If the amplifier's protection is activated by any combination of musical signal and loudspeaker load, there will be a loss of information and a consequent deterioration in the sound quality. To avoid this source of deterioration implies that the amplifier's dynamic output impedance should remain substantially constant. This is somewhat at variance with Mr Peter Walker's proposals as stated in his letter in the December, 1975 issue of *Wireless World*.

J. Vereker,
Naim Audio Ltd,
Salisbury,
Wilts.

METAL DETECTORS AND ARCHAEOLOGY

I am writing as a consequence of the article published in your April issue "Sensitive metal detector" by D. E. O'N. Waddington. I beg to call into question the propriety and wisdom of printing such an article, for although you warn your readers about not using such a detector on known archaeological sites, you must realize that such a warning is useless for anyone who is determined to use a metal detector for personal gain, with no regard for other considerations.

You might have just as easily printed details for the construction of a shotgun, and then reminded your readers not to point it at anyone.

In the past treasure hunters have maintained that their equipment was not sensitive enough to detect coins etc more than a few inches below the surface, and so could not destroy archaeological stratigraphy; if the claims which are made in your advertisements are true, you have presented this group with the opportunity to probe to the very earliest levels, to destroy valuable information, which is the heritage of every-body, in their selfish desire for "booty". It is not only the scheduled archaeological sites which are endangered – and the Council for British Archaeology has collected a good deal of damning evidence for the activities of treasure hunters on such sites – it is also those as yet "undiscovered" which could be irreparably damaged.

It is now too late to remedy the harm which your article has quite probably done in contributing to the treasure hunters' armoury, but I appeal to you to consider most seriously the possible consequences that the future publication of a similar feature might have.

Robin N. Sharp,
Dagenham,
Essex.

RHYTHM UNITS

I was surprised to find *Wireless World* trailing behind the current technical scene by publishing an article on constructing a rhythm unit (March, April issues) which has appeared in virtually the same form in at least two other competitive magazines. The article also falls short of the originality we have come to expect from *Wireless World.*

There is a need for an article on a good rhythm unit for home constructors as, although the SGS M252 and 253 i.c.s offer a simple solution, the stock rhythms programmed in the r.o.m. of these units can only be described as passable musically, and not as good as most commercially available rhythm units.

A far better solution for the home constructor would be a more flexible circuit based on many of the currently available ring counters with a diode matrix memory which the constructor can modify at will to provide some individuality to his unit. Also a common weakness of almost all rhythm units available is poor foxtrot or ballad rhythms due to poor simulation of long brush sounds.

Most commercial units get round the problems by simply omitting the long brush or brush sounds entirely. A relatively simple way of overcoming the problem for the home constructor is available by using a noise shaping circuit using one of the currently available voltage controlled amplifier i.c.s fed from a suitable waveform generator such as those used in many synthesizers.

Perhaps this letter will spark off some discussion in your columns as to the advantages of 2-bar versus 4-bar repetitive patterns. Also perhaps someone has devised a simple means of electronic switching of rhythms which would simplify the relatively expensive multi way switches needed in the more flexible units.

I have tried diode switching but the number of isolating capacitors with their associated resistors was too bulky.

J. R. Barber,
Bexleyheath,
Kent.

PRIVATE MOBILE RADIO CONSULTATION

Wireless World is to be congratulated on its coverage of WARC and the possible Home Office approach, and no doubt the interest generated in these pages has contributed to in large measure to the wider consultation now entered into. The Mobile Radio Users' Association pressed for wider consultation when the first Warden report was produced (long before *Wireless World* became involved in the subject) and we were naturally pleased to see the same flag being flown in these pages.

It was surprising, therefore, to read in the April editorial that "... discreet trusties referred to in December ... made, at first, no effort to press for a programme that might dilute their own bargaining strength." Your January article "Who is warden over the Wardens?" referred to myself as joint secretary of the Home Office Mobile Radio Committee representing p.m.r. users through the Mobile Radio Users' Association. May I please take some of your space to explain to readers how the MRUA contributed to considerable widening of consultation, and thus enlighten those of your readers with the unlikely image of myself or MRUA Chairman J. W. Tayler (also representing users at the MRC) as "discreet trusties"!

Following the submission of the Warden report to the Mobile Radio Committee in 1975, when intense and vigorous discussion took place, it was recognised, as Mr Carlton of the EEA mentioned in his letter in your April issue, as the first study of private mobile radio in depth, and likely to be of considerable importance in shaping policy. The MRUA felt, however, that the Home Office approach at WARC ought to be influenced by wider investigation and therefore decided to carry out an independent user survey of private mobile radio. Accordingly in December 1975 *every private mobile radio user in the United Kingdom* was sent a survey questionnaire together with a covering letter outlining the main conclusions of the Warden report. The results of the survey were published in the MRUA magazine *Talk Through* and appeared as an MRC paper, via which we hope the conclusions drawn may contribute to UK policy at WARC. I would submit that the circularisation, not only of all our members, but of *all* p.m.r. users hardly indicates a lack of effort on the part of the MRUA to widen discussion.

Alan Ford,
Secretary, The Mobile Radio Users' Association,
London SW1.

ADVANCED PREAMPLIFIER DESIGN

From his comments on my letter in the March issue on his preamplifier, I am afraid Mr Self did not understand the point of my letter.

The point was that, with the circuits I had tested, the circuit with part passive equalisation did sound better – though it needed music as complex as the opening of Mahler's 8th symphony to show initially that the sound was indeed better rather than just different.

To answer some of the points in Mr Self's reply. An amplifier with a low slew rate can be represented by an amplifier with infinite slew rate followed by a suitable RC filter. If this is capable of distortion, then alternative circuits with reactive components elsewhere within the feedback loop are likely to give distortion. Remember that the rules of negative feedback do not necessarily apply if the feedback is not exactly 180°.

I cannot agree with Mr Self that both amplitude/frequency and phase/frequency responses are identical for similar passive and active equalisation circuits. To a first approximation they may be equal, but the ear is capable of detecting very small differences. Such differences would appear to be attributed to second order effects such as:

(a) A finite closed and open loop gain of the circuit. The gain of a feedback circuit is not

$$G = \left(\frac{R_1 + R_2}{R_2} \right)$$

but

$$\frac{1}{1 + G/A}$$

where A is the open loop gain of the circuit and R_1, R_2 are feedback dividing resistors.

(b) The feedback input has a finite impedance. When the feedback is fed to the emitter of the first transistor this impedance is negative.

(c) The open loop bandwidth of the stage.

Attempts at mathematical analysis would appear to reveal second-order differences attributed to these three factors, but even deciding what form the analysis will take is complicated, let alone doing the calculations.

Obviously the overload margin on passive preamplifiers is much less than feedback equalisation circuits and waveform clipping has been heard on certain records with a high treble content. But it still sounds better and clipping can be avoided by a small increase in feedback. If Mr Self would like to offer his preamp to a qualified hi-fi reviewer for comparison against one of my passive preamplifiers, it would be interesting to see which sounds better when used with equipment of suitable (the highest) quality.

Graham Nalty,
Borrowash,
Derby.

CURRENT DUMPING AMPLIFIER

I was very interested to read the letter in your April issue by Divan and Ghate commenting on the "current dumping" amplifier described in your December 1975 issue. At first it seems incredible that one can entirely cancel out the distortions produced by a pair of output transistors, but having worked through the mathematics of it, I am now convinced. Indeed it will work even if the transfer function of the output pair is complex as well as non-linear, provided of course that the system is stable and the amplifier "A" is perfect and can produce adequate drive to compensate for the imperfections in the output pair.

The best explanation of "current dumping" is that feedback from the output pair to the amplifier is applied in the normal way, but can never completely cancel the distortion, so the error signal generated in the amplifier is fed forward and applied to the load, exactly cancelling any small remaining errors.

I would like to bring to your attention two errors in the equations:

(2) $Z_f \,||\, Z_3 \,||\, Z_{in}$ should read $Z_f \,||\, Z_3 \,||\, Z_{in} \,||\, Z_2$

(4) $Z_{in} \,||\, Z_2 \,||\, Z_3 \,||\, Z_4$ should read $Z_{in} \,||\, Z_2 \,||\, Z_3 \,||\, Z_f$

D. T. Ovens,
Havant,
Hants.

New trends at NAB

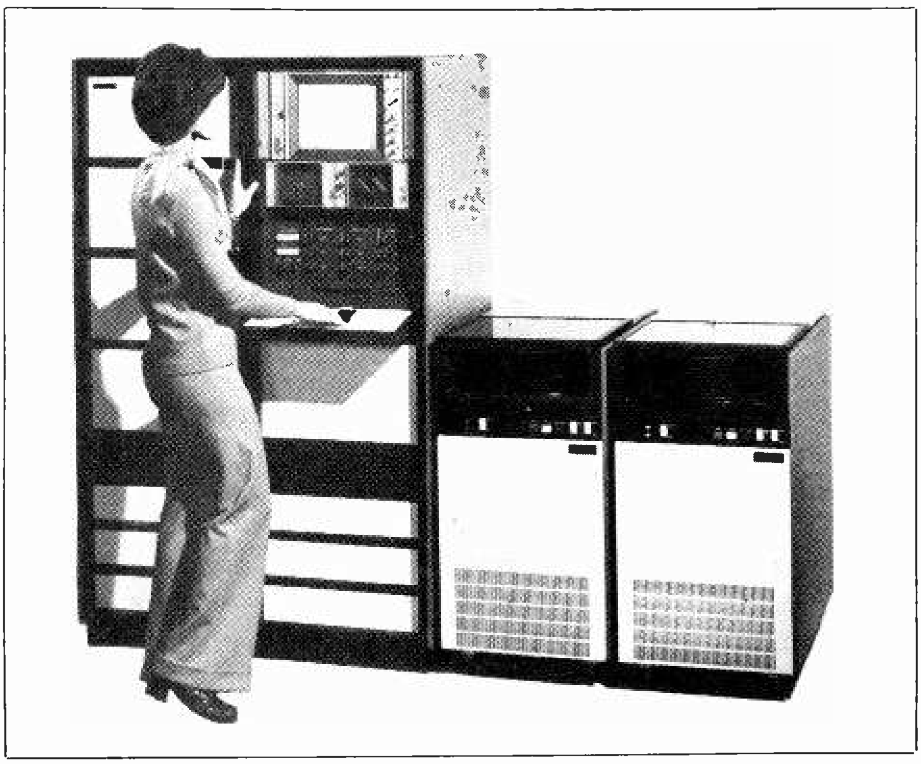
Equipment seen at the Washington convention of the US National Association of Broadcasters

by Pat Hawker, *Independent Broadcasting Authority*

The convention/exhibition of the National Association of Broadcasters returned this year to Washington DC where it spread over three large hotels, some 90,000 sq ft of exhibition space taken up by some 215 firms, and involved (including exhibitors) some 13,000 people. Such a concentration of broadcast equipment — covering every aspect of television and sound radio — not only sends the mind reeling (and the feet tingling) but makes it difficult to pin-point significant trends.

However, 1977 is the year in which light-weight electronic news gathering equipment with ¾-in U-matic tape takes its place in the ordered scheme of things; it has in two brief years won a substantial victory over film and is now pressing outwards into the world of documentaries and beginning to knock even on the doors of prime-time entertainment. This is being helped by the remarkable progress of 1in helical-scan video tape recorders with Ampex, Sony, Fernseh (and its US licensees including IVC who were showing their own redesigned version of the Fernseh machine) and the latest major digital system to appear: the Thomson-CSF/CBS "digital noise reducer," a remarkable piece of digital wizardry that uses adaptive recursive filtering in conjunction with a movement detector to improve the signal-to-noise ratio of 525-line pictures by 9 to 12 dB (and occasionally 15dB). This compact stand-alone box can clear up pictures for such purposes as electronic journalism at low light levels, multi-generation video tapes and U-matic cassettes, telecine film grain reduction and noise problems on microwave and satellite links. One of the major US networks is not expecting to buy any more 2in "quad" video-tape recorders! Ampex this year demonstrated their $200,000 electronic still store based on storing graphics and slides in digital form.

Electronic still store graphic retrieval system, developed jointly by Ampex and CBS, is claimed to be the first commercial broadcasting product to use digital recording techniques for video images.



Together with the mushrooming digital timebase correctors, field and frame synchronisers, digital video effects including picture compression, tracking chroma key, and such special effects as "hall-of-mirrors," picture splits and the like, the use of digital techniques has come a very long way in the few years since the IBA developed the DICE standards converter and Consolidated Video Systems introduced the first commercial digital timebase corrector.

For cameras the latest trend is the modular compact systems with ⅔in pick-up tubes that can be put together in various configurations for electronic news gathering, EFP or studio use. The new Philips "Video 80" is one example; another was the camera marketed in the United States as the CEI-300 but which is made in the UK and will be launched here shortly under the EMI banner. This camera is an example of the increasing use of "Saticon" pick-up tubes which are now being made by RCA as well as Hitachi and which seem set seriously to challenge the lead-oxide tubes, with claimed higher-resolution and absence of "ageing problems." For the larger studio cameras however, the lead-oxide vidicon is still the standard pick-up tube and EEV were showing their new range of highlight overload protection Leddicons with tetrode electronic gun.

A visit to the new headquarters of the Mutual Broadcasting System in Arlington, Virginia showed how rapidly the use of domestic satellite systems for audio distribution is catching on, particularly since the FCC authorised the use of satellite terminals with 6 and 10 ft dishes. The satellite audio circuits offer 8 or 15 kHz channels including stereo pairs instead of the more usual 5kHz at up to about 65dB signal-to-noise ratio. Collins is providing the Public Broadcasting System with some 150 earth terminals for television distribution with 10m dishes. At NAB, RCA were promoting their "Satcom" satellites; Western Union their "Westar"; and the

Portable two-way radio made by RCA can be worn on the belt to enable electronic news gathering teams to communicate with news editor at base.

rate cards indicate that for long haul circuits the satellite systems look set to take over much of the business.

The erstwhile "electronic character generators" are more and more emerging as true graphic production tools and a new production craft of "video typography" is developing — not without some industrial problems as to whom should control them, production people or technicians. ABC described a new system for providing portable titling for sports and other outside broadcasts.

For automation generally the microprocessor is rapidly taking over from the mini-computer with, in particular, the Grass Valley Group launching a modular automation system based on standalone microprocessors that can be brought together to form distributed network systems.

Sound signal processing

One of the most significant differences between American and British practices in sound broadcasting is the amount of signal processing now being applied to American transmissions. Many different techniques for increasing modulation levels and adding "brightness" to audio are being introduced, in an effort to win audience, with few engineers still clinging to the belief that a transmitter should be a linear device! The philosophy seems to be: "I want to sound louder than the guy across the street."

The next step would seem to be the introduction of a.m. stereo on the medium-wave band, with an FCC ruling on this expected by early next year. This will follow field trials of the Motorola, Belar and Magnavox systems by the National AM Stereo Committee and the independent submission to FCC by Leonard Kahn whose independent sideband system has been used in Mexico and in the USA. A lively panel discussion showed that strong feelings exist between Kahn and the Committee's chairman, Harold Kassens, and one suspects that the FCC will find it no easy matter to come up with either a clear cut or compromise decision.

A novel idea introduced by RCA in their u.h.f. exciter is the use of a surface acoustic wave filter for vestigial sideband shaping. Several firms are offering circularly-polarised aerials for television transmission and it is expected that the FCC will shortly authorise circular polarisation for all television channels by those who wish to use it. All-solid-state m.f. radio transmitters included a 5kW unit by RCA.

Increasing use (although relatively modest by European standards) is being made of low-power u.h.f, v.h.f. and also f.m. transposers: some 2300 v.h.f, 1100 u.h.f. and 250 f.m. are currently in operation, many owned not by the broadcasters but by local groups and associations. Some are now powered entirely by solar cells. For v.h.f. transposers providing 1watt output, total power consumption is only 3.5 watts d.c. from 28-volt batteries which can be kept charged by solar cells even in Alaska. At present some "ministations" there receive programmes on tape and play them out with a "24-hour delay" but increasingly these are expected to change to satellite feeds.

For electronic news gathering and other outside broadcasts a wide range of compact microwave links are available and the emphasis this year is on "frequency agile" equipment offering up to about 20 channels to allow teams to avoid mutual interference. Microwave Associates and Nurad also have new broadband rotatable quad-polarised aerial systems for 2, 7 and 13 GHz, remotely controlled. In general higher-gain is being sought for links. Motorola have introduced an optical video link (sub-laser) for use over distances of 1,000-2,000ft. In the USA, it requires no FCC authorisation and at less than $5,000 is considerably cheaper than microwaves. Several firms offer Impatt power amplifiers for increasing output power of link equipment.

Microtime have a new remote synchroniser for outside broadcasts which avoids the use of precision frequency standards, digital frame synchroniser or any return link other than the broadcast signal itself. The technique is to "lock" to a demodulated broadcast signal with a small "window" digital timebase correction at the studio centre and variable distance compensation up to about 50 miles.

Although electronics has made significant impact on the requirement for news film, Eastman Ektachrome have a new video news film that has a tungsten exposure index of 400.

The FCC's approval of "automatic transmission systems" has meant that most transmitters are being offered as suitable for unattended operation. There are also many digital telemetry systems on offer, although the more elaborate automatic measuring equipments still stem largely from Europe (Marconi Instruments, Rohde & Schwartz, Philips) but Charles Rhodes of Tektronix described the "ANSWER II" digital system — which is roughly comparable to the IBA's "DAME" development — though this has not yet reached the demonstration stage.

Rank Cintel showed their successful Mark 3 Telecine; Rank Optics introduced to North America their Varotal "multi-role lens;" Marconi were selling Mark VIII cameras off their stand; Pye had their new 17.5kW v.h.f. tv transmitter on the Philips stand; and Quantel showed that the influence of British work in the digital field continues to make an impact.

CBS have developed a new layout for colour-bar displays which allows colour monitors to be adjusted by eye as accurately as a normal pattern with precision photometer.

The increasing use of individual items of digital video equipment, roughly equally balanced between sampling at three and four times sub-carrier frequency, underlines the urgent requirements in all countries for agreement on digital standards.

American broadcasting

The opportunity to view and listen to television and radio broadcasts in Washington DC also showed the strength as well as the often-emphasised weakness of the American system. The extremely wide choice, the availability of the pick of British programmes and the solid educational material on the Public Broadcasting System, the extremely good international, national and regional news coverage by the networks and independents and by the "all-news" radio stations, the varied selection of music "formats" due to absence of duplication on a.m. and f.m. — all these go a long way to offset the high advertising content, the stereotypes of "prime time" and the inanities of many day-time programmes. The Americans are indeed their own harshest critics. With a financially good year behind them ("We're getting kicked all the way to the bank") the engineers openly say "The programmes are not getting better, only clearer." But this judgement should not deter the visitor from saying that some programmes are in fact not only clearer but better, more varied, and highly professional.

Grateful acknowledgement is made to Mr Howard Steele, Director of Engineering, IBA, for permission to publish. The views expressed, however, are solely those of the writer.

Logic design — 5

Clock-driven circuits

by B. Holdsworth* and D. Zissos†

* Chelsea College, University of London † Dept of Computing Science, University of Calgary, Canada

A four-step algorithm for the design of clock-driven (synchronous) sequential circuits is described. Realistic circuit constraints are automatically taken into account by the design process.

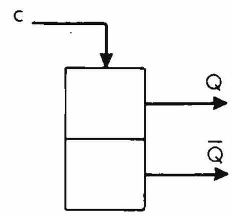
The main features to be considered in the design of clock-driven circuits are reliably correct functioning, observation of gate fan-in and fan-out restrictions and ease of maintenance. It is desirable that maintenance engineers should understand the circuit even though it has undergone simplification – a process which can obscure its function. In general the circuits obtained do not use a minimum number of gates, but the design effort is minimal. The design steps are easy to apply and do not require any specialist knowledge.

Functionally the essential characteristic of synchronous sequential circuits is that their operation is synchronised with clock pulses between which no changes of state can occur.

Clocked flip-flops

Clock driven circuits depend on the use of clocked flip-flops, the principal types of which are described in this section. A clocked flip-flop is a bistable element in which the change of the output signal Q is coincident with either the leading or trailing edge of a pulse signal, commonly referred to as the clock pulse. There are four basic types of flip-flop. Toggle or T flip-flop (TFF); SR flip-flop (SRFF); JK flip-flop (JKFF); D flip-flop (DFF).

Toggle flip-flop. The flip-flop is represented symbolically by the diagram in Fig. 1(a). It has no data input terminals and physically its output "toggles" or changes state with every clock pulse. The logical behaviour of this flip-flop is described by the truth table shown in Fig. 1(b). If the T flip-flop is a modified master/slave JK flip-flop it will turn-on when Q=0 and C is changing from 1 to 0, that is on the trailing edge of the C-pulse. Similarly it will turn-off when Q=1 and C is changing from 1 to 0. The terminal behaviour of this flip-flop is described by the state diagram shown in Fig. 1(c).



c	Q^t	$Q^{t+\delta t}$	
0	0	0	
0	1	1	
1	0	1	Turn-on
1	1	0	Turn-off

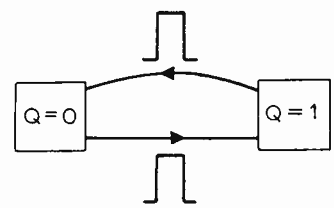


Fig. 1. Symbol (a), truth table (b) and state diagram for a toggle or T-type flip-flop.

SR flip-flop. The sequential equation, $Q=S+\bar{R}Q$, for the SR flip-flop, shown symbolically in Fig. 2(a), was developed in Part 3 of this series. An implementation of an unclocked SR flip-flop, using NAND gates, is shown in Fig. 2(c), and this is frequently drawn in the form shown in Fig. 2(d). A condensed form of the truth table for this flip-flop, called the steering table, is shown in Fig. 2(b) where the entry Φ in the S and R columns means that the input can be either 0 or 1.

By means of the simple modification shown in Fig. 2(e) the SR flip-flop can be clocked. An examination of this diagram shows that if C=0 the outputs of g_1 and g_2 will always be logical 1 irrespective of the present values of S and R, or of any changes in these two inputs. The flip-flop can only change its output during a clock pulse transition and, assuming zero gate delay, the output Q will change state on the leading edge of a clock pulse, when C is changing from 0 to 1.

Examination of the steering table or the circuit shows that a clocked SR flip-flop is turned on when S=1, R=0, and C changes from 0 to 1. Conversely it is turned off when S=0, R=1, and C is changing from 0 to 1. Hence the terminal behaviour of the flip-flop can be described with the aid of the state diagram shown in Fig. 2(g).

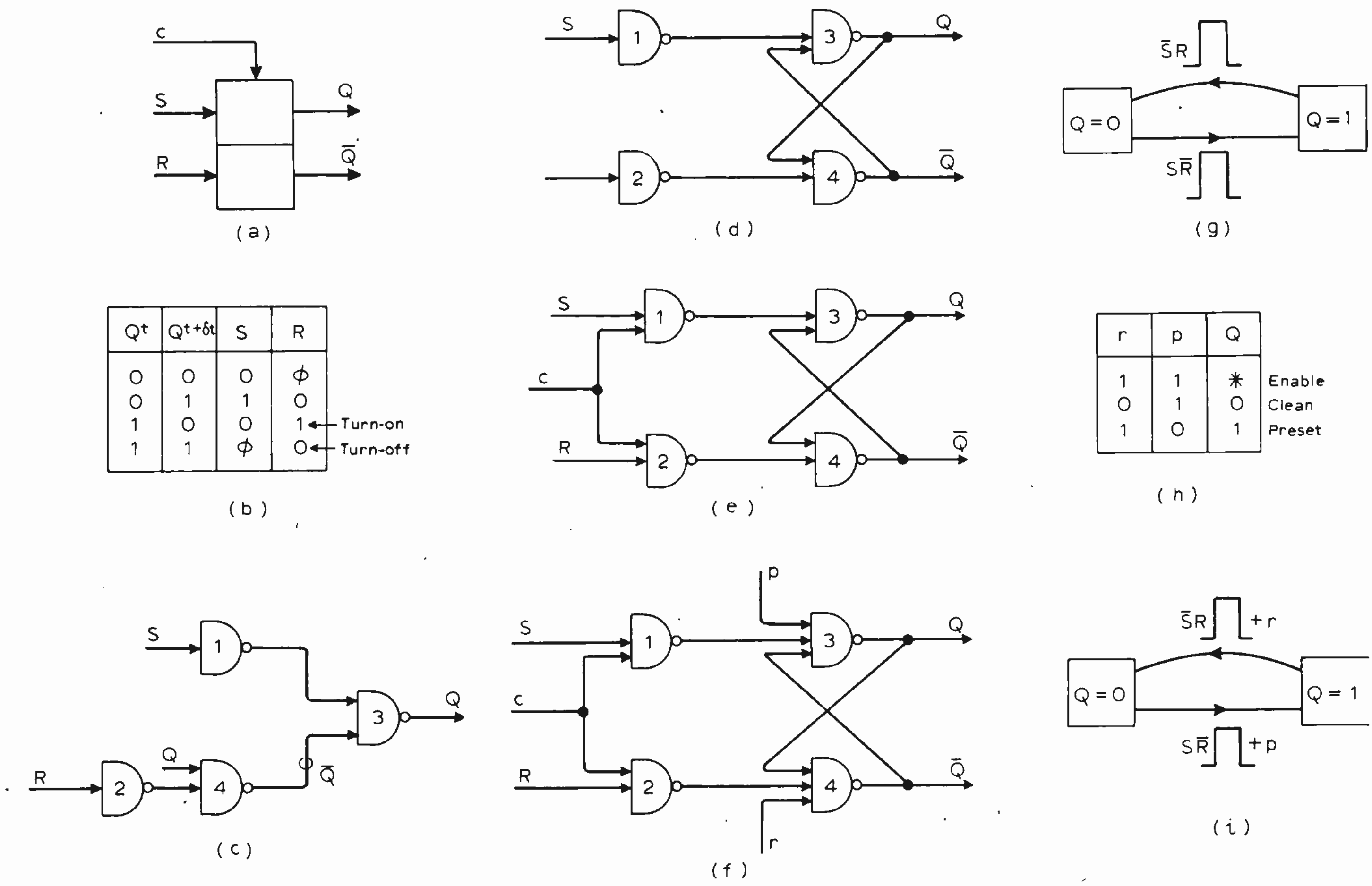
Besides the S, R and C inputs, a clocked SR flip-flop may have one or two additional controls which allow it to assume one of its two states irrespective of whether C=0 or C=1. These controls are frequently called Clear and Preset. Most commercially-available flip-flops are provided with a clear control, whereas the preset control is not nearly as common. The operation of these controls is described by the table shown in Fig. 2(h) and it should be observed that in the circuit of Fig. 2(f) these signals are active when low.

With both controls at logical 1 the flip-flop is enabled and operates in the normal way. If R=0 and P=1 the output $\bar{Q}$ of g_4, in Fig. 2(f) becomes $\bar{Q}=1$. Hence Q=0, and the flip-flop is unconditionally reset. If R=1 and P=0 the output Q of g_3 becomes Q=1, and the flip-flop is now preset. The inclusion of these controls leads to a modified state diagram as shown in Fig. 2(i).

The reader should note that if a preset facility is required when the P terminal is not provided it is possible to interchange the Q and $\bar{Q}$ terminals and the input terminals. The clear terminal can then be used as a preset control.

JK flip-flop. The symbolic representation of the JK flip-flop is shown in Fig. 3(a) and the truth table describing its logical operation in Fig. 3(b). The operation of this flip-flop differs in one respect from that of the SR flip-flop in that it is allowable for J and K to be simultaneously equal to 1. If J=K=1 the flip-flop "toggles", that is, in row 7 the flip-flop changes state from 0 to 1, whilst in row 8 the converse action takes place. In rows 4 and 5 normal reset and set operations take place as described for the SR flip-flop in the last article.

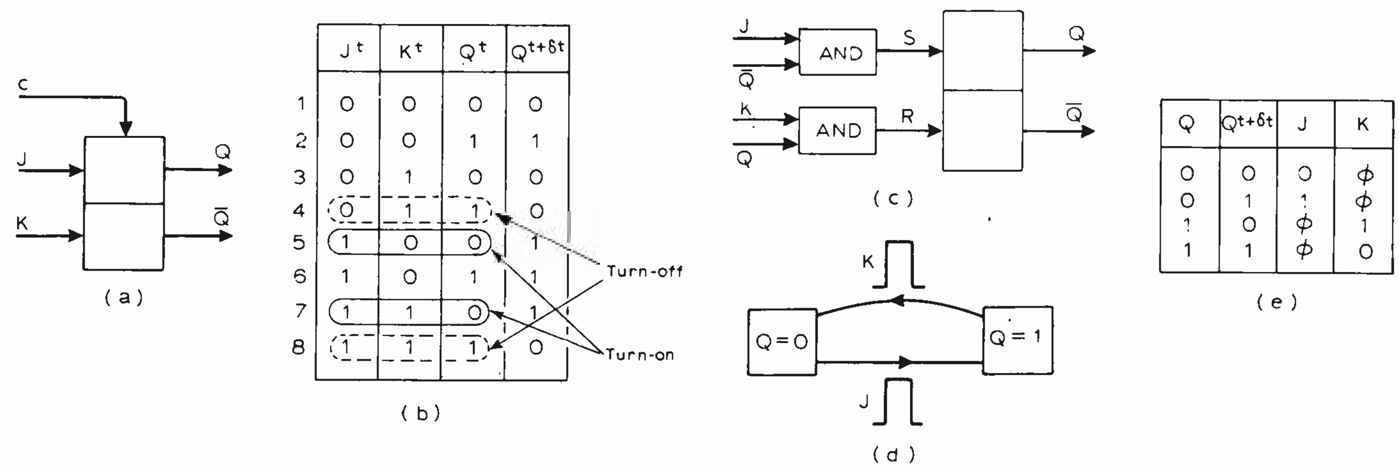
An examination of the truth table shows that the flip-flop is turned on in



Q^t	$Q^{t+\delta t}$	S	R	
0	0	0	Φ	
0	1	1	0	
1	0	0	1	← Turn-on
1	1	Φ	0	← Turn-off

r	p	Q	
1	1	*	Enable
0	1	0	Clean
1	0	1	Preset

Fig. 2. (a) Symbol for the SR flip-flop, whose steering table is at (b), where Φ indicates either 0 or 1. The SR can be realized, in unclocked form, by NAND gates, as in (c) shown rearranged in a more familiar form at (d). A clocked type of SR is seen at (e) and, with preset and clear, at (f). State diagram for the clocked SR is at (g) and the truth table for P and C can be seen at (h). At (i) is the state diagram for a clocked SR with P and C controls.



	J^t	K^t	Q^t	$Q^{t+\delta t}$
1	0	0	0	0
2	0	0	1	1
3	0	1	0	0
4	0	1	1	0
5	1	0	0	1
6	1	0	1	1
7	1	1	0	1
8	1	1	1	0

Q	$Q^{t+\delta t}$	J	K
0	0	0	Φ
0	1	1	Φ
1	0	Φ	1
1	1	Φ	0

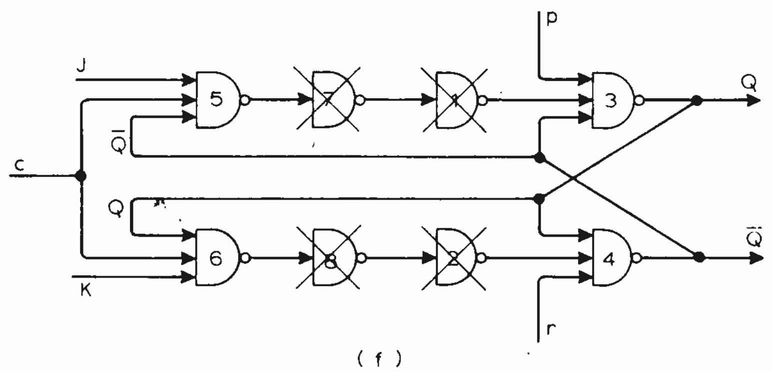


Fig. 3. The JK flip-flop is shown symbolically at (a), with its truth table at (b). That a JK is simply an SR with two NANDs at the inputs is shown by (c). State diagram for a clocked JK is shown at (d) and the steering table at (e). Clocked JK realised in NAND form is at (f), in which the single-input gates are redundant and can be replaced by a wire.

rows 5 and 7, whilst it is turned off in rows 4 and 8.

The turn-on set of Q: $S = J\bar{K}\bar{Q} + JK\bar{Q}$
$= J\bar{Q}$

The turn-off set of Q: $R = \bar{J}KQ + JKQ$
$= KQ$

These two equations indicate that a JK flip-flop is in practice an SR flip-flop preceded by two AND gates which implement the functions $J\bar{Q}$ and KQ respectively, as shown in Fig. 3(c).

The state diagram describing the terminal behaviour of the flip-flop is shown in Fig. 3(d). If the flip-flop is in the state $Q=0$ with $J=1$ and C changes from 0 to 1, it makes a transition to the state $Q=1$. Similarly if in the state $Q=1$ with $K=1$ and C changes from 0 to 1, it makes a transition to $Q=0$.

A steering table for the JK flip-flop is shown in Fig. 3(e). Comparing the steering tables of the SR and JK flip-flops shown in Figs. 2(b) and 3(e) respectively, it will be observed that the JK flip-flop has more Φ or optional input conditions and consequently this type of flip-flop leads to simpler logic when used in the design of clock-driven circuits.

A JK flip-flop can be implemented by connecting the output of the two AND gates in Fig. 3(c) to the S and R inputs of the SR flip-flop of Fig. 2(f). Simultaneously the Q and $\bar{Q}$ outputs of this flip-flop and its clock connections are fed to the inputs of the two AND gates, in conjunction with the J and K lines, as shown in Fig. 3(f). Notice that the AND gates are formed from two pairs of NAND gates in cascade, namely g_5 and g_7, and g_6 and g_8. Clearly gates g_7 and g_1 and gates g_8 and g_2 provide a double inversion. These four gates are therefore redundant and can be omitted from the implementation.

The race-around condition. Unfortunately, satisfactory flip-flop operation is not possible with the circuit shown in Fig. 3(f), for the following reason. If the

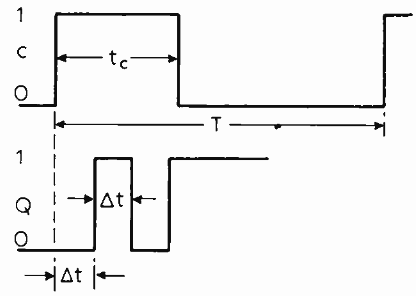


Fig. 4. Illustration of a "race-around", where the output oscillates during the duration of the trigger pulse, t_c.

outputs of the flip-flop, Q and $\bar{Q}$, in Fig. 3(f), change before the termination of the clock pulse the input conditions at gates g_5 and g_6 will also change. For example if $J=K=1$ and $Q=0$, when the clock pulse is first applied Q changes to a 1. This change takes place at $t=\Delta t$ after the start of the clock pulse, as shown in Fig. 4, where Δt is equal to the propagation delay through two NAND gates. At $t=\Delta t$, $J=K=1$, $Q=1$ and $C=1$, consequently there will now be a further change in the output to $Q=0$ at $t=2\Delta t$. The conclusion is that the output of Q oscillates between 0 and 1 for the duration of the clock pulse. Further, at the end of the clock pulse the value of Q is indeterminate.

This phenomenon is called the "race-around" condition. It can be avoided if $t_c < \Delta t < T$. Unfortunately, with modern integrated circuits $t_c >> \Delta t$ and the inequality is not satisfied. This has led to the development of the master/slave or double-rank flip-flop.

Master/slave flip-flop. This consists of two flip-flops in cascade. The leading one, called the master, is connected as a JK flip-flop, whilst the second one, the slave, is connected as an SR flip-flop. Clock pulses are used to enable the master whilst inverted clock pulses are used to enable the slave.

A NAND implementation of a master/slave flip-flop is shown in Fig. 5. Examination of this diagram shows that the master flip-flop changes its state on the leading edge of a clock pulse. For example if $J=1$, $Q_m=0$ and C is changing from 0 to 1, then the output state of the flip-flop changes to $Q_m=1$. Since Q_m is also the set input of the slave flip-flop, $S=1$.

The slave flip-flop is enabled when $\bar{C}$ is changing from 0 to 1, that is on the trailing edge of the clock pulse. If $Q_s=0$, $S=1$ and $\bar{C}$ is changing from 0 to 1 the output state of the slave changes to $Q_s=1$. The change which occurred at the output of the master on the leading edge of the clock pulse is transferred to the output of the slave on the trailing edge of the same clock pulse.

The reader will observe that the slave output cannot change state until after the termination of the clock pulse and consequently the race-around condition can never occur with this type of flip-flop.

D flip-flop. The symbolic representation of a D flip-flop is shown in Fig. 6(a) and its logical operation is described by the truth table in Fig. 6(b).

From the truth table:

$$Q^{t+\delta t} = (D\bar{Q} + DQ)^t,$$

or: $$Q^{t+\delta t} = D^t.$$

The interpretation of this equation is that the output Q assumes the logical value of the input at the time of the clock pulse.

In Fig. 6(c) the terminal behaviour of the flip-flop is described with the aid of a state diagram. Assuming that the flip-flop is of the master/slave type, and if $Q=0$, $D=1$ and C changes from 1 to 0, it makes a transition to $Q=1$. Similarly if the state is $Q=1$, $D=0$ and C changes from 1 to 0, it makes a transition to $Q=0$.

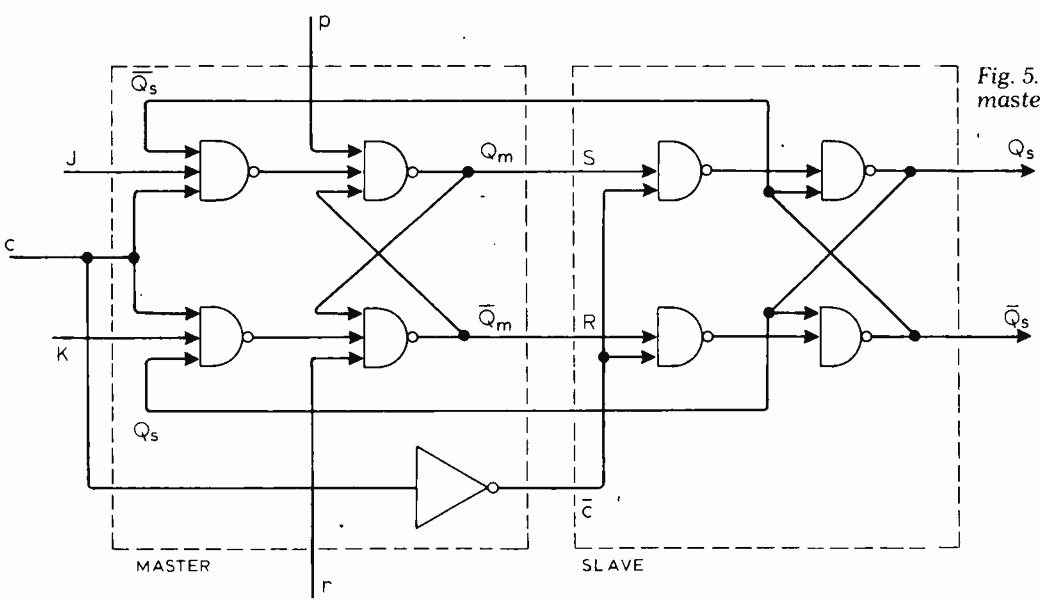


Fig. 5. NAND embodiment of a master/slave flip-flop.

JK versatility. A JK flip-flop can be easily converted to a T type by connecting the J and K lines to logical 1, as shown in Fig. 7(a). The flip-flop then toggles on the receipt of every clock pulse.

To convert a JK flip-flop to a D type the J line, besides being connected to the J input, is also connected to the K input through an inverter, as seen in Fig. 7(b). Referring to the truth table for the JK flip-flop shown in Fig. 3(b), the only entries valid for the configuration of Fig. 7(b) are those in rows 3, 4, 5 and 6. If the column headed J is identified as D and the column headed K is omitted, then the entries in these rows are identical to the entries in the truth table for the D flip-flop shown in Fig. 6(b).

Design steps

The sequence of four design steps for clock-driven circuits is as follows:

(1) **I/O characteristics.** In this step a block diagram is drawn to show the available input signals and the required output signals.

(2) **Internal characteristics.** In the second step the designer specifies the internal performance of the circuit with the aid of a state diagram. The inexperienced designer should be primarily concerned that the specification of the internal circuit operation is complete and free of ambiguities.

(3) **State reduction.** This step is optional and can be omitted. Its main purpose is to provide the designer with the means for reducing the number of internal states used in step 2, if such a reduction is possible. To avoid redundant states this step would be used to reduce the number of states to some power of 2. For example, whereas it would be used to reduce five states to four, it would not be used to reduce four states to three.

(4) **Primitive circuits.** In contrast to the situation with event-driven circuits, the design of clocked circuits does not require that only one secondary signal may change during a transition between two states. This is based on the assumption that all changes of secondary signals take place on the trailing (or leading) edge of the clock pulse that initiates them, and of course before the next clock pulse.

Having allocated the secondary signals, the turn-on and turn-off conditions are written down for each of these signals. For example, in the state diagram of Fig. 8,

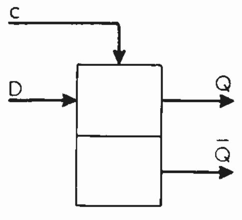
Turn-on set of A: $S_A = S_1\bar{X} + (S_2X)$

Turn-off set of A: $R_A = S_3\bar{X} + (S_0X)$

Turn-on set of B: $S_B = S_0X + S_2X$

Turn-off set of B: $R_B = S_1\bar{X} + S_3\bar{X}$

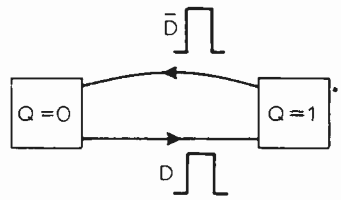
Examination of these equations shows that the turn-on conditions of secondary signal B, S_B, is the disjunction (ORing) of the total states which are necessary for the next clock pulse to



(a)

D	Q^t	$Q^{t+\delta t}$
0	0	0
0	1	0
1	0	1
1	1	1

(b)



(c)

Fig. 6. D type flip-flop symbol (a), truth table (b) and state diagram (c).

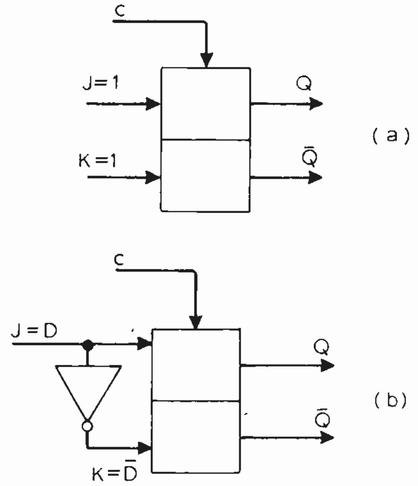


Fig. 7. Illustration of the JK used as a T type flip-flop (a) and as a D type (b)

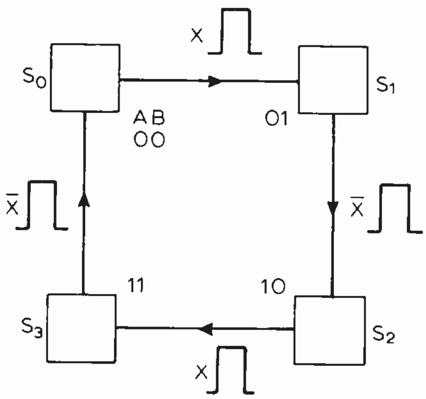


Fig. 8. State diagram for a clock-driven circuit.

cause B to change value from 0 to 1. Similarly the turn-off condition of secondary signal B, R_B, is the disjunction of the total states which are necessary to cause B to change value from 1 to 0.

The expressions for the turn-on and turn-off conditions of the flip-flops can be reduced using as optional products those terms which define "don't care" circuit conditions or alternatively products which define total states involved in transitions in which the signal concerned does not change its value. For example when moving from S_2 to S_3 in Fig. 8, signal A retains its value of 1 and its turn-on conditions can be allowed to arise during this transition. Hence the turn-on equation for A consists of the disjunction of a genuine turn-on condition $S_1\bar{X}$ and an optional product (S_2X). Similarly the turn-off condition for A consists of the disjunction of a genuine turn-off condition $S_3\bar{X}$ and an optional product (S_0X).

The turn-on and turn-off conditions derived by the foregoing process define directly the set and reset signals respectively for a pair of SR flip-flops. However the most readily available and versatile flip-flop is the JK type. As this is used extensively it is worthwhile recalling the relationships derived earlier in this article between S and J, and R and K respectively. They are:

$$S_Q = J\bar{Q} \text{ and } R_Q = KQ$$

Clearly the expressions for J and K can be obtained from the expressions for S and R by dropping $\bar{Q}$ and Q respectively. This is a very useful result and the reader is advised to make a note of it.

The design procedure described above will be illustrated in the next article with the aid of a series of examples.

Literature Received

Catalogue of power supply components (transistor, rectifiers, regulators) and comple Abbey Barn Road, Electronics Co. High Wycombe, Bucks WW401

Application notes from Hewlett-Parkard on the use of spectrum analysers in noise figure (AN150-9), field strength (AN150-10) and distortion (AN150-11) measurements. Hewlett-Packard Ltd, King Street Lane, Winnersh, Workingham, Berks. WW402

Microwave Newsletter from Walmore, on video detectors, balanced amplifiers, fluorglas laminates, Gunn oscillators and a log amplifier. Walmore Electronics Ltd, 11-15 Betterton Street, London WC2H 9BS WW403

Short-form catalogue of digital-to-analogue and a.-to-d. converters, sample-and-hold amplifiers and data acquisition units, all in dual-in-line packages, from Micro Networks. Tranchant Electronics (UK) Ltd, Tranchant House, 100a High Street, Hampton, Middlesex WW404

Guide to the specification and use of surface-coating resins of many types, prepared by Cray Valley Products Ltd, St Mary Cray, Kent BR5 3PP WW405

Instrument-case catalogue from Lektrokit details the complete ranges of Motek and Lektrokit modular cases, including the newer Transistek types. Available from Lektrokit Ltd, 3 Trafford Road, Reading, RG1 8JR WW406

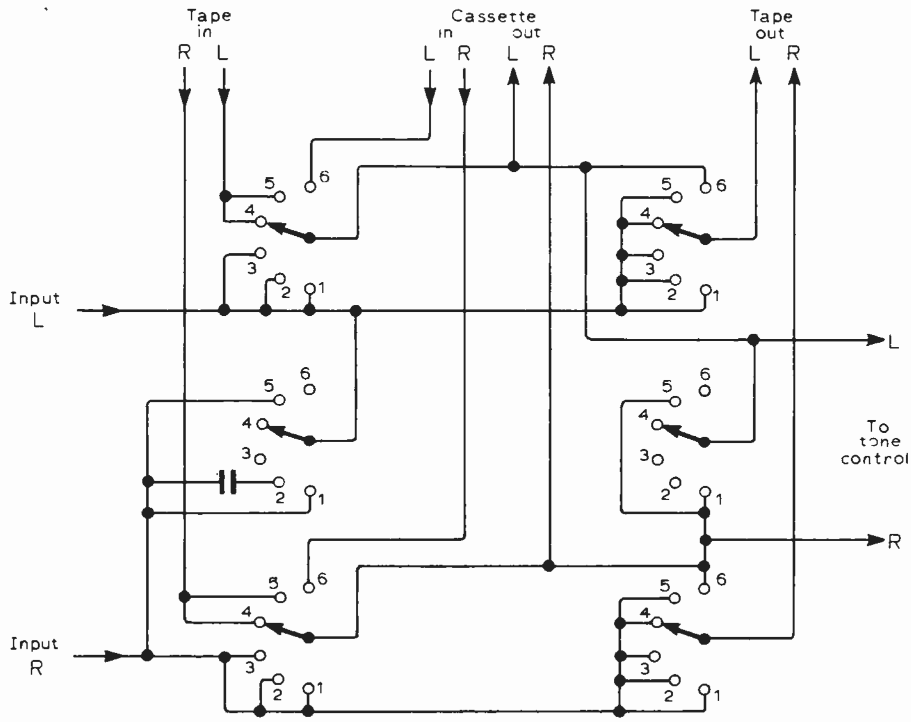
Data sheet on the Weir 250mA, plug-in power supply for op-amps, with an output variable from ± 12V to ± 15V. Weir Instrumentation Ltd, Durban Road, Bognor Regis, Sussex WW407

Circuit Ideas

Audio selector switch

This circuit uses one six-pole six-way rotary switch connected between the preamplifier and tone control and provides the following facilities. Mono, where the amplifier is switched to mono and reproduces the preamplifier or source input and provides tape and cassette record outputs. Hi-blend, where a capacitor is placed across the two channels to introduce high frequency crosstalk. Stereo, and tape stereo where the pre-amplifier input is switched to the tape record output, the tape play input is switched to the tone control, for monitoring, and to the cassette record output to enable dubbing. Tape mono, as above but both source and tape signals are mono. Cassette play where the output is switched to the tone control and tape record output, to enable dubbing from cassette to tape and replay of cassettes. Note that it is not possible to use a 3-head machine on the cassette input and obtain tape monitoring.

M. Hadley,
Sutton Coldfield,
W. Midlands.

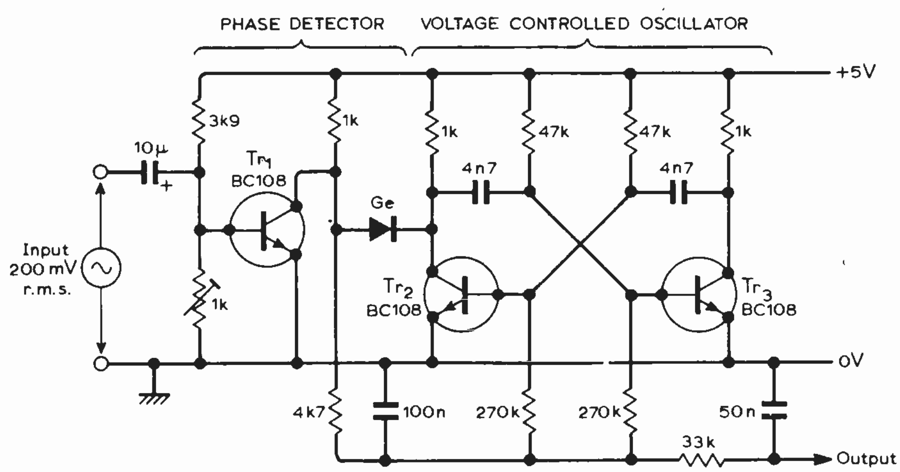


Simple phase-locked loop

The conventional two-transistor multivibrator can be converted into a simple audio frequency phase-locked loop by the addition of a few components. Transistor Tr_1 and the diode are connected as a logic gate, and conduct during alternate half-cycles of the input and v.c.o. waveforms respectively. The output of this phase-detector, when filtered, is most negative when the waveforms are in phase, and most positive when they are in antiphase. Because the diode conducts only when Tr_2 is saturated, the action of the multivibrator remains unaffected. Once phase-lock has been established the v.c.o. settles to an equilibrium phase, lagging the phase of the input by an angle which depends on the difference between the frequency of the input and the free-running frequency of the v.c.o.

With the component values shown, phase-lock is maintained from 100Hz to around 3kHz. Within this range the output changes linearly at about 14mV/Hz. The response to a sinusoidal frequency-modulation is 3dB down at about 50Hz.

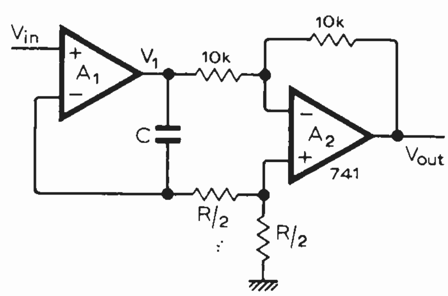
J. B. Cole,
Chester.

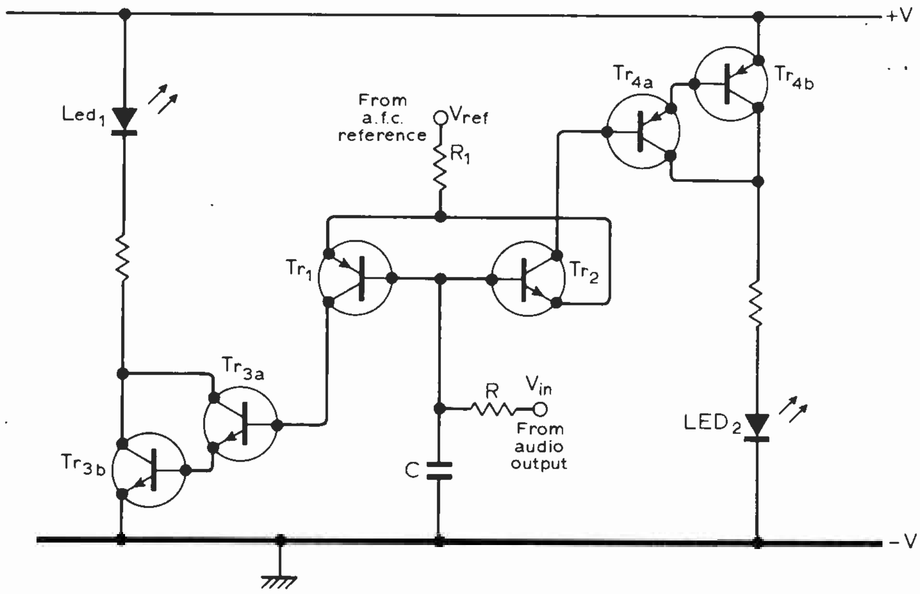


High input impedance integrator

When integrating a voltage signal from a high output impedance source, the usual type of op-amp integrator is often unsuitable if the integrating resistor is smaller or of the same order as the source output impedance. This problem can be overcome using the following circuit. Capacitor C and two resistors provide the integrating time constant. If op-amp A_1 is chosen so that its input offset voltage and input bias currents are sufficiently small so as to be negligible, then the output of A_1 becomes $V_1 = V_{in} + 1/RC \int V_{in}dt$. By the addition of the second amplifier A_2 and the two 10kΩ resistors, V_{in} is subtracted from V_1 and the output is inverted. The output thus becomes $V_{out} = -1/RC \int V_{in}dt$. Consequently V_{out} is the same as the desired output from the simple integrator with the added advantage that the input resistance is extremely high.

G. J. Bulmer,
Falkirk,
Stirlingshire.





Tuning indicator

This gives directional information about a tuning error and consumes virtually no power in the null condition. When a station is correctly tuned or no station is being received, V_{ref} and V_{in} are approximately equal and all of the transistors are non-conducting. If V_{in} exceeds V_{ref} by more than about 0.5V, then Tr_2 conducts and turns on LED_2 via Tr_4. Similarly, if V_{in} is at least 0.5V less than V_{ref}, then Tr_1 conducts, turning on LED_1. Resistor R and capacitor C form a simple low-pass filter to remove the audio component of the output. For the Nelson-Jones tuner, 68kΩ and 2.2μF are suitable. Resistor R_1 should be chosen to limit the current which can be applied to Tr_{3a} and Tr_{4a}.

Because Darlington pairs are used to drive the l.e.ds the transistor types are not critical.

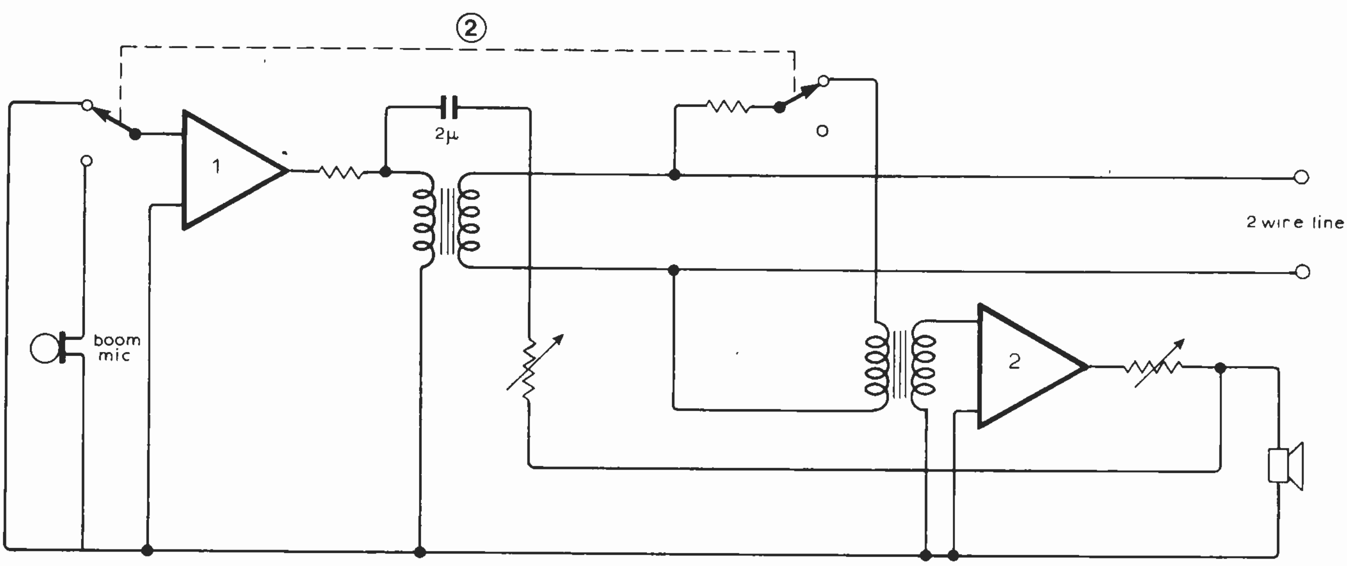
D. J. Thomas,
Coventry.

Two wire intercom

In telephone circuitry the multi-tapped inductor at the telephone-receiver end converts the two wire line into an effective four wire system to give side tone control. A similar principle using only one pair of wires per station in a multichannel intercom network is possible, but obtaining side tone control without using inductors and v.d.rs is difficult due to unavoidable coupling between the receiver and transmitter amplifiers which causes feedback. This circuit solves the problem of obtaining side tone control and does not suffer from instability. Receiver amplifier 2 is disconnected from the balanced lines when the switch is operated, and a receiver path is connected via the 2μF capacitor. This allows side tone control and retains other messages on the lines at a lower level. Amplifiers such as the TDA1054 can be used because they contain a compression circuit. The presence of multiple signals on the balanced lines does not seriously alter the listening level at the earpiece when such compression amplifiers are used.

The above circuit has been tried on a 20 student intercommunication network in a language laboratory with satisfactory results. No further amplification of the signal via the 2μF capacitor was found necessary. The isolating transformers have 1:1, 10kΩ windings.

K. Soma,
Singapore



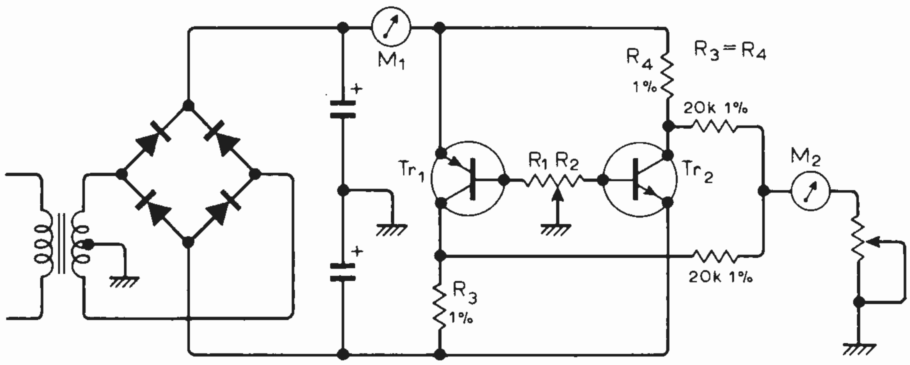
Matching complementary pairs

This circuit allows the accurate matching of power complementary pairs without any danger of failure. Adequate values of R_1, R_2, R_3 and R_4 are necessary to limit the collector currents. By balancing R_1 R_2, equal currents through the transistors are achieved when there is zero indication on M_2. At this point

$$\frac{h_{FE1}}{h_{FE2}} = \frac{R_1}{R_2}$$

As an alternative, the circuit can be used to measure the h_{FE} of a certain transistor comparatively with a known one. Adequate accuracy can be obtained with a linear precision potentiometer, and equal voltages in the two halves of the secondary winding.

Safta Ion,
Romania.

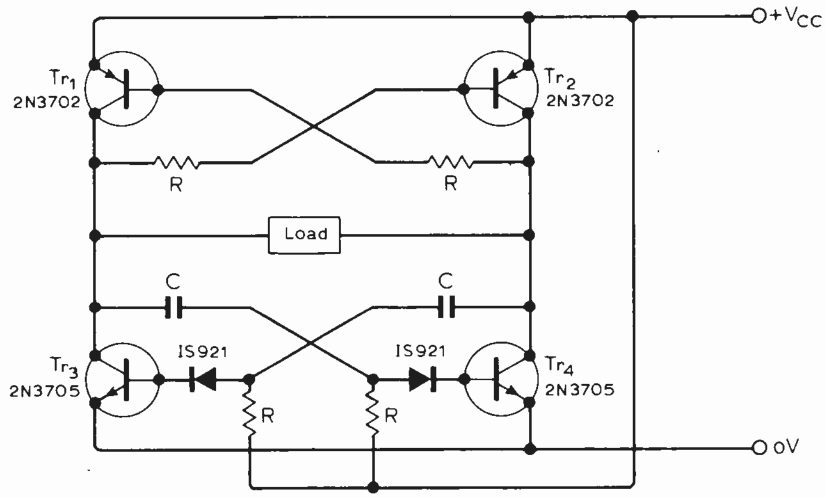


Efficient square-wave oscillator

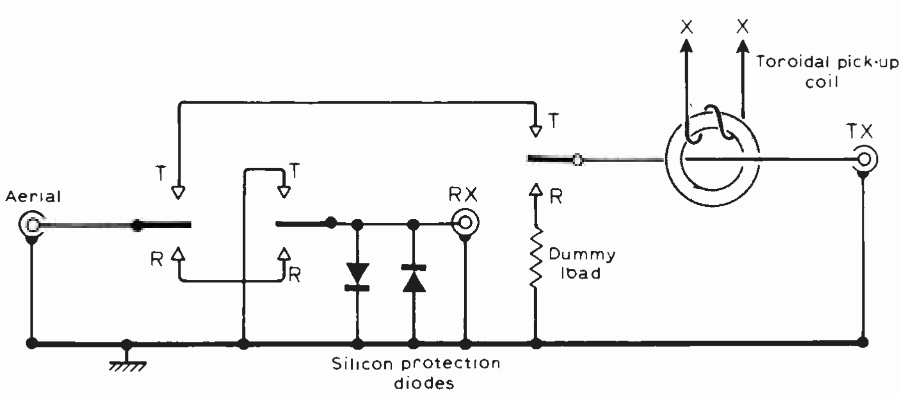
This oscillator was devised for use in battery powered equipment where supply economy was important. It is based on a combination of astable and bistable multivibrators where diagonally opposite transistors switch on and off together. In this way a balanced load will receive a peak-to-peak voltage approaching $2V_{cc}$. Timing is performed in the normal manner and the period of the square wave is approximately 1.4*CR*. The circuit is quite flexible and will tolerate a range of *CR* values but at higher frequencies commutating capacitors will be required in the bistable section. Using a 24V supply, peak load currents of up to 70mA can be drawn.

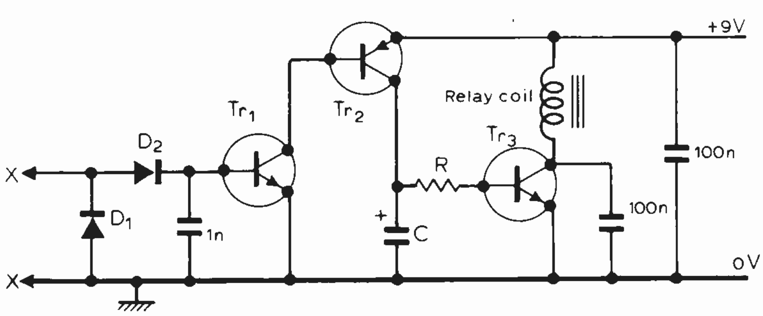
An interesting variant employs two bistable sections. In this way, higher frequency stability can be obtained by driving one of the bistables from an external source.

J. C. Hopkins,
University of Bath.



R.f. operated aerial switch



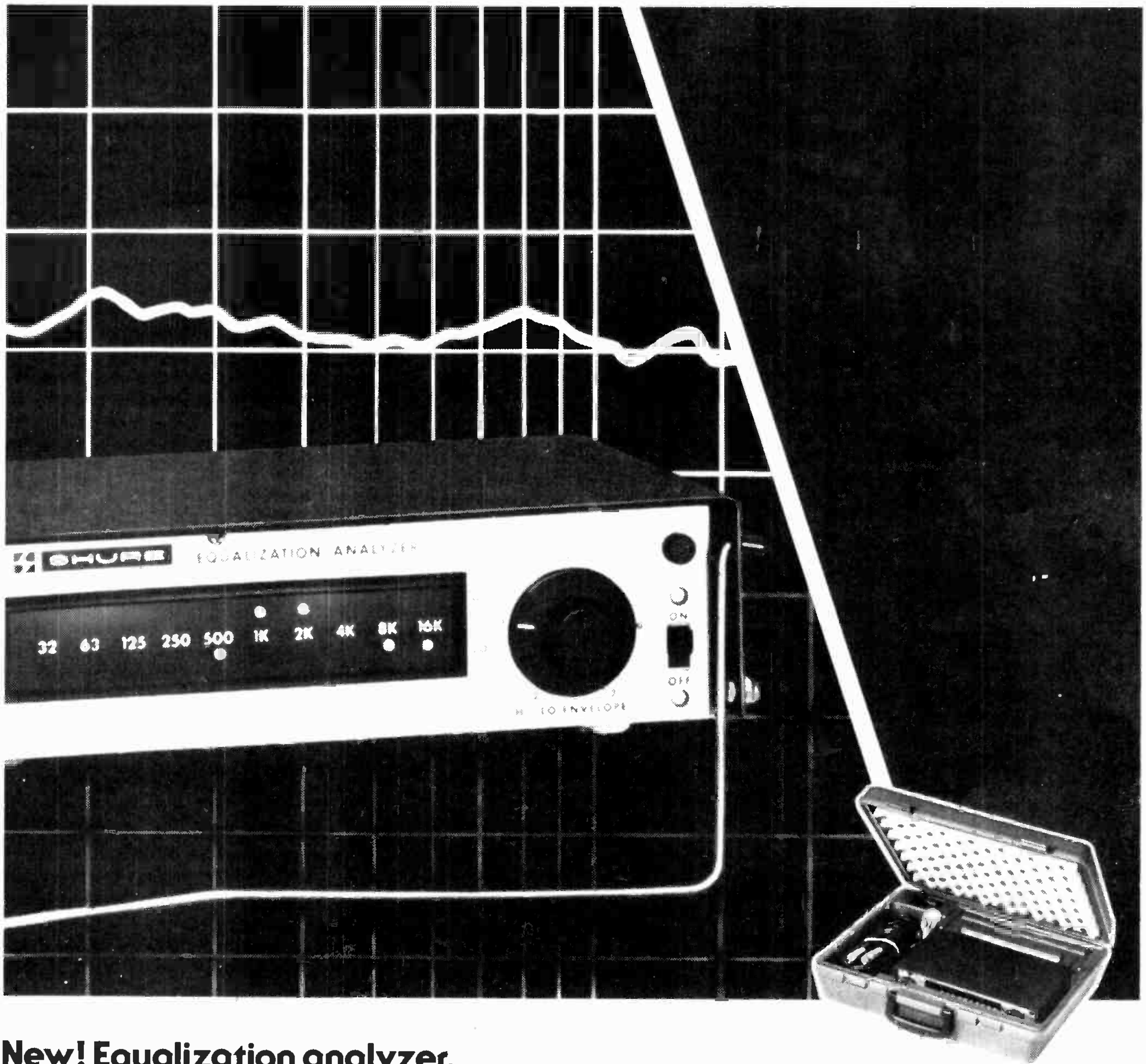


This aerial switch offers good isolation and negligible attenuation, without the use of high voltage bias supplies. The unit is simply connected into the aerial lead and no connections are made to the receiver or transmitter power supplies.

When an r.f. signal appears in the dummy load, a sample is picked up by the coil, rectified, and used to turn on the transistor circuit. The relay then changes to transmit. When the r.f. ceases, the discharge of C produces a small delay so that the relay only switches at the beginning and end of a period of c.w. transmission. The switch to transmit is rapid and a 100μF × 15kΩ produces a delay of two seconds when switching to receive.

A few turns on a toroid is sufficient for a pick-up coil with an output of 1W. In the receive condition the circuit requires only 30μA so a battery can be left in circuit. With short leads and the unit mounted in a screened case, the circuit functions from topband to two metres. The transistors are general purpose silicon types but D_1 and D_2 should be germanium.

I. Braithwaite,
Clitheroe,
Lancs.



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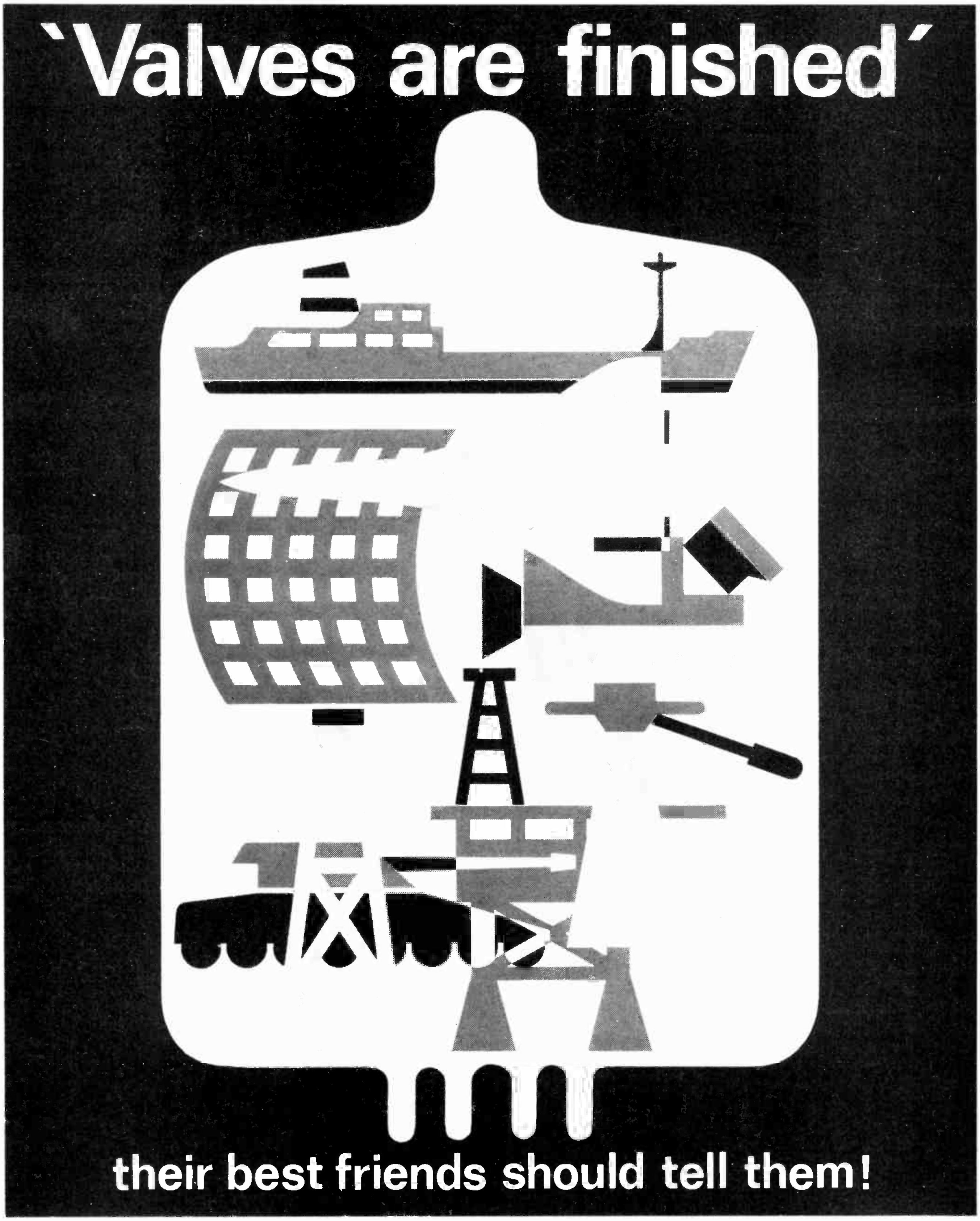

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Annan Opts Out

Technical decisions to be taken by Public Enquiry Board

The Home Secretary, then Roy Jenkins, announced the setting up of a Committee on the Future of Broadcasting on April 10, 1974. Its members, whose background made the committee a monument to the amateur tradition, were appointed three months later. Their enquiries have cost £¼ million, before printing costs of £60,000, and would have been even more expensive but for their decision to forgo trips to the USA and Sweden in the interests of saving public money.

It had been expected that Annan would provide clear signs as to the effects that new technology would have on broadcasting, particularly the development of satellite and cable broadcasting. But, as one journalist complained at the press conference on publication of the already widely-leaked report, only 35 of the report's 500 pages deal with the new technology, and such technical matters as the committee had been expected to decide have been hived off on to one of the many new bodies the committee recommends be set up.

The disappointment many interested in the future of broadcasting may feel is hardly mitigated by the report's value as a fairly well-written and comprehensive survey of the state of British broadcasting now. Others may wonder how much of the evidence that was submitted, some 6,000 letters from the public, actually reached the committee: the names of those listed as having given evidence is confined to the broadcasting establishment and the 400 organisations to whom Lord Annan wrote inviting their views.

Lord Annan: Emphasises accountability, but scraps access

New authorities

The most controversial recommendations adopted were those to set up an Open Broadcasting Authority instead of giving ITV the fourth tv channel, and the separation of local radio from the BBC and IBA under the control of a new authority. Ostensibly the latter recommendation is part of a geographically-based strategy for broadcasting. The BBC is to be responsible for national broadcasting, the IBA for regional programmes, and the local broadcasting authority for local transmissions. Equally, both may owe as much to a Janus-like inability, in the interests of preserving a unanimous committee view, to decide between commercial and publicly-financed broadcasting. The OBA would act as a publisher, says Annan, administering a channel intended to serve all kinds of minority interests, with programmes provided by the Open University, the ITV companies and ITN, and freelance producers. It would be responsible for a v.h.f. radio channel which will become available when the 405-line service is discontinued in 1982. The BBC should provide transmission facilties for the channel, which should, like the fourth channel, contain a high proportion of educational programmes.

The main criticism of the proposal for an OBA, though it has been praised as a highly imaginative attempt to devolve broadcasting from the "broadcasting duopoly" of the BBC and IBA, has been that no clear idea has emerged for financing it. Annan says "This variety of programming will be achieved only if the finance for it is drawn from a variety of sources. Sponsored programmes should be allowed on this channel, though on no other. Broadcast time should not be sold, but major industrial and financial companies who now help to finance opera productions or sponsor sporting events should be able to sponsor the television presentation of them. The Arts Council might wish to collaborate with the OBA to ensure that some of the productions by the companies which receive sizeable grants from the council are made available to a wider audience through television." Charities might provide programmes for certain audiences, such as the handicapped. The CBI and TUC might provide programmes for their members. The rest of the programmes could be provided by block advertising; that is to say, advertising not interlaced with the programmes.

Coupled with the Committee's view that "we do not see in access programmes an opportunity to democratize broadcasting," the OBA is a further step away from the Reithian idea that all channels should provide a mixture of majority and minority programmes. The minorities are relegated to a crackpot channel or cultural ghetto, leaving the three established channels to play the ratings game even harder.

Local radio

Local radio's financing under its new authority would also be a mixture of ads and institutional whimsy. "The stations would be predominantly owned by people living and working in the locality . . . At least some of the stations might be run by non-profit-distributing trusts based in the locality. More generally, the authority should encourage the growth of co-operative and other joint forms of financing to stimulate a direct involvement by the community in its own broadcasting services . . . Advertising should provide the main source of income and a balance should be maintained between local and national advertising tilted favourably towards the local advertisers. But it will not be possible to finance all stations by advertising, particularly those in rural areas.

"These areas might be helped in a number of ways. For example, where there is a community of interest, profitable stations might be required to provide a satellite service in a contiguous rural area." High rentals in towns would subsidise country services.

The committee rejected the creating of a single authority to assume responsibility for all broadcasting, on the grounds that sooner or later it would "lead to one body of people being in a position to impose their views on the whole of broadcasting output. It would also increase the risk of political control over broadcasting." In general, the report says, the existing relationship between parliament, the broadcasting authorities and the public was adequate, but a separate complaints commission should be set up, financed by the authorities.

Yet another body Annan wants set up in the blizzard of newly-created sinecures is a £150,000 a year Public Enquiry Board whose functions would include the holding of public hearings "in taking a general view of broadcasting services in the public interest." One of the board's main functions would be "to discover what the public thinks about proposals for new broadcasting services: for example the use of the fifth television channel or satellite broadcasting services." Some of the committee felt that the Board could vet applications for licence fee increases, ending the BBC's ritual biennial lobbying campaign. Sadly, only two dissented from the view that the board should be recruited entirely from the civil service.

Telecommunications

Perhaps the most relevant proposal for readers of *Wireless World* is that to set up a Telecommunications Advisory Committee. It would represent the broadcasters, the Post Office, the cable operators and the manufacturers, and would advise the Home secretary on technical matters relating to broadcasting, replacing the present Television Advisory Committee. The committee rejected a proposal for a single transmission authority, such as the Post Office, to take over responsibility for all broadcast transmission facilities.

As we have said, the Annan committee chose to devote most of its deliberations to non-technical, organizational matters, making only tentative suggestions or recommendations on techniques.

Television

One chapter of the report is concerned with transmission frequencies and area coverage for sound and television broadcasting. One of the more urgent problems was the extension of u.h.f. television to small pockets of population (500-1000) who are not served by existing transmitters by reason of terrain, particularly in Scotland and Wales. The urgency is due to the planned removal of television from Bands I and III, which currently serve some of these people. The BBC and IBA are pressing ahead with this work and Annan approves of priority being given to Scotland and Wales, though would not like to see local difficulties in these areas holding up development in the rest of the UK.

The committee considers that population groups of less than 500 should be expected to sort out their own difficulties, with the technical advice of the BBC and IBA. When the lack of coverage is due to terrain, relay services will help, but where the problem is that signal is being blocked by a new property development in an otherwise good signal area, the developer should meet the cost of alternative equipment, for example cables.

In some cases, it is suggested that overhead television cables should share poles with electrical and telephone cables or, again, that very low power transmitters could put out a single programme composed of cassettes provided by the BBC and IBA, the operation to be financed by local authorities.

Annan recommends that v.h.f., 405-line television should cease in 1982. By this time, it is hoped that the majority of homes will be able to receive u.h.f. transmissions — already 90% can do so. In view of this, the extensions of coverage mentioned above are, indeed, urgent.

The committee heard from James Redmond, BBC Director of Engineering, that a group of four u.h.f. television channels above 854MHz (854-960MHz is not currently available) will be needed to complete the Phase I plan and to carry out Phase II — the coverage of population groups of 500-1000 souls. Crawford committee recommended the use of these frequencies and Annan endorses that.

Of the many ideas aired in recent months on the use of Bands I and III when 405-line television comes to an end, Annan chose the most obvious — another television channel. The proposal is to use Band III and as much of Band I as is needed to provide a 625-line colour service on v.h.f. planned to cover large towns and regional districts. Because the service areas will overlap and because 625-line colour needs more bandwidth than the 405-line monochrome, a good deal of Band I and III will go for this purpose. Annan says that bits of Band I might be usable for something else *(Wireless World*, August 1976, p36 and May, 1977, p.63).

Sound

The BBC have planned and Annan approves the reorganization of h.f. and m.f. allocations. In brief, R4 is to be broadcast on l.f. instead of R2, and R3 is to go on the current R1 frequency. The changes mean that R1 and R2 will each have two frequencies, giving R1 and R4 an improved coverage in some areas. R3 will suffer, as will R2 in Wales (at least after dark) but not in vain, since wonderful R1 will be improved. The Annan committee says it approves of this scale of values.

On the subject of interference, Annan says that imported 27MHz equipment such as walkie-talkie transceivers should be subject to a more rigorous application of the law, which prohibits sale, installation, importation and use of equipment working in certain frequency bands.

Also with an eye on possible interference to medium frequency transmissions, Annan recommends that the use of the 100-108MHz band for national services should be considered, in spite of the likely expansion of mobile radio. In the space to be cleared for broadcasting (97.6-100MHz) the committee recommends that educational users (Open University) should be accommodated, at least in the main.

New services

No clear idea can be gained from the report as to the future of teletext. The committee appears to have spent most of its time on this subject discussing the effect of teletext on newspapers and how to make the public pay for it. No technical proposals were put forward and even the "political" recommendations were rejected by five of the committee members. The outcome seems to be that teletext should go on as it is, but that after a few years, it should be looked at again to see whether the newspapers are still worried about it. What happens if they are is not clear.

On cable services, the committee were of the opinion that the current state of affairs, with widely-varying service areas and techniques, is not a blueprint for any future national cable communications facility. Instead, they say "there is no doubt" that, sometime in the future, a national wideband cable network will carry telephone, television, sound, fax, data, etc. Perhaps an element of doubt could be allowed: in 1972, five years of inflation ago, the TAC estimated the cost of a 6-channel system at £500M and that of a 24-channel one at £1500M, the work to take 20 years. The committee says that it hopes the relevant equipment and materials will be cheaper by the time we can afford it! Meanwhile, to prevent expensive reorganisation when that day dawns, Annan recommends that cable companies installing medium networks (town-sized) should conform to PO specification.

Satellite broadcasting has been seen as both substitute for and complement to cable transmission. Annan says that it seems unlikely to be given much priority during the next fifteen years. But the committee foresees discussion on the subject and recommends that the BBC should represent the UK in any such talks and that they should be responsible for transmissions.

Annan recommends that experiments be carried out on the broadcasting of stereo television sound, mainly with the intent of transmitting two languages simultaneously. The use of the term "stereo" seems strange.

Traffic information by radio is mentioned in the report and the committee thinks that the BBC proposal *(Wireless World* p.47, Oct. 1976) stands the best chance of performing the task.

Lord Annan gave the 1977 Fleming Memorial Lecture on the committee's work at the Royal Institution on April 28. The lecture was under the auspices of the Royal Television Society. On June 1 the Royal Television society is to hold a symposium on the Annan report chaired by Lord Hill: Lord Annan and his committee are expected to attend. P.R.D., J.T.D.

Electronic systems — 7

Visual perception

by R. Ashmore *Assistant Editor, Wireless World*

Although visual perception does not fall directly into the category of electronic systems, it is the most common form of electromagnetic communication within the frequency spectrum. We feel justified, therefore, in including a brief description of its function, and using it to show how certain of its characteristics are exploited in the design of colour television tubes.

Visual perception and radio communication both depend upon the propagation of electromagnetic waves, but, whereas radio waves can have wavelengths of several metres, visible light waves have wavelengths of between 400 and 750nm ($1nm = 10^{-9}m$). Since all electromagnetic waves propagate at the speed of light, the frequency range of light waves can be determined from the formula:

$$\text{Velocity} = f\lambda = 3 \times 10^8 m/s$$

which gives a range between 400 and 750 terahertz ($1THz = 10^{12}Hz$).

The receivers, in the case of visual perception, are the human eyes, see Fig. 1. Each eye is roughly spherical in structure with an outer wall or cornea. The lens, which is encapsulated, separates the front (anterior) chamber, containing a transparent watery fluid, from the back chamber (vitreous body), containing a transparent jelly-like tissue. Light coming from outside the eye is refracted in the cornea and lens and is distributed over a light-sensitive layer (the retina) according to the laws of geometrical optics. Since the transparent region behind the lens of the human eye has a refractive index nearly as high as that of the lens, the light is bent mainly due to the difference between the refractive index of air and the lens material. However, although the lens is rather unimportant in imaging, it is important for the perception of scenes at different distances. This is done by changing its shape; for example, the radius of curvature is reduced for near vision so that the lens becomes more powerful and adds more to the primary bending accomplished by the cornea.

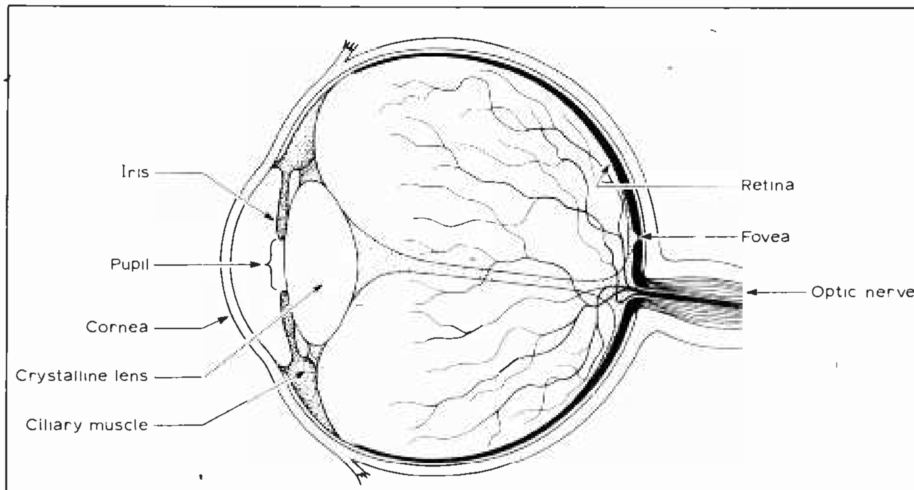

Fig. 1. The human eye.

The retina, see Fig. 2, is supported by the wall of the back chamber and consists of several layers in front of an opaque pigment. The light passes through the retinal layers and stimulates the rods and cones, in contact with this pigment, which produce neural pulses. These pulses travel back through the various retinal layers to the outer one, consisting of fibres connected to the optic nerve, and so are sent to the brain. It is believed that the rods function principally in weak light, such as exists during twilight; they provide vision only in shades of grey and are not capable of distinguishing colours. The cones, however, function in bright light and respond specifically to certain wavelengths of the spectrum (ie, to colours) and also allow the perception of much finer details. The central area of the retina, where the density of the cones is greatest, is a circle of about 0.5mm in diameter and is called the fovea. The cones are placed roughly 2μm apart in the fovea.

Each eyeball is attached to six extrinsic muscles which hold it in position in its orbit and rotate it to follow moving objects. In order that three dimensions can be perceived, both eyes work together and are normally focussed on a common object. In addition to the extrinsic muscles there

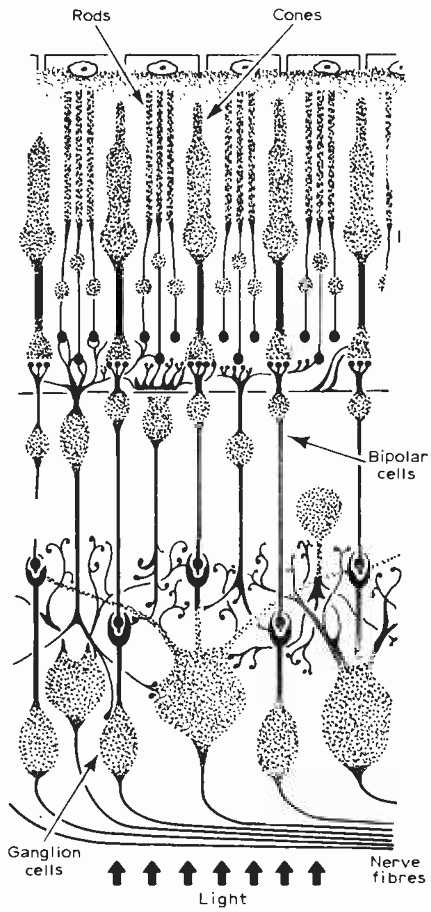

Fig. 2. Structure of the retina of the human eye.

are also muscles inside the eyeball. These include the muscles required to change the shape of the lens, as described, and the iris. The iris is a circular muscle which forms the pupil through which light passes to the lens, lying immediately behind it. This muscle contracts to reduce the proportion of light reaching the retina, in a similar manner to the aperture adjustment on a camera. The iris is pigmented and is found in a wide range of colours. The actual colour is unimportant to the functioning of the eye, as long as it is reasonably opaque. In albinos this pigment is missing, and so their vision is defective in strong light.

The range of pupil area control by the iris is from about 3 to 48sq.mm. However, the eye works efficiently over a brightness range of 10 :1, but for dim illumination a process of adaptation takes place slowly (a few minutes) in order to achieve this wide range of response.

Brightness perception

When viewing objects it is their angular size which is important to the eye. The fovea subtends a viewing angle between one and two degrees. The smallest angle which can be perceived is considerably less than this, but it is still a few times larger than that corresponding to the spacing between the cones.

The eye integrates the quantity of light falling on it over a short period, but if the period is extended to a few tenths of a second, flashing is perceived—and it is essential to perception that we see when an object has disappeared or moved. Between these extremes an annoying flickering sensation is experienced—particularly on the edge of the visual field. Flicker effects disappear completely at frequencies above 70Hz (the "flicker fusion frequency"), and are not particularly annoying above about 35Hz.

When viewing a 50 field/second television display with a 2:1 frame interlacing, both space and time variations of the phosphor areas become important in determining whether or not the resulting picture appears to flicker. Numerous tests have established that this field rate is acceptable. However, if the field rate were reduced slightly the flicker would become noticeable. In fact the present field rate, when viewed from the corner of the eye, appears to flicker to some people. This is because some of the nerve fibre processors of the eye have evolved to detect small movements at the edge of the visual field. In the distant past this property was important for man's survival.

Colour perception

Differences in colour are due to differences in the wavelength (or frequency) of light emitted from objects. Unlike radio communication it is conventional to discuss light in terms of wavelength rather than frequency, since wavelength is easily measured with optical instruments (e.g. a diffraction grating). Long visible wavelengths are in the red and infrared region and short wavelengths are in the violet and ultraviolet range. As the wavelength decreases the colours perceived are: red, orange, yellow, green, blue, indigo and violet.

Although radiation of light of a given spectral distribution will produce a given colour sensation to an observer, it is not true to say the converse since, a given colour sensation can be produced by infinitely many different spectra. This is because colour is a psychological sensation. Laws dealing with this aspect are as follows:

1—The eye can discern only three types of colour variation: hue, brightness, and saturation.

2—If, in a mixture of two unequal colours, the proportion is steadily changed, the colour of the mixture changes.

3—When lights of two given colours are mixed, the result is always the same, regardless of the particular spectral compositions that produce the two colours in the mixture.

4—When two lights are mixed, the luminous intensity of the mixture equals the sum of the luminous intensities of the components.

The second law indicates that a wide range of colours can be produced from only a few basic (or primary) colours, suitably mixed. It has been found that three primary colours are sufficient; these are red, blue and green. By mixing red, blue and green *light* in various relative amounts. a wide range of non-primary hues may be produced. For example, red and blue produce magenta, red and green produce yellow, blue and green produce cyan, and red, blue and green produce white. (Note that this is mixing lights *not* pigments).

White is a completely unsaturated colour so, by controlling the components of the three primaries in the mixing process, the saturation as well as the hue can be altered.

Colour mixing can be most conveniently represented by sources of the three primary colours placed at the vertices of a triangle. Magenta, yellow and cyan will be produced along the sides and, assuming the primary sources have appropriate relative intensities, white light will be produced at the centre. The hue of the light varies around a circle whose centre is at the centroid of the triangle. The saturation of the colour varies from the periphery to the centre of the triangle, being fully saturated at the periphery and fully desaturated at the centre. Along a line from any corner to the centre of the triangle the colour (hue) is the same and it varies only in saturation.

This mixing process has direct relevance to colour television principles where the wide ranges of hue and saturation required for faithful reproduction are achieved by mixing red, blue and green light. In colour television systems the mixture may be accomplished in any one of three ways.

In the first method, the lights are generated by separate sources and then combined optically. A second way is to view the primary colours in rapid succession. If the rate of succession is correct, the eye will recognize only the combination colour and it will not perceive the component colours. The third method is to use a single tricolour picture tube with the different colours being obtained from hundreds of thousands of separate phosphor dots in each primary colour. If these dots are placed closely enough, the eye will not distinguish them individually but will "see" only the resultant colour.

The second method is no longer used in broadcasting and the first method is only used in projection colour television equipment (see September 1976 issue). However, the three types of colour television common today, NTSC, PAL and SECAM, all depend upon the third method. A typical picture tube may have about 1,320,000 colour phosphor dots, each about 400nm in diameter, and arranged in triangular clusters each containing one red, one blue and one green dot. Separate electron beams excite each dot to a predetermined brightness. The systems then depend on the human eye and brain functions to blend these primary colours together to obtain the required colour.

It is a requirement of colour television systems that they be compatible, that is, the colour signals should be receivable on black-and-white receivers without causing any degradation from normal monochrome picture quality. This also means, of course, that the programme producer must ensure that there are brightness variations associated with hue differences in scenes as well as acceptable colour designs: otherwise, if two different adjacent colours are of the same brightness (tonal) value, information will be lost when this scene is viewed on a black-and-white receiver.

For almost a century it has been observed that, in normal viewing, the acuity of the human eye for colour detail is much less than that for brightness detail. This becomes evident when one tries to match cloth against a single thread; it is unlikely that the colours will look the same when the thread is woven into a cloth. This human eye characteristic is also used to advantage in colour television systems. As long as fine detail is carried by the brightness signal, there is no need to transmit it on the colour signal as well. This means that the information content of the colour signal can be very much smaller than that of the brightness signal and consequently its frequency band can be limited to about 1MHz, which is quite small compared with the overall video bandwidth of about 5MHz.

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

Interactions of loudspeakers and rooms

How the listening-room modifies the performance of the loudspeaker

by James Moir, F.I.E.E. *James Moir and Associates*

The frequency response of a loudspeaker, the relation between the applied voltage and the axial sound pressure level is not a fixed relation as might easily be imagined, but is critically dependent upon the acoustic characteristics of the surroundings. This is particularly true when the loudspeaker is used in a room of domestic dimensions, that is, any room less than about 30ft long. In fact at frequencies below about 100 Hz the loudspeaker response is almost entirely controlled by the acoustic performance of the room and by the position of the loudspeaker in that room. The problem will be examined and the principles explained, leading it is hoped to an understanding of the results to be expected when positioning a loudspeaker.

There are several effects involved: some are the results of the reaction of the room on the acoustic output of the loudspeaker, and others are the result of the room acoustics modifying the frequency spectrum of the sound energy emitted by the loudspeaker. It does this as a result of the room acoustics selectively amplifying favoured frequency bands in the loudspeaker output. A brief review of those aspects of room acoustics that are particularly significant may be helpful.

Room acoustics

The basic acoustic phenomena that characterise the acoustic performance of a room at the bottom end of the audio frequency range are most easily understood if one considers what happens when a loudspeaker is clamped to one end of a long pipe, closed at the far end, but with a microphone inserted in the end. This is the simplest case, equivalent to a corridor-like room with one dimension much larger than either of the others. If single-frequency tones are applied to the loudspeaker and the signal frequency varied, the sound pressure indicated by the microphone will be found to exhibit a maximum at the frequency at which the pipe is almost exactly one half wavelength long. A typical result is shown in Fig. 1, from which it will be seen that there is a peak at 148 Hz with smaller peaks at integral multiples of this frequency. At the lowest frequency the peak will be seen to be about 20 dB above the level at adjacent frequencies.

The peak in the sound pressure distribution occurs at this frequency because it is the only frequency at which the wave reflected from the closed end of the pipe arrives back at the loudspeaker exactly in phase with the wave being emitted at that instant by the loudspeaker, though it is one cycle later in time. Thus at this specific frequency the sound pressure continues to build up until the energy dissipated in the pipe is exactly equal to the energy being supplied by the loudspeaker. At frequencies on either side of this resonant frequency, the wave arriving back at the loudspeaker after reflection from the far end is not in phase with the wave being emitted at that instant by the loudspeaker and so reinforcement does not occur.

Thus 'standing waves' are set up in the tube, the sound pressure distribution along the tube at this basic-mode frequency being as shown in Fig. 2 with maxima at the end and the minimum in the centre of the length. If the frequency is swept through the audio range, the sound pressure at the end microphone varies as shown in Fig. 1. It will be noticed that small peaks occur at the harmonic frequencies that are 2x, 3x, 4x etc., the basic resonant frequency. The peaks occur at these harmonic frequencies because the wave reflected from the far end has gone through an exact number of cycles during its transit

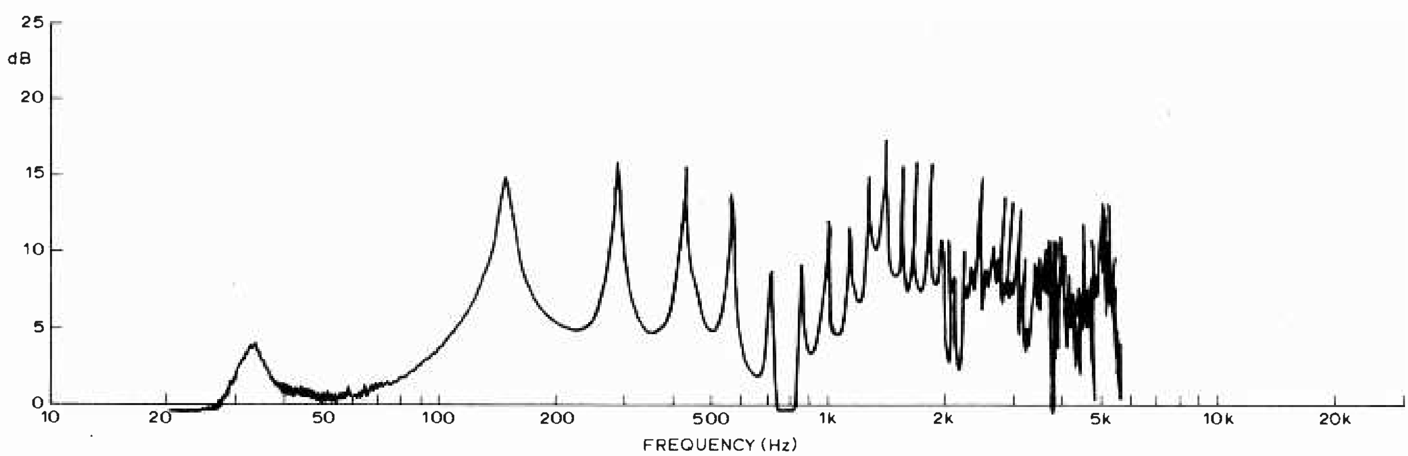

Fig. 1. Resonances in a long, narrow tube. Fundamental resonance is at 148 Hz, given by the Rayleigh equation $f_r = \frac{C}{2}\sqrt{\frac{1}{L^2}}$*, where C is the velocity of sound (13,500 in/s) and L is the tube length (45.6in).*

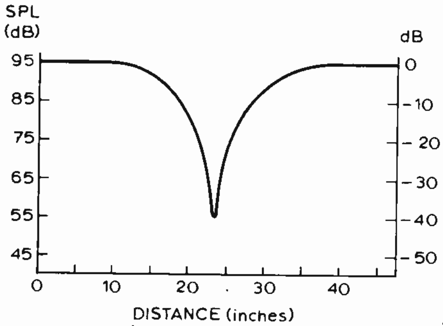

Fig. 2. Sound pressure distribution along the tube used in the example of Fig. 1.

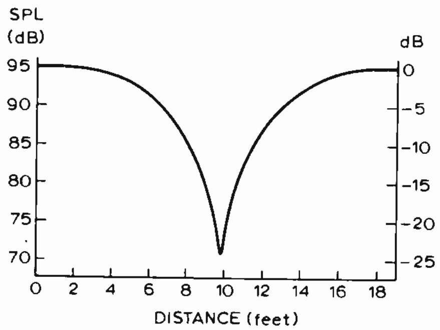

Fig. 3. Sound pressure distribution along the long axis of an unfurnished room.

up and down the tube and, in consequence, arrives back at the loudspeaker exactly at the instant that the wave being emitted is passing through the same point on the waveform, though it is several cycles later in time.

This is an example of what happens in a one dimensional space where the length is very large in comparison to the width and height, but exactly the same situation exists in any three dimensional space. The sound pressure pattern produced in space is considerably more complicated, for the type of pressure distribution indicated in Fig. 1 exists independently along each of the three axes of the room. Thus if the acoustic frequency is swept slowly up the audio range the pattern of Fig. 1 will appear along the long axis of the room at the frequency that makes this axial length equal to half a wavelength. Further increase in frequency will produce an identical pattern across the room at the frequency at which the width is half a wavelength and the same sound pressure pattern will appear again between floor and ceiling at the frequency at which the height is exactly half a wavelength. At other intermediate frequencies the pattern of the sound pressure distribution in space will be the sum of the three-mode distribution and will be much more complex.

Room resonances. The frequencies at which these resonant modes will appear in a three-dimensional space can be calculated by an equation due to Rayleigh

$$f_r = \frac{C}{2}\sqrt{\left(\frac{A^2}{L^2}+\frac{B^2}{W^2}+\frac{D^2}{H^2}\right)}$$

where L, W and H are the length, width and height of the room, A, B and D are the integers 1,2,3,4,5 etc., and C = velocity of sound (1125 ft/sec).

The frequencies of the lowest modes are well separated, but the mode frequencies gradually get closer together as one moves up the frequency range. The sound pressure distribution along the long axis at the basic mode frequency of an actual room measured without the soft furnishings, (settee, easy chairs and carpet) is illustrated in Fig. 3. It will be seen to be very similar to the pressure distribution in the pipe.

In addition to the three basic resonances at frequencies at which the length, width and height are one half wavelength, there are harmonics of each basic mode frequency at 2,3,4,5, times the basic mode frequency. There are further resonances at frequencies determined by combinations of the axial dimensions. These can be obtained from the Rayleigh equation by including both the length and width terms inside the bracket. Yet another group of resonances are obtained by inserting the length, width and height terms inside the bracket. All these basic mode frequencies are accompanied by their harmonics, their frequencies being predicted by making A, B and D equal to 1,2,3,4 etc., in turn.

Sound energy losses. The discussion has concentrated on predicting the frequencies at which the room resonances appear, but the amplitudes of the resonances are also important. The amplitude of each of the resonances is determined by the amount of sound energy dissipated by the air movement that occurs and by the extent of the vibration of the building structure that results from the cyclic sound pressure changes at the wall/air boundaries. The energy required to vibrate the wall, ceiling and floor must be abstracted from the acoustic wave and these energy losses determine the Q and amplitude of the resonances. In practice, the amount of sound energy absorbed is rarely equal in each mode of resonance and, in consequence, the Q and the amplitude of the resonances vary between modes.

Table 1. Listening-room Q for three average rooms.

	Frequency	Mode	Q
Room 1	31 Hz	1.0.0.	22
	58 Hz	2.0.0.	12
	90 Hz	3.0.0.	12
	44 Hz	0.1.0.	24
	71 Hz	0.0.1.	22
Construction. 11" cavity brick walls except end wall along longest mode made of plasterboard partitioning. 20% of one side wall fitted with double glazed window. Solid concrete floor with wood finish. Ceiling of plasterboard on wood joists. Comfortably furnished.			
Room 2	36 Hz	1.0.0.	11
Construction. 11" cavity brick walls with approx. 10% of wall area fitted with single glazed openable windows. Wood joist floor with plasterboard on wood joist ceiling. Comfortably furnished			
Room 3	50 Hz	1.0 0.	10
	99 Hz	2.0.0.	11
	149 Hz	3.0.0.	14
	67 Hz	0.1.0.	11
Construction. 9" solid brick walls with approx. 6% of wall area fitted with single glazed openable windows. Wood joist floor with plaster on lathe on wood joist ceiling. Unfurnished.			

At low frequencies the vibration of the building structure is the primary source of energy dissipation, a board-on-joist floor or a plasterboard ceiling being particularly effective sound absorbers of frequencies below about 150 Hz. This is a function of the integrity of the structure and is not susceptible to calculation in advance of the construction – prior experience must be relied upon. Table 1 lists the Qs that have been found to be typical of ordinary building construction and domestic furnishings. At frequencies above about 200 Hz structural resonance is less effective in absorbing sound energy and the Qs are increasingly determined by the amount of sound energy absorbed by the soft furnishings. This can be calculated with adequate accuracy but in any event these higher frequency modes of resonance are usually less important for they are more closely spaced in frequency and thus lose their separate existence.

Reactions on the loudspeaker

The presence of these resonant modes modifies the performance of the loudspeaker in several ways. Their effect on the power output of the loudspeaker is probably the easiest to understand and will be discussed before going on to the more complex effects. Reference to Fig. 3 will show that in a typical room the maximum sound pressure at the anti-node near either end wall is some 24 dB higher than the sound pressure at the node in the centre of the room. Shifting the loudspeaker from a position against the end wall to the centre of the room reduces the sound power output at the mode frequency by the amount equal to the difference in sound pressure at the node and anti-node. Thus at the resonant mode frequency the sound power output from the speaker is some 24 dB higher when it stands against an end wall than it is when standing in the centre of the room. Note that the Q of the resonance is not altered by the change in speaker location; this is determined by the sound energy losses that are present in that particular mode.

As excitation of the mode is a minimum when the loudspeaker is half way along the mode at the pressure minimum in the wave, this allows the amplitude of any one resonance to be minimised by suitable placement of the loudspeaker in the room. If the speaker is mounted in the centre of one end wall, the length mode will have the maximum excitation but the cross mode resonance will have the minimum excitation and in consequence the minimum amplitude. Placing the loudspeaker half way between floor and ceiling in a corner will provide equal excitation for the two modes of resonance along the length and width axis, and the minimum excitation for the floor to ceiling mode, while placing the speaker on the floor in a corner will excite all three groups of modes.

The polar diagram of a loudspeaker has a generally unrecognized effect on the degree to which the many resonant room modes are excited. A loudspeaker with an omni-directional polar diagram will tend to excite all modes equally, whereas a loudspeaker with a figure of eight response has nominally zero low frequency output in the plane of the radiator. This will always result in a reduction in the extent to which a number of the resonant modes are excited and may allow the speaker to be placed in a position that minimises the excitation of a particularly annoying mode. Thus we have techniques for controlling the amplitude of a few of the resonances and it remains to be decided what should be attempted.

Loudspeaker location. Peaks in the frequency response at low frequencies cannot be avoided, but it is a reasonable first assumption that the overall response should be as smooth as possible. This will generally be achieved by attempting to excite as many resonant modes as possible, a result that can be approximated by mounting the loudspeaker near the floor in one corner. A position near the ceiling in the corner is just as effective, though it may have other disadvantages. This discussion has assumed that all the resonant modes have the same amplitude and are equally annoying, that the loudspeaker system has a uniform frequency response down to a frequency below the lowest room resonant frequency, and that the programme has significant energy in the low frequencies. None of these assumptions may hold in practice and in any specific situation it is not possible to predict in advance which is the most advantageous location for the loudspeaker.

However, there is a simple experimental technique that allows the best location to be found. Loudspeakers are now generally bought in pairs for use with a stereo system and the performance of both loudspeakers is likely to be very similar. If both are driven by the same mono signal, one speaker may be placed in a corner and the second in any alternative domestically acceptable location. Switching from one to the other will allow a comparison of the sound quality obtained in the two locations. The speaker giving the least acceptable sound quality may then be moved into a third position and the comparison repeated until the optimum position is found. It is highly likely that the best stereo performance will be obtained with the second speaker in a position symmetrically placed with respect to the best mono location, but the suggestion is well worth checking before finalising the positions.

Boundary reflections. The effects so far discussed are what might be termed the reverberation acoustic effects, but there are other inter-actions between the loudspeaker and the room boundaries that are of significance. When the loudspeaker is placed close to the wall or on the floor, the sound that travels direct from loudspeaker to the listener is followed within a few milliseconds by sound that has been reflected from the floor and adjacent wall, and from the wall surface behind the loudspeaker. At every point in the room there will be a path length difference between the direct and reflected sound that will result in phase cancellation and produce a crevasse in the response, but at other frequencies the direct and reflected sounds will be in phase and produce peaks in the response of the listeners ears.

The immediate reaction is that anything that introduces peaks and dips into the response curve can only result in some degradation in the sound quality. This is probably true, though it is certain that the hearing system can to a large extent ignore peaks and dips in the response when they are produced by the room, though it would consider them disastrous if they were present to the same extent in the direct response of the loudspeaker as measured in free space. This is well illustrated by the curves of 4(a) and (b) the frequency response curves of a good loudspeaker (a Quasar) taken in the open air and again in the listening room with the microphone in the normal listening position and the loudspeaker in its usual location near one corner. Subjectively judged, the effective loudspeaker response at the listening position is that measured in the open air and consequently very different to that measured at the listening position in the room.

The peaks and dips due to reflection from the wall surfaces in the immediate vicinity of the speaker can generally be greatly reduced by the use of *thick* sections of a good sound absorbent immediately behind the speaker and on the adjacent wall. The accent is on *thick* sound absorbent sections, for where the peaks and dips occur in the frequency range below about 500 Hz, the thin sound absorbent materials such as the common acoustic tiles are of little value. We use blocks of polyurethane foam about 3ft x 2ft and six inches thick, but the seat cushions from a settee or easy chair are a satisfactory substitute when experimenting.

Whether these absorbents are of value in any particular situation can only be determined by actual trial, the technique described earlier for determining the optimum loudspeaker position being useful. Switch a mono signal between one speaker in the optimum position, on the left hand side of the room, and a second speaker on the right hand side with the sound absorbent behind it. This allows an immediate comparison of the effect from the listening position normally used. Clearly, if you are a believer in the use of omni-directional loudspeakers this technique is not for you.

Sound power output. Apart from the effect of the corner location upon the frequency response there is yet another interaction that is significant. If a loudspeaker is located on the floor in the centre of the room, the diaphragm looks out into a solid angle of 180 degrees (2π steradians). If it is then moved down the floor/wall corner, in the middle of the long wall, the included angle is reduced by half (to π steradians) and on moving it to the corner of the room but still at floor level, the solid angle seen by the diaphragm is again reduced by half to one quarter of its original value (to $\pi/2$ steradians). Each reduction in the included angle doubles the acoustic impedance presented to the diaphragm and so doubles the acoustic output, at least in the low frequency end of the range where the polar diagram of the speaker in free air would be substantially circular.

The effect is well illustrated by Fig. 5 — measured values of the sound power for the same loudspeaker standing first on the floor in the centre of a room, then against the wall in the centre of the long wall, and finally when standing in the corner. The measurements were made in one-third-octave bands with the loudspeaker supplied with a pink noise signal. It will be seen that below a frequency of 250 Hz each move from centre towards the corner location increases the power output, the step approximating 3dB at the lowest frequency.

The overview

The various effects may now be summarized and integrated. Standing the loudspeaker in a corner will increase the power output at low frequencies, will excite the maximum number of room resonances and will probably produce the smoothest overall frequency response. If one dimension of the room is much larger than either of the others the frequency of the lowest mode of resonance will be well below that of the next higher mode and this may result in the lower mode being unduly prominent. This effect is more significant in small rooms. Moving the loudspeaker among the long wall towards the centre of the room will

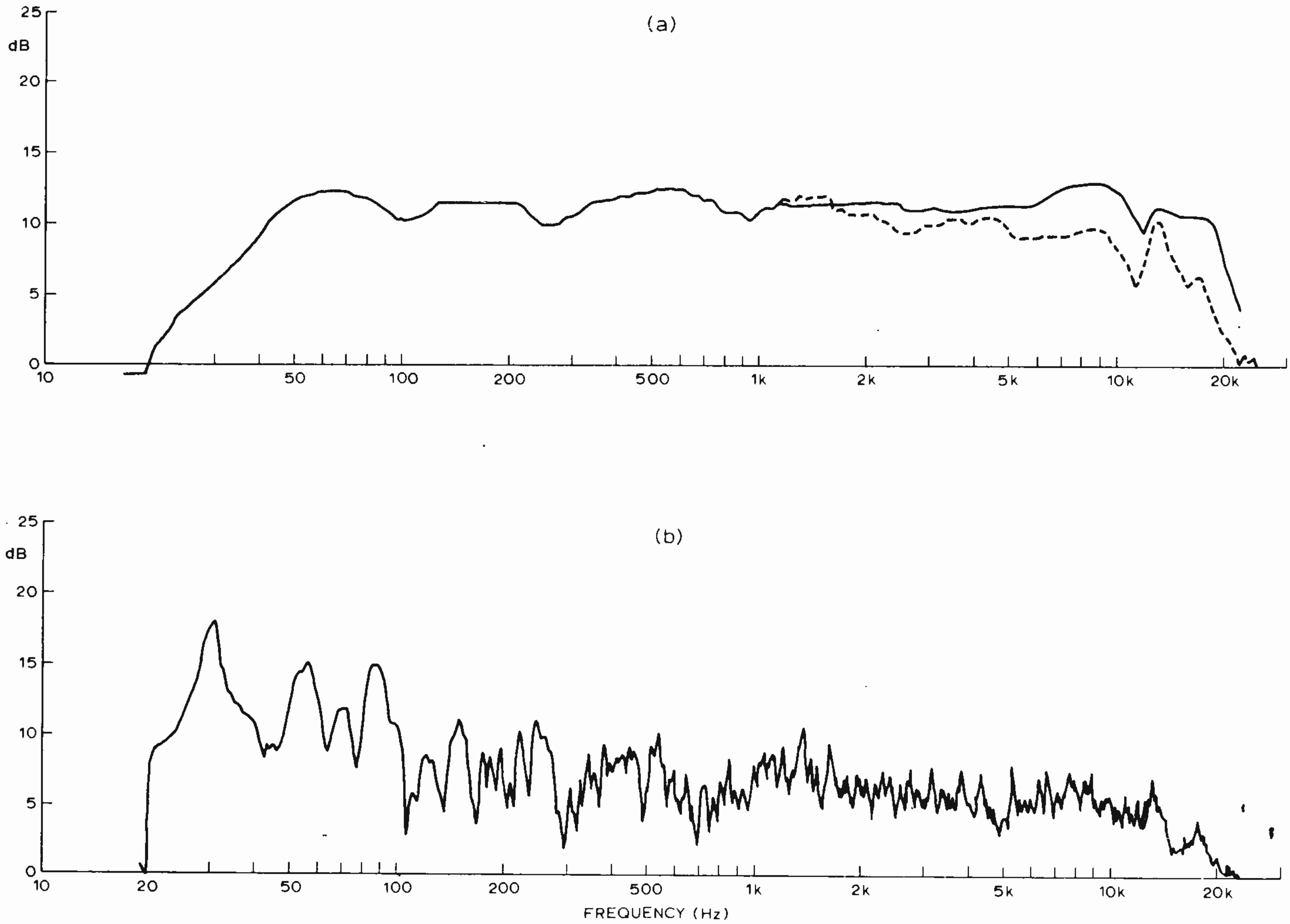

Fig. 4. Judged subjectively, the perceived loudspeaker response is that measured in the open air (a) rather than that produced by room interactions (b).

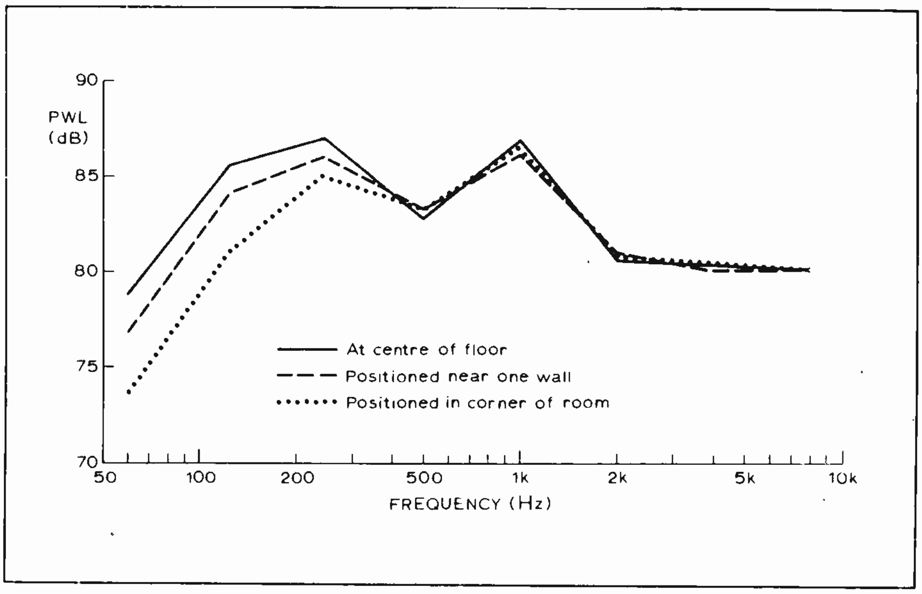

Fig. 5. Measured values of speaker output at different positions in a room.

reduce the amplitude of the lower mode without changing the amplitudes of the other primary modes of resonance. This may reduce the 'bass boom' effect that is characteristic of isolated low-frequency resonances of high amplitude.

Standing the speaker directly on the floor, or against any wall will result in reflections from these adjacent surfaces that will cause phase cancellation between the direct and reflected waves and produce peaks and dips in the frequency response at the listeners ears. Moving the speaker away from the wall will move the dips and peaks down the frequency band towards the lower frequencies where they may be less obstrusive. Exactly the same effects occur as the louspeaker is lifted off the floor.

The loudspeaker designer may have balanced the frequency response taking advantage of the reinforcement due to the floor, in which case the user is likely to find that the performance of the loudspeaker is greatly improved by standing it on the floor in his listening room. Conversely if the designer balanced the response with the speaker supported on a stand above the floor, the user may find it advantageous to mount the speaker in the same manner.

It will now be appreciated that there are very complex interactions between a loudspeaker and the room in which it is mounted. Generally, they are too complex to allow any specific directions for mounting loudspeakers to be given, but an understanding of what happens is an excellent guide when attempting to find the optimum location for your loudspeakers in your rooms.

My thanks are due to Mr. W. R. Stevens of our laboratory who obtained almost all the experimental data used to illustrate the conditions in a typical listening room.

References

Standing Waves in listening Rooms. Moir, *Wireless World* June 1958.

Acoustics. Beranek, McGraw Hill. Chapter 10.

Acoustics for Radio and Television Studios Gilford.

Peter Peregrinus. Inst. Elec. Engs.

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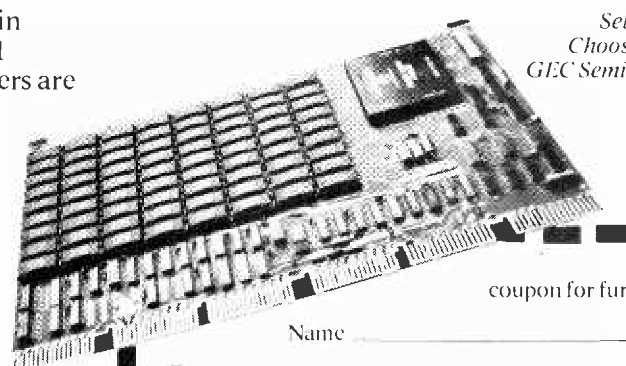

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Using a microprocessor

An example of the design of an industrial system

by J. Skinner, *Leafields Engineering Ltd*

Many electronic engineers will have had little or no experience of the computer world and its specialised language. The prospect of having to tackle a new discipline will probably daunt many who at the moment are wondering "what can microprocessors do for me?". The purpose of this article is to show how the initial barrier can be overcome. This is not intended to be an exposition on microprocessor (m.p.u.) technology or even a detailed description of how they operate — for that, consult the manufacturers' handbooks. What is intended is that we shall select one particular model, the Intel 8080, and proceed through all of the steps required for a particular application. Most of the available application reports demonstrate a programme for the application well enough but leave out much of the information that the beginner needs.

There is no doubt at all that the arrival of the microprocessor concept makes available to the electronic engineer what has always been available to the computer man, a very versatile and powerful tool, which is capable of replacing complex logic systems with a mere handful of components. A most attractive feature of m.p.u. systems is the ability to standardize the hardware (circuit and therefore p.c.b.). Differing requirements for successive applications are accommodated entirely in programming software. Unfortunately, the cost saving made in using standard hardware is usually consumed by the additional cost of software preparation. The ability to modify system operation simply by altering software is however a major advantage, particularly where this is required for equipment already in service.

Obviously, the application described in this article can only be a typical one; however, the design techniques are the same for most basic types of application, so that the reader should be able to design his own system by following the pattern described.

The Intel system was chosen because it appears to be one of the most popular in use. Unfortunately, there is no software compatibility between the various types that are available – the processing power of the 8080 is continually being surpassed by competitors and Intel themselves are in the race to produce more advanced systems. However, most engineers will only need to use a small part of the m.p.u.'s total ability It takes time to become fully familiar with the technique of using each model, so that the temptation to try each new product as it appears must be resisted, unless the advantage gained in changing can be shown to be worthwhile. This fact is equally true with programming technique – much time can be spent in producing an efficient programme, when the real object is to carry out a task, not to produce more and more efficient programmes.

One further word of warning. Those with computing experience will obviously wish to use the m.p.u.'s capabilities to the full and will often be considering complex applications. Programming for such functions is simplified by the use of various compiling languages and by machines designed to translate the programme into the programmed memory used by the m.p.u. system. In this type of application, the expense of compiling machines is justified by the job which the system is to carry out. On the other hand, many industrial applications can be achieved by the provision of less than 100 words of programme. This can be constructed directly into the "machine code" used by the m.p.u., without resort to special language or compiling machines although, if these are available they will make the task much easier. The system described later in this series was developed using a single programming aid costing £120, and even that was not a necessity.

Basic system

Figure 1 illustrates a fairly basic layout for a microprocessor system.

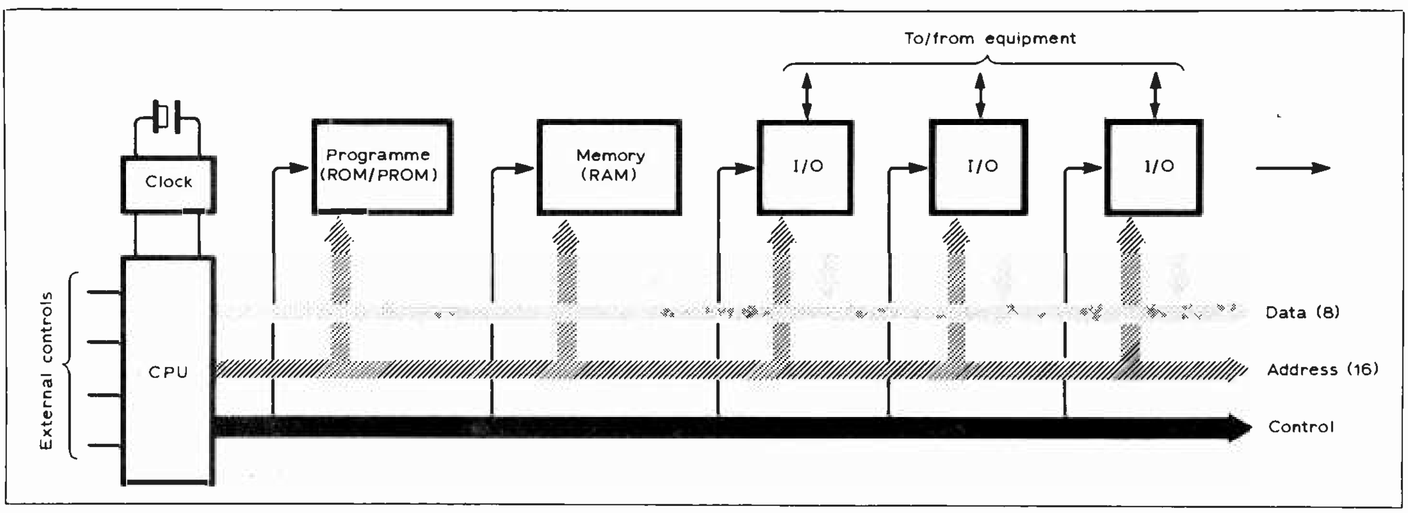


Fig. 1. Basic layout of a microprocessor.

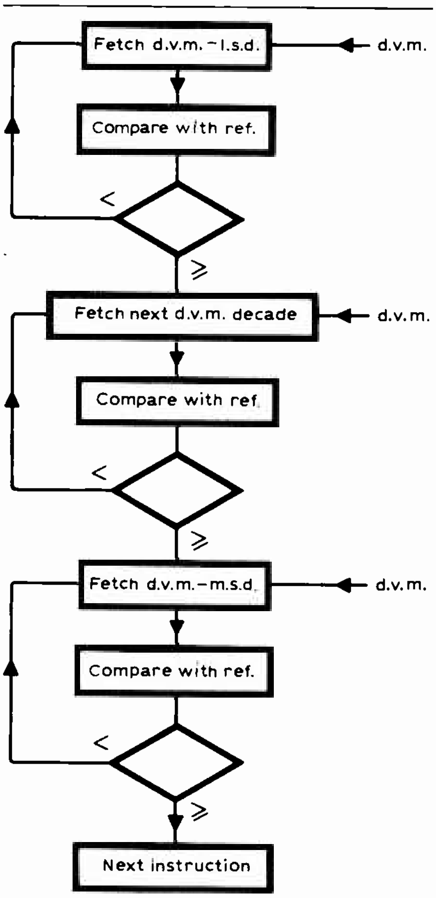


Fig. 2. Flow chart showing sequence of events during the feed of a b.c.d. input.

Central processor unit. The c.p.u. is the computing element of the system, carrying out logical and arithmetic functions at high speed, which is coupled to other elements via two sets of bus lines. The data bus is used for transfer of data between the elements of the m.p.u. system and also, in some cases, with the outside world. The 8080 has eight of these data lines providing a basic resolution of 1 in 256. Other makes of c.p.u. are available with 4, 16 and even 32 data bus lines. The second set of bus lines is used to address other elements. The 8080 has 16 address bus lines, thus providing 65,536 addressable locations (known as 65k). Some c.p.u. types combine some of the data and address busses. There are also a number of control functions, too detailed to deal with here.

Clock control. The c.p.u. element is driven by a clock system, which differs widely between various makes of c.p.u. The 8080 requires a two-phase system and Intel provide a circuit element dedicated to this function. Some types use a relatively slow clock, the ultimate being a single-step system. Single stepping is useful for proving correct operation and a means of providing this facility for the 8080 will be described later.

Programme store. Instructions to the c.p.u are stored in this element in binary form. A read only memory (r.o.m.) is usually used where the programme has been proved and is required in quantity. For development purposes, a re-programmable r.o.m. (p.r.o.m.) or even a random access memory (r.a.m.) may be used. The p.r.o.m. or r.a.m. provide the user with a means of modifying his programme where this is found to be necessary during the course of development. These elements will be discussed in detail later in the article.

Memory. Random-access memory, as described above, is used here for temporary data storage. Data may be shifted in and out of this element as the c.p.u. commands. Most c.p.u.s themselves contain some temporary storage, the 8080 containing seven user registers of 8 bits each. The c.p.u. storage may be sufficient for some simple systems. If, however, the system is intended to be universal, it is best to include r.a.m. in the design; it can always be omitted if it is found to be redundant.

I/O. This is shorthand for Input/Output, the elements which couple the m.p.u. data bus to external systems. There are a number of types available, providing for parallel or serial applications. Other features such as data latching are also available.

Handshaking. This term describes the method of coupling a high-speed system such as the m.p.u., to a low-speed system such as a printer. Operation of the m.p.u. is held until the appearance of a "ready" signal from the printer. A block of data is then transferred to the printer and the m.p.u. again held until that block of data has been dealt with. The printer "ready" line thus slows down the operation of the m.p.u. to suit its own slow speed.

Interrupts. This is a means of halting the c.p.u. in its execution of programme. The c.p.u. may then be required to wait until commanded to re-commence or it may be commanded to proceed with another set of programme instructions until a further interrupt returns it to continue with the first instruction set. Where a number of peripherals are sharing the c.p.u., a priority schedule may have to be observed.

The above description is, of necessity, brief. No mention has been made of the c.p.u architecture, the logical components of the c.p.u. and the way in which they are linked together.. No m.p.u. system can be developed, built or tested without reference to the manufacturer's data. Most manufacturers provide valuable assistance in the form of instruction and programming manuals and it is recommended that these be studied before purchase of components. Many potential users will be interested in the kits and ready built and tested modules that are available, although to date, we have not found any that suit our own requirements. True, unwanted components can be left out, but when one has to add extra component boards then it is perhaps better to start afresh. (All of the components used in the system to be described can be housed on a single board.)

Programming

Having looked at the general m.p.u. system, we can now examine methods of instructing the system to carry out its task. As mentioned previously, the aim is to provide the reader with enough *basic* knowledge to develop a programme to suit his own problem.

The 8080 is an 8-bit system. That is, the system deals with binary states in blocks of 8, each of the 8 data lines dealing with a single *b*inary dig*it*, or bit, the block forming a "data word" or "byte". Words of more than 8 bits can be dealt with in several bytes, although they will obviously take longer to handle. Either binary, or binary-coded decimal data can be handled, as will be demonstrated later. First, though, a look at the programme requirement.

The c.p.u. has the ability to carry out a number of definite tasks, known as the instruction set, each instruction being initiated by a unique 8-bit control word. The binary words controlling the c.p.u. are known as "machine code", which is often written in base 8 (octal code) or base 16 (hexadecimal code or Hex). The machine code instructions are stored in logical sequence by the programme memory and used as required by the c.p.u. The first task, therefore, is to construct the logical sequence of events which the m.p.u. system is to follow. This sequence is known as the programme.

The best way to construct a programme is to set down the sequence of events in the order in which they must occur. The diagram so constructed is known as a flow chart – users of PERT diagrams will find the technique a familiar one. The flow chart will show inputs and outputs and will comprise events and decisions. Where decisions are made, the programme will branch into 2 or even 3. Return loops provide a means of searching for the existence of a particular state of affairs.

As an example, one can take the output of a 3-digit, binary-coded decimal digital voltmeter into the m.p.u. system, assuming the d.v.m. data to be staticised. The data is to be compared with constants held in c.p.u. registers, the programme proceeding when d.v.m. values are equal to or greater than the constants. The use of b.c.d. implies 4 bits per decade. For simplicity, we shall deal with one decade/byte, the hundreds being termed the most significant decade and the units the least.

Each decade is thus circulated around its sampling loop until it is equal to or greater than the desired value. When that value is reached, the c.p.u. moves on to deal with its next instruction as in Fig. 2. The important thing to remember

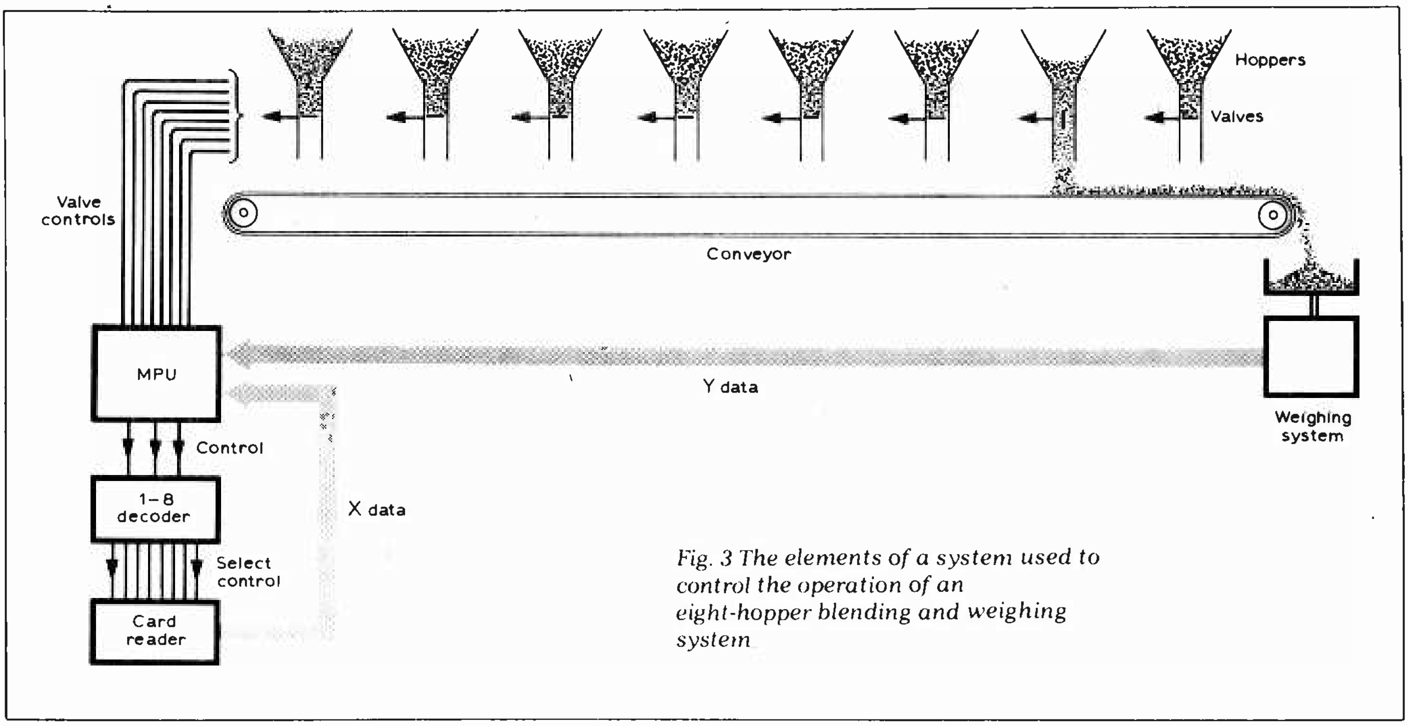


Fig. 3 The elements of a system used to control the operation of an eight-hopper blending and weighing system

in constructing programmes is not to try to achieve all in one attempt. It is best to break up the programme into small groups, one or more of which may be of use in another part of the programme, which should be constructed to make this possible. Where a section is of general value it is known as a subroutine. Most manufacturers maintain a library of subroutines for subscribers' use and these can be useful in providing proved programmes.

The flow chart should be constructed without reference to a particular instruction set. When it is complete the instruction set can be consulted and the assembly list prepared. (The assembly list is the schedule of c.p.u. instructions assembled in sequence.) The complete flow chart and software for a specific problem can now be developed, leaving the hardware details until the next article. The example developed above will be used but, to widen the scope of the discussion, we shall make a few improvements – always difficult to resist.

First, though, a word about the use of discrete logic. There are many logical functions which are effectively carried out by existing logic blocks, and there is always a temptation to use them where such functions are required. There is usually no reason why they should not be used except that they tend to reduce the versatility of the m.p.u since a purpose-designed printed-circuit board is needed. However, if the use of discrete logic considerably simplifies the programme then there is a case for its inclusion – each application must be assessed on its own merits. In the example describe below, discrete decoding reduced the number of I/O elements required and resulted in a cost saving. Where process time is important, the number of programme steps can be reduced with the use of discrete logic functions.

This example described is intended to illustrate the versatility of the m.p.u. and some of the techniques which can be employed.

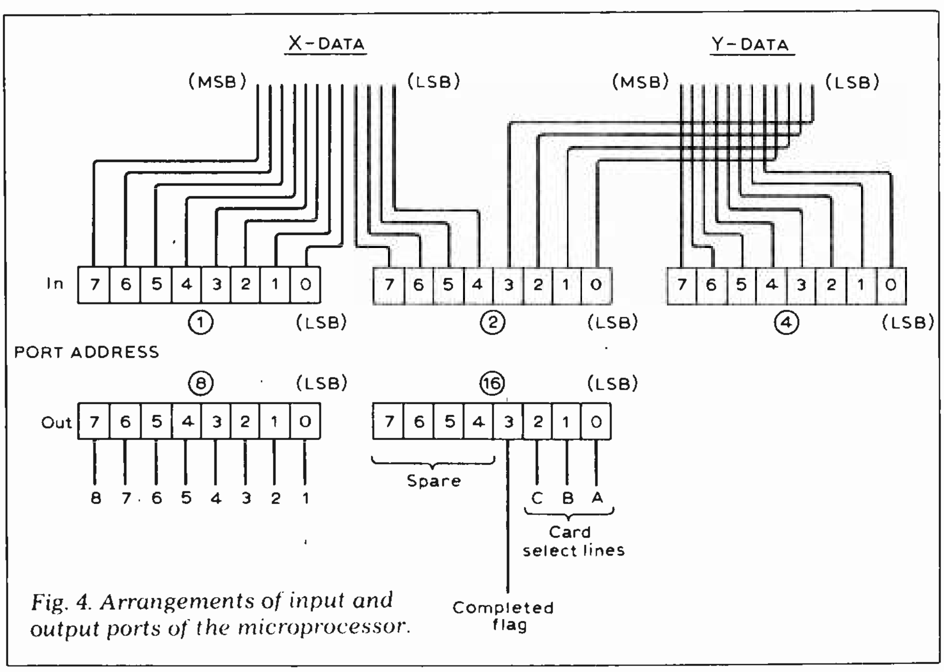


Fig. 4. Arrangements of input and output ports of the microprocessor.

Problem

It is desired to control a dispensing system which has a hopper feed on each of eight supply lines, as shown in Fig. 3. The hoppers are controlled by solenoid valves and feed a digital weighing system. The quantity to be dispensed from each hopper is prescribed on punched card.

The sequence of operation is as follows.

(1) Operator inserts a card into reader and operates the START control.

(2) System reads the card data for one hopper and opens the valve for that feed line.

(3) The weighing system is monitored until the quantity required from that line has been dispensed; the valve is then closed.

(4) The sequence is repeated for each line in turn until all lines have been dealt with. A "completed" signal is then generated.

Solution

Card Reading. The method of dealing with the data stored on punched card (or on any other storage medium) will depend on the equipment used. The simplest way is to put the data on common bus lines and provide a 'channel select' signal. For eight channels, one can simply raise a command signal on one of eight output lines, or use a one-out-of-eight decoder, driven from three output lines. As a decoder is cheaper than an extra I/O block, we opted for the decoder in this case. Supposing 1% accuracy was specified, a three-decade measurement system would be required. Either binary or b.c.d. could be used, but b.c.d. is simpler to deal with and would probably be provided from the weighing system. The input bus to the m.p.u. system is therefore 3-decade b.c.d. (i.e. 3 × 4 lines).

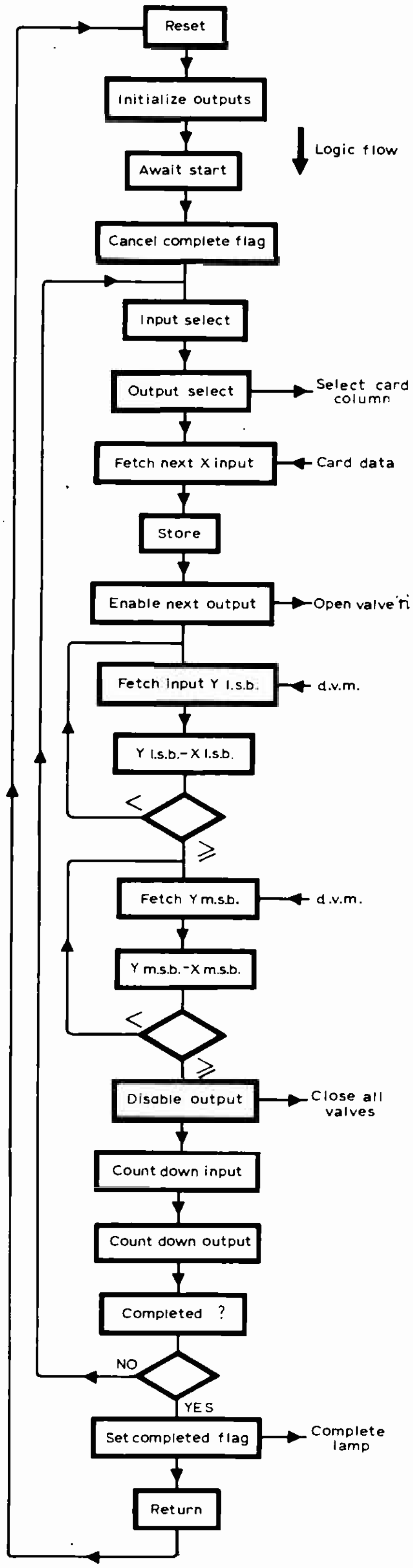


Fig. 5. Completed flow chart for the system of Fig. 4.

Weighing data unit. The input from the weighing system is also 3 × 4 lines. Again several possibilities of handling the weighing system data exist. The data could be fed to the card data bus and used when required by means of an output select signal, or it can be given its own I/O ports. The card reader would probably be connected to the m.p.u. system with its own separate cable, bus control being fitted at the card reader end to reduce the number of cables and connector pins It would probably be most economic then to provide separate I/O ports for the weight data. Multiplexing control outputs might be required in some instances but are left out in this description for the sake of simplicity.

Valve control. The requirement here is for 1 of 8 to be selected. A three-line binary decoder could be used except for the fact that one of the outputs from a decoder is always active unless an illegal input is supplied. We decided to use a separate I/O block here.

Remaining outputs. Three ports are required for the 'card select' lines and one further port for the 'complete' signal.

Weigher outputs. In the example discussed earlier, we dealt with the d.v.m. b.c.d. outputs in three separate bytes, one byte per decade. This is wasteful of I/O ports, and we shall now economise and use one byte per 1½ decades of data, calling the bytes m.s.b. and l.s.b. The same system is applied to the card data lines, as shown in Fig. 4, where the second I/O block is shared between card and weigher l.s.b. data. Data entry to the c.p.u. is via a temporary, eight-bit register known as an accumulator. Data held in the accumulator may be processed directly by the c.p.u. or transferred to other storage registers.

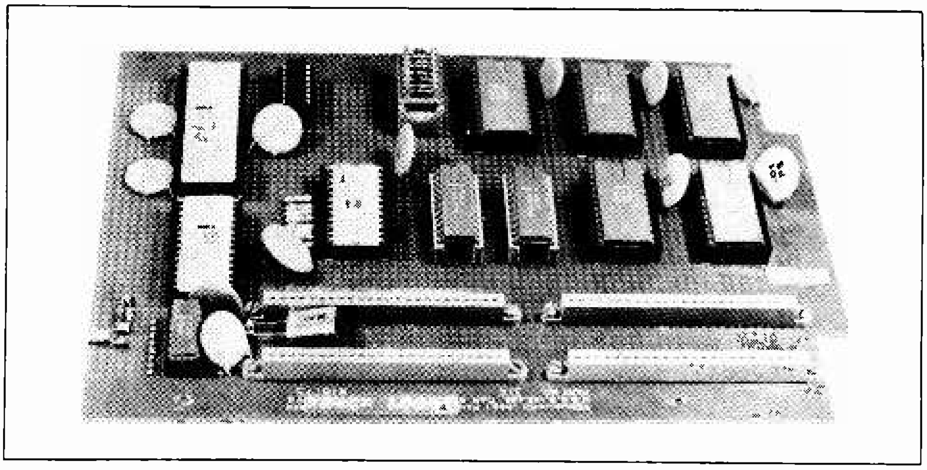


Fig. 6. A complete prototype m.p.u. system. The c.p.u. is at rear left, input and output blocks right rear and front, r.a.m.s in the centre and r.o.m. the white i.c. centre left.

We shall now proceed to show how the card and weigher l.s.b. data held in the second I/O block can be separated. The technique is known as "masking" and is simply applying a logical AND function to eliminate the unwanted data, as in Table 1, where the top row is the mixed data, the second row the other AND input and the third row the AND output. (D is weigher data, d is card data). The outputs are shifted right by four places to give the card data in the correct sequence.

Table 1

d	d	d	d	D	D	D	D
1	1	1	1	O	O	O	O
d	d	d	d	O	O	O	O
O	O	O	O	d	d	d	d

Similarly, the weigher data is separated by the complement of the second row of Table 1. The flow chart for the system is shown in Fig. 5. Card columns are selected in sequence and the data read off. The appropriate valve is then opened and the d.v.m. data compared with the card reading When the correct weight is dispensed, the valve is closed. The number of card columns and also the number of valves operated is counted down from the total number stored in c.p.u. registers and when all have been dealt with in sequence, the 'complete' signal is generated and the system returned to await the start.

Next month the machine code and the hardware requirements for this programme will be described.

Broadcast stereo coder

2 — Circuit description and construction

by Trevor Brook *Surrey Electronics*

The complete coder is shown in Fig. 10. IC_1 and IC_2 provide regulated and short-circuit protected plus and minus 15-volt lines. The output voltage of these i.cs has reasonable temperature stability, which is desirable for the negative line, since it provides the reference for oscillator amplitude. Though short-circuit protected, the regulators cannot withstand reverse polarity at their outputs, so D_{16} and D_{17} prevent damage, should the two supplies be inadvertently shorted together.

The 19 kHz sine-wave oscillator described in part 1, IC_3, has one addition, the chain of diodes D_{11-14} across the output. There is the chance that, when starting, the oscillator output could hit the supply rails and thus go beyond the linear region of the multiplier, IC_4. When the multiplier is overdriven its output, instead of rising further, distorts and begins to fall, which means that the comparator no longer receives an input in proportion to the oscillator amplitude and the oscillator stays locked into a condition where it oscillates at the supply clipping point. Diodes 11 to 14 clip the oscillations below the multiplier's serious non-linearity level without affecting the oscillator distortion when running normally, at the designed output of 1 volt r.m.s.

Multiplier IC_4 has its X+ and Y+ inputs tied together, so that it acts as a linear frequency doubler with R_{23} providing trimming of 19 kHz feedthrough rejection. The rejection figure obtainable worsens as the multiplier's maximum permissible input swing is approached, hence the reason for driving at 1 volt.

The loss occurring in the multiplier is recovered by IC_5 and, since it must provide over 30dB gain, a wide bandwidth op-amp is used, a 531. A 748 can just about manage the job but it introduces a significant temperature-dependent phase shift, a very undesirable characteristic in this part of the circuit.

Notch filter IC_6 has virtually unity gain at 38 kHz and is within the capabilities of a 748. Of all the active notch arrangements I have tried, the Wien bridge seems the most repeatable. No very high impedances are involved, the loss at double notch frequency is less than 0.2dB, the corresponding phase shift is small and stable, and a notch deeper than 30dB can be obtained at 19 kHz. Two adjustables set the time constant of one bridge arm and the circuit Q and both are adjusted for the deepest notch. Perhaps IC_6 and its associated circuitry is a lot of trouble to avoid a simple LC rejector; but custom-wound inductors are also a lot of trouble, have poor tolerance and the possibility of causing distortion if ferrite cored.

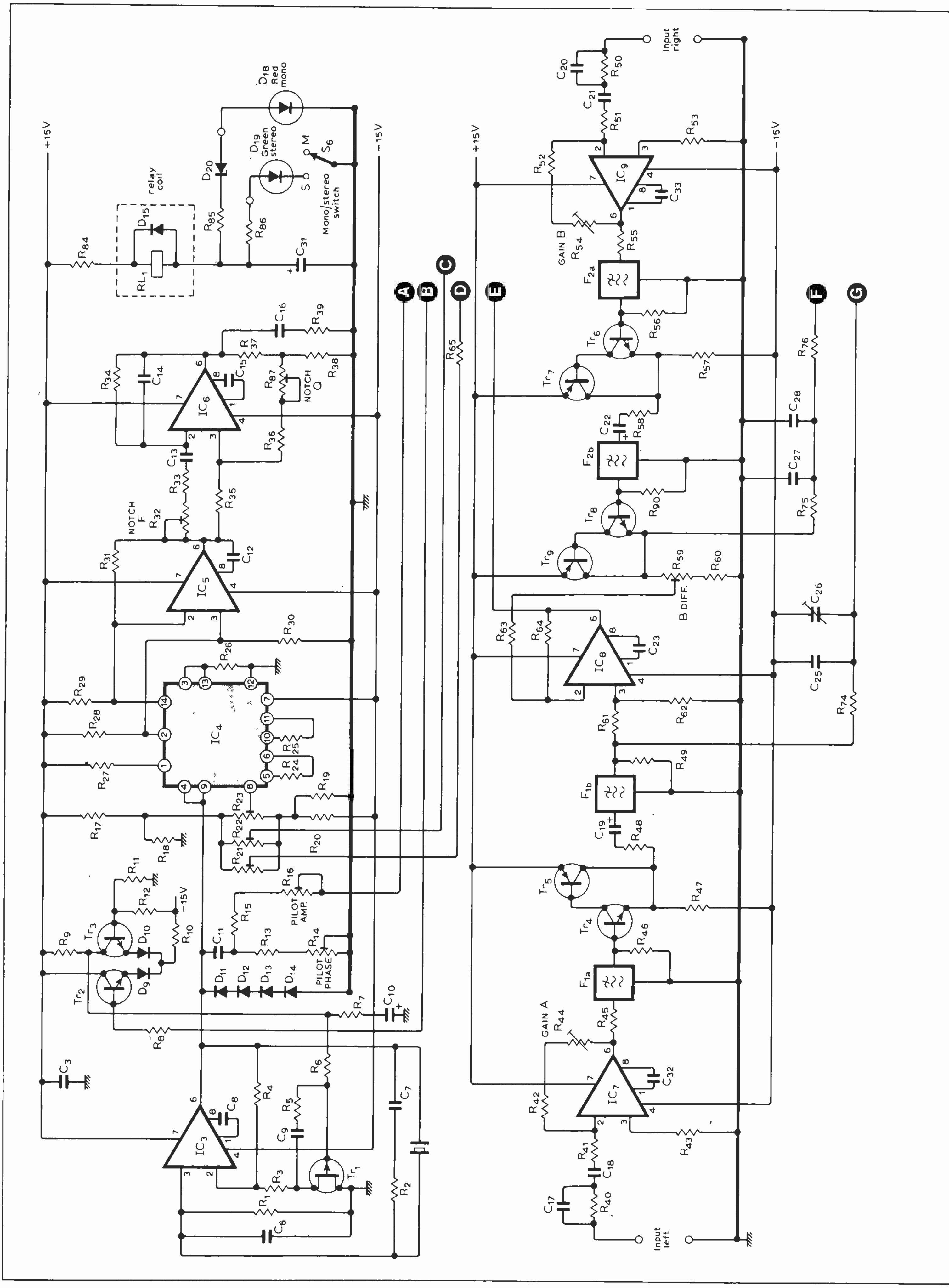
Capacitor 16 couples the 38 kHz into the balanced modulator and blocks the accumulated d.c. offset. Though only a volt or so, it is unlikely to be temperature stable so R_{39} establishes a stiff grounding for the multiplier. The value of C_{16} is chosen with R_{39} to cause small phase shift, yet provide some welcome roll off at low frequencies, since the 531 is a disgustingly noisy little animal. The comparator sensing point is also taken from here, again with no worries about superimposed d.c.

Left-channel audio passes through R_{40} and C_{17} where it receives pre-emphasis of 50μs. Capacitor 17 may be omitted for a flat frequency response or a link could replace R_{40} on the board and R_{40} be placed by a switch bank with various capacitors to give a choice of pre-emphasis. A straightforward audio amplifier IC_7 drive the first filter section through its correct source impedance, R_{45}. The filter is terminated by R_{46} and feeds into a compound emitter follower, Tr_4, Tr_5: single-transistor emitter followers cause too much distortion, even at signal levels below 1 volt as here. Resistor 48 is the source impedance for F_{1B} which is terminated by R_{49}. Arrangements on the right channel are identical apart from F_{2B}'s terminating resistor which is split between a preset, R_{59}, and a fixed resistor. These filters are normally intended for use as a stereo pair, but on an experimental coder there appeared a surprisingly large phase shift between the M and S signals as 15 kHz was approached. This turned out to be due to crosstalk (at −60dB) between the two halves of the filter which produced a spurious signal of different phase on the 'silent' channel. The cure adopted here is to feed each channel back through the second half of its original filter block and keep the left and right channel blocks well apart.

The A and B signals emerging from F_{1B} and F_{2B} are fed via their phase shifting networks, R_{74}, C_{25}, C_{26} and R_{75}, C_{27}, C_{28}, to the output adder IC_{11}. The different values for C_{25} and C_{27} is explained by different paths through the differencing amplifier and difference in circuit board capacity for the two channels.

The differencing amplifier, IC_8, uses a 748 rather than a 741, since less phase shift is introduced at the higher audio frequencies and the change with temperature of the remaining phase shift is lower. The second drawback of the multipliers used here is that they produce a small amount of second harmonic distortion and, though this is immaterial in the doubler configuration, it is relevant when using the balanced modulator configuration. Such distortion on the audio port will produce second harmonic distortion for difference signals below 7.5 kHz and beat tone distortion for frequencies between 7.5 and 15 kHz. On the 38 kHz port, the effect will be to give an output, with associated sidebands, at 76 kHz. Like feedthrough, these effects worsen as the multiplier is driven harder and here the carrier level, and audio level for a full difference signal, are set 6dB below the multiplier's non-linearity point. The audio takes precedence and goes to the X port, which has the better linearity specification. The objection to driving the balanced modulator at even lower levels is that noise would become obtrusive. The double-sideband, suppressed-carrier difference signal from IC_{10} is fed to the adder at the correct level via R_{72}.

The gain of 15dB required from IC_{11}, the output adder, for the S signal, is possible from a 748 and the noise level of these devices is also good enough for this position. The signal components may be switched individually by the d.i.l. switch mounted on the board, S_{1-4},



Input right
Input left
+15V
−15V
relay coil
Mono/stereo switch
Red mono
Green stereo
NOTCH F
NOTCH Q
GAIN A
GAIN B
B DIFF.
PILOT AMP.
PILOT PHASE

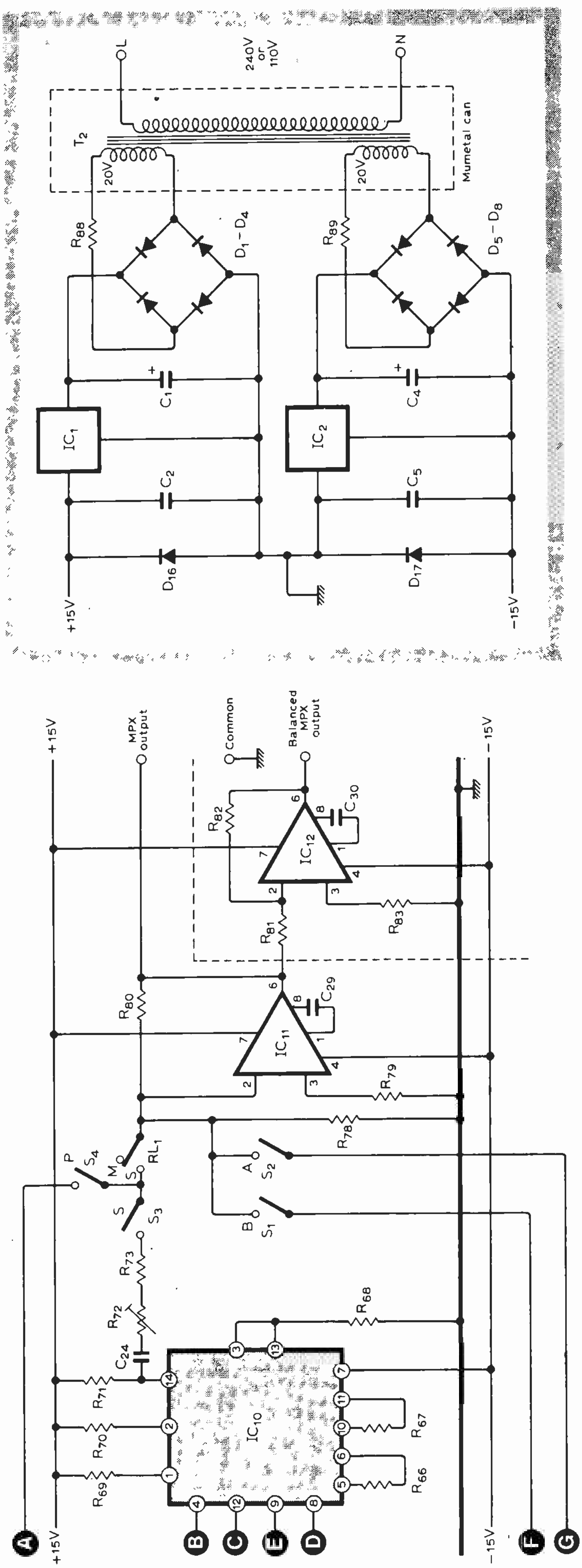


Fig. 10. Circuit diagram of complete coder. (The junction of C_{16} and R_{39} should be taken to be the line marked B.)

and R_{78} is present to stop the 748 going unstable should all the switches be turned off. A balanced output is produced by IC_{12}, which is a unity gain inverter.

The sine-wave pilot signal is taken directly from the oscillator output, passed through a trimmable phase shift network C_{11}, R_{13}, R_{14}, and then attenuated suitably by R_{15}, R_{16} before reaching the adder. Mono/Stereo switching is achieved by a reed relay mounted on the board immediately by the adder, which disconnects the pilot and S signal. The reverse diode and capacitor around the relay coil completely remove any click due to the switch but some click remains as the reed contacts make or break. There is no d.c. offset being switched and no capacitor charging as the contacts close and the click only occurs if the pilot is switched on at the d.i.l. switch. The reason is that the 19 kHz sine wave is being interrupted instantaneously: another way of thinking of it is 100% amplitude modulation, and a continuum of sideband energy will extend from d.c. to infinity. The peak level of the click at the coder output viewed on a 'scope with a 15 kHz filter and no de-emphasis is −30dB. Some coders leave the S signal on when in the mono mode but it is no trouble here to remove it and it seems good practice to do so if stereo performance is not compromised.

The little arrangement around the red and green l.e.d.s allows mono and stereo indicators to operate along with the reed relay, while only using a single-pole switch contact, which closes for stereo. This allows for easy remote switching. The green l.e.d. passes full relay current in stereo and the red l.e.d. draws a small current in mono which is insufficient to hold the relay in, yet subjectively gives the same brightness because of the greater efficiency of red l.e.d.s.

Construction

To achieve a compact layout, as well as to avoid links and keep signal tracks short in the interests of reducing crosstalk within the coder, the p.c. board has to be double sided. The whole coder, including its power supplies and mains transformer, is accommodated on a board 165 by 165mm. To avoid hum pickup it is essential for the board-mounted mains transformer to be magnetically shielded. Though the board track layout is designed to avoid ground loops, many i.cs have built-in loops which make them susceptible to hum induction when in a magnetic field in the same plane as the i.c. chip. This applies particularly to the multipliers and regulators used here, and a cylindrical Mumetal can for the mains transformer provides over 30dB reduction in its hum field, a more than adequate margin. The heatsinks provided for the regulators run hardly warm to the touch and only reach 30°C above ambient under supply overload conditions. However, their sides provide convenient points for glueing down the large smoothing capacitors to prevent them from vibrating and their leads fracturing under severe mechanical shock. Clear Bostik 1 is suitable for the purpose.

All the trimmers are visible-setting, single-rotation types. None of them is doing more than providing a very fine trimming adjustment, so multiturn types are not justified. In addition, being able to see the position of a preset is extremely useful as an unusual setting frequently leads to discovery of an incipient fault.

Resistors which have a bearing on gain, phase or important time constants are 2%, with thick film types being preferred for the lower values where they are available, since they have a lower temperature coefficient (±100ppm) than the 2% metal oxide types (±250ppm). Similar comments apply to capacitors where 1% silver mica types are used for the notch filter and pilot phase corrector with a low temperature-coefficient polycarbonate type for C_{16}. Stripboard construction is not likely to be successful, but printed circuit boards are available from the address at the end. Ground tracks radiate along the board from the output adder and there are in addition several, apparently redundant, ground tracks forming ground guards to reduce board leakage and intertrack capacity. The positioning of circuit sections on the board also contributes to minimal 19 or 38 kHz pickup along the audio paths or by the output amplifier. The long-tail pair comparator transistors in the oscillator are mounted together and a drop of glue between them will do no harm. While the difference signal is at a fairly high impedance, the capacity of its line has to be kept low to avoid loss or phase shift of the upper sideband and this is done by IC_{10} being directly next to the adder.

The board pins connecting the plus and minus 15V lines through the board to their distribution tracks across the top can be omitted until correct functioning of the power supplies has been checked. To simplify initial checking it is a good idea to omit the pre-emphasis capacitors as well, C_{17}, C_{20}, so the coder can be set up with a flat frequency response.

Printed circuit boards
A set of p.c.bs comprising one double-sided board, which measures 6½ × 6½in, and two smaller single-sided boards is available at £7.50 inclusive from M. R. Sagin at 23 Keyes Road, London N.W.2.

X_1 19kHz crystal, RC 13U (Surrey Electronics, The Forge, Lucks Green, Cranleigh, Surrey).

Mains transformer (Surrey Electronics).

F_1, F_2. BLR2011N filters (Harrogate Radio Ltd, 2/3 Sykes Grove, Harrogate, W. Yorks).

Heat sinks. Redpoint TV3 (Elecrovalue, 26 St. Jude's Road, Englefield Green, Egham, Surrey).

Relay, d.i.l. switch, trimmers and trimmer capacitors can be obtained from Doram Electronics, PO Box TR8, Wellington Road, Industrial Estate, Wellington Bridge, Leeds 12.

The next article will describe the alignment of the decoder.

Parts list

R_{1}	1.8k	R_{51}	6.8k ± 2%	C_{10}	33μ 10V
R_{2}	1.8k	R_{52}	39k ± 2%	C_{11}	1n ± 1%
R_{3}	18k	R_{53}	39k	C_{12}	3.3p
R_{4}	39k	R_{54}	22k	C_{13}	4.7n ± 1%
R_{5}	1M	R_{55}	1k ± 2%	C_{14}	4.7n ± 1%
R_{6}	1M	R_{56}	4.7k ± 2%	C_{15}	3.3p
R_{7}	470	R_{57}	3.3k	C_{16}	10n ± 5%
R_{8}	1k ± 1%	R_{58}	1k ± 2%	C_{17}	500p ± 1%
R_{9}	1M	R_{59}	470	C_{18}	1μ ± 5%
R_{10}	47k	R_{60}	4.3k ± 2%	C_{19}	6.8μ
R_{11}	1.8k ± 2%	R_{61}	100k ± 2%	C_{20}	500p ± 1%
R_{12}	8.2k ± 2%	R_{62}	470k ± 2%	C_{21}	1μ ± 5%
R_{13}	8.2k ± 2%	R_{63}	100k ± 2%	C_{22}	6.8μ
R_{14}	2.2k	R_{64}	470k ± 2%	C_{23}	3.3p
R_{15}	330k ± 2%	R_{65}	8.2k	C_{24}	1μ ± 5%
R_{16}	100k	R_{66}	8.2k ± 2%	C_{25}	10p
R_{17}	10k ± 2%	R_{67}	8.2k ± 2%	C_{26}	20p
R_{18}	470 ± 2%	R_{68}	5.6k ± 2%	C_{27}	47p
R_{19}	470 ± 2%	R_{69}	3.3k	C_{28}	20p
R_{20}	10k ± 2%	R_{70}	3.3k	C_{29}	3.3p
R_{21}	4.7k	R_{71}	3.3k ± 2%	C_{30}	3.3p
R_{22}	4.7k	R_{72}	2.2k	C_{31}	6.8μ
R_{23}	4.7k	R_{73}	9.1k ± 2%	C_{32}	5p
R_{24}	8.2k ± 2%	R_{74}	4.7k ± 2%	C_{33}	5p
R_{25}	8.2k ± 2%	R_{75}	4.7k ± 2%		
R_{26}	5.6k ± 2%	R_{76}	22k ± 2%		
R_{27}	3.3k	R_{77}	22k ± 2%	D_{1}	1N4001
R_{28}	3.3k	R_{78}	10k	D_{9} – 14	1N914
R_{29}	3.3k	R_{79}	6.8k	D_{15}	1N4001
R_{30}	100k ± 2%	R_{80}	47k ± 2%	$D_{16\ 17}$	1N4001
R_{31}	150k ± 2%	R_{81}	6.8k ± 2%	D_{18}	Red l.e.d.
R_{32}	470	R_{82}	6.8k ± 2%	D_{19}	Green l.e.d.
R_{33}	1.5k ± 2%	R_{83}	6.8k	D_{20}	6.2V Zener
R_{34}	1.8k ± 2%	R_{84}	470		
R_{35}	47k ± 2%	R_{85}	3.3k		
R_{36}	18k ± 2%	R_{86}	470	Tr_{1}	2N5457
R_{37}	1.8k ± 2%	R_{87}	4.7k	Tr_{2-4}	BC239C
R_{38}	47k ± 2%	R_{88}	15 1/2W	Tr_{5}	BC309
R_{39}	1ok ± 2%	R_{89}	15 1/2W	Tr_{6}	BC239C
R_{40}	100k ± 1%	R_{90}	4.7k ± 2%	Tr_{7}	BC309
R_{41}	6.8k ± 2%			Tr_{8}	BC239C
R_{42}	39k ± 2%	C_{1}	2200μ/40V	Tr_{9}	BC309
R_{43}	39k	C_{2}	100n		
R_{44}	22k	C_{3}	100n	$IC_{1\ 2}$	L131 or
R_{45}	1k ± 2%	C_{4}	2200μ 40V		TDA1415
R_{46}	4.7k ± 2%	C_{5}	100n	IC_{3}	748
R_{47}	3.3k	C_{6}	47n	IC_{4}	MC1495L
R_{48}	1k ± 2%	C_{7}	4.7n ± 1%	IC_{5}	531
R_{49}	4.7 ± 2%	C_{8}	3.3p	$IC_{6\ 7\ 8\ 9}$	748
R_{50}	100k ± 2%	C_{9}	100n	IC_{10}	MC1595L

● *continued from page 38*

Matrix H decoder component suppliers

The integrated circuits used in the BBC matrix H decoder are normally available only to QS licencees of Sansui Electric Co. By special arrangement, Sansui have agreed to supply the i.cs to constructors on the understanding that they are for private use and not for resale. (At the time of writing, Sansui's QS licensing arrangement does not allow manufacturers or kit suppliers to deviate from the Variomatrix circuit.) Price is £9.98 per set of four i.cs plus v.a.t. from Sansui Audio Europe S.A., Spares Department, 39 Maple Street, London W1. Printed circuit boards for both the variable matrix and the phase shift circuits will be available at £6 inclusive per pair from M. R. Sagin, 23 Keyes Road, London NW2.

Acknowledgment

Thanks to C. B. B. Wood, Head of BBC Engineering Information Department, and P. S. Gaskell and P. A. Ratliff of the Engineering Research Department, authors of BBC report RD1977/2, whose information has been freely used, especially that of the listening tests, and to R. Ito of Sansui Electric Co. for their help during the preparation of the article on the purpose-built Matrix H decoder.

Interference from amateur stations

2 — A discussion of the results of the RSGB investigation published in March

by I. Jackson G3OHX

Before discussing the answers to the survey questions certain points must be mentioned concerning alterations made to the figures given by some amateurs. These "corrections" were made for the following reasons:

In question 2 of section 1 a lot of amateurs gave answers in fractions of years (especially those where the answer was less than one year). To simplify matters these were rounded up to whole numbers.

In a few cases in section 2, the answer to question 1 was lower than any of the answers in question 2. This is not possible as it must at least be equal to the highest answer given in question 2 and could be the total of all three answers. To avoid possible exaggeration, the answer to question 1 was made up to equal the highest answer in question 2.

In cases where the answer to question 1 exceeded the total of the answers in question 2, some amateurs gave no figures for question 2 and the result was allowed to stand. This is reasonable because, in certain circumstances, the amateur might not be informed of all the facts, or even bother to find out.

Again in section 2, in quite a number of cases, the answer to question 7 exceeded that of question 6. As it was the intention that answer 6 should include the figures of answer 7, answer 6 was made to be at least equal to answer seven.

The first two and last two questions in sections 3 and 4 showed the same anomalies as in section 1, and the same corrections were applied.

Compilation of the results

The survey returns were separated into the three groups Class A, Class B and "Both A and B" amateurs. Each group was divided into wired and non-wired (to see if any great differences were apparent between amateurs in wired tv areas and non-wired tv areas).

Survey results

Questions are referred to in the following form where it is convenient to do so. For example, section 3, question 2b is 3.2b, etc.

A total of 1221 survey forms were returned. This represents about 9.5% of the RSGB licensed membership. Figures in *Radio Communication*, January 1976, assume that 60% of UK licensees are members. While returns could have been greater, it must be remembered that a fair number of licensees are permanently inactive. While some replies did indicate that the amateurs concerned were not currently operating, most suggested a reasonable level of activity. It is probable that the majority of replies came from fairly active amateurs. The return rate represents about 5.7% of all UK licensees.

The average time period covered by the survey was 6.54 years. However, operation ranged from over 40 years to just a few days. Of course, the average Class A figure is much greater than the others because of the relatively recent introduction of the Class B licence.

Thirty-six per cent of amateurs are "slightly worried" about interference. Those "not worried at all" or "moderately worried" are equal to 26%. Only 10% are "severely worried". Class B licensees are less worried than the others, even though 31% have problems on 144MHz (see results for 1.4).

Of the h.f. bands 1.8 to 28MHz, 1.8MHz is the least troublesome. This might be expected because of the low permitted power and great frequency separation from the tv channels. 7MHz is worse, but most interference occurs from operation on the remaining four bands where over 20% of amateurs are unable to operate freely. 21MHz is the worst band for the "A" class (this result may be influenced somewhat by past experience rather than by present troubles, although the question asks for the latter). The more recently licensed "A and B" class have relatively less trouble on 21MHz than "A". However, such differences are small.

The worst of the lower h.f. bands is 3.5MHz, probably because of its popularity in the evenings (and hence tv hours). Surprisingly, the new "A + B" group has less trouble than the older "A" group despite the recent growth of colour tv (which is maybe more susceptible to video frequency interference). 7MHz is not too troublesome. Technically this band is usually too high to cause direct video breakthrough and sufficiently low to avoid severe harmonic problems. It is also not very popular for evening use because of the level of interference from illegal commercial and broadcasting stations.

On the v.h.f. bands 144MHz is by far the most troublesome on average, but this is mainly due to the Class B licensees (for whom it is undoubtedly the most popular band). However, despite the prolific use of the f.m. mode (which is reputed to cause minimal interference) 31% of "B" amateurs cannot operate without problems. "A+B" amateurs also have considerable trouble on this band where 20% are affected — similar to the h.f. bands. 432MHz is troublesome mainly for Class B amateurs since it is probably the second most popular band for them. On 70 and 432MHz "A" and "A+B" results are similar. Having obtained their full licences, the "A+B" amateurs are likely to move to the h.f. bands (though not necessarily abandoning v.h.f.).

As question 4 asks for information pertaining to present problems (and not those in the past) it is probable that differences between "A" and "A+B" are due to reasons of band popularity. For similar reasons, the high incidence of trouble on 144MHz with Class B amateurs is not that they have problems peculiar to them — it is more likely the very high proportion of them on that band. Accordingly, they are the least worried group, even though about a third of them have problems (see 1.3).

The answers to question 5 follow the same general pattern as in 1.4 but the percentages are about one-half lower. However, there are exceptions. In this question results are likely to be influenced by lack of interest or popularity. Few Class B amateurs avoid the 144MHz band because their choice is obviously limited. The "A+B" group avoid 70MHz in disproportionate numbers. It is unlikely that this is only for reasons of possible interference, but rather that, having obtained a full licence, they choose to explore the new pastures of the h.f. bands.

Although there is a visible correlation between the expected troubles and the actual troubles in question 4, because of the other influences mentioned, maybe one should be a little cautious before concluding that any particular band deserves a bad reputation for interference problems.

No attempt has been made to correlate the incidence of t.v.i. and the tv channels received since, with the change to u.h.f., the answers would not be particularly meaningful if any deductions about v.h.f. tv were attempted. In addition, a high proportion of amateurs were very vague about which channels or transmitters were received in their area. Many did not give any answer, and some answers were obviously incorrect. It seems a waste of time piecing together these scraps of evidence to obtain a largely academic answer.

Regarding differences between "wired" and "non-wired" amateurs, the "wired" represented less than 10% of all the returns. There were no outstanding differences in the answers given by these two categories, so no attempt has been made to carry out detailed separate analyses.

Television interference

The amount of t.v.i. caused by each of the three groups, A, B and A + B, was found from 2.1 to be very similar. On average, each amateur has 2.65 cases of interference. Complete lack of t.v.i. may result from infrequent operating or when the amateur is lucky enough to live in an area of low housing density. If amateurs who have no t.v.i. are excluded, the average number of cases rises to 3.4. Of all classes of amateur, 17.36% have no t.v.i. at all.

Answers to question 2.2 showed that Band 1 t.v.i. affects Class A amateurs more than the others. This result probably reflects problems which occurred before the growth of the u.h.f. tv service, rather than present trends. When t.v.i. occurs these days, it is almost certainly a u.h.f. set which is affected. This is illustrated by the figures obtained for 2.2c.

Results for 2.3 indicated that the Post Office was involved in about 30% of the cases of t.v.i. known to the amateur, and again there is little difference between the three groups. Using the figures in "Technical Topics," September 1975 issue of *Radio Communication*, to obtain a yearly average of the number of cases of t.v.i. (1968 to 1974) with which the authorities dealt, it is possible to make an estimate of the number which actually do occur. The yearly average of investigated cases is about 1,044. If this represents 30% then 3,480 cases occur of which 2,436 are never reported to the Post Office.

Again in answer to 2.4 the results are surprisingly similar for the three groups and 46% of t.v.i. cases are cured by the amateur or other parties without the help of the Post Office. Working with a figure of 3,480 t.v.i. cases per year, the amateur cures 1,600 of them. Assuming that the Post Office cure all of the cases in which they are involved (maybe this is a little optimistic) and that no cures are effected without the help of the amateur or the Post Office, this leaves 836 cases of t.v.i. uncured each year (24%).

According to the results of 2.5 only 9% of the cases of t.v.i. were cured by modifications to the amateur station.

Answers to 2.6 showed that 58% of the cases of t.v.i. were cured by modifications to the tv installation. Comparing this answer with that of the previous question clearly illustrates that the amateur is usually not to blame for t.v.i. Of course, it is not possible to tell if the uncured t.v.i. cases would give the same ratio if sufficient work was done to effect cures. However, if all uncured cases were blamed on the amateur (highly unlikely) this still gives a result which shows that the tv installation is more to blame. The ratio is 58% to 33%. (Note: this adds up to 91% and not 100%, showing that one should be a little cautious in drawing conclusions from results of this type, unless the differences being discussed exceed the expected errors).

The results obtained for 2.7 indicated that 52% of tv sets were cured of t.v.i. by external modifications alone, that is there was no need to meddle inside the tv set. It is reasonable to conclude that, when t.v.i. occurs, the amateur has about a 50-50 chance of curing it by using a simple tv filter. Compared with the 58% cures recorded in the previous question, over 90% of the cures effected at the tv installation are by external filtering alone. Hence the amateur has a good chance of overcoming his problems without too much trouble.

It is interesting to note that only 17% of all amateurs recorded that they had no t.v.i. problems at all. Group B has the least trouble (24% free) and group A + B the most (13%). It is difficult to give an explanation for this. Perhaps group B uses f.m. more, while group A + B are keen to use the more interference-prone modes of the h.f. bands. It is likely that the A + B amateur, having taken the trouble to obtain a full licence, is more active than the ordinary Class A.

Seen from the pessimistic side, the average amateur has an 83% chance of t.v.i. problems.

Radio interference

Answers to 3.1 showed that the amount of broadcasting interference (b.c.i.) caused by each of the three groups is similar. On average, each amateur has 0.86 cases of interference. If amateurs who have no b.c.i. are excluded, the average rises to 1.9 of all classes of amateur. 56% of the amateurs have no b.c.i. at all.

On average, a.m. and f.m. radios are affected almost equally according to the results of 3.2. However, Class B amateurs cause twice as much b.c.i. to f.m. than to a.m. This is presumably because of the proximity of the 144MHz band to the f.m. broadcast band. Cheap a.m. portables tend to suffer from harmonic mixing problems and are prone to interference from h.f. transmitters.

The results from 3.3 indicated that the Post Office was involved in about 14% of the cases of b.c.i. known to the amateur. Using the figures in "Technical Topics" (see previous reference) the average number of cases of b.c.i. from 1968 to 1974 was 101 per year. Hence an estimate of the actual number is 721.

Answers to 3.4 showed that 28% of b.c.i. cases are cured without the help of the Post Office. Class B licencees solve more of their own problems. As they cause worst b.c.i. to f.m. radios, it is probable that, in many cases, a filter in the coax downlead effects a cure. With most a.m. radios there is no external aerial to filter, thus making the cure more difficult. The lower cure rate for radios probably reflects the reduced concern of the owners of the affected equipment. Working with a figure of 721 cases of b.c.i. per year, the amateur cures 202. Assuming all Post Office cases are cured (even less likely than for t.v.i.) this leaves 418 uncured each year (58%).

Only 5% of the cases of b.c.i. were cured by modifications to the amateur station according to the results of 3.5.

The results obtained for 3.6 indicated that 28% of the cases of b.c.i. were cured by modifications to the radio installation. Comparing this to the answer of the previous question indicates how seldom the amateur is to blame for b.c.i. Of course, it could be argued that the uncured cases are the fault of the amateur, but there is no reason that this should be so.

Answers to 3.7 showed that only 13% of radio sets were cured of b.c.i. by external modifications alone. This represents 46% of cures effected at the radio installation — a much lower proportion than for t.v.i. Some of this difference may be accounted for by the fact that many a.m. radios have no external aerial and are battery operated, thus there is nothing to filter externally.

The survey showed that 56% of all amateurs have no b.c.i. problems at all. As with t.v.i., the A + B amateurs have the most trouble. This may reflect the effects of somewhat greater enthusiasm on their part compared with the other two groups. Class B amateurs have the least b.c.i. Maybe this is due to the use of f.m. on 144MHz. A + B amateurs have the most b.c.i. cases.

Audio interference

The A + B group have somewhat more audio frequency interference (a.f.i.) cases than the others according to 4.1. The average number of cases of all the amateurs is 1.24. If amateurs with no a.f.i. are excluded, the average rises to 1.85. 33% have no a.f.i. at all.

A surprisingly high amount of Post Office involvement is recorded in 4.2 especially when considering that audio equipment is not protected by the Post Office. Presumably they become involved as part of investigations into b.c.i. problems. The three groups are again very similar.

Answers to 4.3 showed that 33% of a.f.i. cases are cured without the help of the Post Office.

On average, according to the results of 4.4, 4% of the cases of a.f.i. were cured by modifications to the amateur station. However, this is 10% for Class B alone — much greater than the others. It seems likely that, in most cases, such modifications involved the repositioning of the aerial to reduce the local field strength.

Results from 4.5 indicated that 33% of the cases of a.f.i. were cured by modifications to the audio installation. As an audio installation is not designed to receive radio signals, the amateur should not be blamed for such interference, especially if he has taken action to minimise his local field strength.

Answers to 4.6 showed that 18% of the audio installations were cured of a.f.i. by external modifications alone. It can be seen that the Class B amateurs are relatively least successful with external cures. This might be expected as interference pick-up via the external leads is more predominant on the lower frequencies. At v.h.f. the internal wiring is long enough to act as an efficient aerial. A proportion of audio equipment (record players, stereograms, etc) do not have any external wires, other than the mains lead. Thus it follows that most of the cures will be internal.

The survey showed that 33% of all amateurs have no a.f.i. problems at all. Class B amateurs have the least (39%) while A + B amateurs have the most (23%). As with t.v.i. and b.c.i. it could be that this is indicative of the level of activity and enthusiasm.

The results indicated that the percentages of amateurs having "no interference at all" were similar in each of the three groups. Class B amateurs have the least trouble (15% free) while the A + B group have the most (7% free).

Amateurs provided a variety of additional information on how interference affected them. Often the numerical answers in the preceeding sections were expanded. Case histories and tips on curing interference were also given. Several complimentary comments were received concerning the survey, the special interference issue of *Radio Communication* and the work of the RSGB Interference Committee. A few adverse comments criticizing the survey questions were also received. While there may have been a certain amount of justification, most adverse comment came from those who had apparently not read the questions correctly or who had mistaken the aims of the survey.

Summary

Although the results of each section have been discussed in detail, the following features are worthy of emphasis.

There are few outstanding differences between the three groups A, B and A + B. However, Class B licencees are less worried about interference. Indeed, this group has fewest interference problems of all kinds. Perhaps this is largely due to the extensive use of f.m. on 144MHz.

When the effects of band popularity are considered, no amateur band is outstandingly troublesome in causing interference. It is reasonable to conclude that it is not generally possible to choose a particular band with the certainty of avoiding interference.

The incidence of t.v.i. to u.h.f.-tv is considerable. It greatly exceeds that to Band I or to Band III. While this probably reflects the decline of the use of the old 405-line system, it also indicates that t.v.i. is certainly not on the decline, even though u.h.f.-tv is potentially more immune to interference. Similarly, v.h.f.-f.m. radio suffers as much as l.w./m.w.-a.m. radio.

The Post Office become involved in only a minority of interference cases, hence their yearly figures are substantially lower than in reality. A great deal of interference is cured by the amateur without the Post Office being informed.

Only a small proportion of interference is cured by modifications to the amateur station. A much greater proportion involves modifications to the affected tv, radio or hi-fi installation. External devices are effective in the majority of cures for t.v.i., but somewhat less so for b.c.i. and a.f.i.

Few amateurs have had no t.v.i. problems, although b.c.i. and a.f.i. are less troublesome. Even fewer have no problems of any kind.

Conclusion

It may be considered that more statistical data could have been derived from the results of this survey or that methods other than simple averages used. However, it must be remembered that the primary aims of the survey were strictly limited so that the results could be used to formulate definite courses of action rather than to obtain information of a largely academic nature.

It is certainly evident that the poor e.m.c. of domestic equipment is to blame for the vast majority of interference cases, rather than defects at the amateur station. It follows, therefore, that only an improvement of e.m.c. standards can bring about a significant reduction in the number of cases of interference which occur.

Silver Jubilee look at Wireless World 25 years ago

So Queen Elizabeth has been on the throne for twenty-five years. Not much has happened to the British monarchy in that time, as one might expect, but a great deal has happened in the world of "radio, television and electronics" as this journal was subtitled in 1952. After all twenty-five years is almost a generation (witness Prince Charles). A good many of the present readers of *Wireless World* had not even been born in June 1952 and larger group were still pre-school toddlers. To them now the contents of our June 1952 issue will not seem all that surprising because it is a whole life-time away.

The first thing one notices is the complete absence of any mention of semiconductor devices. Even though the transistor had been invented in 1948 it still had not come into general use in electronic circuitry. Valves were dominant, as one gathers from the circuit diagrams and a thorough-looking four-page article on "Valve life testing". The only inkling one gets of the semiconductor revolution to come is a small advertisement for germanium and silicon diodes.

Television was then developing fast and was obviously considered important, for the issue contains five main articles on this subject and about half a dozen shorter items. There is a report on an IEE convention at which 83 papers were presented on "The British contribution to television," and the editor rashly remarks in his leader that "many of us left the Convention with the feeling that the British 405-line system represents the best compromise for the foreseeable future". But one is reminded of the unfortunate "lininess" of the 405-line pictures by an article on how to make a "line eliminator". This used an auxiliary focusing coil to "stretch" the c.r.t. spot to fill in the gaps, and was offered as an alternative to the earlier technique of "spot wobbling" using an oscillatory vertical deflection. Short reports dealt with submarine television and an enquiry by opticians into whether eyestrain was caused by television viewing. Of course, colour television had not yet arrived. The monochrome tv licence was then £2.

The field of audio engineering had not yet grown to its present size and importance — there was no "audio" in the journal's subtitle – and is represented in the June 1952 issue by only two articles, one on boundary-displacement magnetic recording and the other on the now quaint sounding "Futher notes on thorn needles". There was, however, a letter discussing hot-stylus disc cutting.

One cannot fail to notice the effect of long-term inflation in the prices quoted in advertisements, and the journal itself was then only two shillings (10p) compared with its present 40p. An advertisement from Ferranti Ltd under Situations Vacant offers jobs for "Senior Engineers or Scientists to take charge of research and development sections" with salaries "... in the range of £1,000-£1,600 per annum". Engineers and scientists for research and development work could expect £500-£1,000 per annum.

New Products

Miniature drill kit

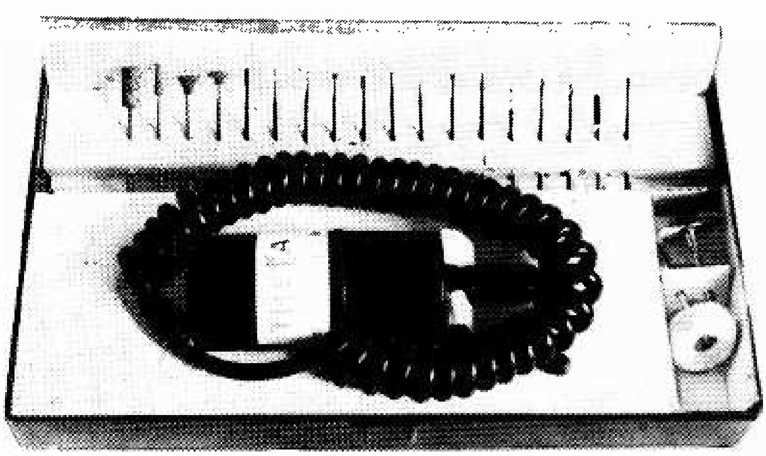
A tooling aid, called the Theta Micro-drill Kit, is based on the type 704 Micro-drill. This 12V d.c. drill, which measures 110mm long by 35mm diameter and weighs 200g, has a capacity of up to 2.4mm and runs at 9000 rev/min, with a supply current of 0.8A. It is supplied with three collets and 0.5, 1.0 and 1.5mm drills, and is fitted with an on/off switch and extendable lead. The kit also includes a felt polishing mop, a brass brush, a nylon brush, four mounted abrasive stones and nine steel burrs. Theta, P.O. Box 10, Martock, Somerset TA12 6LT.
WW301

Signal conditioning system

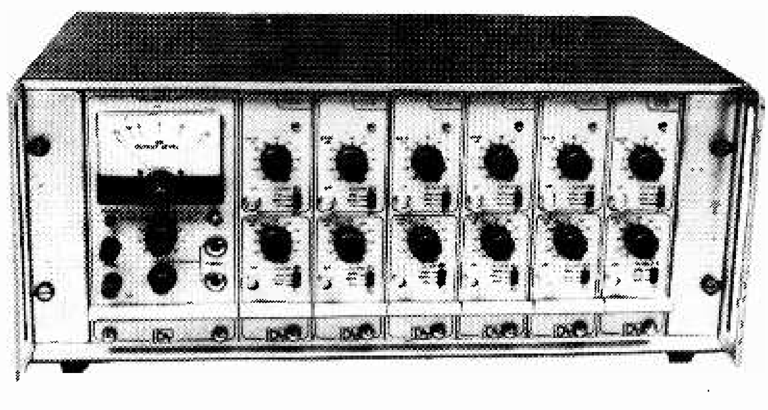
An a.c. signal conditioning system, introduced by Data Acquisition Ltd, is designed for use in the field of sound and vibration equipment. The DA1420 comprises a power supply, monitor unit and six dual channel modules in a 19 by 7in mounting frame. The system, which has a frequency response covering the range 20Hz to 20kHz ±3dB, processes signals from vibration transducers or microphones accepting input levels from 100μV to 10V r.m.s. Gain ranges of −20 to +80dB are provided to give suitable voltage outputs for instrumentation tape-recorders. Additional features include three high-pass filter settings and phone and oscilloscope monitoring points. Data Acquisition Limited, Brookfield House, Hopes Carr, Stockport, Cheshire SK1 3BQ.
WW302

Low-cost pressure transducers

Pressure transducers in the JPC series have rugged body-diaphragm assemblies which enable them to be used for measurement and control applications requiring accuracies of up to 0.25%. The makers claim that, unless ruptured, this construction also eliminates fluid leakage into the electronics through the pressure cavity. The transducers cost less than £25 each and are made from 17-4 ph stainless steel, which is compatible with most media. Ritro Electronics (UK) Limited, Grenfell Place, Maidenhead, Berkshire.
WW303



WW301



WW302

Soldering flux

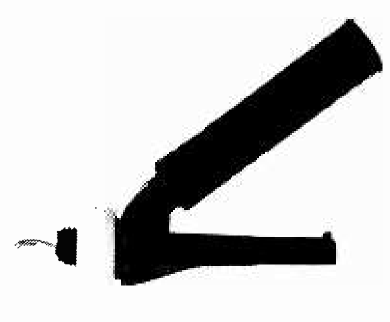
Alpha 850 is a water-soluble flux designed for high speed soldering and tinning operations. The flux, which is suitable for automated rinsing and spraying systems, requires no additional rinse additives, spitting is at a minimum, and foaming is almost eliminated. After cleaning, the residues have up to one-twentieth of the corrosion potential of existing alternatives. Alpha Metals Limited, 457 Kingston Road, Ewell, Surrey.
WW304

Stepping motors

Bipolar-wound motors, in the 42MS300 series from Moore Reed and Company Ltd, have holding torques of 86kg-cm and step angles of either 1.8 or 0.9 degrees, with no-load pull-in rates of 350 pulses per second. The units, which measure 105mm diameter by 150mm length, can be provided with a variety of windings and shaft configurations, depending upon the drive and load characteristics required. Shaft extensions are also available. Moore Reed and Company Limited, Walworth Industrial Estate, Andover, Hampshire.
WW305

Fluid level switch

The RSF33 is a fluid-level float switch which can be mounted into the side of a tank by means of a single nut. It can be used reliably in fluids having specific gravities down to 0.785, thus enabling it to be used for diesel and other hydrocarbons. The RSF33 uses reed switches, for reliability and long life, and is available in two versions — 100W, 240V and 50W, 440V. The switch can be used for high level indication or, by rotating it through 180°, for low level indication. FR Electronics Limited, Leigh Park, Wimborne, Dorset.
WW306



WW306

Small preamplifier

The Model PRE38 preamplifier is battery-operated and is no larger than a cigarette pack. Its gain may be varied so that it can be used for microphones or in tape deck-to-amplifier matching. Characteristics include an input range from 3 to 200mV at 47kΩ, an output range from 200 to 800mV at 500Ω and a frequency range from 20Hz to 20kHz. Distortion is less than 0.1% and the signal-to-noise ratio is better than 60dB. It is claimed that the unit will run for many months on one PP3 battery. Eagle International, Precision Centre, Heather Park Drive, Wembley HA0 1SU.
WW307

P.c.b. workframe

A low-cost p.c.b. holder, the Seno PCB Workframe, will accommodate boards measuring up to 240 by 200mm. The frame is designed for quick and accurate adjustment and can be angled to suit the user by simply turning a knob. Widespread feet provide a solid and stable working support and fold away for easy transportation. Alternatively, the workframe, which is made from heavy-gauge mild steel, may be screwed directly to a bench. Decon Laboratories Limited, Ellen Street, Portslade, Brighton, Sussex BN4 1EQ.
WW308

Solid-state relays

Two solid-state relay series', Series 2 and Series 3 from International Rectifier, conform to the IR standards for zero voltage switching, optical isolation and fast response. Series 2 is for applications under 8A where control may be fed direct from logic level signals. These packages are designed for panel or chassis mounting. Series 3 is for current ratings up to 2A. These devices are in low-profile (10mm) packages. Both series are designed for CSA and UL approvals. International Rectifier Company (GB) Ltd, Hurst Green, Oxted, Surrey.
WW 309

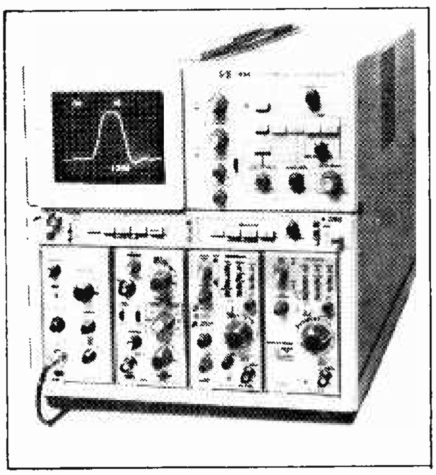
Microwave transistors

Two low-noise microwave transistors, the HXTR-6103 and the HXTR-6104, are suitable for use as low-noise amplifiers in the 1 to 4GHz range. Model 6103 has a 2.2dB maximum noise figure at 2GHz, and a minimum associated gain of 11dB. Model 6104 has a 1.6dB maximum noise figure at 1.5GHz, and its associated gain is 13dB minimum. Both devices are packaged in HPAC-100 cases and meet the requirements of MIL-S-19500 and MIL-STD-750/883. Hewlett Packard Limited, King Street Lane, Winnersh, Wokingham, Berkshire RG11 5AR.
WW310

New Products seen at the All Electronics Show

Storage oscilloscope

The 7834 storage oscilloscope, from Tektronix UK Ltd, has a 400MHz mainframe bandwidth and a writing rate of 2500cm/μs. The scope, which can capture single-shot risetimes as fast as 1.4ns, also has multimode storage and a four-plug-in-compartment mainframe, making it, it is claimed, the most versatile storage oscilloscope on the market. The multimode storage gives fast transfer, fast variable persistence and bistable storage. Fast variable persistence provides the maximum stored writing rate of 2500cm/μs and storage times of up to 30s, and fast bistable storage increases the normal writing rates up to 350cm/μs. When viewing changing waveshapes, the persistence of the tube can be adjusted to give continuous bright displays of new information as old information fades. Tektronix U.K. Ltd, Beaverton House, P.O. Box 69, Harpenden, Herts.
WW 311



WW311

WW313

Chassis mounting guides and card frames

Two products introduced at the show by Lektrokit Ltd were a range of telescopic sliding guides for mounting chassis, card frames and instrument cases in racks and cabinets, and a range of card frames for mounting p.c.bs. In addition to enabling frames to be fully withdrawn on ball bearings, the guides also allow them to be rotated about their centre line (tipped backwards and forwards), thus providing access to the circuit cards inside. The card frames, which are compatible with Motek chassis and submodules, have been designed for use with standard 100mm Eurocard p.c.bs and are available in three depths and two heights. A maximum of 38 cards can be accommodated by each unit. Lektrokit Limited, 3 Trafford Road, Reading, Berks. RG1 8JR.
WW 312

Digital multimeter

A 3½-digit multimeter, launched at the show by Telonic-Altair UK, has a 0.5in liquid crystal display and an accuracy of 0.1%. The Data Tech Model 22 measures direct voltages from 100μV to 1kV, alternating voltages from 100μV to 750V r.m.s. and direct and alternating currents from 0.1μA to 20A. Resistance measurement ranges from 0.1Ω to 20MΩ. The instrument, which can be fixed against the wrist to leave both hands free, has automatic polarity, overload protection and a battery indicator. It is claimed to provide 200h minimum battery life on AA disposable cells and 60h per charge on optional nickel-cadmium batteries. Mean-time-before-failure is calculated to be over 35,000h. Telonic Altair UK, 2 Castle Hill Terrace, Maidenhead, Berks SL6 4JR.
WW 313

Insulation tester

Hunting Hivolt Ltd were showing a portable insulation tester capable of delivering output voltages of up to 10kV

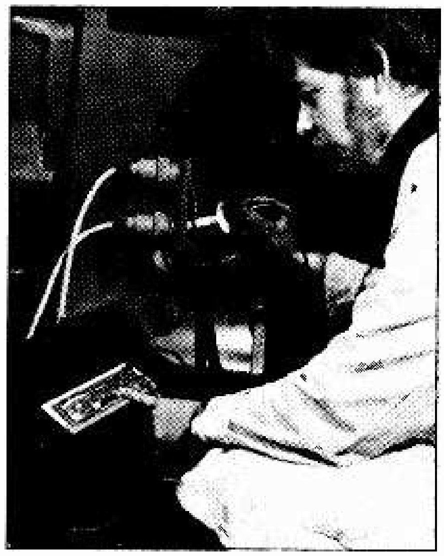
at 250μA. This instrument, called the Check IT, is nominally rated at 7kV but it can be controlled up to the maximum output of 10kV using a ten-turn potentiometer. Push-button switches provide four metering modes: output kV, and leakage currents of 1, 10 and 100μA f.s.d. The tester, which is priced at £320 and is claimed to be the cheapest on the market, includes two current overload protection facilities. Hunting Hivolt Limited, Riverbank Works, Old Shoreham Road, Shoreham-by-Sea, Sussex BN4 5FL.
WW 314

Microprocessor evaluation kit

The Motorola MEK6800D2, displayed by Cramer Electronics Ltd, is an expandable tool for those who wish to develop systems using the M6800 microprocessor, without investing in expensive terminals. All the parts needed for a working system are provided in the kit, with the exception of the power supply. In addition to the expansion available on the microcomputer module, r.a.m., r.o.m. and input/output parts can be accommodated at a later date to implement more complex systems. Machine language problems can be entered through the system keyboard or via an audio-cassette interface system, and l.e.d. displays are provided for monitoring data and address information. A crystal-controlled clock generator is used to eliminate timing adjustments. The MEK6800D2, priced at £175, has 16 input/output lines and four control lines and offers facilities for both parallel and serial interfacing. Cramer Electronics Limited, 16 Uxbridge Road, Ealing, London W5 2BP.
WW 315

P.c.b. power supplies

On show at the Coutant Electronics stand was the MPSU/1 p.c.b.-mounted power supply unit. This is a three-rail unit which has been produced specifically for microprocessor-based systems. It provides +12V/250mA, +5V/1.5A and −12V/250mA outputs and will operate from 99-127V or 198-254V, 45-65Hz supplies. Line and load regulations are less than 0.05% and 0.15% respectively, and low-frequency ripple and noise is less than 2mV. Also on show was the SU25/5 power supply which has the same basic specifications as the above, but supplies 5A at 5V. This unit has an "overpower" temperature-sensor protection facility which ensures that the power dissipation of the series element is contained within defined limits. If these limits are exceeded the available current output is reduced automatically. Coutant Electronics Ltd, 3 Trafford Road, Reading RG1 8JR.
WW 316



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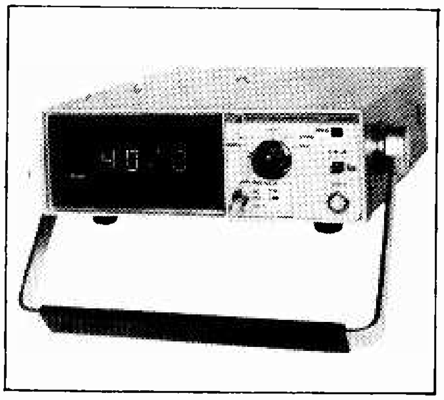

WW320

P.c.b. wiring contacts

Holtite wiring contacts, introduced at the show by Semiconductor Specialists Ltd, convert plated-through-holes into plug-in sockets. These press-fit contacts, made by Augat Incorporated, are precision machined to provide a tapered entry and a four leaf contact for component leads. The contacts are claimed to offer maximum heat dissipation without soldering, thus eliminating damage and corrosion problems due to soldering. It is also claimed that the contacts may be installed at a rate of 30,000 per hour. The profile of a p.c.b. with Holtite contacts installed is less than the length of the component leads, permitting card rack spacing equal to that of soldered boards. Semiconductor Specialists UK Limited, Premier House, Fairfield Road, West Drayton, Middx.
WW 317

Cutter for non-ferrous cable

A hand cutter, demonstrated by Giltech Components Ltd, is designed to cut copper or aluminium multi-strand cable and wire. The UP-B41 is eight inches long overall and has heat-treated high-carbon steel shearing edges, of the patented "off-set-bite" type, which eliminate compression and frayed ends. The frame of the tool has heavy-vinyl handle covers and is made of drop-forged heat-treated steel. Giltech Components Limited, 22 Portman Road, Battle Farm Industrial Estate, Reading, Berks RG3 1ES.
WW 318

Analogue memories

On show at the Kemo Ltd stand was the AM series of analogue memories. Included in this range are memory extensions which enable the storage capacity of a memory to be increased from its normal limit of 4k-words to 32k-words. These extensions are designed to be supplied integrally with the AM4096 unit, as a single rack-mounting unit. Memory lengths of the extensions are 4, 12 and 28k-words, resulting in 8, 16 and 32k-word analogue memories. Also being shown for the first time was the AM24K analogue memory, which has a digital static store of 24k-words. New input facilities allow this instrument to be used for the generation of complex waveforms. Kemo Limited, 9-12 Goodwood Parade, Elmers End, Beckenham, Kent BR3 3QZ.
WW 319

Digital milliohmmeter

A milliohmmeter, from Telonic Altair UK, has five ranges from 400mΩ to 4kΩ, with a resolution of 100μΩ on the 400mΩ range. The VP2941A, as it is called, has a four-wire resistance that compensates for all resistance drops in the test lead. This instrument, which has a large seven-segment l.e.d. display, includes a "hold" function, to temporarily store the measurement reading, and a circuit for protection against back e.m.fs due to large inductances. The VP2941A may be supplied by a.c. mains or battery. Telonic Altair UK, 2 Castle Hill Terrace, Maidenhead, Berks SL6 4JR.
WW 320

Autoranging counters

Two auto-ranging counters, types 8846 and 8847, were launched at the show by Malden Electronics Ltd. These counters are cheaper, lower-frequency versions of the 8837, 250MHz counter, described in our March issue. The 8846, priced at £150, has a six-digit l.e.d. display and measures up to 15MHz. The 8847, priced at £160, has a seven-digit display and a capability of 80MHz at 10mV sensitivity. Gating times on both instruments may be manually selected to 0.1, 1.0, or 10s by front-panel push buttons. Malden Electronics Ltd, Malden House, 579 Kingston Road, Raynes Park, London SW20 8SD.
WW 321

Pocket dosimeter

Brandenburg Ltd were showing a pocket-sized dosimeter, which is designed to give an audible warning of the

presence of X-rays or gamma radiation. The device, measuring only 19 × 50 × 120mm, has no external controls or contacts, so that there are no contamination catchpoints, and it cannot be switched off. Recharging is carried out by an inductive link between the dosimeter and a base station. The warnings are in the form of short bursts of sound whose repetition rate increases as the dose rate increases. By pre-programming at the base station, the unit can also give a continuous alarm signal when a preset cumulative dose level is exceeded. A further alarm indicates when the battery needs recharging. The instrument contains a geiger tube and two digital counting circuits, which perform the necessary alarm functions. Brandenburg Limited, Nuclear Engineering Division, 939 London Road, Thornton Heath, Surrey CR4 6JE.
WW 322

P.r.o.m. programmer

Microsystem Services launched two products at the show. The first, a p.r.o.m. programmer designated as the Model 7, is a portable machine which can be remotely controlled to programme all p.r.o.ms currently on the market. It will also perform a complete p.r.o.m. pre-test automatically or manually. The second product is a four-bit processor board, available in two versions known as the Pop-100 and the Pop-101. Both boards have space for up to six 1702A e.p.r.o.ms and the read/write memory is an 80 × 4 r.a.m., which is organized in 64 general-purpose four-bit registers and 16 addressed status registers. The boards have 13 priority-encoded input lines which are primarily intended for a keyboard interface. Type 101 is complete with an l.e.d. seven-segment readout, a numeric keyboard and three function keys. Microsystem Services, Duke Street, High Wycombe, Bucks.
WW 323

Hall-effect devices

Among the products at the show were a number of Hall-effect devices recently introduced by Sprague Electric UK Ltd. The ULN-3020T and the ULS-3020T are digital switches each consisting of a silicon Hall cell, amplifier, trigger, output stage and regulator. These devices operate from a 24V supply and have a sensitivity of 350 gauss. The ULN-3008M linear amplifier is a silicon monolithic i.c. with provision for gain and offset adjustment suitable for linear modulating systems. This device operates from a 16V supply. Another device, a digital dual-output switch designated as the ULN-3007M, can be interfaced directly with bipolar or m.o.s. logic circuits and will operate from 5 to 16V. Sprague Electric UK Limited, 159 High Street, Yiewsley, W. Drayton, Middx.
WW 324

Home Office cuts in monitoring facilities

Towards the end of the financial year, John Golding MP, Parliamentary Under Secretary of the Department of Employment, was asked by the assistant secretary of the Post Office engineering union to raise with the Home office the cessation of work for Post Office staff employed on radio investigation duties. According to the union, the restriction on interference investigations lasted for about three months, up to the end of the financial year, and included all work except that affecting the safety-of-life services.

A spokesman for the Home Office told *Wireless World* that problems had arisen due to government cash limits and a delay in their accounting process. This had resulted in work on most services, not including broadcasting, being stopped for a period of two to three weeks only. Asked whether this problem could recur he said that this was unlikely, but it was possible that there would be a reduction in general monitoring services throughout the new financial year. Meanwhile, however, the radio investigation services were functioning at full strength.

Optical fibre phone link

The second optical fibre link in the UK designed for a public service, a 9km high-capacity digital system eventually to carry telephone traffic between Hitchin and Stevenage, was demonstrated by a group of four ITT companies in April. Capable of handling 1,920 telephone conversations, it conveys information by pulse code modulation along the fibres at a rate of 140 Mbits/s between telephone exchanges at the two towns. (The first UK public service optical link was part of Rediffusion's radio and television cable distribution network at Hastings — see February News p.40.)

The 7mm diameter optical cable, containing a number of fibres, runs through normal telephone cables ducting between the two towns, at which the Post Office exchange buildings house the multiplexing and optical terminal equipment. Two repeaters are spaced at 3km intervals along the route. Each repeater has two regenerators, one for each direction of transmission. Altogether six gallium aluminium arsenide lasers are used in the system.

The cable comprises two working fibres, a spare fibre, four metal conductors (two of which carry power to the repeaters and two of which are "order wires" used by technicians) and a filler fibre that rounds out the cable mechanically. These eight cores are grouped round a central steel strength member and completely sheathed in polyethylene.

The new system works with standard multichannel digital multiplex equipment. Installation will be completed during the summer, and there will then be a period of testing, with test signals and speech, to demonstrate the system's ability to handle live telephone calls. (See WW, August 1976 p70).

News in brief

National Semiconductor bipolar f.e.t. **op-amps** are to be cheaper. The LF355/356/357 line is down to 52p from £1.45 for plastic packages in 100 lot quantities, and the hermetically sealed types, once £1.72, are now 73p.

Radio Prague has a new transmitter. At 355m its two masts at Liblice are the highest constructions in Czechoslovakia. The station broadcasts at 1.5MW on 638kHz. Radio Hvezda (Star) also has a new transmitter operating experimentally in Eastern Slovakia at 600kW.

The **soil sampler** on Viking 2 stopped while carrying out the final biology experiment, say NASA. The reason was the onset of the Martian winter, bringing temperatures near the freezing point of carbon dioxide (−123°C). The machine now waits for spring.

ERA is to do a three year study of methods of assessing industrially generated **harmonics in electricity supply** sytems.

Community Communications, a newly formed pressure group campaigning for better funding for **community communications projects** and more local access to and ownership of radio and tv, has set up a working party to respond to the Annan report. More information from Richard Dunn, 30 Golden Square, London W1.

Five aircraft, two Navy radar stations, two instrumentation towers and assorted bouys have been used to study the Pacific Ocean during March as part of the preparations for the launch of the Seasat A **oceanographic satellite** in May 1978. The study along the entire US Pacific coast was carried out by a team representing 23 government and academic groups with headquarters at the Scripps Oceanography Institute, La Jolla, California.

Metal detector

It appears that many readers are having difficulty in obtaining Vinkors for L_2 in this design. Circuit Services, of 36 Hallowes Crescent, South Oxhey, Herts., tell us that they are able to supply this component and also sets of components.

Ferro-Mag (Electrical) Ltd, of 2 Watkin Road, Wembley, Middlesex HA9 0LE, also tell us that they intend to manufacture coils for the L_2 position if they find there is sufficient interest.

Sidebands by mixer

The grand design

Feelings of wanting to pat policemen on the head and of irritation at long hair (". . . they should never have stopped conscription . . .") don't, at first glance, have a lot to do with integrated circuits. But any electronics enthusiast who has survived to his middle years (say ?!) with his enthusiasm undimmed will possibly recognise the connexion. The older you get, the more difficult it becomes to prevent yourself bringing forth remarks like "You don't mean to say you actually *buy* coils?" or "There was no such thing as a 'gain block' when I was your age – we had to build amplifiers." Pomposity, pontification, no doubt, but they're very hard to avoid.

All this head of steam began to build up when the writer started thinking about building an amateur v.h.f. transceiver. I looked at one or two designs and decided that they weren't suited to the attentions of one who can break two screwdrivers while mending a fuse. So the only thing to do was to design one: I've always had this belief that the paperwork and the cold chisel stuff are a lot more fun than actually using whatever it is you've made.

Like a fool, I mentioned what I was doing to a colleague, tender in years and possessing no respect for age. "You have to be joking!" he said. Well, I was on the defensive right away. Nothing is more calculated to stiffen the old neck and start the red mist rolling down than to tell me I'm joking when I'm not. Besides, I couldn't see what was funny about it.

"Nobody *designs* things like that any more," he said. "Get yourself half a dozen i.cs from Wundakit and the job's a good 'un." And, aside from the curious mode of speech these young people adopt, he was perfectly right. So I went off the idea of building a transceiver and started a book case instead.

Now, I will readily admit, if pressed, that I'm a square. Or any other regular lamina that it is currently fashionable to jeer at. But it does strike me as regrettable that the modern idea of designing a piece of equipment is to gather together a lot of ready-made, reach-me-down modules and fit them together in a manner somewhat like that adopted by a pre-school tot playing with its bricks. It's so *impersonal*.

But, I suppose, it would be unnatural to ignore the existence of i.cs. If one wants a calculator, or digital clock, or even a simple (!) operational amplifier and there is an i.c. to do the job it doesn't make very much sense to take up a cubic yard of space with discrete components. The question is, do experimenters get as much enjoyment out of an orderly row of black things with legs as they used to from two or three active and a lot of passive components. The real point about it all is that before i.cs came down to earth, amateur engineers were limited in their projects by cost and complexity. Now, they are not. At least, not to anything like the extent that they were. I mentioned "gain blocks" earlier – operational amplifiers which have a high enough gain to make a feedback amplifier almost totally independent of amplifier characteristics. You just use them as any other component. Years ago, the design and construction of this "component" and then the period during which it wouldn't stop oscillating, took up most of the first half of a project, and then the gain wasn't really enough because that was how you'd stopped it oscillating.

So, being freed from all that basic stuff, perhaps the experimenter can go on to design really exotic machinery which would just not have been a runner BIC (before integrated circuits). Well, to some extent, this does happen. A teletext decoder BIC would have been quite some device and a calculator or microprocessor not economically possible. But, apart from these and a few video games, where are the large-scale projects? If you compare the complexity of a 1950 amplifier with one built in the days when a grid leak resistor was a pencil line of the right thickness drawn on the wooden chassis and then compare a 1977 design with the 1950 one, the returns are seen to be diminishing.

It seems to me that there are two aspects of i.cs that can be exploited by the amateur. They can be used to build equipment smaller and cheaper and more easily than was previously possible or, with a comparable amount of sweat and effort that used to be necessary, they can make possible a whole new sweep of supergear. If a TV receiver could be made with 15 valves, a few hundred transistors ought to be capable of something quite remarkable. Perhaps a television tuner that reacts to the merest hint of a thought pattern or a car that will, on detecting a muttered "Home, James" glide silently off into the night. A prize of 10p will be given to the inventor of the most earth-shattering equipment of 1977, provided that a complete, working unit is submitted.

Oil in the head

I listened, some weeks ago, to the BBC's "binaural" recording of a feature programme on the oil rig "Sea Quest" and was very favourably impressed. The main improvement, to my mind, that this technique affords is the removal of sound from inside the head to its more usual location in the world outside. The headphones I used (the technique makes very little difference to the sound reproduced from speakers) were the "closed" kind, with rubber cushions and a solid unit completely insulating the ears from outside sources. The previous recording I had heard using this "dummy head" method was the Sennheiser demonstration disc, the presenter of which emphasized that the effect of being involved in the proceedings rather than an onlooker was due to the "open" headphones, not the recording technique. Whatever the cause, and no doubt my learned colleagues will have something to say about that, the result is a vivid experience and I advise anyone who missed the broadcast to hear the next one.

Tele-what?

As an (alleged) nation of shopkeepers, you would think that we would have a rather better developed eye for the main chance, wouldn't you? It is now several years since the IBA and BBC came up with Oracle and Ceefax (and the P.O. with Viewdata) and embarked on the experimental period of transmissions, but the set makers are still waiting for an economic way of using the facility. Only the enthusiast, like several hundred of our readers, is able to spend time (which equals money, to the accountant) assembling a hundred or so t.t.l. i.cs to make a decoder. A manufacturer must have either a ready-made board or a maximum of half a dozen i.cs before he can produce a teletext receiver at a price most customers are willing to pay.

So where are they? Our engineers at the broadcasting organizations and the Post Office have presented us with a brand new communications facility which could very well be no end of a good thing for the export market when the Continentals catch on, and the semiconductor people hang about as if there were all the time in the world. Texas Instruments have Tifax XM11 in production at about 1000 units a month and some set makers will use this. Although being the first module to emerge, it doesn't have the latest control facilities and is not Viewdata-compatible, although the newer DM11 is updated. Mullard are reported to be handing out a clutch of teletext chips to interested parties, but, when asked to confirm this, giggle in a hunted sort of way and mutter "Later, later . . ." G.E.C., Plessey and ITT and no doubt several other firms are in the field, but have nothing to offer yet. Still, there are always the Japanese – maybe they'll cobble a decoder together one weekend and flood the market with it, thereby absolving our lot from further worry.

WW — 019 FOR FURTHER DETAILS

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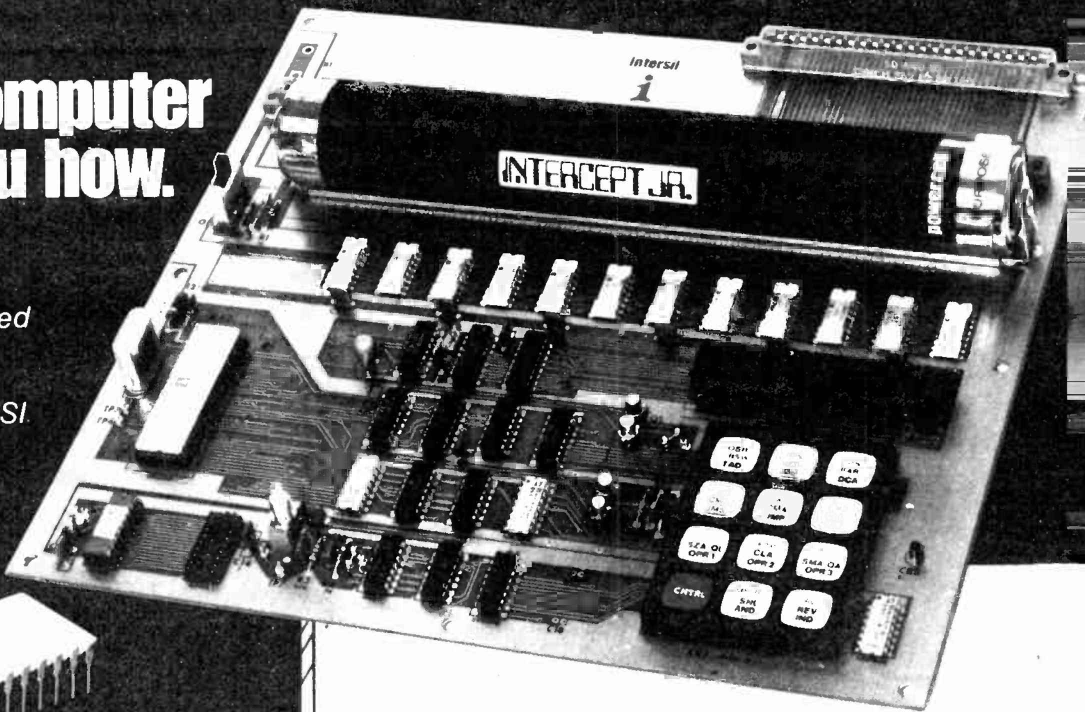

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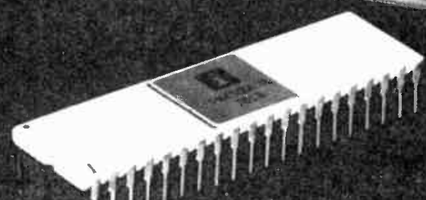

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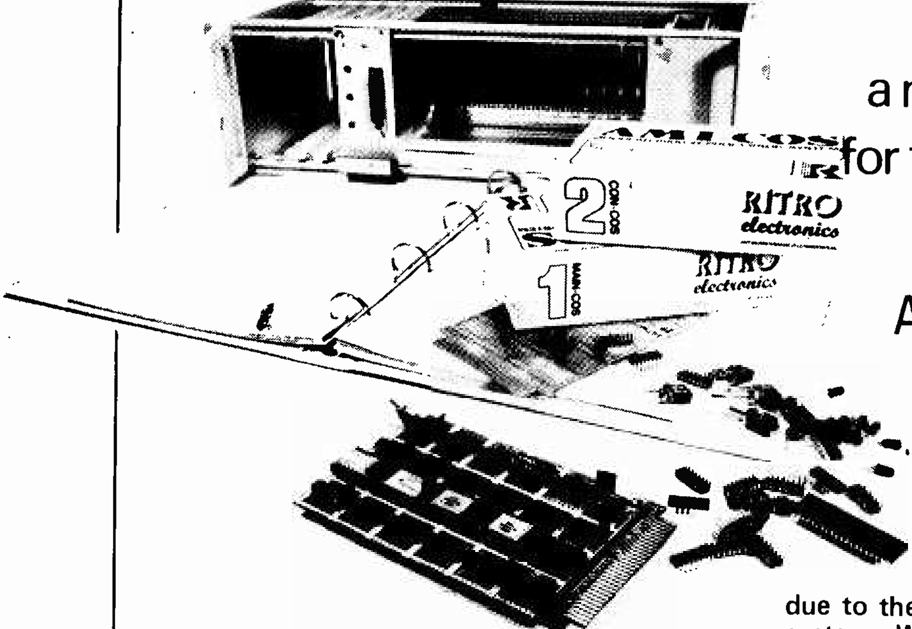

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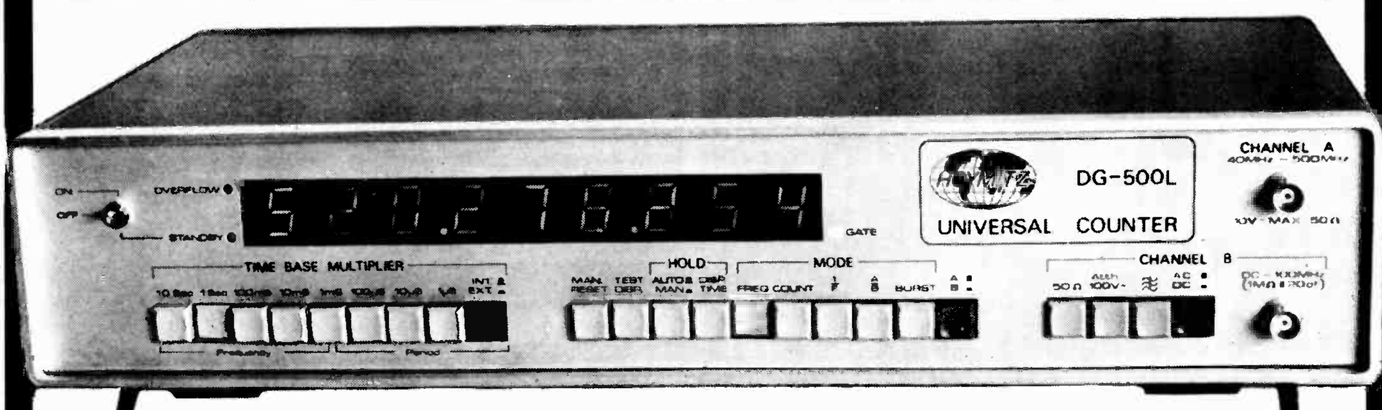

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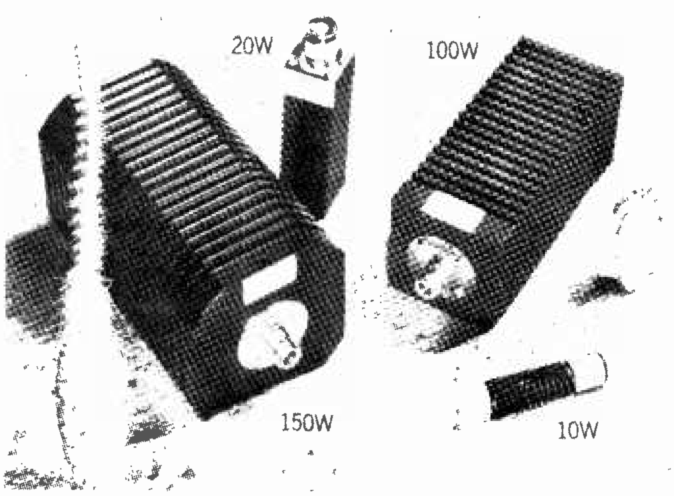

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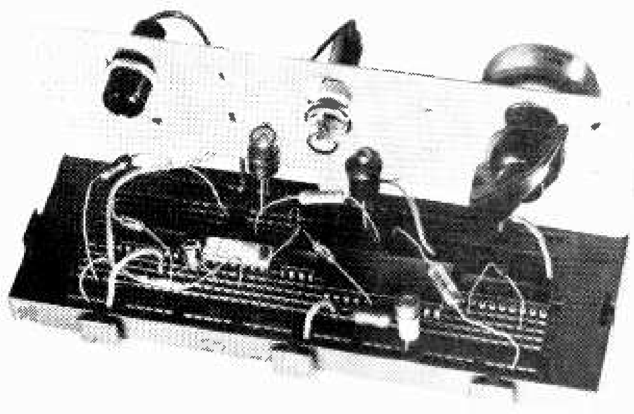

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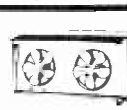
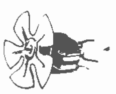


DUAL EXTRACTOR FAN. 240v 50 Hz Two thick stack shaded pole motors make this a highly efficient unit producing a powerful airflow Mounted in heavy steel frame each has five element 6½ blades Size 22½" x 14" x 5½" deep **£10.95.** carr £2 75



SINGLE FAN with motor similar to above Very useful in home and workshop Remember last summer Keep cool this year **Only £3.95.** p&p 65p

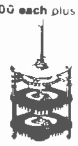
PROGRAMME TIMERS

Magnetic Devices Ltd Synchronous 230V 50Hz motor geared down to 1 rev per 8 hours Drives shaft mounting three cams, each of which actuates an on/off micro-switch with 10 amp contacts Any switch can be set to remain on from 4 to 8 hrs Push-on connections Overall size 4½" x 4½" x 3⅜" **£4.75** plus 85p p & p Ideal for switching on and off radios and lights as burglar deterrent in unoccupied premises

Smiths 200/250V synchronous motor geared down to 40 r p m Size 2½" x 2½" x 1½" **£2.25** each plus 25p p & p **4 or more £1.50 each** plus 70p p & p per pack of 4

Midgley Harmer Ltd 200 250v synchronous motor geared to 1 rev per 7½ mins All dimensions 2¼" **£1.50** each plus 25p p & p **4 or more £1.00 each** plus 48p p & p per pack of 4

ROTARY STUD SWITCH



PLESSEY. 30 way 2 bank Single pole Contacts 1 amp 240v AC DC 005Ω res Break before make Stop infinitely adjustable allowing for any desired arc of travel Ideal for instrument and model switching Size 2⅛" dia overall x 2⅛" deep plus 1⅝" x ¼" dia spindle **£2.25.** p&p 20p **5 off £1.95 each.** p&p 40p

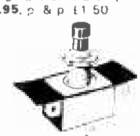
UNI-SELECTOR

240v AC or DC operation Split 30-way double bank contacts Overall size approx 2¾" dia x 2½" deep Brand new Bargain at **£4.50.** p&p 65p

TRANSFORMERS

DAVENSET AUTO
2KVA continuously rated Tapped for any voltage from 5 260v in steps of 5v With an isolated winding of 0-5-10v at 8½ amps this transformer is an extremely useful buy Push-on connections Size 8" x 5¼" x 6½" A really robust job Bargain at **£23.50.** Carr £3 00
750VA continuously rated Tapped as above with 0-5 10V isolated winding of 5 amps Same connections Size 4½" x 3¾" x 4¼" Also bargain at **£12.50.** Carr £2 00
GRESHAM
Pri 10-0 200 220 240v Sec tapped 0 3½ 7 11 32 33 34-35 at 10 amps to give 24 useful voltages **£6.00** carr £1 00
TORROIDAL
Pri 15 0-210-240v Sec 140v at 35 m/a 31v at 500 m/a c t 10v at 1 9 amps Scr Size 3½" dia x 1½" **£3.95** p & p 30p
MINIATURE
Pri 240V Sec 6v at ½ amp Size 1¾" x 1½" x 1¼" Ideal as power supply base for models, radios, cassettes, etc **£1.50** ea p & p 20p 6 off £1 00 ea p & p 45p
GOODYEAR 1KVa automatic transformer 0 110 115-120-200-220-240v Fully shrouded Terminal block connections Size 5" x 4¼" x 5½" plus block cannot be bettered at **£13.95.** p & p £1 50

ARROW SWITCH



Press on off Single hole fixing SP ST Size 1⅞" x ⅞" Stud extends ½" Rated 1 amp at 240v 2½ amps at 125v Price for 5 (min qty) **£1.75** p & p 30p 10 or more 30p each p & p 40p

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Glass encaps N o contacts Glass length 1 " dia ⅛ overall length 1" 10 off £1 00 p & p 25p **100 off £8.00,** p & p free **1000 off £68.00,** p & p free

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Complete with magnet contacts M C 3 amp vacuum sealed 1¼" x ¼" dia

10 for £2.50
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Plus 50p p & p any quantity

MOTORS

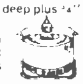
CITENCO F.H.P. reversible geared motor 220/240v 50 Hz 1 Ph cap start cont rating 0 2 amps Gearing 144/1 final drive 19 rms Torque 14 5 Kg/cm 5/16" dia shaft Size 6" x 3⅞" dia plus base Brand new Limited quantity **£16.50.** p&p £1 50

CROYDON 1/10 HP. reversible motor 230 240v 50 Hz 1 Ph Cap start Cont rating 1500 rpm ⅜" dia shaft Size 8" x 4¼" dia plus base New **£17.50.** carr £3 00

1/8 HP. reversible geared motor 220/240v 50 Hz 1 Ph cap start, cont rating Gearing 5 1 Final drive approx 280 rpm ⅜" dia shaft Size 14" inc gearbox x 5½" dia plus cap and base New Robust £23 95 carr £3 00

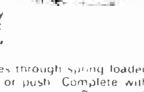
ACADEX shaded pole motor Open frame 230v 50 Hz Double ended 5/32" dia spindle each 1¾" long Ideal for fans models etc Size 1¾" x 2⅛" x 1⅛" deep plus spindles **£1.50** p&p 45p

CROUZET shaded pole motor Open frame 115/230v 50 Hz 1425 rpm Size 2½" x 2¾" x 1⅜" deep plus ¼" long x 5/32" dia spindle **£3.50** p&p 62p



PAPST motors. Noted for advanced design and superb construction Rotating diecast outer body acts as flyweight and eliminates wow and flutter 50 Hz capacitor start
MODEL HSKZ 32 80-6/12 220v Dual speed tape deck motor 500/1000 rpm 12 mm drive shaft gives tape speeds of 9 53/19 05 cm/sec (3¾/7½ ins sec) respectively Size approx 5½" dia x 3½" plus 1⅜" spindle **£16.50.** p&p £1 10
MODEL RO 32 65-4 Dual voltage 125/250v Size 2⅞" x 3⅛" Spindle 5/16" dia **£12.50.** p&p £1 10
MODEL HSZ 20 25-2 Basically 42v but can be operated from mains with additional capacitor A magnificent small motor Size 1⅜" x 2⅜" spindle 5/16" dia **£5.95.** p&p 45p

SOLENOIDS 240V A.C.



MAGNETIC DEVICES LTD No 1) has 20lb pull for 50% duty. 1½" travel push or pull Shackle both ends Size 1¼" wide x 3⅛" high x 4" long plus 3" arm travel **£6.75** plus p & p £1 00
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Type No.	CPS 40	SPS 5	SPS 7W	SPS 9(1)
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O/p volts	4.5/5.5 (3)	4.5/6.0 (3)	12/18	4.5/6.0 (3)
Amps. Max	1.25	2.0	0.5 (2)	10.0
Ripple (4)	0.5	0.5	0.15	0.1
Regulation %	0.02	0.02	0.005	0.02
Price	£14.00	£26.00	£28.00	£51.00
Carr/p. & p.	60p	£1.20	£1.20	£1.20

Notes (1) Programmable (2) Each rail (3) Zero volts protection (4) Pk Pk M V All have stability of 10 000 1 current limiting re-entrant and output impedance of 0 25Ω at 100 KHz

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A	3MM	5-6V 60 MA	D	3MM	2 5V 360 MA
B	4MM	4v 250 MA			5 6 60 MA
		5V 60 MA	E	4MM	6V 200 MA
		12V 40 MA			6 3 200 MA
		12V 100 MA			14V 40 MA
		14V 75 MA	F	4MM	2 7V 60 MA
		28V 40 MA			12V 160 MA
C	5MM	28V 40 MA			14V 80 MA
G	Small telephone jack type 6 or 24V				

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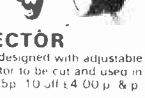
Dozens of uses in Home Farm Workshops & Lab



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Snap action 5 amps at 240 410 A C size base 3⅛" x 1⅛" x 1⅛ plus heavy duty roller plunger 1¼" ext or 1" when compressed Very robust for tireless operation weather proof Price **£2.20** plus p & p 40p

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Self priming Works from electric drill or suitably powered motor for ¼" drive shaft ½" hose connections Through put 2 3 galls per min at 2400 rpm Dozens of uses in home and workshop Giveaway at £2 75 p&p 20p

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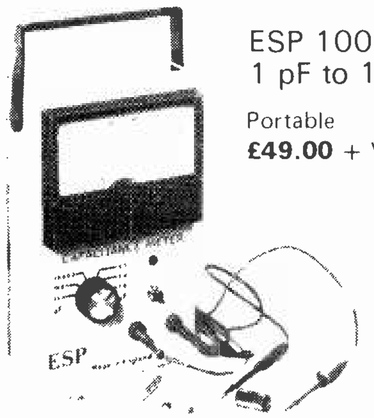

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1 pF to 10 μF

Portable
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Wide scale
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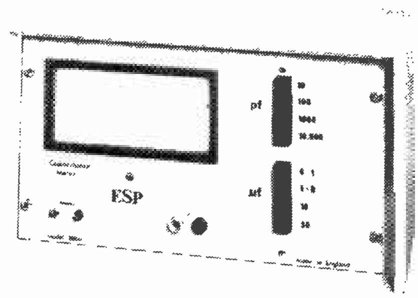

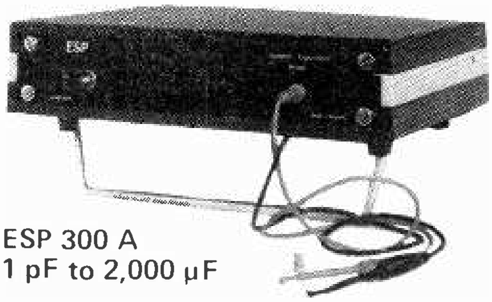

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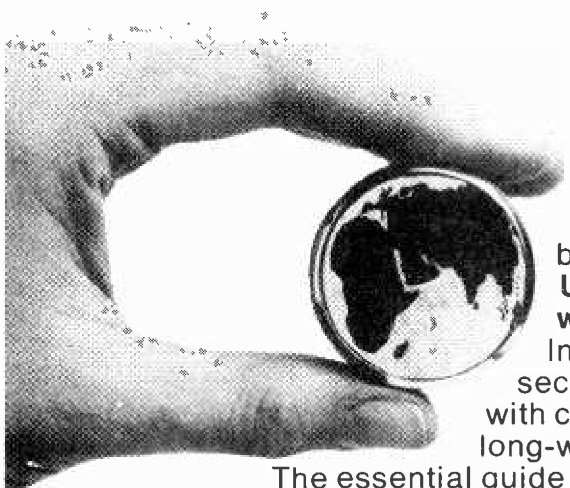

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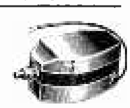

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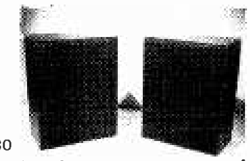

Size 14½in x 9¾in x 6in 50 to 14,000 cps 8 watts rms 8 or 4 ohms

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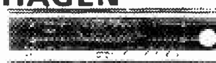

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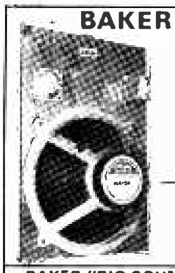

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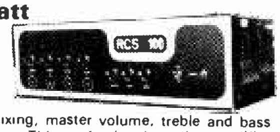

Four inputs. Four way mixing, master volume, treble and bass controls. Suits all speakers. This professional quality amplifier chassis is suitable for all groups, disco, P.A., where high quality power is required. 5 speaker outputs. A/C mains operated. Slave output socket. Produced by demand for a quality valve amplifier. 100V line output to order. Send for leaflet. Suitable carrying cab **£14.** Price **£85** carr. £2.50

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

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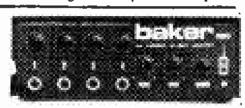

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100 WATT DISCO AMPLIFIER CHASSIS

volume, treble, bass controls. 500 M.V. or 1 volt input. Four loudspeaker outputs 4 to 16 ohm. All transistor **£52**

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BALANCED TWIN RIBBON FEEDER 300 ohms. 5p yd.
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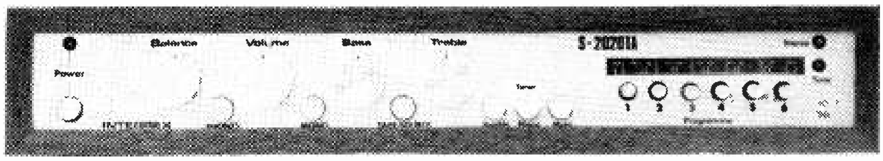
S-2020TA STEREO TUNER/AMPLIFIER KIT

SOLID MAHOGANY CABINET



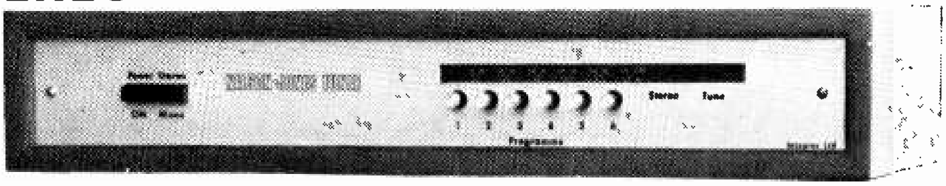
A high-quality push-button FM Varicap Stereo Tuner combined with a 24W r.m.s. per channel Stereo Amplifier.

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.

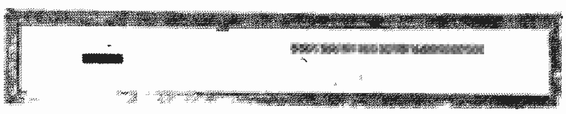


Brief Spec. Tuning range 88–104MHz. 20dB mono quieting @ 0.75μV. Image rejection – 70dB. IF rejection – 85dB. THD typically 0.4%.
IC stabilized PSU and LED tuning indicators. Push-button tuning and AFC unit. Choice of either mono or stereo with a choice of stereo decoders.

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

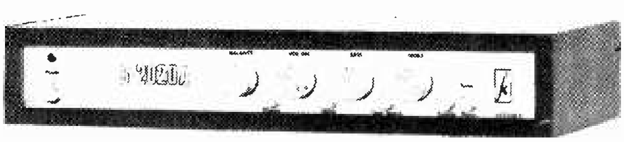


A low-cost Stereo Tuner based on the 3302 FET RF module requiring no alignment. The IF comprises a ceramic filter and high-performance IC Variable INTERSTATION MUTE. PLL stereo decoder IC. Pre-decoder 'birdy' filter

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

PRICE: Stereo £31.95+VAT

S-2020A AMPLIFIER KIT



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

Power 'on/off' FET transient protection.

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

PRICE: £33.95+VAT

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

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CA3030	1.24	LM387N	1.05	NE567	1.80	TAA621	2.15	TCA730	3.22	5A 200V	0.40
CA3036	0.97	LM388N	1.00	SAS560		TAA661B	1.32	TCA740	2.76	5A 400V	0.49
CA3045	1.40	LM389N	1.00	SAS570		TAA700	3.91	TCA750	2.30	8A 100V	0.43
CA3046	0.89	LM702C	0.75	SO42P		TAA930A	1.00	TCA760	1.38	8A 200V	0.49
CA3048	2.23	LM709C	0.65	76001N	1.57	TAA930B	1.05	TCA800	3.13	8A 400V	0.62
CA3049	1.66	LM709N	0.45	76003N	2.55	TAD100	1.95	UAA170	2.00		
CA3052	1.62	LM710C	0.60	76008K	2.50	TBA120	0.65	UAA180	2.00		
CA3053	0.60	LM710N	0.60	76013N	1.70	TBA400	1.50	CD4000	0.20	**BRIDGE**	
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CA3086	0.51	LM741C	0.65	76023N	1.70	TBA510	2.21	CD4006	1.10	W01	0.33
CA3088	1.59	LM741N	0.50	76023ND	1.57	TBA510Q	2.30	CD4007	0.20	W02	0.34
CA3089	2.52	LM741-8	0.40	76033N	2.55	TBA520	2.21	CD4008	0.97	W04	0.40
CA3090	3.80	LM747N	0.90	76110N	1.46	TBA520Q	2.30	CD4009	0.57	W06	0.50
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LM304	2.45	LM1808	1.92	76226N	1.94	TBA540Q	2.30	CD4013	0.57	B80C1500	0.75
LM307N	0.65	LM1828	1.75	76227N	1.51	TBA550	3.13	CD4014	1.01	B80C3200	1.15
LM308N	1.17	LM3301N	0.85	76228N	1.75	TBA55DQ	3.22	CD4015	1.01		
LM309K	2.10	LM3302N	1.40	76530N	0.91	TBA560Q	3.22	CD4016	0.56		
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LM323K	6.40	LM3905	1.60	76544N	1.44	TBA641Q	2.50	**SOCKETS**		**LEDs**	
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LM348N	1.91	MC1035	1.75	76546N	1.44	TBA700	1.52	14 Pin	0.16	5mm Red	0.20
LM360N	2.75	MC1303	1.47	76550N	0.41	TBA700Q	1.61	16 Pin	0.18	3mm Grn	0.25
LM370N	3.00	MC1305	1.85	76552N	0.65	TBA720Q	2.30	22 Pin	0.30	5mm Grn	0.26
LM371N	2.25	MC1306	1.00	76570N	2.08	TBA750	1.98	24 Pin	0.35	3mm Yel	0.25
LM372N	2.15	MC1310	1.91	76620N	1.10	TBA750Q	2.07	28 Pin	0.45	5mm Yel	0.26
LM373N	2.25	MC1312	1.98	76650N	1.10	TBA800	1.20	40 Pin	0.55		
LM374N	2.25	MC1327	1.54	76660N	0.60	TBA810	1.16	**TRIACS**			
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AF239	0.74	2N706	0.24	2N2924	0.15	2N3662	0.23	2N3906	0.22	2N5457	0.32
ASY28	1.20	2N718	0.27	2N2926G	0.13	2N3663	0.26	2N3962	0.85	2N5458	0.33
ASY55	0.65	2N914	0.35	2N2926Y	0.13	2N3702	0.17	2N4058	0.20	2N5485	0.38
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BC167B	0.12	2N1483	1.20	2N3108	0.50	2N3706	0.16	2N4125	0.17	40311	0.45
BC169B	0.12	2N1613	0.35	2N3133	0.45	2N3707	0.18	2N4250	0.24	40363	1.20
BC171B	0.15	2N1711	0.37	2N3392	0.16	2N3708	0.16	2N4266	0.20	40673	0.73
BC182	0.11	2N1893	0.38	2N3393	0.15	2N3709	0.18	2N4284	0.35	AC126	0.37
BC182L	0.14	2N2060	5.00	2N3417	0.40	2N3710	0.16	2N4286	0.20	AC127	0.44
BC184L	0.14	2N2219	0.30	2N3439	0.88	2N3711	0.18	2N4288	0.20	AC152	0.50
BC212A	0.14	2N2221	0.22	2N3441	0.85	2N3771	1.85	2N4403	0.18	AC153	0.49
BC214L	0.16	2N2222	0.25	2N3553	1.05	2N3773	2.90	2N4822	0.75	AC187K	0.55
BD135	0.37	2N2222A	0.25	2N3565	0.15	2N3794	0.20	2N4916	0.20	AC188K	0.55
BF195	0.13	2N2368	0.25	2N3566	0.15	2N3819	0.36	2N5129	0.20	ACY22	0.40
BFX84	0.40	2N2369	0.25	2N3567	0.17	2N3854A	0.25	2N5192	0.75	ACY30	0.60
BFY51	0.38	2N2646	0.75	2N3571	3.70	2N3856A	0.25	2N5222	0.18	AF106	0.55
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Miniature type (22mm diam.) Counting up to 15 turn 'Helipots'. Brand new with mounting instructions. Only **£2.50 each**

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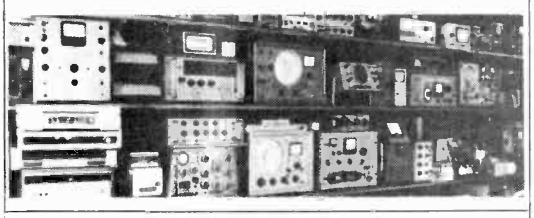
NOTICE. All the pre-owned equipment shown has been carefully tested in our workshop and reconditioned where necessary. It is sold in first class operational condition and most items carry our three months' guarantee. Calibration and certificates can be arranged at cost. Overseas enquiries welcome. Prices quoted are subject to an additional 8% VAT.



HEWLETT PACKARD 432A. Power meter
BRANDENBURG 0-20KV EHT Gen. **£105**
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HEWLETT PACKARD 431C power meter **£125**
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TEKTRONIX type 575 Transistor curve tracer
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Midget crystal clock type XSZ. BN 15221.
Selective UHF v/meter, bands 4&5. USVF.
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ICL type 2640 Paper tape readers 250cps New **£95**
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Made by Rotron Holland. These are very high quality quiet running fans, specially designed for the cooling of all types of electronic equipment. Measures 4.5x4.5x1.5. 115V AC. 11 Watts. The list price of these is over £10 each. We have a quantity available brand new for only **£4.50 each**

500V TRANSISTORISED INSULATION TESTER

Lightweight small size (13x7x4cms). Reads insulation from 0.2-100MΩ at 500V pressure. Runs from standard 9V PP3. Brand new **£16.50**

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Type Multi-minor Mk 4. Light, small size instrument (14x9x3½ cms). Measures volts AC. DC to 1KV. DC 1 from 0.1mA-1A. Resistance ranges 10KΩ V DC 1KΩ VAC. Tested and in excellent condition **£8.50**

MUIRHEAD DECADE OSCILLATORS type 890A.

1Hz-110kHz in four decade ranges. Scope monitored output for high accuracy of frequency. Excellent generator. £135.

WW — 075 FOR FURTHER DETAILS

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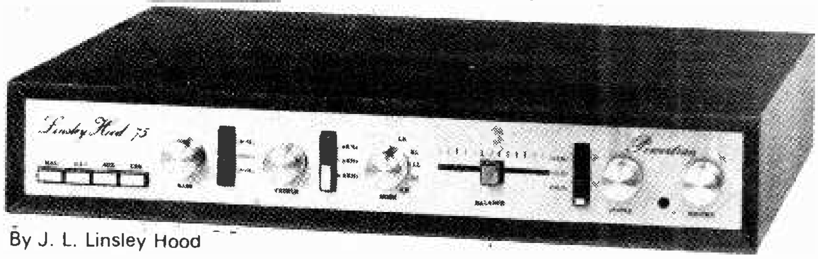
POWERTRAN ELECTRONICS INCORPORATING AMBIENTACOUSTICS

HI-FI NEWS 75W/CHANNEL AMPLIFIER



By J. L. Linsley Hood

In Hi-Fi News there was published by Mr Linsley-Hood a series of four articles (November, 1972-February, 1973) and a subsequent follow-up article (April, 1974) on a design for an amplifier of exceptional performance which has as its principal feature an ability to supply from a direct coupled fully protected output stage, power in excess of 75 watts whilst maintaining distortion at less than 0.01% even at very low power levels. The power amplifier is complemented by a pre-amplifier based on a discrete component operational amplifier referred to as the Liniac which is employed in the two most critical points of the system, namely the equalization stage and tone control stage, positions where most conventional designs run out of gain at the extremes of the frequency spectrum. Unusual features of the design are the variable transition frequencies of the tone controls and the variable slope of the scratch filter. There is a choice of four inputs, two equalized and two linear, each having independently adjustable signal level. The attractive slimline unit pictured has been made practical by highly compact PCBs and a specially designed Toroidal transformer.

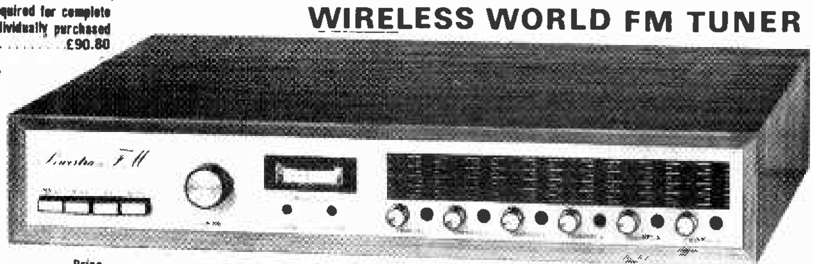
Pack		Price
1.	Fibreglass printed-circuit board for power amp	£1.15
2.	Set of resistors, capacitors, pre-sets for power amp	£2.50
3.	Set of semiconductors for power amp	£6.50
4.	Pair of 2 drilled, finned heat sinks	£1.10
5.	Fibreglass printed-circuit board for pre-amp	£1.90
6.	Set of low noise resistors, 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, semi-conductors for power supply	£5.40
13.	Set of miscellaneous parts including DIN skts, mains input skt, fuse holder, inter-connecting 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 system. Total cost of individually purchased packs £90.80

FREE TEAK CASE WITH FULL KITS

KIT PRICE ONLY **£79.80**

WIRELESS WORLD FM TUNER



Designed in response to demand for a tuner to complement the world-wide acclaimed Linsley Hood 75W Amplifier, this kit provides the perfect match. The Wireless World (Skingley and Thompson — April, May 1974) 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

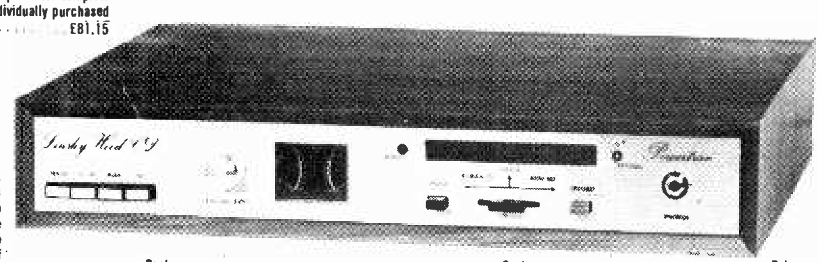
Pack		Price
1.	Fibreglass printed board for front end IF strip, demodulator, AFC and mute circuits	£2.15
2.	Set of metal oxide resistors, thermistor, capacitors, cermet preset for mounting on pack 1	£4.80
3.	Set of transistors, diodes, LED, integrated circuits for mounting on pack 1	£5.25
4.	Pre-aligned front end module, coil 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 metal work parts including silk screen printed facia 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 10.3" 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

FREE TEAK CASE WITH FULL KITS

KIT PRICE only **£70.20**

LINSLEY-HOOD CASSETTE DECK



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

Pack		Price
1.	Stereo PCB (accommodates 2 rep. amps, 2 rec. amps, 2 meter amps, bias/erase osc. relay)	£3.35
2.	Stereo set of capitors, M.O. resistors, potentiometers for above	£9.80
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	£21.95
7.	Function switch, knobs	£1.90
8.	Dual VU meter with illuminating lamp	£8.70
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 facia 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 compete stereo cassette deck. Total cost of individually purchased packs £90.05

SPECIAL PRICE FOR COMPLETE KITS £85.90

PRICE STABILITY

Order with confidence! Irrespective of any price changes we will honour all prices in this advertisement for two months from issue date provided that this advertisement is quoted with your order. E&OE VAT rate changes excluded.

All components are brand new first grade full specification devices. All resistors (except where stated) are low noise carbon film types. All printed circuit boards are fibre-glass, drilled, roller tinned and supplied with circuit diagrams and construction layouts.

Value Added Tax not included in prices.

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AUDIO KIT SUPPLIERS TO THE WORLD

T20+20 and our new T30+30 20W, 30W AMPLIFIERS

Designed by Texas engineers and described in Practical Wireless the Texan was an immediate success Now developed further in our laboratories to include a Toroidal transformer and additional improvements, the slimline T20 + 20 delivers 20W per channel of true Hi-Fi at exceptionally low cost The design is based on a single F/Glass PCB and features all the normal facilities found on quality amplifiers, including scratch and rumble filters, adaptable input selector and head phones 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 new model is 30W 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	7.25
8. Toroidal transformer — 240V prim. e.s. screen	5.60	7.20
9. Fibreglass PCB	3.50	3.90
10. Set of metalwork, fixing parts	5.20	6.20
11. Set of cables, mains lead	0.40	0.40
12. Handbook (free with complete kit)	0.25	0.25
13 Teak cabinet 15.4" x 6.7" x 2.8"	4.50	4.50

SPECIAL PRICES FOR COMPLETE KITS!

T20+20 KIT PRICE only **£34.20**

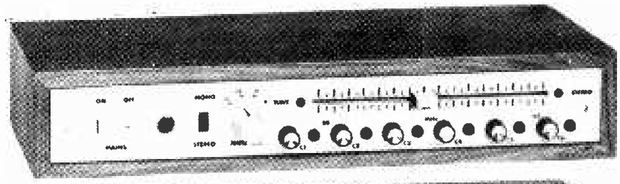
T30+30 KIT PRICE only **£39.50**

2 MATCHING TUNERS!

WW SFMT II

Following the success of our Wireless World FM Tuner kit we are now pleased to introduce our new cost reduced model, designed to complement the T20 and T30 amplifiers The frequency meter of the more advanced model has been omitted and the mechanics simplified, however the circuitry is identical and this new kit offers most exceptional value for money. Facilities included are switchable afc, adjustable, switchable muting, channel selection by slider or readily adjustable pre-set push-button controls and LED tuning indication Individual pack prices in our free list.

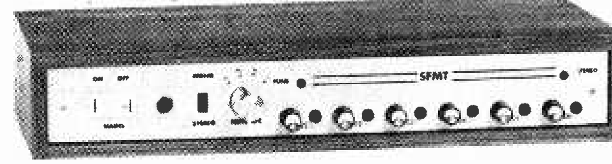
KIT PRICE **£47.70**



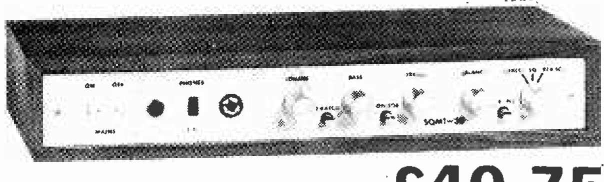
POWERTRAN SFMT

This easy to construct tuner using our own circuit design includes a pre-aligned front end module, PLL stereo decoder, adjustable, switchable muting, switchable afc and push-button channel selection. As with all our full kits, all components down to the last nut and bolt are supplied together with full constructional details

KIT PRICE **£35.90**



CONVERT NOW TO QUADRAPHONICS!



SQM1 — 30 KIT PRICE £40.75

With 100s of titles now available no longer is there any problem over suitable software. No problems with hardware either. Our new unit the SQM1-30 simply plugs into the tape monitor socket of your existing amplifier and drives two additional speakers at 30W per channel A full complement of controls including volume, bass, treble and balance are provided as are comprehensive switching facilities enabling the unit to be used for either front or rear channels, by-passing the decoder for stereo-only use and exchanging left and right channels. The SQ matrix decoder is based upon a single integrated circuit and was designed by CBS whilst the power and tone control sections are identical to those used in our T30 + 30 amplifier which the SQM1-30 matches perfectly Kit price includes CBS licence fee

SQ is a trade mark of CBS Inc

Special offer to T20 + 20 and Texan owners!
Owners of T20 + 20 and Texan amplifiers, which have no tape monitor outlet, purchasing an SQM 1-30 will be supplied on request, a free conversion kit to fit a tape monitoring facility to the existing amplifier. This makes simple the connection to the highly adaptable SQM 1-30 quadrophonic decoder/rear channel amplifier.

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 rumble filters and wide range tone controls which may be either rotary or slider operating For those intending to get the best out of their speakers, we also offer an active filter system described by D C Read, which splits the output of each channel from the pre-amplifier into three channels each of which is fed to the appropriate speaker by its own power amplifier. The Read/Texas 20W, or any of our other kits are suitable for these 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
Active Filter	
FILT Pk 1 F/Glass PCB	£1.40
FILT Pk 2 Resistor, Capacitor set (metal oxide 2%, polystyrene 2½%)	£4.20
FILT Pk 3 Semiconductor set	£2.25
2 off Pks 1, 2 3 rqd for stereo sctive filter system	
Read/Texas 20W Amp	
READ Pk 1 F/Glass PCB	£1.00
READ Pk. 2 Resistor, Capacitor set	£1.20
READ Pk 3 Semiconductor set	£2.30
6 off pks 1, 2, 3 required for stereo active filter system	
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

Further details of above and additional packs given in our FREE LIST

SQ QUADRAPHONIC DECODERS

Feed 2 channels (200-1000mV as obtainable from most pre-amplifiers or amplifier tape monitor outlets) into any one of our 3 decoders and take 4 channels out with no overall signal level reduction On the logic enhanced decoders Volume, Front-Back, LF-RF balance, LB-RB balance and Dimension controls can all be implemented by simple single gang potentiometers

These state-of-the-art circuits used under licence from CBS are offered in kits of superior quality with close tolerance capacitors, metal oxide resistors and fibre-glass PCBs designed for edge connector insertion. All kit prices include CBS licence fee

M1 Basic matrix decoder with fixed 10-40 blend All components, PCB . . . **£5.90**

L1 Full logic controlled decoder with "wave matching" and "front back logic" for enhanced channel separation. All components PCB **£17.20**

L2A. More advanced full logic decoder with "variable blend" for increased front back separation. All components, PCB . . . **£22.60**

L3A Decoder similar to L2A but with discreet component front end with high precision 6-pole phase shift networks for increased frequency response. All components (carbon film resistors), PCB . . . **£25.90**

Also available with M.O. resistors, cermet pre-set — add . . . **£4.20**

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2N3055	£0.45	BC109C	£0.12	BFR39	£0.30	MPSA14	£0.30	TIP41A	£0.70
2N3442	£1.20	BC125	£0.15	BFR79	£0 30	MPSA55	£0.25	TIP42A	£0.80
2N3711	£0.09	BC126	£0.15	BFY51	£0.20	MPSA65	£0.35	TIP41B	£0.75
2N3904	£0.17	BC182	£0.10	BFY52	£0.20	MPSA66	£0.40	TIP42B	£0.90
2N3906	£0.20	BC212	£0.12	CA3046	£0.70	MPSU05	£0.50	1N914	£0.07
2N5087	£0.25	BC182L	£0.10	LP1186	£6.50	SBA750A	£1.90	1N916	£0.07
2N5457	£0.45	BC184L	£0.11	MC1310	£2.20	SL301	£1.30	IS920	£0.10
2N5459	£0.45	BC212L	£0.12	MC1351	£1.05	SL3045	£1.20		
2N5461	£0.50	BC214L	£0.14	MC1741CG	£0.65	SN72741P	£0.40	FILTERS	
2N5830	£0.35	BCY72	£0.13	MFC4010	£0.95	SN72748P	£0.40	FM4	£1.00
40361	£0.40	BD529	£0.55	MJ481	£1.20	TIL209	£0.20	SFJ10 7MA	£1.50
40362	£0.45	BD530	£0.55	MJ491	£1.45	TIP29A	£0.40		
BC107	£0.10	BDY56	£1.60	MJE521	£0.60	TIP30A	£0.45		

EXPORT NO PROBLEM

Our Export Department will be pleased to advise on postal costs to any country in the world. Some of the countries to which we sent kits in 1976 are shown surrounding this advertisement.

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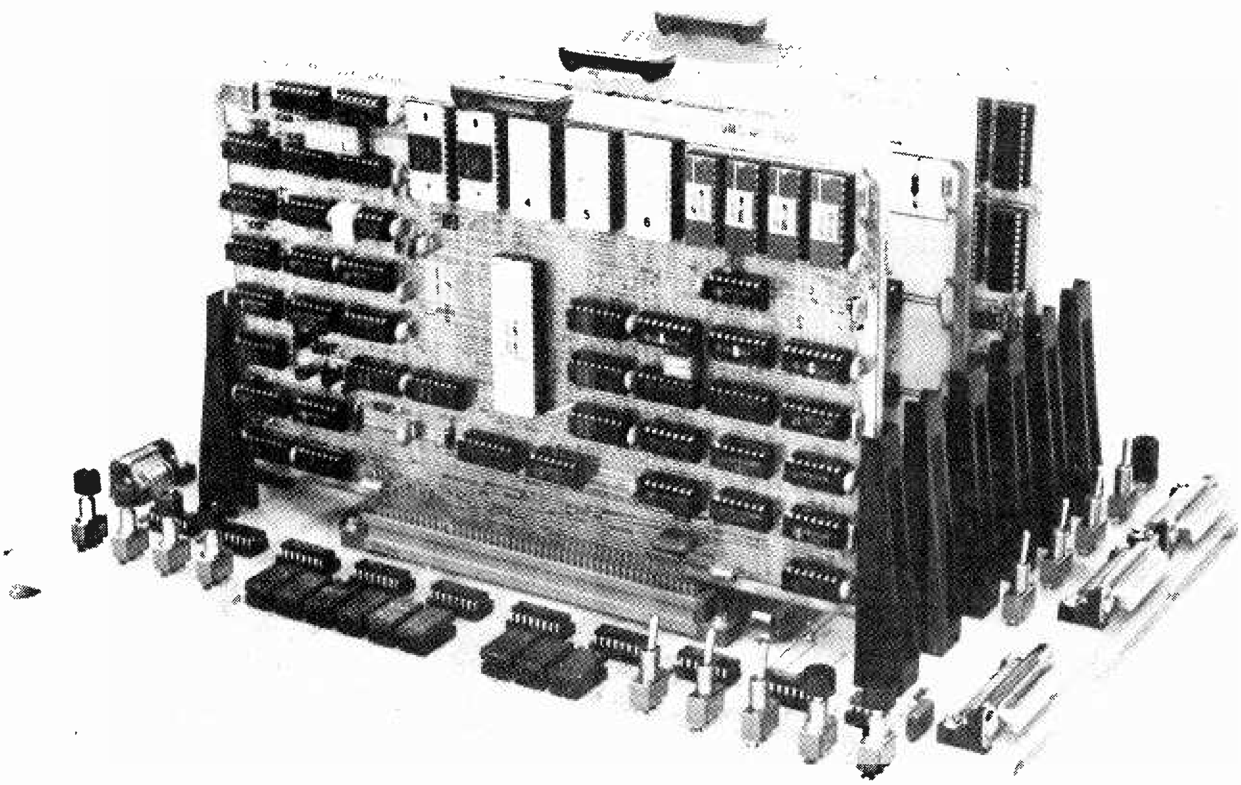

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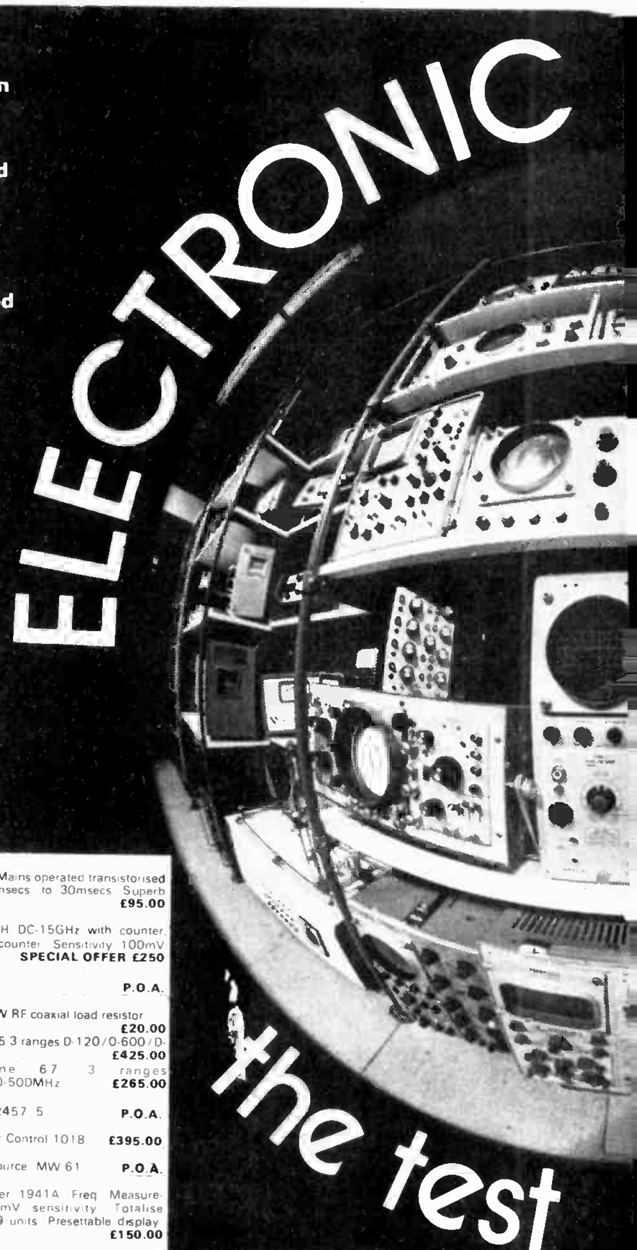
Electronic Brokers Ltd. are one of the leading electronic instrumentation companies in the UK, providing a full range of services to Universities, Industry, Colleges and Governments both at home and overseas.

We have the largest stocks of secondhand test equipment in Europe as well as a selected range of new products. These are on display at our London showrooms where customers can examine the equipment of their choice and see it working.

Electronic Brokers Ltd. have fully equipped workshops on the premises to test and report on the majority of equipment we sell.



SIGNAL SOURCES

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V H F Square wave Generator SG21 10 KHz-100MHz Max o/p 2V **£35**
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. 200 V to 20V (Sine) Distortion 1% 1 4mV to 140V (Square). Brand new condition £70.00

GENERAL RADIO
Unit Oscillator 1209C Freq 250-920MHz Accuracy 1% Drift 0 2% O/pin to 50ohms = 150mW supplied with Power Supply Type 1201—CQ **£145**

HEWLETT PACKARD
10515A Frequency Doubler Extends the useable 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 Brand
211A Square Wave Generator 1Hz-1MHz **£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 1 µV-0 2V 50ohms Impedance **£450**
Audio Signal Generator 206A 20Hz-20KHz ± 2% accuracy Distortion ± 1% **£90**
612A-U H F Signal Generator 450-1230MHz 0 1µV-0 5V (50 ohms) 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**
TF867 Signal Generator 15KHz-30MHz O p volts 0 4µV-4V **£185.00**
TF2005R Two Tone Source The instrument comprises two identical low-distortion a f oscillators and a monitored attenuator unit to form a compact test set for the measurement of inter-modulation distortion using the methods recommended by S M P T E and C C I F Frequency range 20Hz to 20KHz in six bands (each oscillator can be adjusted and used independently) Harmonic distortion Less than 0 05% between 63Hz and 6KHz when using unbalanced output Generally less than 0 1% under other conditions Intermodulation Below —80dB with respect to the wanted signal Amplitude Reference Level Up to +10dBm from each oscillator Output attenuator 111dB in 0 1dB steps Output impedance 600Ω unbalanced or 600Ω 150Ω or 75Ω balanced and centre-tapped **£485.00**
S H F Signal Generator 618C 2 8 7 6GHz ± 1% 50 ohms **£500**
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**
F M /A M Signal Generator TF995A/5 1 5-220MHz in 5 bands 0 1µV-200mV F M up to ±120KHz from 50Hz-15KHz A M up to 50% from 100Hz-10KHz o/p (1) 2µV-200mV (2) with terminating unit 1µV-100mV Int mod freqs 400Hz 1KHz & 1 5KHz Distortion (1) on internal F M ± 25Hz (2) on internal A M 6% at 30% mod **£300 to £450**
A M Signal Generator TF801D 1 Freq range 10-470MHz R F output 0 1µ-1V Piston attenuator 50ohms Impedance Modulation Int A M 1KHz Ext A M 30Hz-20KHz Low spurious F M & drift V S W R 1 2 or less **£400-£800**
A M Signal Generator TF801D/1S Military version 10-485MHz **£450-£800**
R C Oscillator TF1370A 10Hz-10MHz Square Wave up to 100KHz High Outputs up to 31 6V **£285**
Phase/A M Signal Generator TF 2003 0 4-12MHz **£150**
AM Signal Generator TF 801B/3S 12-485MHz 0 1µV-1V **£195**
R C Oscillator TF1101 Frequency range 20HZ-200KHz Output Direct into 600Ω 0-20V 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-£150**
FM/AM Signal Generator TF937/1 CT320 35KHz-18 3MHz As seen condition **£80**
Signal Generator TF144H/4 Late models in super condition **£500 to £650**
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MARCONI-SANDERS
Microwave Sweep Generator type 6600A c/w 6619 plug in 1 7GHz-4 2GHz **£2900.00**

MUIRHEAD L F Decade Oscillator D880A 2-phase 0 01HZ-11 2KHz **£295**
Decade Oscillator D890D 1Hz-11 2KHz **£260**

NEUWIRTH (WEST GERMANY)
VHF Signal Generator MS4/U Freq Range 9 6MHz to 230MHz Turret Osc for each band Accuracy 1 2% o/p 30mV-1µV Freq Dev 1KHz-100KHz Amp Mod 0-100% **£175.00**

PHILIPS
PM 5167 Function Generator Sine triangle square positive pulse negative pulse and ramp 9 1 and 1 9 0 001 Hz to 10MHz (sawtooth and pulse up to max 1MHz) Output 40V(P-P) Impedance 50 ohms Variable DC Offset External sweep Single shot set phase Hold function Overange warning light Superb condition **£615.00**
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Pulse Generator PM5775 **£800.00**
Pulse Generator PM5776 **£900.00**

SANDERS
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RHODE & SCHWARTZ
S H F generator SMCB-BN 41042 1700 5000MHz **P.O.A.**

WAYNE KERR
Video Oscillator O 222 7KHz-8KHz in 6 ranges **£75**

WANDEL & GOLTERMAN
U H F Power Oscillator LMS-68 c/w plug in Oscillators

Type LO-4	4- 41MHz
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Type LO-170	170-330MHz
Type LO-610	610-960MHz

MULTIMETERS

AVO
Test Leads **£4.00**
Multiminor Mk 4 c/w carrying case & leads **£13.50**

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DYNAMCO
Type 7200 15MHz Dual Channel Portable c/w Plug Ins 7201 & 7212 Solid State 10mV/div to 5V/div X10 on channel 1 permits 1mV/div to 12 5V/div Calibrated Sweep Delay c/w batt pack **£310.00**

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Time Interval Meter 369 Mains operated transistorised unit Time Intervals 100nsecs to 30msecs Superb condition **£95.00**

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Wattmeter Termaline 6835 3 ranges D-120/0-600/D-1200W 30-500MHz **£425.00**
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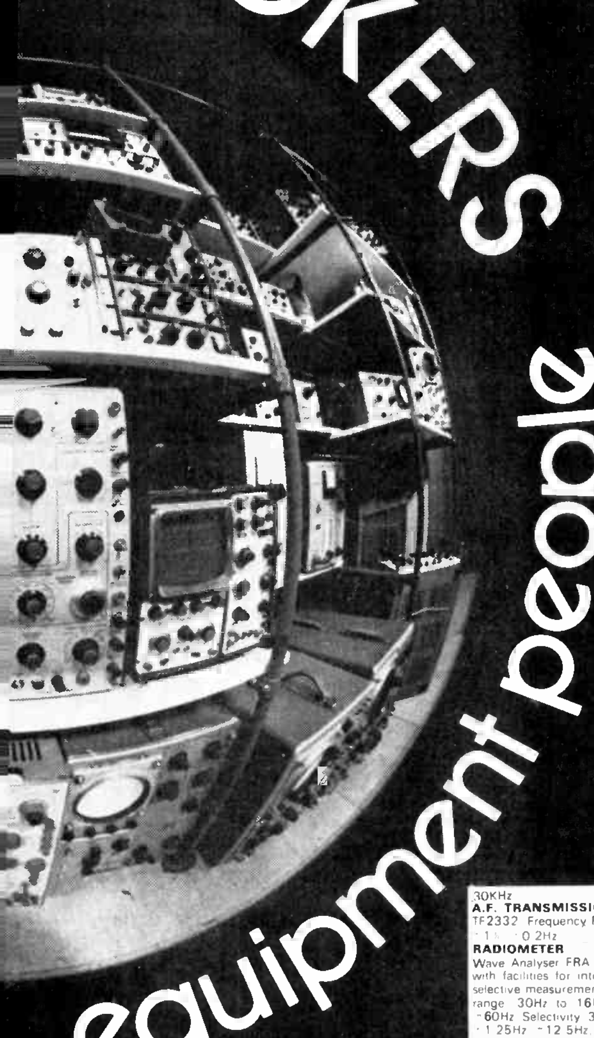

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Type 210 Modulation Meter (earlier version of 210A) **£85-£100**
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VZM2 Distortion measuring set for phase and amplitude mod For multichannel FM Radio Systems up to 12MHz base bands **£350**

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SOLARTRON
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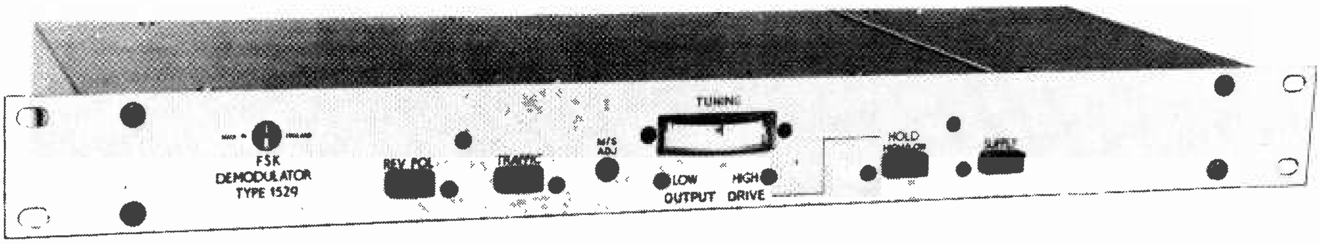

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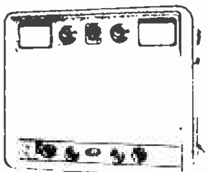

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Range 15KHz to 30MHz Output 0 4 V to 4V Built in crystal **£138.**

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Prices on application

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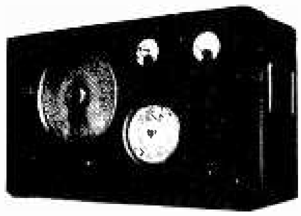

TF 801D/1/S SIGNAL GENERATOR. Range 10 485MHz in 5 ranges R F output 0 1 V 1V Source C M 50Ω output impedance Internal modulation at 1KHz at up to 90%

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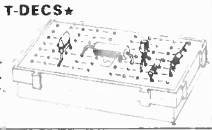

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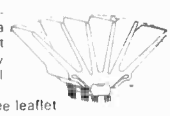

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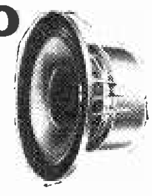

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Fane Pop 55, 12" 60 watt	£16.95
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Goodmans 10P 8 or 15 ohm	£6.95
Goodmans 12P 8 or 15 ohm	£16.50
Goodmans 12P-D 8 or 15 ohm	£18.75
Goodmans 12P-G 8 or 15 ohm	£17.75
Goodmans Audiom 200 8 ohm	£14.95
Goodmans Axent 100 8 ohm	£8.50
Goodmans Axiom 402 8 or 15 ohm	£22.00
Goodmans Twinaxiom 8" 8 or 15 ohm	£10.60
Kef T27	£8.50
Kef T15	£10.75
Kef B110	£10.95
Kef B200	£11.95
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Kef DN8	£2.75
Kef DN12	£7.25
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Goodmans Mezzo Twinkit pair	£51.95
Goodmans DIN 20, 4 ohm, each	£15.75
Helme XLK35 pair	£26.75
Helme XLK40, pair	£38.50
Helme XLK30 pair	£21.95
Kefkit 1 pair	£59.50
Kefkit III, each	£56.00
Richard Allan Twinkit each	£13.95
Richard Allan Triple 8 each	£20.75
Richard Allan Triple 12 each	£25.95
Richard Allan Super Triple each	£29.50
Richard Allan RA8 kit pair	£37.80
Richard Allan RA82 kit, pair	£59.40
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Dept. WW
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WW—067 FOR FURTHER DETAILS

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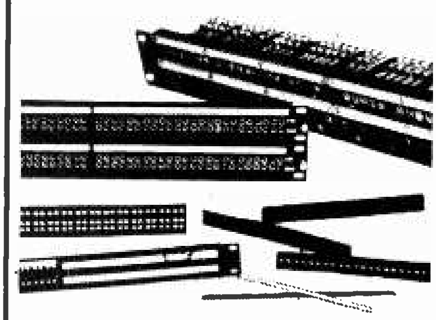

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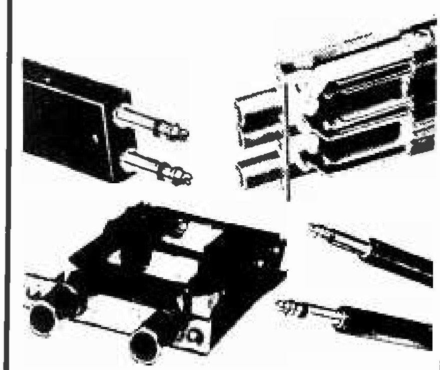
No supplier offers a wider range of panels, inserts and accessories for just about any configuration. And you can get them in any stage of assembly . . . individual components, sub-assemblies, or complete pre-wired and connectorised assemblies ready to install.



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Singles . . . twins . . . back-to-back . . . 2+1 . . . patch and switchboard cords . . . most standard types are available for immediate off-the-shelf delivery.

For information on these and our range of B.P.O. type components contact: COMMUNICATION ACCESSORIES and EQUIPMENT LIMITED.

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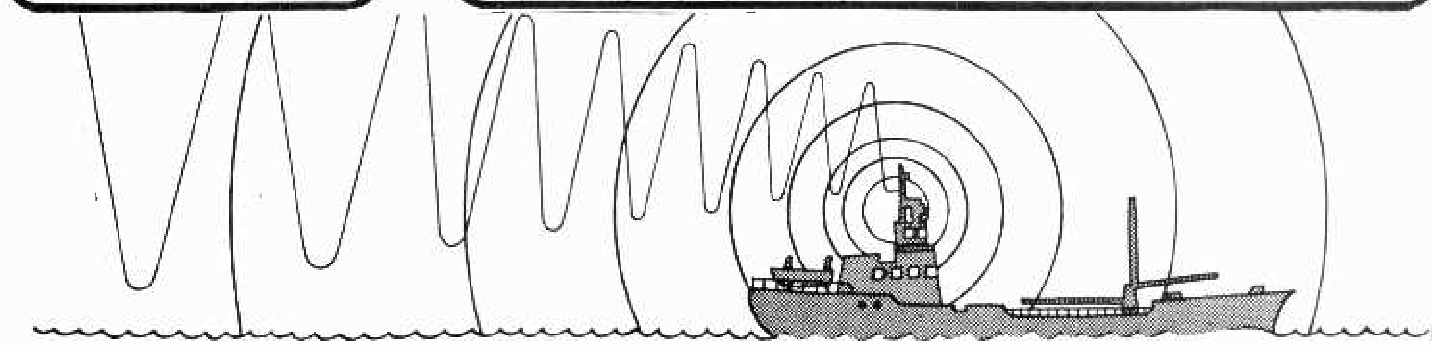
WW—081 FOR FURTHER DETAILS

Appointments

Advertisements accepted up to 12 noon Monday, May 30, for the July issue, subject to space being available.

DISPLAYED APPOINTMENTS VACANT: £7.50 per single col. centimetre (min. 3cm).
LINE advertisements (run on): £1.10 per line, minimum three lines.
BOX NUMBERS: 50p extra. (Replies should be addressed to the Box Number in the advertisement, c/o Wireless World, Dorset House, Stamford Street, London SE1 9LU.)
PHONE: Eddie Farrell on 01-261 8508
Classified Advertisement Rates are currently zero rated for the purpose of V.A.T.



Radio Officers–now you can enjoy the comforts of home.

Working for the Post Office Maritime Services really makes sense. You still do the work that interests you, but with all the advantages of a shore-based job: more time to enjoy home life, job security and good money. To qualify, you need a United Kingdom Maritime Radiocommunication Operator's General Certificate or First Class Certificate of competence in Radiotelegraphy, or an equivalent certificate issued by a Commonwealth Administration or the Irish Republic.

Starting salaries, at 25 or over, are £2905 rising to £3704 after three years service. Between 19 and 24, the starting salary varies from £2234 to £2627 according to age. In addition, a supplement of £312 p.a. is payable. You'll also receive an allowance for shift duties which at the maximum of the scale averages £900 a year and there are opportunities to earn overtime. There's a good pension scheme, sick pay benefits and prospects of promotion to senior management.

Right now we have a few vacancies at some of our coastal radio stations, so if you're 19 or over, preferably with sea-going experience, write to:
ETE Maritime Radio Services Division (L690),
ET 17.1.1.2., Room 643, Union House,
St. Martins-le-Grand, London EC1A 1AR.

Post Office Telecommunications

PIPCO
(S & W SERVICES)
For Electronic Engineers, Technicians & TV Service Engineers
26a High Street
Hounslow, Middx.
Tel: 01-572 7363
Telex Pipco Hounslow 935413
(6552)

SERVICE/ CALIBRATION ENGINEER

The Service Department of a small expanding Electronic / Computer Company requires an additional Service / Calibration Engineer. The work is varied and involves the calibration and maintenance of the complete spectrum of test equipment. A thorough knowledge of fault finding techniques and modern measurement methods is essential also a basic knowledge of logic would be advantageous.
The company is situated at Kings Cross, London, and the salary is negotiable according to age and experience.

For further details please contact:
Mike Jones, Service Manager
49-53 Pancras Road, London NW1 2QB
Telephone: 01-837 7781
(7246)

Garnett College

Closed Circuit Television (Video-Workshop) Engineer

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.

Salary scale £3190-£4702.

Further details and application forms, returnable by 17 May, from the Chief Technician, Garnett College, Downshire House, Roehampton Lane, London SW15 4HR. 01-789 6533

(7230)

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We are looking for a young electronics engineer to join a small energetic company just starting up. This is a golden opportunity for a self-motivated engineer with an enthusiasm for electronics to grow with this company, working with the most up to date technologies. A good salary and fringe benefits are the rewards to the person we feel will be able to work with us on all aspects of the company's work.

Apply, stating experience and qualifications to
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The Market House
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(7236)

H.M.G.C.C.

has vacancies for

ELECTRONIC ENGINEERS

to work in fields of

a. VHF/UHF communications equipment design
b. General circuit design analogue and digital

Qualifications

Candidates should have one of the following academic qualifications:

i Degree in Science or Engineering
ii Degree standard membership of a Professional Institution
iii HNC or HND in a scientific or engineering subject or equivalent qualifications.

Experience

For the grade of Higher Scientific Officer the following post-qualification is also required, 2 years for candidates with 1st or 2nd Class Honours degrees and 5 years for other candidates.

Salaries

Scientific Officer (under age 27)
£2462-£3840
Higher Scientific Officer
£3567-£4767

A pay supplement of £313.20 per annum is included in the above salary scales. An additional supplement of 5% of total earnings subject to a minimum of £130.50 per annum and a maximum of £208.80 per annum is also payable.

Application forms may be obtained from:

The Administrative Officer
HM Government Communications Centre
Hanslope Park
Hanslope
Milton Keynes MK19 7BH

(7239)

RADIO TECHNICIANS

Government Communications Headquarters has vacancies for Radio Technicians. Applicants should be 19 or over.

Standards required call for a sound knowledge of the principles of electricity and radio, together with 2 years experience of using and maintaining radio and electronic test gear.

Duties cover highly skilled Telecommunications/electronic work, indluding the construction, installation, maintenance and testing of radio and radar telecommunications equipment and advanced computer an analytic machinery.

Qualifications: Candidates must hold either the City and Guilds Telecommunications Part I (Intermediate) Certificate or equivalent HM Forces qualification.

Salary scale from £2,230 at 19 to £2,905 at 25 (highest pay on entry), rising to £3,385 with opportunity for advancement to higher grades up to £3,780 with a few posts carrying still higher salaries. Pay supplement of £313.20 per annum.

Annual Leave allowance is 4 weeks rising to 6 weeks after 27 years' service.

Opportunities for service overseas.

Candidates must be UK residents.

Further particulars and Application forms available from:

Recruitment Officer
Government Communications Headquarters
Oakley, Priors Road
CHELTENHAM, Glos GL52 5AJ
Tel. Cheltenham 21491 Ext. 2270
(STD 0242-21401)

(7219)

ELECTRICAL & RADIO TRADING

The above long established weekly trade magazine has a vacancy for a

NEWS REPORTER/ WRITER

Ideally the candidate should have had reporting and writing experience within newspaper, public relations or related areas. The position calls for someone with a quick and active mind who may well have an interest in radio and domestic electrical appliances. The latter is not so important as the ability to present stories in a bright and imaginative way to the readers of its industry.

Apply to the Editor, Alfred Sorkin, who will forward on an application form. Telephone 01-261 8621. Electrical & Radio Trading, IPC Electrical-Electronic Press Ltd., Dorset House, London SE1 9LU.

(7229)

ELECTRONIC DESIGN/ DEVELOPMENT ENGINEERS

FERRANTI OFFERS YOU FREEDOM

..... freedom to create. Over the years leading design and development engineers have been attracted to Ferranti by our reputation for truly innovative engineering and together they have formed specialised teams involved on a variety of sophisticated projects related to the Tornado, Sea Harrier, Jaguar, Nimrod 2 and other front line aircraft.

We now require additional engineers to join these teams engaged on the creative work of designing and developing airborne radar, laser and inertial navigation systems and their associated test equipment.

Engineers are required in the following technical fields:-
Digital and analogue electronic circuitry design.
Design and application of small digital computers.
Microwave and laser techniques.
Advanced instrument design including gyroscopes of inertial quality.
Design of small mechanical structures and analysis of stress.

In addition to the above we have vacancies for production engineers with either electrical or mechanical backgrounds in these fields.

Applicants should have some design/development experience to offer in avionics and a desire to expand their experience to project leader level.

Edinburgh, with its outstanding facilities for education, housing, sport and entertainment, is one of the ideal cities in Europe in which to live, work and bring up a family. And to make moving here easier, we pay realistic relocation expenses. Salaries are negotiable and the Company operates a contributory pension and life assurance scheme.

Apply in writing, with full details of experience and qualifications to

Staff Appointments Officer,
Ferranti Limited,
Ferry Road,
EDINBURGH, EH5 2XS.
Please quote Ref. WW/3

FERRANTI

(7000)

GEC COMPUTERS LTD., Europe's largest and most experienced company specialising in real-time computer applications are expanding their activities and are seeking the following staff for their engineering hardware development department:

SENIOR SYSTEMS ENGINEERS
SENIOR LOGIC DESIGNERS
ELECTRONIC ENGINEERS
INTERMEDIATE/JUNIOR LOGIC DESIGNERS

SENIOR SYSTEMS ENGINEERS AND LOGIC DESIGNERS are required for advanced processor design. Applicants must have a relevant degree or equivalent qualification and have had several years' experience in the computer field including design of complex digital equipment. They must have the ability to understand sophisticated central processor design and be able to play a significant and creative role in this activity.

ELECTRONIC ENGINEERS are required for the design and development of computer memories, power supply units, displays, processors and peripheral equipment. Applicants must have a relevant degree or similar qualification, e.g. HND, and a minimum of 1-2 years' practical experience.

INTERMEDIATE/JUNIOR LOGIC DESIGNERS are required to work on either the development of computers and associated equipment or the design and development of special purpose equipment. Applicants must have a relevant degree or other suitable qualification, e.g. HNC, ET5, etc., and have had some practical experience of digital design. Simple programming experience would also be an advantage, although this is not essential.

Starting salaries are dependent upon qualifications and experience.

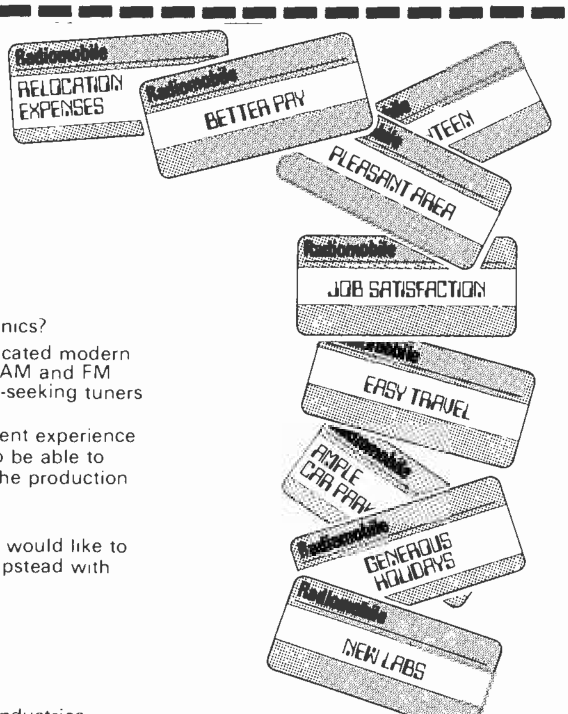
Those interested should apply in writing to Mr D. F Watts, Personnel Department, GEC Computers Limited, Elstree Way, Borehamwood, Herts.

GEC Computers Limited GEC

(7199)

Radiomobile
Britain's Car Radio Specialists

Electronics — is this you?



1. Do you have a good qualification in electronics?
2. Are you interested in the design of sophisticated modern receivers for car entertainment systems — AM and FM stereo radio, stereo cassette players, signal-seeking tuners and the like?
3. Do you have the right character and sufficient experience of receiver design for volume production to be able to design this type of equipment right up to the production stage?

If your answer is 'YES' to all three, and if you would like to work in a modern laboratory near Hemel Hempstead with first-class amenities, telephone or write to.

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RADIOMOBILE LIMITED
Eaton Road, Hemel Hempstead, Herts
Tel Hemel Hempstead 63511

Radiomobile is a subsidiary of Smiths Industries

7194

MEDICAL PHYSICS TECHNICIAN
(Electronics)

Required to work in the electronics section of our Physics Department. The work involves the design, development and manufacture of a wide range of medical and research instruments. Experience with both digital and analogue integrated circuits is very desirable.

Salary scale will be Medical Physics Technician II or III, i.e. £3,597-£5,147 inclusive of all allowances, subject to age, qualification or experience. Minimum qualifications are ONC or equivalent but an HNC in Electronics or an allied subject would normally be expected.

Further details may be obtained from Mr. D. Ritchie, Chief Technician, ext. 399

Application forms and job description are obtainable from:

Mr. B. L. J. Sorrell
Personnel Assistant
St. George's Hospital
Blackshaw Road, London SW17
Tel. 01-672 1255, ext. 121

Closing date for applications 1st June, 1977

CAN YOU WRITE AND SELL?

We are looking for a rare combination. Someone who can help produce technical catalogues, and sell our range of products. That means he or she will have to be a good, lucid writer, with an understanding of electronics, and also proficient at talking technical language with our customers, who range across industry, local government, schools and universities, at home and abroad.

We are Europe's biggest sellers of second user electronic test equipment, and we have also established a New Products Division. So of you want to progress with a company that is going places, this is the job. Salary paid will be based on experience.

Write with full details to:
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49-53 Pancras Road, London NW1 2QB

(7247)

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Required for fault finding on our range of oscilloscopes. This is an interesting and rewarding post for an engineer with a sound knowledge of semi-conductor circuits.

For your chance to join a market leader, write with full details to

The Chief Test Engineer
SCOPEX INSTRUMENTS LTD.
Pixmore Industrial Estate
Pixmore Avenue
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Some travel is involved, both in the U K and abroad The successful candidates will have a sound practical and theoretical electronics background with a knowledge of several of the followigg

Analogue circuits using integrated and discrete components, operational amplifiers, simple digital circuits, servo systems, hydraulics

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Applicants must hold a current driving licence Salary up to £4,000 p a

Telephone Mr Crabtree on 01-998 1552 for further information or write to

SERVOTEST LIMITED
Sarsfield Road, Perivale
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(7238)

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require

SALES ENGINEER

Due to expansion, we have a vacancy for experienced person to design, estimate and commission video studio installations, CCTV, etc.

Self-motivation, ability to negotiate at all levels and enthusiasm are the qualities required.

Excellent salary, negotiable, company car plus expenses.

Please write or telephone for an application form or send résumé of career to date in strictest confidence.

M. Murray, Managing Director, Rew Audio Visual Company Ltd., 10/12 High Street, Colliers Wood, SW19 2BE. 01-540 9684/9.

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01-731 4353

(7155)

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Only the most talented electronics designers can improve our performance

Perfecting the quality of sound under difficult conditions is the challenge of designing in-car entertainment systems — and at Radiomobile, we've risen to that challenge, developing the science and the art of "mobile sound" well beyond the competition.

To maintain our impressive technical and market lead in the UK, we need the best receiver designers we can get: men and women whose interest in perfection goes right through to the production stage and who are capable of inspiring junior engineers as well as producing inspired designs themselves.

The range of products is wide and advanced enough to challenge the most experienced and well-qualified engineer: AM and FM stereo radio, stereo cassette players, signal-seeking tuners, and quadrophonic sound.

This is a senior post, based at our Design Centre in Hemel Hempstead, carrying an attractive salary and very good career prospects. There are excellent fringe benefits, including assistance with relocation to the Hemel Hempstead area.

Telephone for an application form or send C.V. to Miss I. S. Thom, Personnel Manager, Radiomobile Limited, Goodwood Works, North Circular Road, London NW2. Tel: 01-452 3333 ext 4340.

Radiomobile
Radiomobile Limited

7255

ITA are expanding their manufacturing and service departments and require

ENGINEERS

familiar with tape recorders or electro-mechanical assemblies Pleasant working conditions and attractive salaries are offered together with the right prospects for the future Apply to **The Chief Engineer, ITA, 1-7 Harewood Avenue, Marylebone Road, London NW1. Tel: 01-724 2497.**

(7225)

CONTRACTOR/INSTRUMENT Maker required to produce 1,000 unipivot Pick-up arms monthly. Box No. (7198)

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Opportunity for Apprenticeship with old-established company.

All replies will be answered

Applicants must give details of their INTERESTS

Apply to: Box No. WW 7251

(7241)

Rolls-Royce Limited

Electronic/ Instrumentation Draughtsmen

The Experimental Department based in Derby has vacancies for the post of Electronic Instrumentation Draughtsmen.

Candidates (male or female) must have completed a formal drawing office training and ideally should possess at least an ONC (Electrical). They should have experience in electronics, instrumentation and printed circuit design.

The work is concerned with design and detailing of specialist electronic equipment for use on Test Beds, Rigs, Instrumentation and Process systems throughout Rolls-Royce. It includes:—

(a) Drawing circuit/logic diagrams, wiring schedules and routing diagrams.

(b) Mechanical design of small mechanisms, cabinet and chassis work.

(c) Printed circuit layout and design and the production of relevant artwork.

Salary will be paid according to age, qualifications and experience.

The Company operates a Staff Pension Scheme.

We should be pleased to discuss re-location expenses with the candidates who are invited for interview.

Enquiries should be sent to:—

ROLLS ROYCE

Mr J A J Clarke, Senior Personnel Officer
Rolls-Royce Limited
PO Box 31 Derby DE2 8BJ
Telephone: Derby 42424 Extension 109

7201

SENIOR ENGINEER/SECTION LEADER

Required to work on cable television systems.

The candidate should hold a degree or equivalent qualification and have some knowledge of either HF, video, or modulator/demodulator circuit design.

A knowledge of the circuitry of colour TV receivers and basic digital systems should also be an advantage.

Salary will be commensurate with qualifications, age and experience.

If you are seeking a responsible position in R & D write giving details of your career to date, or telephone:

Dr. G. O. Towler, B.Sc., Ph.D. (Manager)
Research & Development Establishment
BRITISH RELAY LTD.
Cleeve Road, Leatherhead
Surrey KT22 7NN
Telephone: Leatherhead 76056

(7240)

BRITISH RELAY TV

Design and Development Engineers

Flow Measurement — Luton

Here at Kent Instruments Limited, one of the world's foremost companies involved in process control instrumentation, we need talented men and women to join our expanding multi-discipline development teams.

Electronic Development Engineers

You will be responsible for systems and circuitry design/development on a new generation of products which make full use of advanced measurement techniques. These challenging positions, in a dynamic department, call for innovative, graduate-level engineers, aged 25 plus, with a minimum of three years' experience in analogue or digital circuit design.

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You will join a team of professional engineers responsible for the design of precision electro-mechanical mechanisms and transducers for our comprehensive range of flow measurement devices. The team's activities will provide the kind of setting which will appeal to HND/degree engineers, aged 25 plus, with at least three years' design/development experience in a high technology environment associated with fluid dynamics.

Appointments will be made at various levels dependent on experience and qualifications. We offer four weeks holiday, good pension/life assurance/sickness pay schemes and relocation expenses where appropriate.

Please telephone or write for an application form to Mike Hopkins, Personnel Officer, Kent Instruments Ltd., Biscot Rd., Luton, Beds. LU3 1AL.
Tel: Luton (0582) 24558 – anytime day or night.

the GEORGE KENT group

Electronics Engineer

Telemotive U.K. Limited is a Company in association with a major U.S.A. manufacturer with world leadership in the radio control of industrial machines, systems, and processes, in collision prevention, in remote positioning, and in other industrial electronics activities.

Our principal products are founded on the Near Field Induction Effect and on other inductive techniques in the 300 kHz band. No other U.K. Company has a comparable product line, and our business therefore offers engineering experience of unusual interest. Training in our techniques is provided.

Our current requirement is for a young engineer with versatile abilities because at different times the work will involve application engineering, testing, commissioning of systems on customers' sites, field and base service, the anglicisation of designs originating in other countries, and a measure of production control. In each of these fields there is scope for personel engineering contributions.

The position involves some travelling within the U.K. and will take the engineer into a wide variety of industries.

Telemotive is a good employer. It only employs people who are exceptional in their particular job, and it treats them accordingly. The salary will depend upon the capability of the chosen applicant.

Please forward personal details to

Telemotive U.K. Limited

TELEMOTIVE HOUSE, 100 HIGH ROAD
BYFLEET, WEYBRIDGE, SURREY
BYFLEET 47117

(7253)

CIRCUIT DESIGN ENGINEER in Cambridge

We wish to appoint an enthusiastic engineer with several years' experience of semi conductor circuit design to develop a series of active processing modules for incorporation into a comprehensive range of audio mixers, distribution systems and switching equipment

The successful candidate should be qualified to degree or HND/HNC standard and possibly have a background in audio engineering or related fields, but proven circuit design capability with a knowledge of integrated circuits, thick film and digital techniques are the main criteria.

Join a successful and continually expanding company in the field of international broadcast engineering. For further details write or telephone: Mr. D. Barnicoat, Pye TVT Limited, PO Box 41, Coldhams Lane, Cambridge CB1 3JU, Telephone Cambridge 45115.

Pye TVT Limited
The Broadcast Company of Philips

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OVERSEAS APPOINTMENTS

ELECTRONICS TECHNICIANS

Petty-Ray is one of the leading companies in the field of oil exploration and due to our ever increasing work load require young single personnel, preferably aged between 21-25, who are looking for a varied and interesting career working overseas.

You should be educated to HNC/ONC in Electronics or C and G Radio and TV Technician level, and on appointment you will be assigned to one of our field crews either in Africa or the Middle East for on-the-job training in the operation and maintenance of digital siesmic recording equipment.

Candidates must be in possession of a current driving licence.

We offer a good starting salary which is tax free, food and accommodation will be provided and rest leaves are generous.

If you would like to have more information about these vacancies why not write, giving brief career details to the Personnel Officer:

Petty-Ray Geophysical Division
GEOSOURCE UK LTD.
3-5 The Grove, Slough, Berks

(7221)

EMI

Opportunities in Electronics Development

Pantak (EMI) Limited, one of the world leaders in industrial, security and medical X-ray equipment have important career opportunities for personnel to join our expanding electronics development team working on exciting new projects. As a result of this expansion, we are now looking for:-

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To report to a Project Engineer and be responsible for the work of junior engineers.

Responsibilities will include the developing, testing and recording of various projects as required. You will also deal personally with outside technical contacts, document the work of your team and ensure that worldwide regulations and standards are met.

Ideal candidates for these key positions will be aged 30 plus and have a degree or HND qualifications. We are looking for experience in analogue and digital circuit techniques. A knowledge of high frequency inverters, control and power supply systems will be an advantage.

Development Engineers

Reporting to Senior Development Engineers, you will be required to develop prototype equipment involving technical studies and modifications through to the final pre-production stage.

You will hold a degree, HND or HNC (Electronics) or equivalent. Some previous development knowledge will be an advantage.

Prototype Electronic Wiremen/Women

To join the development team working on interesting new projects in close liaison with all levels of development staff. You should be able to work from prototype engineering information and from this be capable of preparing and using schedules and running lists.

Benefits we offer include:

- **Excellent salaries**
- **Career opportunities**
- **4 weeks holiday**
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- **First class Pension Scheme with free Life Assurance**
- **Staff sales discount on EMI products**
- **Pleasant well equipped working conditions in premises within easy reach of M4**
- **Generous assistance towards removal expenses where applicable**

We'll cover the expenses for your interview so male and female applicants ring Geoff Smith, Technical Manager now on Windsor (075 35) 55611 or write to him at: Pantak (EMI) Limited, Vale Road, Windsor, Berks SL4 5JP

Pantak
A member of the EMI Group of companies
International leaders in music, electronics and leisure

LABORATORY TECHNICIAN

There are opportunities for versatile Laboratory Technicians at the BBC, Equipment Dept., Chiswick, to do interesting and varied work, testing BBC designed equipment, newly manufactured in small batches. This equipment covers most aspects of colour television and stereo radio broadcasting and includes techniques in audio video, digital and radio frequency.

Suitable technicians will have had at least one year's experience of testing small batches of electronic equipment and will be qualified to Final City and Guilds or O.N.C. standard.

Starting salary will be in the range £2,992 to £3,214, rising by annual increments to £3,547 plus 5% pay supplements. Less qualified technicians may start at a training grade.

Request for application form to the **Engineering Recruitment Officer, BBC, Broadcasting House, London W1A 1AA,** quoting reference 77.E.4028/WW and enclosing foolscap envelope. Closing date for completed application forms is fourteen days after publication.

BBC

7248

Electronics Technician
GRADE III

required for the Area Works Department based initially at Copthorne Hospital South, attached to the Cardiological Respiratory Function Laboratory.
Qualifications: H.N.C./O.N.C. ELECTRONICS.
Responsible to: Area Engineer.
Salary scale: £2,931-£3,834 + £312 p.a. supplement.
Experience required: Candidates must possess a wide experience of electronic equipment together with appreciation of the safety aspects of such equipment.
The position offers the opportunity to be involved in a very rewarding aspect of electro-medical engineering and he/she will be under the control of the respective clinician within the above departments for all clinical responsibilities appertaining to his/her duties.

For job description and application form write to Area Engineer, Area Works Department, Shrewsbury Hospital, Copthorne South, Shrewsbury, Salop. Tel: Shrewsbury 52244 ext. 3273.
Closing date 27th May, 1977. (7212)

Salop
Area Health Authority

Radiomobile
Britain's Car Radio Specialists

Technical Assistant
(In-Car Entertainment Service Centre)

The successful applicant will be required to deal with a general and technical correspondence, telephone enquiries on repairs and suppression.

He/she will be required to assist in compiling technical bulletins and service manuals, guarantee analysis and service records.

As the job involves a lot of telephone work, a good command of the English language and a clear speaking voice are essential.

City & Guilds Telecoms / Servicing preferred.

A knowledge of radio servicing and/or car radio suppression would be an added advantage.

This is a Monthly Staff position. Salary will be negotiable, and fringe benefits are those associated with a large and progressive organisation.

Write or telephone for Application form and Job Specification to:
Miss I. S. Thom
Personnel Manager
Radiomobile Limited
Goodwood Works
North Circular Road, London NW2
Tel. 452 3333, ext. 4518

a subsidiary of SMITHS INDUSTRIES LIMITED

(7249)

AREA WORKS ORGANISATION
ELECTRONIC TECHNICIANS (3 Posts)

Three Electronic Technicians are required to join a small team in maintaining sophisticated equipment in use in the Health Service.

1. Technician Grade II required to specialise on equipment used in a Bio-Chemistry Laboratory, including computers — Analysers, etc., to be based at the Hull Royal Infirmary.

   Salary starting at £4,063 rising by increments to £5,101.
   Qualifications required — O.N.C. H.N.C. or H.N.D. or equivalent.

2. Technicians Grade III required to specialise mainly on maintenance of X-Ray equipment:

   One to be based in the Beverley District
   One to be based at the Hull Royal Infirmary
   Salary starting at £3,405 rising by increments to £4,353.
   Qualifications required — O.N.C., H.N.C. or H.N.D. or equivalent.

Job descriptions and application forms may be obtained from the Area Personnel Officer, Humberside Area Health Authority, Springfield House, Springfield Way, Anlaby, Hull. To be returned by 31st May, 1977.

Hull District
Humberside Area Health Authority

(7257)

Electronic Test Engineers

Pye Telecommunications of Haverhill has immediate vacancies for Production Test Engineers, of either sex. The work entails checking to an exacting specification VHF/UHF radio-telephone equipment before customer delivery; applicants must therefore have experience of fault finding and testing electronic equipment, preferably communications equipment. Formal qualifications, while desirable, are not as important as practical proficiency. Armed service experience of such work would be perfectly acceptable.

Pye Telecommunications is a major exporter of radio-telephone equipment, and there are good opportunities for promotion within the Company.

Relocation assistance is available and there is also the possibility of obtaining local authority housing.

Write or telephone without delay for an application form to: Miss C. M. Dawe

Pye Telecommunications Ltd
Colne Valley Road (opposite Mount Road)
Haverhill, Suffolk CB9 8DU Tel Haverhill 4422

(7231)

Radiomobile

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Electronic Engineer (A.T.E.)

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Would you like to work with a minimum of supervision, and join a team of young and enthusiastic engineers? Qualifications should be ONC/HNC level.

Starting salary will be negotiated, and fringe benefits are those associated with a large and progressive organisation.

Telephone or write for application form and job specification to

Miss I. S. Thom
Personnel Manager
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7195

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ATE Field Service Engineers
Servicing Automatic Electrical Inspection Systems throughout the UK.

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Test Engineers
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Further information may be obtained from John Prodger:
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Longacres,
St. Albans, Herts.
Tel: St. Albans 59292.

A GEC-Marconi Electronics Company.

(7252)

mi

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Mr. R. D. Naisbitt, Personnel Director
ELECTROSONIC LIMITED
815 Woolwich Road, London SE7 8LT

7265

Test Equipment Development Engineer

For the leaders in electronics

Our position as leaders in the electronics field, and our committment to research and development makes us an attractive proposition for a young, ambitious Engineer looking to gain experience in a professional and sophisticated environment. Experts in advanced technology, we need to add to our engineering teams, and are therefore looking for a person who can respond to the challenge we offer.

We currently have a vacancy for a Test Equipment Development Engineer. The position involves designing and developing special purpose electronic test equipment for 'in house' usage. More specifically, we are looking for someone capable of circuit design, producing diagrams, building equipment and drawing up calibration and maintenance instructions.

You should be aged at least 25, with approximately four or five years' development experience, together with an HNC in Electronic Engineering, or an equivalent qualification. Also, you should have knowledge of digital circuitry, measuring techniques and construction.

We are offering a competitive salary which will reflect age and experience, together with the full range of company benefits including four weeks holiday, pension scheme, staff restaurant, and active sports and social club.

For further information and an application form please contact: Barry Page, Personnel Department, EMI Ltd., 135 Blyth Road, Hayes, Middlesex. Telephone 01-573 3888 Ext. 639. Or Record-a-Call anytime on 01-573 5524.

EMI EMI Limited

The international music, electronics and leisure Group (7211)

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Every encouragement will be given to the successful candidate to increase his general knowledge both in computing and advances in component technology.

Starting salaries are dependent upon qualifications and experience.

Those interested should apply in writing to Mr D. F. Watts, Personnel Department, GEC Computers Limited, Elstree Way, Borehamwood, Herts.

GEC COMPUTERS LIMITED GEC

(7200)

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in MEDIA SERVICES.

This is a challenging position for someone who is interested in the applications of television in teaching and learning and who will be keen to play a part in this developing field.

The successful applicant will have at least five years experience (preferably in the CCTV field), and will be capable of maintaining a wide variety of TV equipment, including cameras, VTRs, monitors and sound and vision systems. He/she will also be expected to design and modify equipment to the special needs of the Service, and to help the production of films and video tapes.

Salary: £3,156 up to £3,762 + London Weighting £465 + Pay supplement £2.50 or 5% up to a maximum of £4.00 per week.

For further details and application forms, please write to.

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(7262)

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SITUATIONS VACANT

Electronics Engineers

Exciting new projects in Radio Communications

South Coast (Hants/Sussex borders)

Plessey Avionics and Communications at West Leigh, Havant, is a leader in the design, manufacture and development of advanced radio communications equipment and systems.

We are looking for electronics engineers, at various levels, to work on the design and development of a range of sophisticated new products for both civil and military applications. These are ground floor opportunities to become involved in original design and there is considerable scope for career progress. We are currently building up development teams for projects in these areas:

HF/VHF Military Radio

Successful candidates will be involved in the design of new products using advanced miniaturisation techniques. Experience of digital systems and RF techniques at HF and VHF would be particularly valuable. These appointments will be of particular interest to designers willing to work against short time scale development plans on products mainly for the export market.

HF Receiving Systems

Engineers to work on HF receivers, their remote control and digital interface, and on related equipment design. Digital, analogue or RF aptitudes would all be appropriate.

UHF/SHF Radio Relay

Engineers to work on the design of transmitters and receivers at UHF and SHF, IF amplifiers, and baseband amplifiers for multi-channel radio relay equipment.

Radio Relay Systems

Engineers for the design of overall radio relay systems, the development of sub-equipments and systems evaluation. Previous experience in the design and/or commissioning of radio communications systems is desirable.

Candidates should be educated to degree level or equivalent and have at least two years' experience.

Situated in a semi-rural environment near Portsmouth, Chichester, the South Downs and several seaside resorts, we are well placed for housing, shops, school and recreational amenities. Relocation assistance will be given where appropriate and there is a comprehensive range of large company benefits. Attractive salaries will be negotiated in line with experience and qualifications.

Please write with brief career details or telephone for an application form. L. Wise, Recruitment Manager, The Plessey Company Limited, Martin Road, West Leigh, Havant, Hants. Tel (07012) 6391. Applications are invited from either sex.

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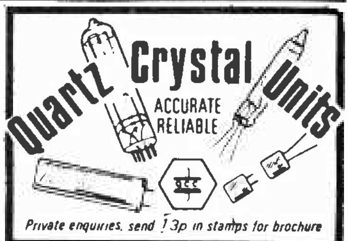

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SITUATIONS VACANT

JUNIOR LABORATORY TECHNICIAN

Designs Department

A number of posts are available in Central London for enthusiastic and forward thinking young students to train as Technicians in the laboratories of the BBC's Designs Department. Their work will include assisting engineering and laboratory staff in the development, construction and testing of units of sound and television broadcasting equipment.

The successful candidates will probably be aged 18-20 and have a keen interest in, and possibly some experience of, electronics. They will have some 'O' levels – two preferably will be scientific – and they will be either recently qualified to O.N.C. or City and Guilds part II (T4) standard, or have recently commenced the final year of such a course.

Salary according to qualifications in the range £2514-£2706 (plus from £10.86 to £17.38 p.m. pay supplement according to earnings under current Incomes Policy). Excellent opportunities for promotion. Summer leave arrangements honoured.

Requests for application forms to **The Engineering Recruitment Officer, BBC, Broadcasting House, London W1A 1AA**, quoting reference number 77.E.2164/WW and enclosing addressed foolscap envelope. Closing date for completed application forms is 14 days after publication.

7233

BBC

Yorkshire Television

Broadcasting Electronics Engineer

Vacancies exist in Yorkshire Television's Engineering Department for two Engineers. Duties, within this small group, will include system planning and installation and design and construction of specialised equipment. Experience of digital techniques would be an advantage.

Applicants should be qualified to at least HND or equivalent or have several years relevant training and experience in TV broadcasting engineering.

Salary in the region of £4,000 with promotion prospects to Senior Engineer within two years.

Applications in writing please giving brief details of qualifications and experience to

Personnel Executive
Yorkshire Television Ltd
The Television Centre Leeds LS3 1JS 7258

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(33)

SITUATIONS VACANT

JOIN ONE OF BRITAIN'S MOST SUCCESSFUL ELECTRONIC COMPANIES

SE Labs is part of the rapidly expanding and highly successful Medical Electronics Division of the EMI group. At our recently-opened factory in Frimley, our employees are engaged in the manufacture of sophisticated display equipment associated with the revolutionary EMI-Scanner computerised X-ray examination system. Right now we are looking for people to fill the following vacancies.

DESIGN ENGINEERS

Experienced Design Engineers are required in the Technical Services Department.

The job involves, designing production test equipment both analogue and digital, investigating text methods, liaison with our design team, and be responsible for the subsequent manufacture of all test equipment.

The successful candidates will also be required to write analogue and digital test programs for computer based automatic test equipment. (The Company is an established user of A.T.E.)

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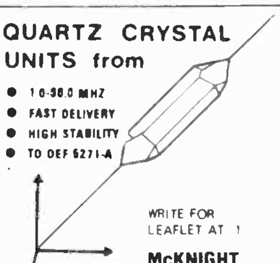

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WW 6/77

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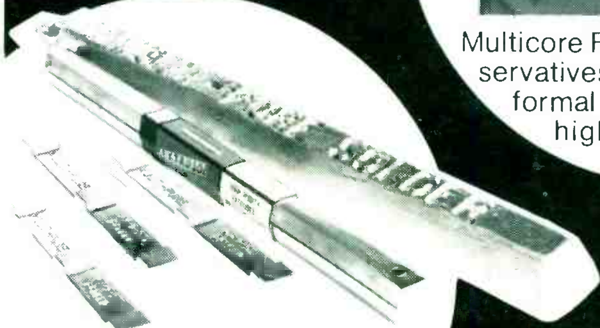

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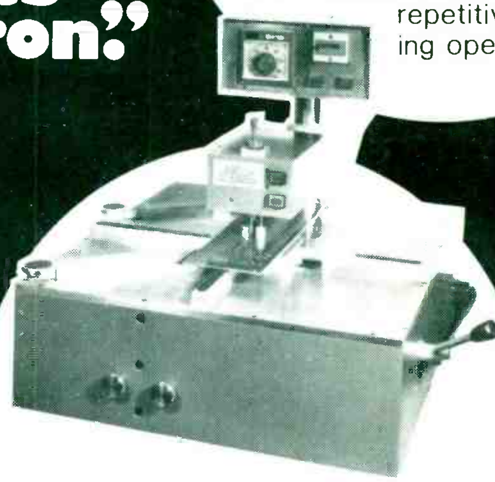

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