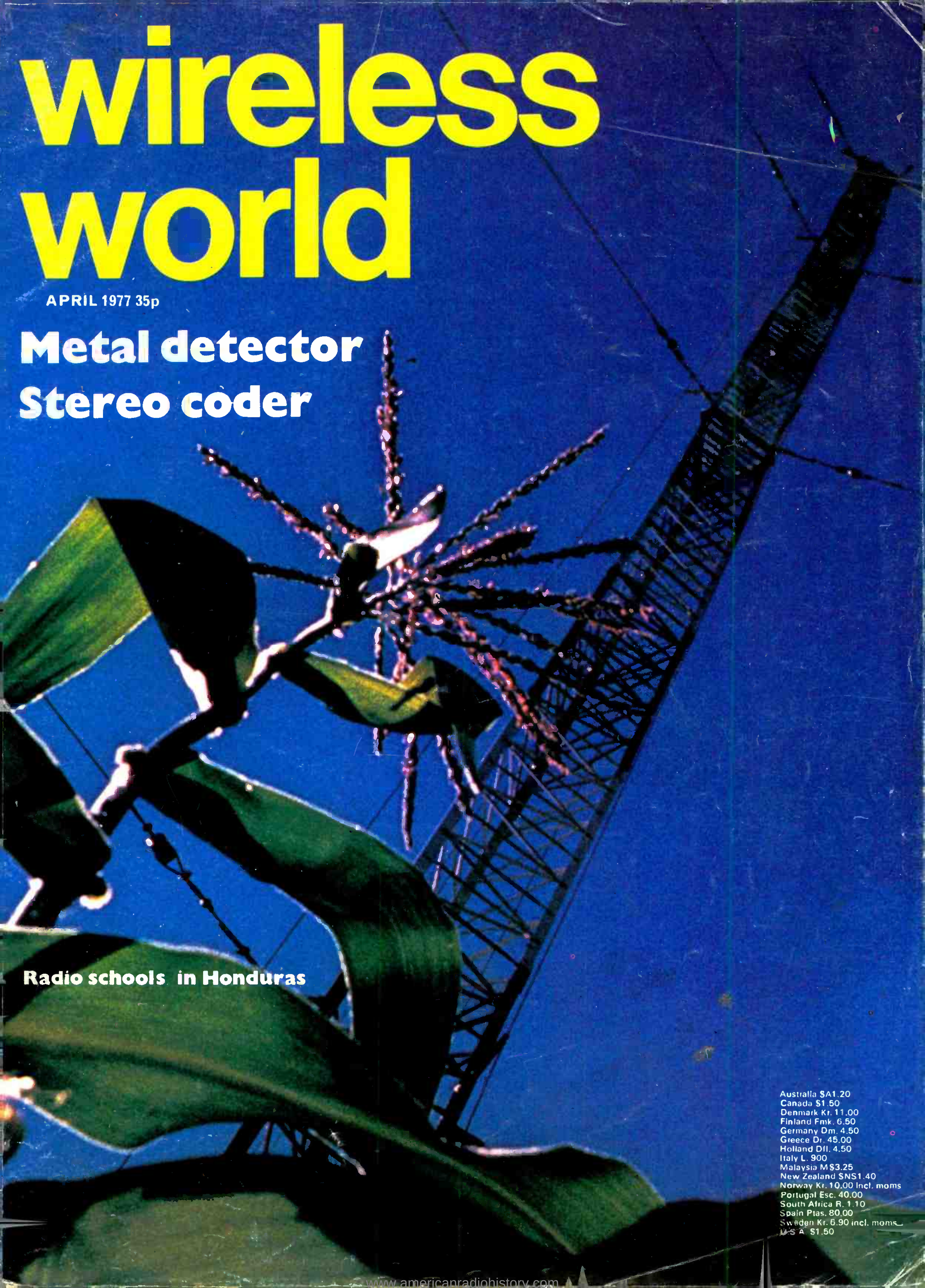
wireless world

APRIL 1977 35p

Metal detector
Stereo coder



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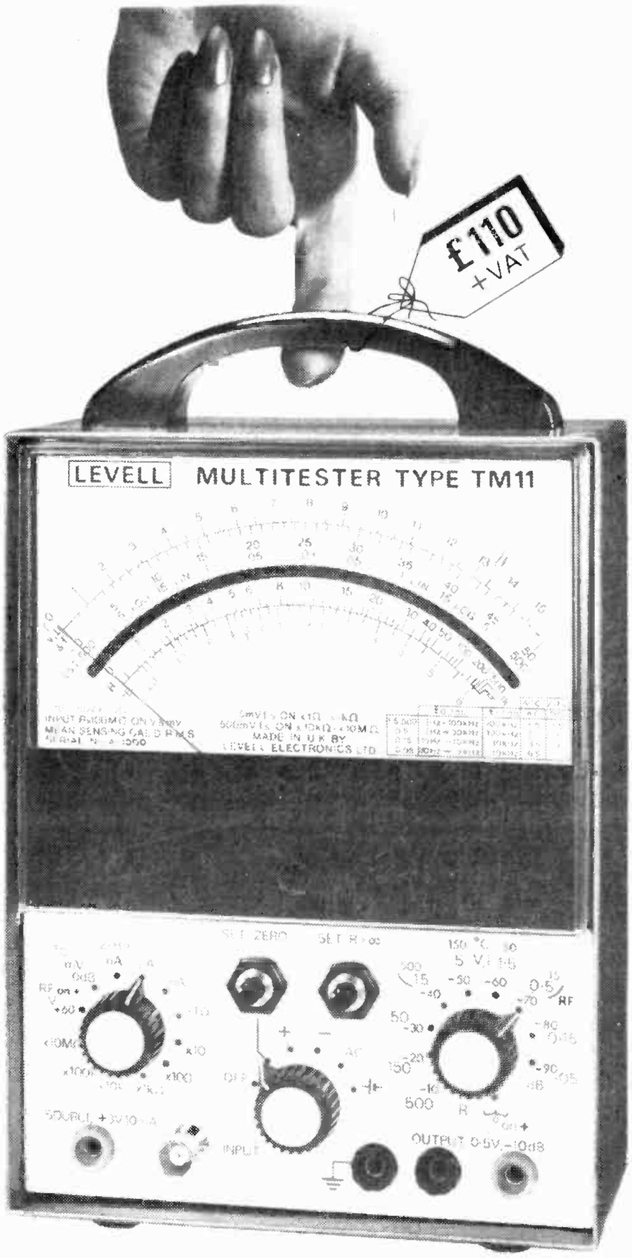

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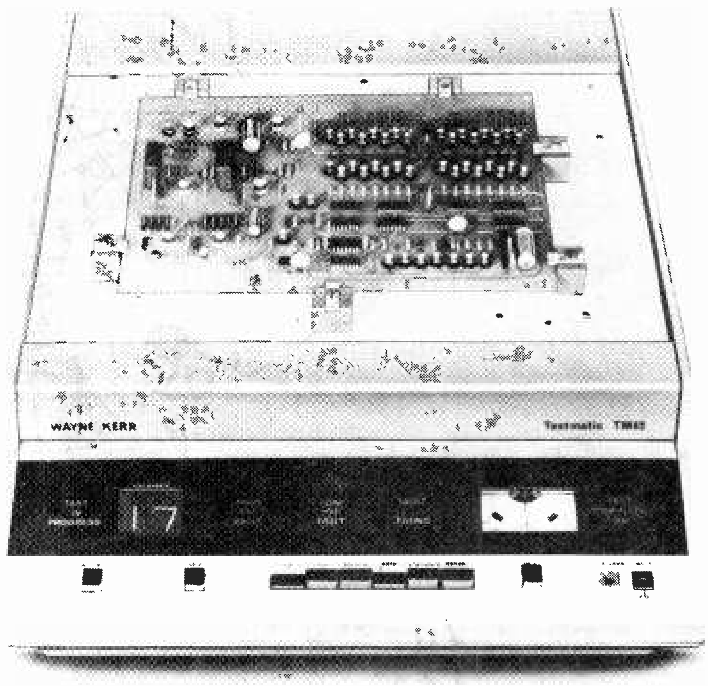

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WW4/77

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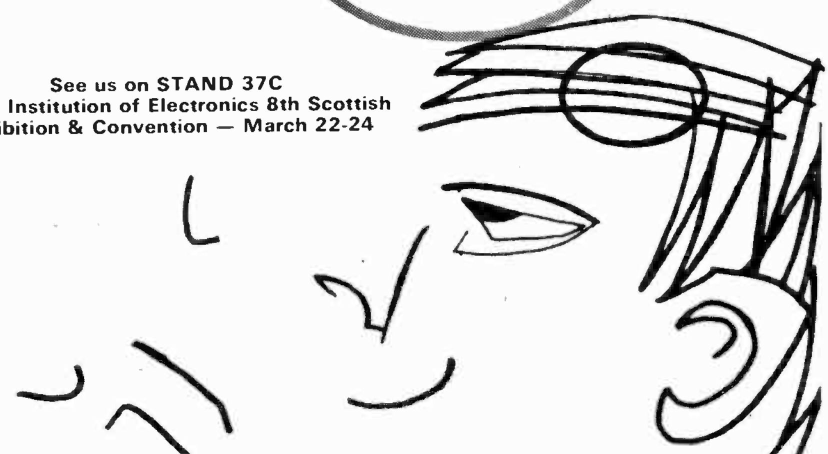

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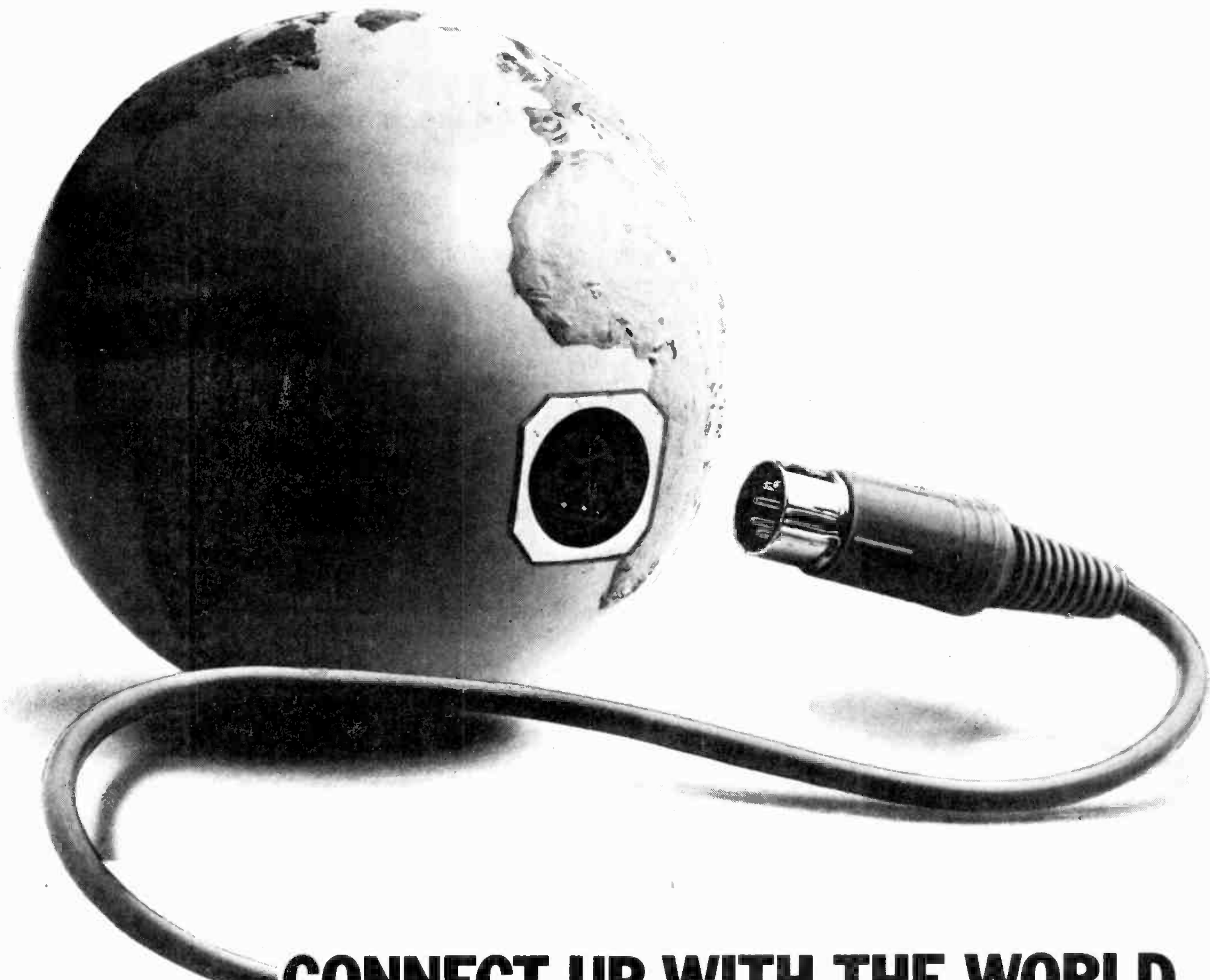

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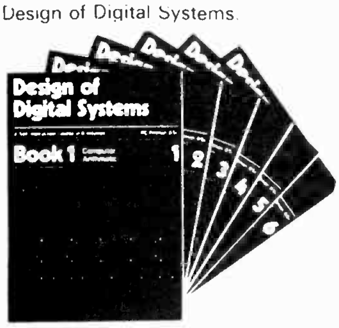

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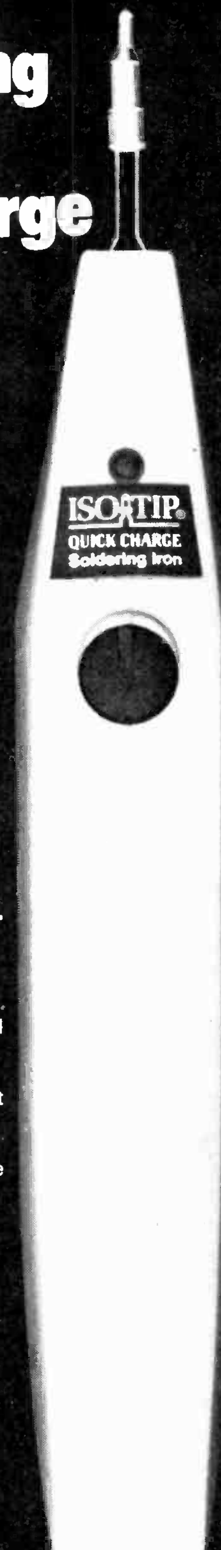
WW4

Introducing the new Quick Charge Cordless Soldering Iron



- **Solder heat in five seconds**
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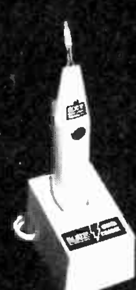

Illustration actual size.

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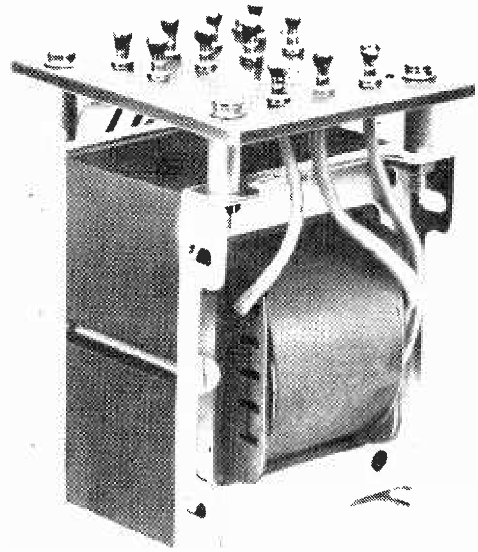

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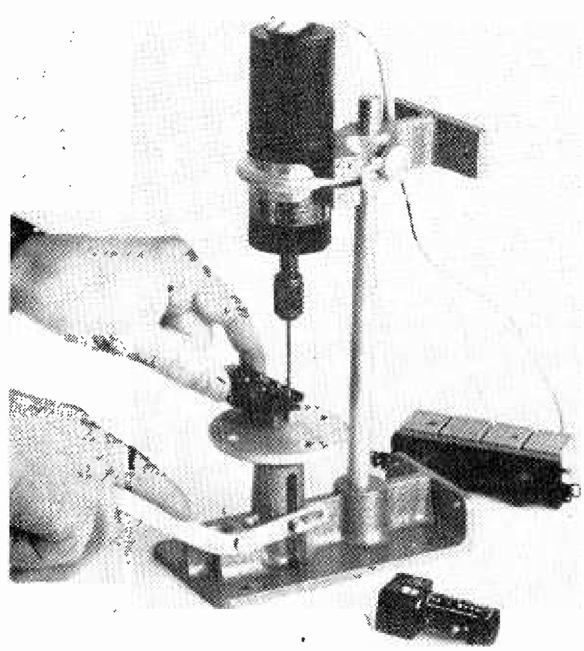

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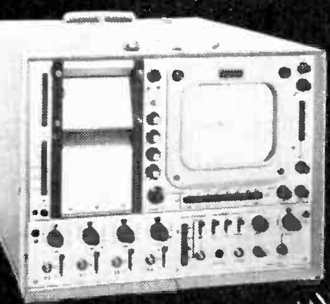

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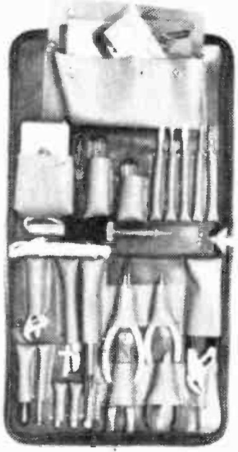

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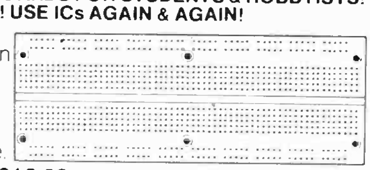

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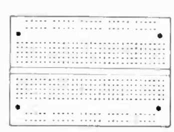
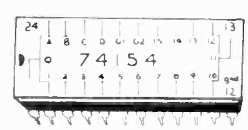


SK50. Half size version of SK10 for tight places and student use. Takes 4 DILs **£7.80.**



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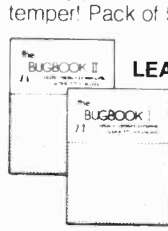

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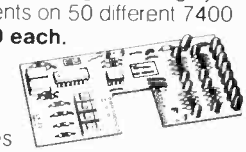

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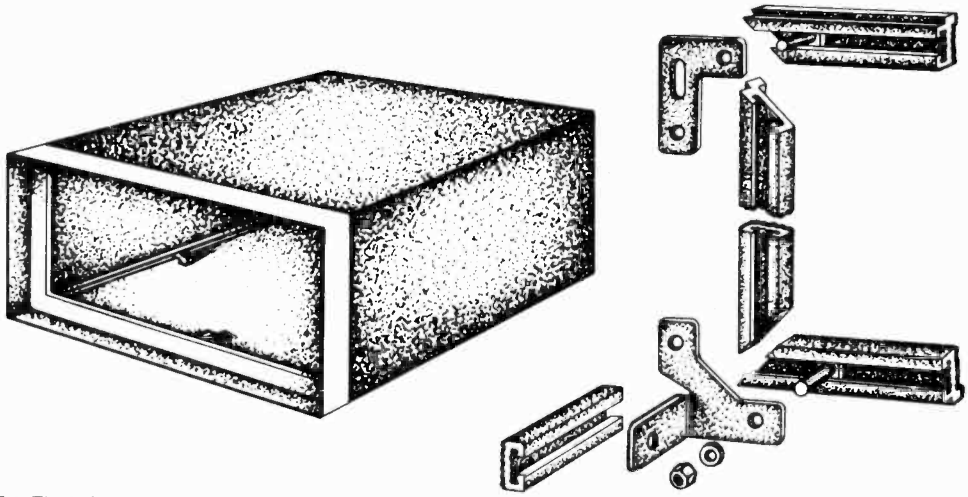

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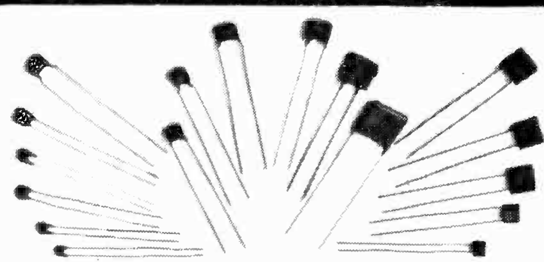

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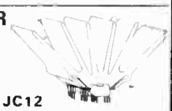
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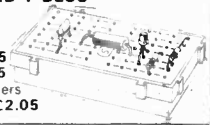
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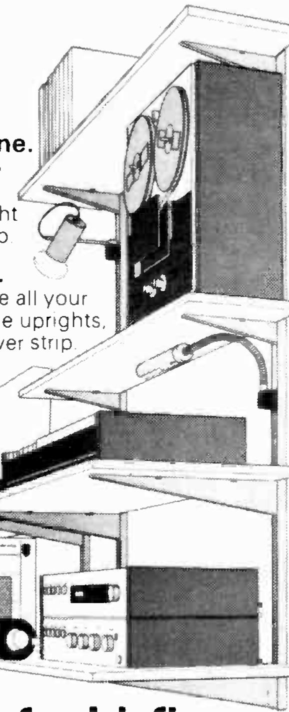

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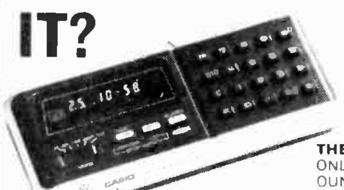

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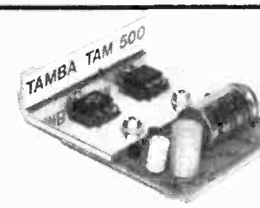

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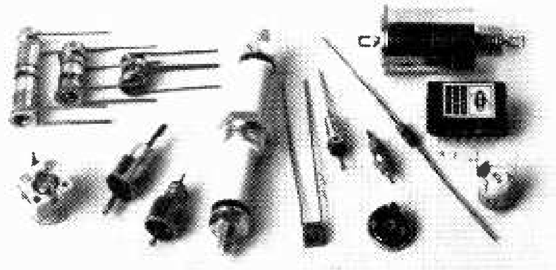

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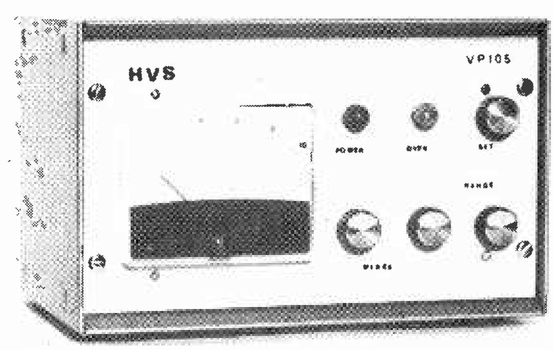

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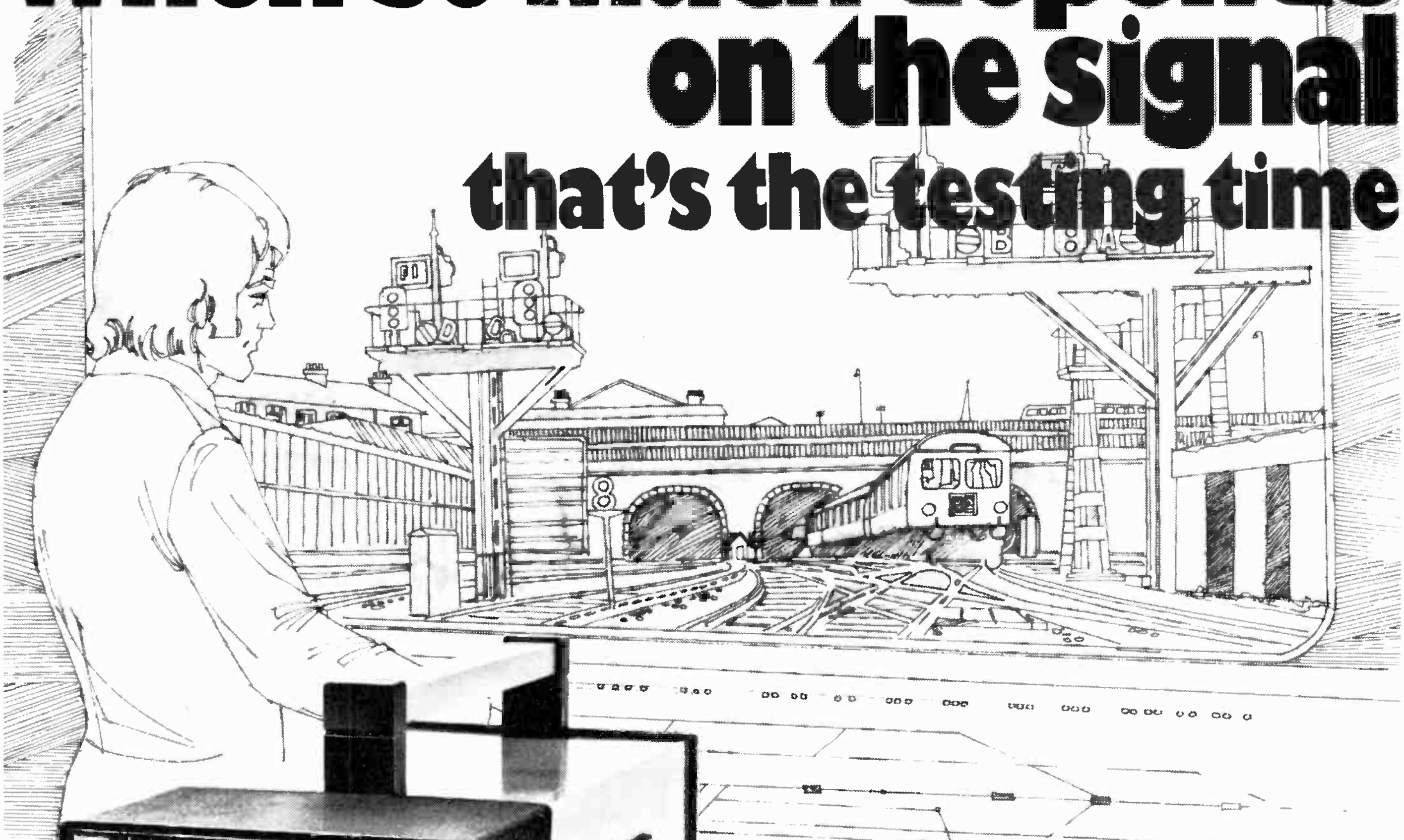

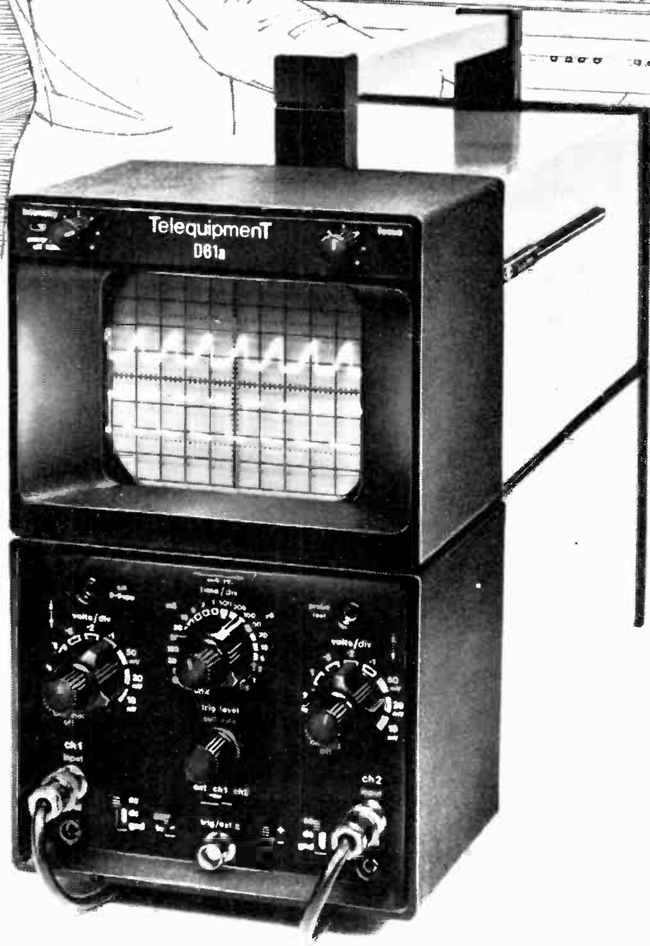

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APRIL 1977 Vol 83 No 1496

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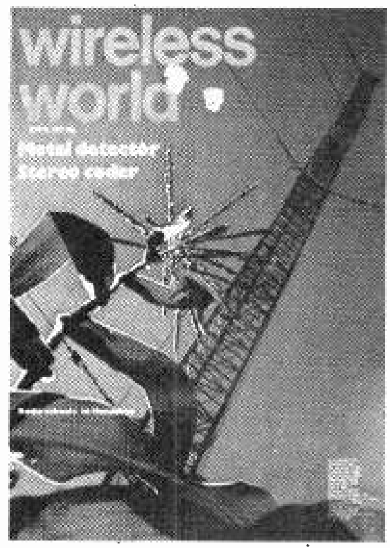

Front cover, showing the medium wave aerial at Radiolándia, Comayagua, Honduras, introduces the article on education by radio in that country (page 57).

Photographer Paul Brierley

IN OUR NEXT ISSUE

Electrolytic capacitor tester. Enables the value of an electrolytic capacitor to be measured automatically and the result displayed directly by meter. Leakage is also indicated.

Two-stage linear amplifier. A discussion of the design of solid-state 50W and 300W linear amplifiers for the h.f. band (1.6-30MHz).

Radio in the '80s, a look forward to sound receiver design and the ideal set of the future by the BBC's chief engineer of radio broadcasting.

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Time, gentlemen. Please!

When this issue of *Wireless World* appears on the news stands the deadline for submissions to the Home Office on British policy on frequency reallocations for the 1979 WARC will be only six weeks away. (See News of the Month, March p.37). Yet a few months ago even this much consultation seemed out of reach. The Home Office is to be congratulated on reversing its policy of selective consultation and giving the public a chance to have their say. It could be argued, indeed, that the process might have begun much earlier had the electronics industry and its representatives been less acquiescent in the Home Office's reluctance to encourage public intrusion. Even though the discussions to which the discreet trusties we referred to in December found they had an exclusive entrée were on matters of public concern far beyond their immediate interests, they made, at first, no effort to press for a programme that might dilute their own bargaining strength.

But it is for the electronics industry, singly and collectively, to put its own house in order. The immediate need is to make sure that the 1979 package is a fair reflection of the views of all those with an interest in the allocation of frequencies. The Home Secretary's statement is only a beginning. Indeed it contains a surprising admission of the inadequacy of what he has craftily called "the preliminary phase" of the work for the conference: although, he says, a substantial measure of consultation with users and manufacturers has already taken place, during the next phase "those known to have an interest will be specifically invited to comment." One wonders how "substantial" the measure of consultation during the preliminary phase could have been.

One hopes, too, that equal weight will be given to the public's views as to those "specifically invited." This can only be the case if the public is as well informed as those "known to have an interest," yet we have not received any details of the Home Office proposals for disseminating the contents of the Warden reports and any others relevant to the WARC. If the "wider programme of consultation" is to be anything more than an empty political gesture these reports must be made public.

The ten days following the publication of the next issue of *Wireless World* will not give enough time to read the available material, to consult colleagues, and to draft a considered proposal. The consultation period should be extended, just as the Annan committee extended theirs. An extension to the end of the year would give officials a clear year to collate and prepare the British case. Is that so much to ask?

NRDC surround-sound system

Michael Gerzon reveals the thinking behind system 45J

by Michael Gerzon, M.A., *Mathematical Institute, Oxford*

This article gives a feel for how it has proved possible to evaluate the whole range of possible methods of encoding and decoding surround-sound based on fundamental psychoacoustic principles. Although the full development was highly mathematical, the basic principles underlying the Ambisonic or NRDC 45J system* of surround-sound are described without mathematics, this new system being the best possible according to the methods used.

Up to now, surround sound system design has to a considerable degree been based on guesswork as to what signals fed to an array of loudspeakers will produce a "desirable" directional affect. As an exhaustive experimental evaluation of the directional effect of arbitrary crosstalk patterns for even just a square speaker array involves consideration of a six-parameter family of crosstalk configurations, and as even small variations of the crosstalk pattern can produce significant alterations of directional effect, it would be necessary to do experiments for about 10` different crosstalk patterns before one could say that a system could be optimized purely on the basis of experimental data. This is impracticable.

A very general theoretical framework has been developed[1] to assist in maximizing the information that can be deduced from limited experimental tests on human directional psychoacoustics. Certain aspects only of this psychoacoustic framework are discussed in this article.

At low frequencies, the information reaching the brain consists of the sum of the inputs to the two ears, i.e. an omnidirectional or "pressure" sound pick-up and the difference of the inputs to the two ears, i.e. a sideways-pointing figure-of-eight or "velocity" pick-up, Fig. 1. Most low frequency (<700Hz) theories of hearing assume that only the interaural phase is used to determine direction, which is equivalent to saying that only those components of the sideways figure-of-eight pick-up that are in-phase or out-of-phase with the pressure signal components are used by the ears. In practice the 90°-phase components of figure-of-eight pick-up do affect localization quality toward the top end of this low frequency range, and produce an effect called "phasiness."

In practice, the head may rotate, so that the forward-pointing figure-of-eight pick-up of sound information is also used to determine sound direction. The relative intensity of in-phase figure-of-eight signals in the forward and sideways direction defines a vector pointing in the apparent sound direction according to Makita's theory and is susceptible to calculation as described in reference 4. The length of this vector (divided by the pressure amplitude) should be one for real-world sounds, and so decoders should be designed with a pressure-to-velocity ratio assuring this requirement for all reproduced sound directions at low frequencies, in addition to ensuring correct Makita localization. It is an incorrect velocity-vector length that makes the side image reproduction so poor in conventional "discrete" quadraphonics.

If there is too high a phasiness, it is clear that this can be reduced for a given decoder design by subtracting from the figure-of-eight signals a suitable amount of 90° phase-shifted pressure signal. In practice, the amount of unwanted 90°-shifted figure-of-eight information varies with sound direction, so that phasiness compensation to reduce phasiness in one direction will tend to increase it in the opposite direction. Nevertheless, it is possible to use this technique to give a subjectivity optimized phasiness, as shown in Fig. 2.

The block diagram of Fig. 2 is a psychoacoustically optimized decoder consisting of a phase-amplitude matrix producing pressure, forward and sideways velocity and 90° phase-shifted pressure signals from the input channels; the design of the phase-amplitude matrix depends on the encoding system.

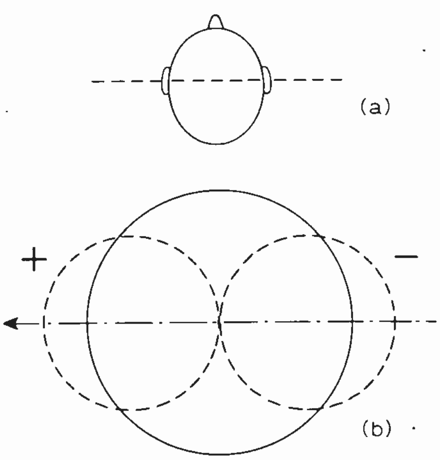
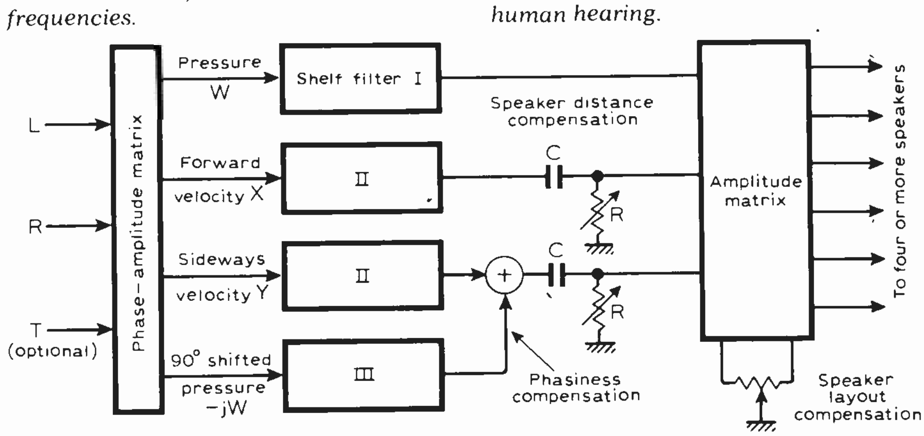


Fig 1: Pressure and velocity (figure-of-eight) pick-up characteristics of the sum and difference of the inputs to the two ears of a listener at low frequencies.

Fig 2: Block diagram of decoder satisfying the main psychoacoustic requirements. Shelf filters are all-pass types designed to have identical phase responses, and make the decoding matrix varying frequency according to the frequency-dependent properties of human hearing.



* System 45J is the subject of a UK-section AES meeting to be held on 12 April at the IEE, savoy Place. 19.00h. Title is "Hearing and surround-sound," by P. B. Fellgett, M. Gerzon and T. Takagi.

The shelf filters are frequency-dependent gains that permit adjustment of the relative velocity and pressure gains so that at low frequencies the velocity-vector length is correct, and at higher frequencies other psychoacoustic requirements, described later, are satisfied. The "distance compensation" is high-pass RC filtering of velocity, typically — 3dB at 20Hz, to compensate the bass boost of the velocity signals produced at the listener by the curved sound field (caused by finite loudspeaker distance). It is mainly the phase response of this filter that is psychoacoustically important. The output amplitude matrix produces speaker feed signals, dependent on the speaker layout used, that create correct pressure and velocity at a central listening position.

At higher frequencies, about 700 to 5kHz, a different class of theories of hearing take over. In these theories localization is via signal energy, and is determined by drawing a vector pointing to each speaker having length equal to the energy of a sound from that speaker. The sum of these vectors is a vector pointing in the intended sound direction, which direction is the "energy vector localization." The length of this vector, divided by total energy (energy vector magnitude) is 1 for real-world sounds, and should be as large as possible in decodecs for good localization.

There is a transitional frequency band, 250 to 1.5kHz over which both classes of theories may apply, and it is important that decoders should give both correct pressure/velocity and energy localizations as far as possible over this transitional range. This is ensured by designing decoders to give Makita and energy vector localizations that are identical at all frequencies; this may be ensured for many types of speaker layout (rectangle, hexagon, etc.) by a suitable design of output matrix. The shelf filters in Fig. 2 are then chosen to give optimum velocity magnitude at low frequencies and optimum energy vector magnitude at high frequencies. Note that this design procedure involves designing not only optimum low and high frequency decoding matrices, but an optimal variation of the matrix over the transition frequency range.

One result that emerges from this theory is a remarkable mathematical theorem to the effect that the optimal accuracy of reproduction of images in non-speaker directions via a rectangle of speakers can be obtained *only if the four speakers are fed with not more than three information channels;* it may be shown that $-L_B+L_F-R_F+R_B$ should always be zero for best results. Experiment confirms the theory.

Given that we have a means of designing decoders for optimal psychoacoustic results for any encoding system capable of producing suitable pressure and velocity signals, the aim is then to find the best encoding system, i.e.. the one whose optimized decoder gives better results than for all other encoding systems.

It is possible to classify mathematically all systems with not more than three channels that are capable of satisfying the Makita, energy vector and velocity magnitude requirements via suitable decoders. This classification involves about 40 pages of mathematics, but can be solved exactly. The theory involved also gives the detailed parameters of decoders that optimize the reproduced psychoacoustics of the directional effect for every sound direction.

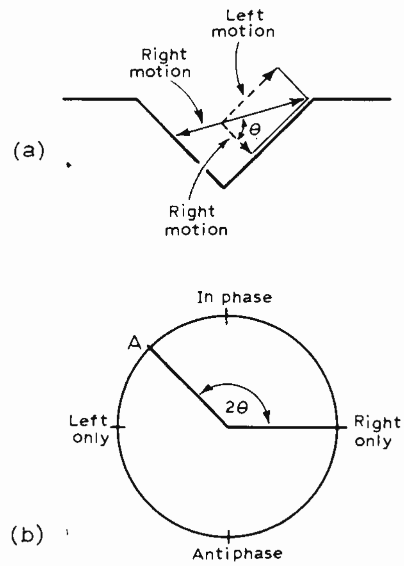


Fig 3: Angle θ of stereo stylus motion in record groove corresponds to an angle 2θ on a circle representing possible stereo positions.

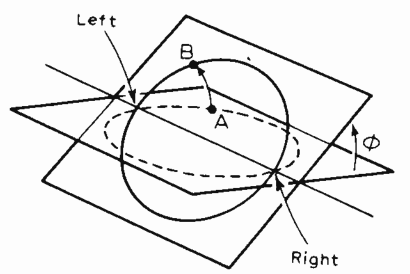


Fig 4: Circle point A goes to point B on sphere by a rotation by angle θ equal to the phase lead on the left channel.

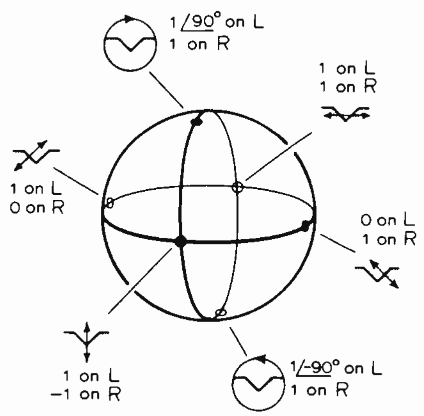


Fig 5: Typical stylus motions (for sine wave signals) and left and right channels gains corresponding to various points on the energy sphere.

The requirements on surround-sound performance of such systems include the following.

- The two baseband stereo signals L and R must be decodable for surround directional reproduction in a way satisfying all the basic psychoacoustic criteria discussed earlier.
- It must be possible to supplement the baseband with a third signal capable of being decoded with improved directional effect. A fourth channel is not required as it can only degrade directional reproduction.
- To achieve high quality from carrier discs, which have certain inherent theoretical limitations determinable by standard information theoretic analysis, it is necessary to bandlimit the subcarriers to a few kHz.
- It is required that satisfactory decoders be designable for the case when the third channel is bandlimited, not only in directional effect, but also in flat reproduced frequency response in *all* encoded directions. The directional effect requirement for such "2½ channel" use means that, as the third channel is attenuated the Makita (and hence energy vector) localization of a three-channel decoder should remain unaltered.
- Within these above constraints, the two channel decoding should be capable simultaneously of low phasiness for front-stage sounds, good localization at the left and right side positions, and with a uniform reproduction of ambience information around the listener on "natural" ambient recordings.

A way of describing the two-channel baseband encoding is the "energy sphere" (ref. 2) which represents the relative phase and amplitude gain of each sound on the two channels as a point on a sphere. A sound recorded on the two groove walls of a stereo disc (Fig. 3), without the use of phase shifters is represented by a point A on the horizontal circle of this sphere, at an angle from the right-most point of the circle twice as big as the angle made by the stylus motion from the right-channel-only direction of stylus motion. In this way all in-phase and out-of-phase lines of stylus motion are mapped to points around a circle. If the left channel is now made to phase-lead one right channel by a phase angle ϕ, then the point B on the sphere representing the method of encoding is also obtained from A by rotating the circle about its left/right axis by an angle ϕ as shown in Fig. 4. Stylus motions and left and right channel phases and gains corresponding to various points on the energy sphere are shown in Fig. 5.

One may describe a method of encoding by the way its energy sphere point varies with encoded direction. The locus traced out on the sphere as the

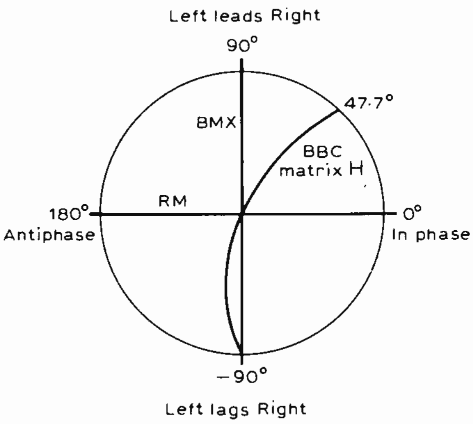


Fig 6: View from right side of energy sphere, showing RM (Regular Matrix) BMX and BBC Matrix H system two-channel encodings. Angles indicated round edge show the phase lead of the left channel.

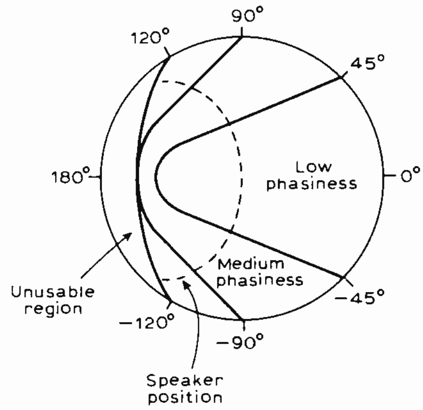


Fig 7: Quality of mono and stereo reproduction shown on energy sphere viewed from right side. "Speaker position" curved indicates appearing to come from one speaker only in stereo.

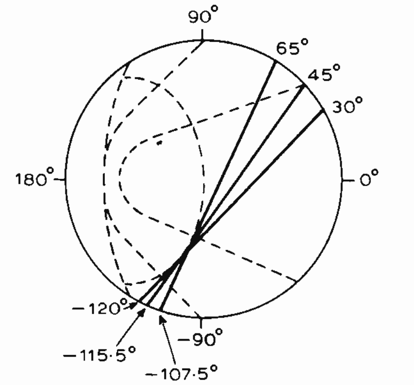


Fig 8: Three possible choices of two-channel encoding system having optimized mono and stereo reproduction.

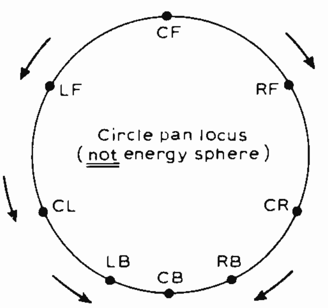


Fig 9: Showing optimized non-symmetric distribution of different encoded directions within the circle "pan locus" of the systems shown edge-on in Fig 8. C_F stands for "centre-front," R_B for "right-back," C_L for "centre-left" and so on. This figure is not a picture of the energy sphere.

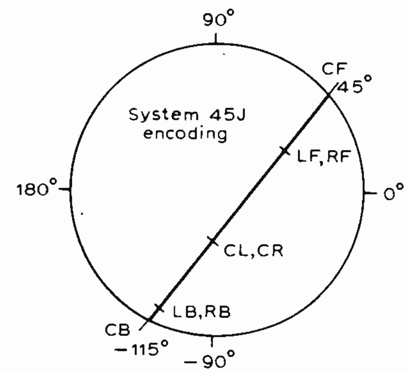


Fig 10: Energy sphere (side view) picture of two-channel version of System 45J encoding.

sound rotates through 360° is shown as the "pan locus" of the encoding system. The best-behaved systems are those in which the left-half and the right-half of the pan locus are mirror images of one another. For such systems, it is convenient to view the locus on the sphere from the right hand side; Fig. 6, shows the side view with various existing system pan loci. The angles round the edge indicate the relative phase lead of the left channel over the right channel, and the centre point represents left-only or right-only.

Fig. 7 gives a rough indication of the acceptability of the mono and stereo quality, as previously discussed. The shaded nearly antiphase region at the back of the sphere must be avoided for direct sounds, both because sound in this region is excessively attenuated in mono, and because the sound is very "phasey" and hard-to-localize in stereo. (It is not always undesirable to have reverberation information in this region, however). Approximate regions of low and medium phasiness effects in stereo are also shown, although the boundaries are not in practice sharply defined. It is possible to have a sensation of unpleasant phasiness for some programme material even when it is all in one low phasiness region, and some material can sound acceptable even in the high phasiness region. In practice, it is found preferable to minimize stereo phasiness for front-sector sounds, even if this means making phasiness marginally worse for rear-sector sounds.

The stereo image must have full stage width. This need not mean the locus passing through the left-only point, but can be achieved as long as the pan locus touches the "speaker position" curve Fig. 7 along which sounds appear to lie in one speaker only in stereo. Thus to get good mono and stereo compatibility, the locus must be moved as far forward as possible, especially for front-encoded sounds, while touching the speaker-position curve.

Another constraint lies in the requirement for good surround decoding. The effect of using a bent locus, see Fig. 6, rather than a circle locus (whose side view is a straight line!) is that surround decoders give poor side-image localization and it can be proved that this is inevitable for any design made for such systems according to psychoacoustic theory. The asymmetry between side-to-side and front-to-back performance of bent loci means also that ambience reproduction is poor and that 2½-channel decoders cannot give a substantially flat frequency response for all directions of encoding. For these reasons, a circle-locus system must be chosen; otherwise surround reproduction quality inevitability must be degraded.

Pulling a circle locus as far forward as it will go on the sphere while touching the speaker position curve yields possibilities shown in Fig. 8. As the front-centre interchannel phase angle increases from 30° to 65°, the stereo phasiness becomes progressively worse for front-sector sounds, but better for back-sector sounds, and mono compatibility improves. One can argue indefinitely about which compromise of compatability properties is best, but we have found that the 45°/-115.5° locus seems best to satisfy the needs of the widest range of users, including record companies and broadcasters. Moreover, this locus has good performance when used with existing regular matrix (RM) and UMX equipment for decoding. Thus a changeover to this standard should cause minimal disruption, and could simplify the confused market situation by reducing the number of systems on the market.

A further optimization of reproduced surround effect comes from a careful choice of the way different encoded directions are distributed within the circle locus. Low decoded front-stage phasiness in surround may be combined with uniformly reproduced ambience if a sound-azimuth distribution within the circle locus is chosen, as in Fig. 9. This distribution helps widen the stereo presentation for front-stage sounds, thus also giving much better stereo compatibility. The front quadrant of directions alone gives an image filling over 0.8 of the stereo stage in subjective tests. Such "asymmetric circle encoding" requires a careful choice of third-channel encoding to achieve the best 2½-channel decoded results; the mathematics of this is described in reference 4.

The resulting system of encoding, Fig. 10, is called System 45J, and was chosen only after both exhaustive theoretical studies and experimental tests, as well as international discussions within the audio industry. As it is the first system design based on a complete mathematical analysis of both system theory and human psychoacoustics, it is possible to say with some confidence that no system appreciably different from it can exceed its performance in optimal surround-sound decoding, so that no further system change is ever likely to be needed for horizontal encoding.

Unlike all previous proposals, System 45J can handle virtually any legitimate requirement in terms of recording philosophy and yet be suitable for listening in mono, stereo, two-channel surround, 2½-channel surround or three-channel surround, giving good results in all modes. There are no sound positions which producers should not use, no incompatibility with types of recording technique such as coincident microphones, and no requirement that variable-matrix decoders be used with their inevitable side-effects.

This choice of encoding system does not prevent equipment manufacturers from using their own decoding philosophy if they desire. For example, both Sansui Variomatrix and the logic decoders can easily be adapted or designed for System 45J. However, if optimum musical results are required, decoders satisfying the maximum number of requirements of human directional psychoacoustics should be used. We have outlined how such decoders may be built*; and in the near future, a decoder will be publicly demonstrated reproducing sounds via an arbitrary rectangle speaker layout, that can also be hooked up to feed a hexagonal six-speaker layout for an even closer approach to the ideal illusion.

So far, experimental testing has been carried out via about 30 psychoacoustic decoder designs for a wide variety of encoding systems, and a broad spectrum of studio technology developed to get the best possible results. This information will be made available to the industry. The use of System 45J with this technology gives results that are far more convincing and musical, even via two channels, than was the underdeveloped "quadrophonic" approach to surround sound which has now been rendered obsolete by this work. This work was done as a part of the Ambisonic project of the U.K. National Research Development Corporation.

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2. M. A. Gerzon. Geometric model for two-channel, four-speaker matrix stereo systems, *JAES* vol. 23. 1975, pp98-106.
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4. M. A. Gerzon. Optimum choice of surround-sound encoding specification, 56th AES convertion, Paris March 1977

Following articles will give circuit details of a decoder based on these principles and which will decode system 45J and stereo for square, restangle and hexagon speaker layouts, with distance and psycho-acoustic compensation. — Tech. ed.

Post Office "holding back technical improvement"

Sixty-one votes prevented Mr Nicholas Ridley from introducing a bill on February 1 to end the Post Office monopoly of the supply of telephone equipment. Seeking leave to introduce a bill he said: "It may be that there are some subscribers who want telephones of different colours from those provided by the Post Office, and they cannot get them. The Post Office monopoly prevents it.

"A more important example is the pushbutton telephone device. We have these in this House, and I can well understand why they have not been allowed outside. If they were unleashed upon the unsuspecting public, dissatisfaction with the Post Office would increase apace. But there is no reason why a really effective push-button telephone should not be offered to subscribers."

Other examples, he said, included automatic telephone dialling equipment, loudspeaking telephones, and more varied answering equipment. "Telephone engineers believe that eventually it will be possible for the telephone connected to one's house to operate as a minicomputer and to give access to one's bank, department store or supermarket direct, and to allow one's meter to be read direct by the telephone. There are all sorts of imaginative, labour saving and exciting devices all within the realms of possibility. But there is one small difficulty – the Post Office is sitting on them, and its monopoly is preventing the proper development of these technical devices."

This criticism also affected the degree of choice available to those subscribers with their own exchanges. His bill proposed that a committee of independent people should check that any equipment developed for the home was compatible with the Post Office network.

The reply to Mr Ridley, the Conservative member for Tewkesbury, a civil engineer and the opposition spokesman on technology and trade from 1969 to 1970, was given by Mr Ian Wrigglesworth, the Labour and Co-operative member for Thornaby and press spokesman for National Giro. He gave a number of reasons why the bill should not be read. The first was that the Carter committee on the future of the Post Office was still sitting, and would probably consider this very point. The second was that the Annan committee was also sitting; "It will no doubt comment on the future of cablevision and on the whole question of common carrier cables."

A third reason he gave was that the testing of each piece of equipment to be connected to the system would be "a cumbersome, expensive and ineffective process and the consumer would have to bear the costs." Another was that all Mr Ridley hoped to achieve was the creaming off of profitable parts of the Post Office's operations, of which this was one, leaving the Corporation with unremunerative services like the expensively-maintained 'phone boxes. There was already competition among private firms for making small private branch exchanges, special telephones, data transmission and teleprinter equipment provided by the Post Office, though he agreed the range of the equipment so provided ought to be extended. "The Post Office needs to be much less cautious and more aggressive in its marketing and in the number of pieces of equipment that it provides." Joint efforts with manufacturing industry to provide exportable equipment for sale abroad ought to be done through putting pressure on the Post Office.

In the division 175 members voted for the motion, 236 against.

New hope for solar power

A student working on a PhD thesis on the properties of films at the department of plasma physics at Sydney University appears to have discovered an important way of tapping solar energy. Until now, solar cells have managed to produce temperatures of a maximum of 150 C, but the reports from Australia indicate that the new method is able to achieve 300 C as well as being cheaper than other methods. Details of the method are not yet available, but it appears to be based simply on a characteristic of one film that was tried, with chromium oxide as a main constituent, in converting much of that part of the sunlight it absorbs into heat. The student is a pupil of Dr Charles Watson Monro, the professor of plasma physics, and Professor H. Messel.

News of the development came about a week before the government published its long awaited paper on solar energy (Solar Energy: its potential contribution within the United Kingdom-Dept of Energy, Energy paper 16, HMSO £3) and announced that the Department of Energy would be adding £3.6 million to the £2.4 million already being spent by the Industry and Environment Departments in r & d on solar energy. The main areas of the new study will be in domestic water and space heating. Up to half the cost of suitable projects by commercial firms would be supplied.

A lecture on "An experimental energy-saving house" will be given at the IEE, Savoy Place on April 21 at 5.30.

Characteristics and load lines

5 — Non-linear load lines

by S. W. Amos, B.Sc., M.I.E.E.

Part 3 (October 1976) and Part 4 (February) were devoted to linear load lines but in practical circuits load lines can be non-linear for a number of reasons. In this part we shall examine the forms of non-linearity of load lines that can occur and the effect this has on circuit performance.

A.c. and d.c. load lines

When a load resistor R_1 is capacitance-coupled to a following resistor R_2 there are effectively two load lines, one representing the steady-state or d.c. conditions in the circuit and the other representing the signal-frequency or a.c. conditions: these are sometimes known as the static and dynamic load lines. Because the a.c. resistance in the load circuit is necessarily less than the d.c. resistance, the a.c. load line has a greater slope than the d.c. load line and intersects it at the quiescent point as shown in Fig. 1. As a result the output voltage available from an amplifier is reduced by the connection of R_2: in Fig 1 the peak-to-peak value of the voltage is reduced from AB to ab. It is possible that the reduced output may still be adequate for the following stage but the restriction of output voltage is sometimes serious and it is useful to know precisely how great it is. The calculation is easy because the voltage developed across an unshunted load resistor R_1 is IR_1 where I is the alternating component of the active device output current. For the shunted resistor the output voltage is $IR_1R_2/(R_1 + R_2)$ in which the reactance of the coupling capacitor is assumed negligible compared with R_2 at the operating frequency. The ratio of the two voltages is $R_2/(R_1 + R_2)$ which shows that if the shunting resistor is equal to the load resistor the output voltage is halved. To limit the reduction in output voltage to 10 per cent of that developed across R_1 alone, R_2 must not be less than 9 R_1. This underlines the requirements, well-known for a voltage amplifier, that the output should be terminated in a high-value resistor.

Fig. 1 also shows the output current waveform as a reminder that there is no corresponding reduction in amplitude as a result of shunting the load. On the contrary the effective reduction in the value of the load resistance increases the current output.

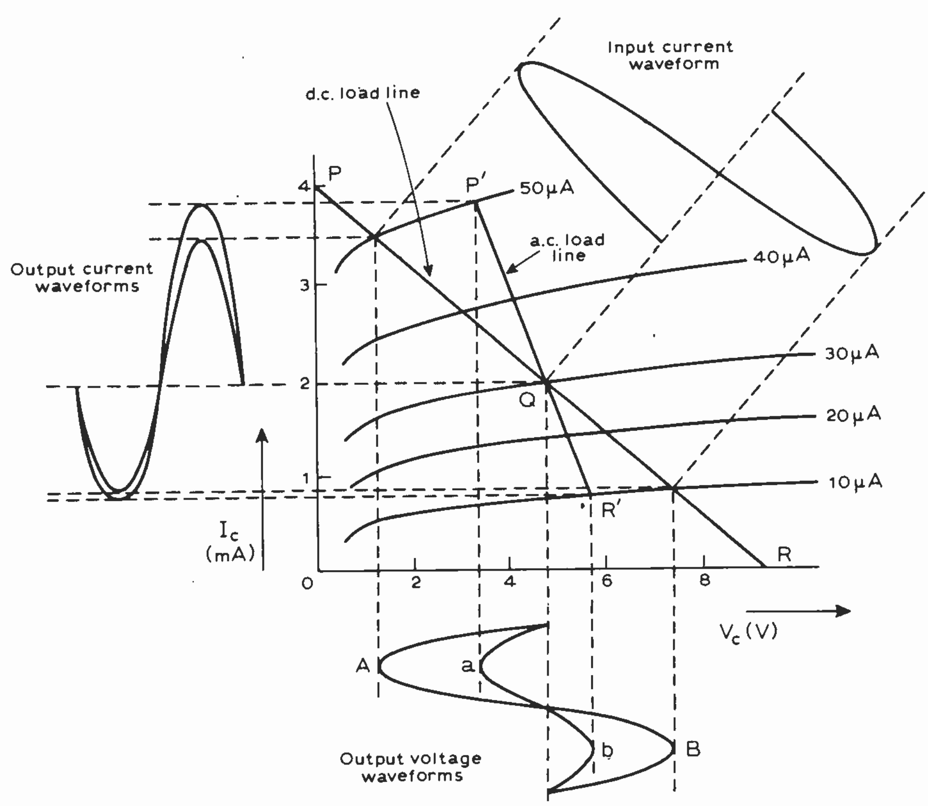


Fig. 1. The reduction in output voltage due to the different slopes of d.c. and a.c. load lines.

Suppose the amplitude of the input signal to an amplifier with an unshunted load resistor is adjusted so that the operating point moves over the entire length of the d.c. load line. If the load is now shunted the operating point transfers to the a.c. load line which is rotated clockwise with respect to the d.c. load line about the quiescent point. As a result one half cycle of the output signal is clipped as shown in Fig. 2. In effect the a.c. load line now includes a short length of the voltage axis and is thus non-linear. This may seem an academic point because any distortion arising from such non-linearity could easily be avoided by reducing the amplitude of the input signal so that the excursions of the operating point are confined to the linear portion of the a.c. load line. The reduction in amplitude required to do this is given by the expression deduced above $R_2/(R_1 + R_2)$. This is not an academic point, however, because in diode a.m. detectors harmonic distortion can arise from precisely this cause if there is a resistive

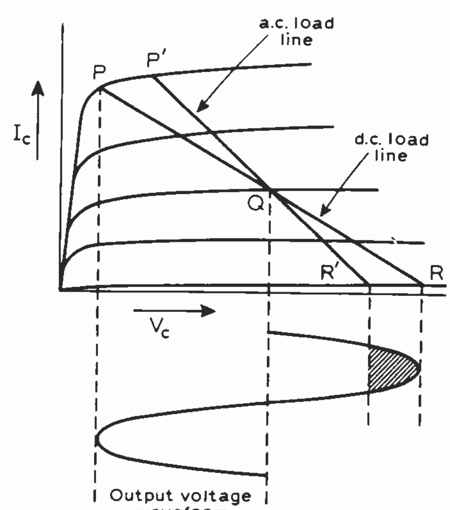


Fig. 2. Clipping of output voltage waveforms as a result of the difference in slope between a.c. and d.c. load lines.

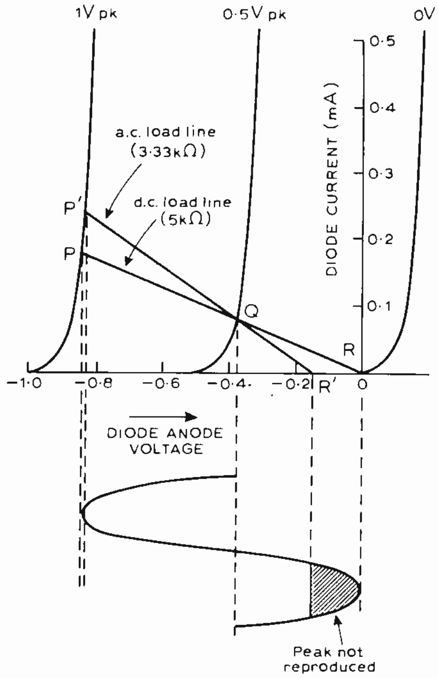


Fig. 3. Clipping of output voltage of a diode detector as a result of the different slopes of the a.c. and d.c. load lines.

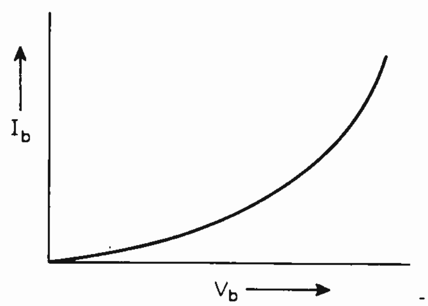


Fig. 4. Relationship between base current and base voltage for a bipolar transistor.

shunt on the diode load. The mechanism of the effect is illustrated in Fig. 3 which shows the anode voltage/anode current characteristics for a diode. These are sometimes known as rectification characteristics and each curve shows the relationship between current and voltage for a particular value of peak input.

It is assumed that the diode feeds a capacitor which charges up to the peak value of the applied signal. Thus for a 1—V peak input signal the diode anode takes up a voltage of −1 V for zero anode current. If current is taken from the diode the anode voltage falls as indicated by the slope of the characteristics. If the signal applied to the diode is amplitude-modulated the peak value varies in accordance with the waveform of the modulating signal and for a 0.5-V peak signal, modulated 100 per cent, the input swings between zero and 1V. The diode load can be represented by a d.c. load line as discussed earlier and PQR shows a load line for 5 kilohms, a value commonly used in transistor a.m. receivers. Q is the quiescent point where

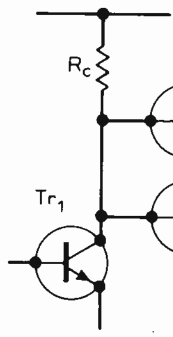


Fig. 5. Skeleton form of a driver feeding a complementary class-B stage.

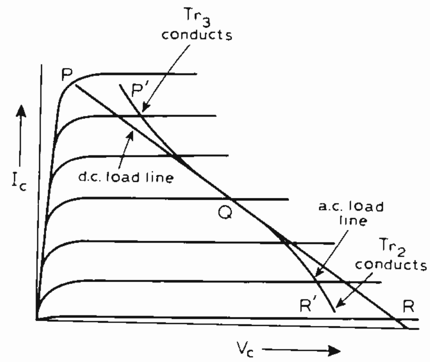


Fig. 6. D.C. and a.c. load lines for the circuit of Fig. 5.

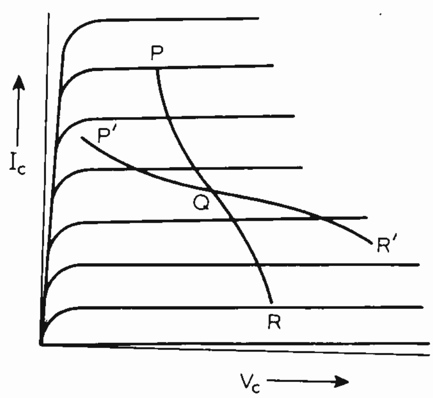


Fig. 7. A.C. load line P'QR' shows the effect of doubling the step-down ratio of the driver transformer feeding a class-B stage.

the characteristic for 0.5-V peak value intersects the load line. In the absence of modulation, therefore, the diode anode has a voltage of −0.38V and the diode current is 0.07mA. When 100 per cent modulation occurs the operating point moves up and down the d.c. load line between the limits of 0.86V (1.7mA) and zero. This represents the performance of the detector if its true load at signal frequencies is 5 kilohms.

In a practical circuit, however, the output of the diode must be applied to the following stage, normally an a.f. amplifier, and this stage has an input resistance which shunts the diode load. Let us assume that this has an input resistance of 10 kilohms. The a.c. load resistance is thus 3.3 kilohms and the a.c. load line therefore has a slope corresponding to this value of resistance and passes through the quiescent point as shown by P'QR' in Fig. 3. This load line intersects the voltage axis at −0.15V, so clipping one of the peaks of a 100 per cent modulated input to the detector as shown by the shaded area. This represents serious distortion because the upper third of the amplitude range of the signal is not reproduced. The detector can operate reasonably successfully only if the depth of modulation of the input signal is limited to 67 per cent. The tendency in a.m. broadcasting is, in fact, to keep the modulation percentage high so to give a good signal-to-noise ratio. Thus to enable the detector to handle high modulation percentages the shunting effect on the diode load must be minimised and the a.f. amplifier should therefore have an input resistance high compared with the value of the diode load. Perhaps the easiest way of ensuring low distortion would be to interpose an emitter follower between the diode load and the a.f. amplifier.

Non-linear load resistance

So far in this series it has been assumed that the loads presented to active devices are purely resistive: the load lines are accordingly linear, showing the direct proportionality between current and voltage for such loads.

If, however, active devices are connected in cascade as in multi-stage equipment the load for one stage is often largely determined by the input resistance of the following stage. For a bipolar transistor the input resistance is not linear but varies with input voltage as indicated by the I_b–V_b characteristic in Fig. 4. The slope of this curve is low for small values of V_b showing that the input resistance is high for such values but as V_b increases the slope increases and the input resistance decreases. For small alternating signals the changes in input resistance may be negligible and it is common in the design of small-signal amplifiers to assume that the input resistance is constant throughout each cycle of input signal. For large signals, however, the variations are significant and must be taken into account in designing circuits. This is particularly true of the input resistance of class-B stages where the transistor is biased near collector-current cut-off and is driven into conduction by the input signal. Because a transistor so biased can amplify only one half cycle of a sinusoidal input, class-B stages in linear equipment are operated in push-pull. This makes the stage symmetrical so that the input resistance for a particular value of positive-going input is the same as for a negative-going input of equal amplitude.

As input increases, however, input resistance decreases. To deduce the effect of such input-resistance variations on the shape of the load line for the driver stage consider the circuit shown in Fig. 5. The d.c. load line for R_c is PQR in Fig. 6 and this represents the relationship between Tr_1 collector voltage and collector current in the absence of any shunting effect from the following class-B stage. Q is the quiescent point at which, we shall assume, the two class-B transistors Tr_2 and Tr_3 are almost cut off. The effect of a resistive shunt on R_c is to introduce an a.c. load line which passes through Q and is rotated clockwise with respect to the d.c. load line to an extent which increases with decrease in the value of the resistive shunt. Thus the rotation is slight for small-amplitude signals (i.e. for operating points near Q) for which the class-B stage presents a high resistance. The rotation increases however as signal amplitude increases and operating points move away from Q. Thus the a.c. load line has the elongated S shape shown as P 'QR' in Fig. 6.

If a sinusoidal signal is assumed applied to Tr_1 base it is possible to deduce from Fig. 6 the waveform of the corresponding collector current and voltage. The curvature of P 'QR' is such that it can cause serious distortion of the collector-voltage waveform but this is not generally of importance because it is the shape of the current waveform which matters and, provided the load line is reasonably steep, there is unlikely to be serious distortion of the current waveform. This is to be expected because a current amplifier should be presented with a low-value load. Such a load ensures that any load-value variations have negligible effect on the output current and that most of the current enters the class-B stage rather than R_c.

If a transformer is used to couple a class-B stage to the driver stage, the turns ratio can be adjusted to present the driver stage with a desired value of load resistance. As an example consider Fig. 7 which shows at P'QR' the load line representing the input resistance of a class-B stage. If the step-down ratio is doubled, the effective resistance at the primary winding is quadrupled and the driver stage is called upon to deliver twice the voltage swing and one half the current swing. The load line thus rotates anticlockwise about the quiescent point and its new position is at P'QR'.

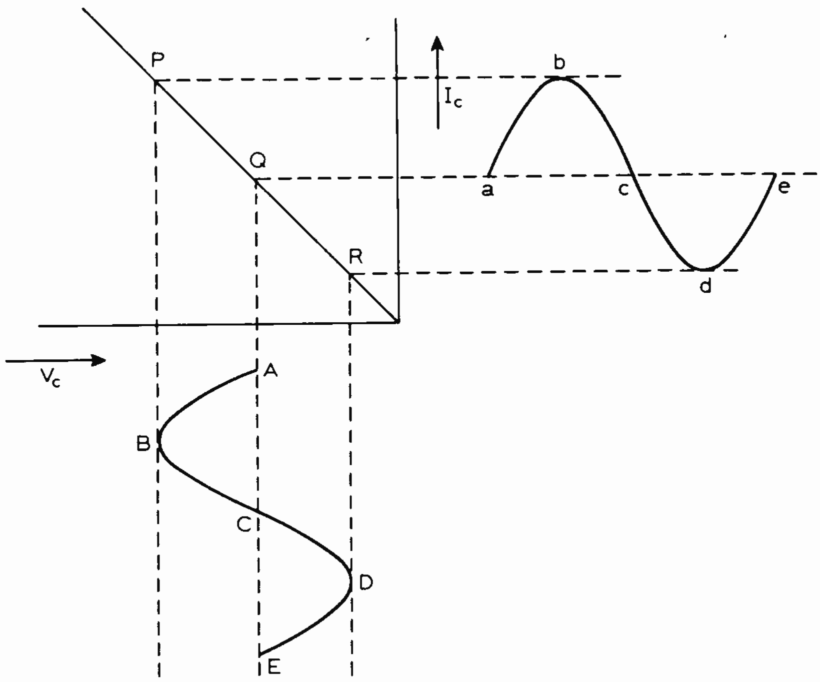


Fig. 8. Current-voltage relationship for a linear resistor.

Elliptical load lines

In linear amplification where transformers are used between cascaded stages it is normal practice to make the primary inductance so large that the reactance even at the lowest frequency is large compared with the load resistance. The effective load is then purely resistive and the load line is linear as described earlier.

Suppose, however, that the shunt reactance is not large and absorbs an appreciable fraction of the output current, or that an inductor is connected in series with a load resistor to extend the upper frequency limit as in a video amplifier. How does the reactance so introduced affect the load line?

To determine this consider Fig. 8 which shows the current-voltage relationship for a linear resistor initially free of associated reactance. It is assumed that the resistor is the load of a transistor and the voltage plotted along the horizontal axis is not the voltage drop across the resistor but the voltage at one end of it, e.g. the collector voltage of the transistor feeding the resistor. The other end of the resistor is assumed connected to the positive supply terminal. Thus an increase in the collector voltage means a decrease in the voltage across the resistor and a proportional decrease in the (collector) current through it. If the collector current varies sinusoidally as shown at *abcde* the corresponding collector voltage *ABCDE* is inverted with respect to it.

Suppose now that the resistor is shunted by an inductor with a reactance at the frequency in use of twice the ohmic value of the resistor. The sinusoidal current *abcde* flows in the resistor as before but there is now an additional current (in the inductor) which has half the amplitude of the resistive current and lags it by 90°. This reactive current is shown as *a'b'c'd'e'* in

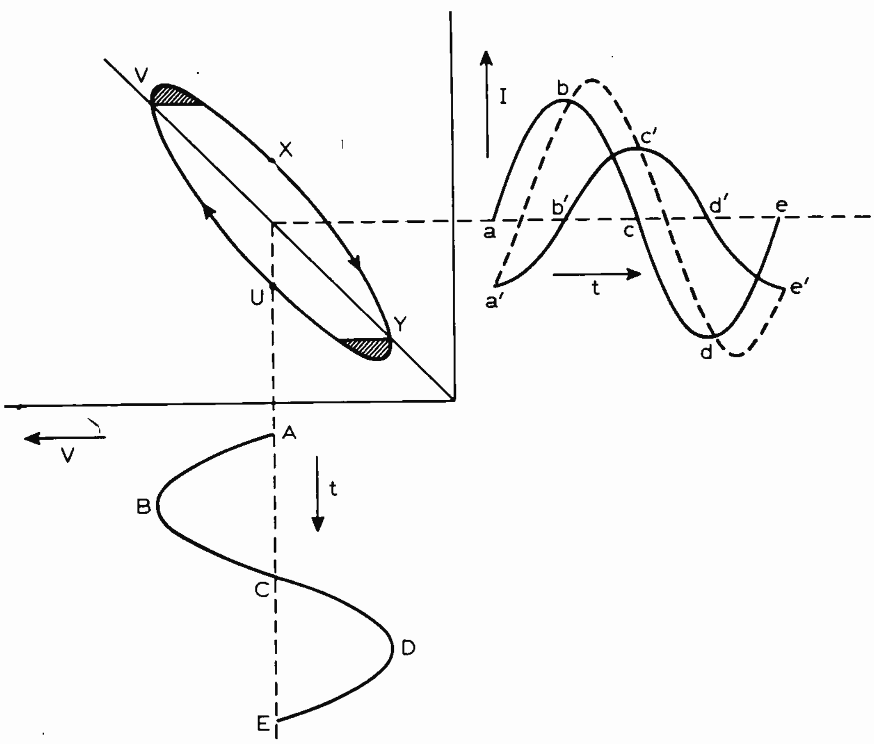


Fig. 9. Derivation of the elliptical load line for a parallel LR combination.

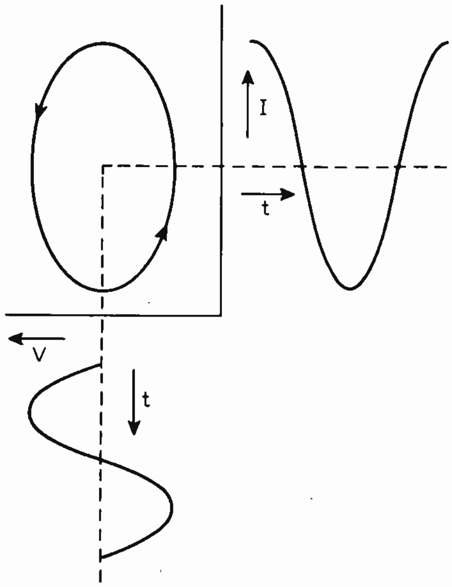


Fig. 10. A purely-reactive load has a load line in the form of a true ellipse. This ellipse and the associated current and voltage waveforms apply to a purely-capacitive load.

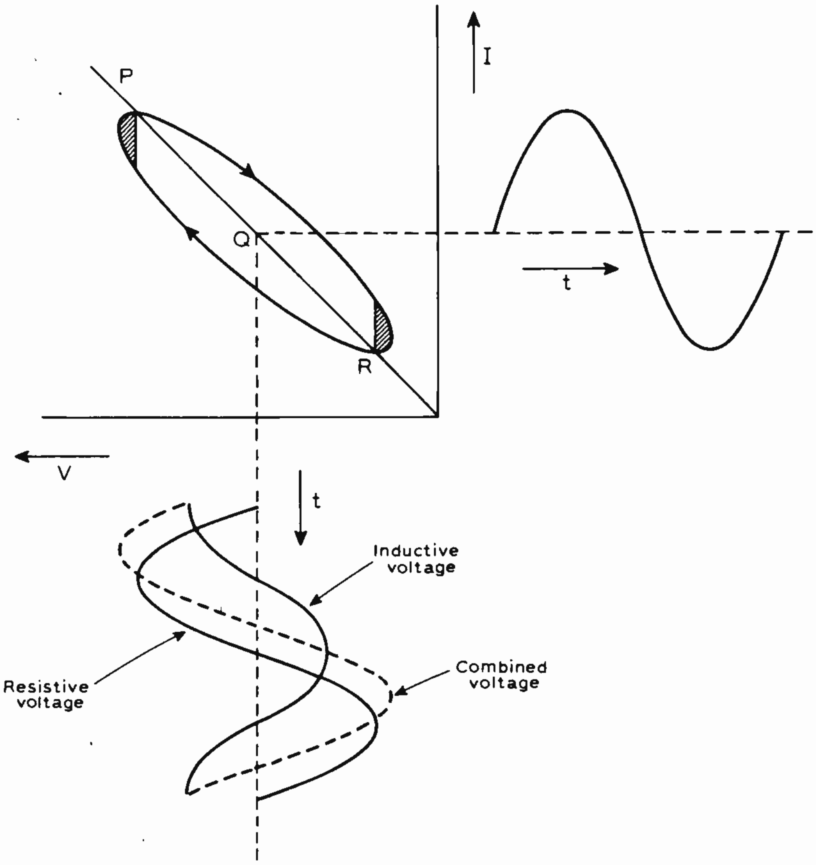


Fig. 11. Elliptical load line for a series LR combination.

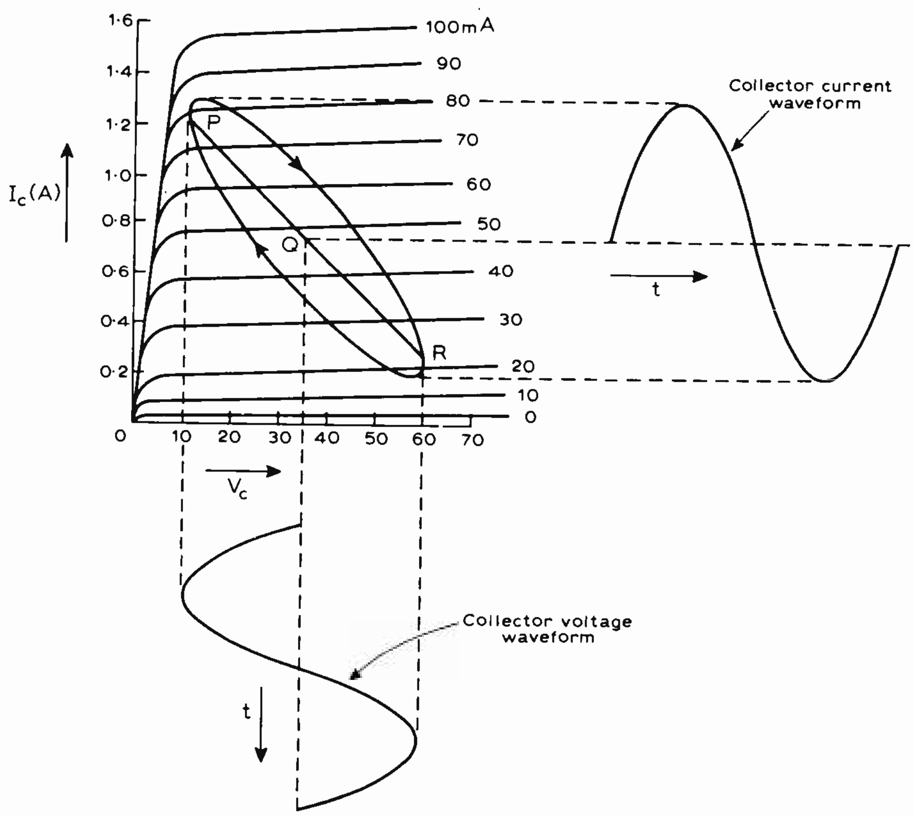


Fig. 12. An elliptical load line superimposed on a set of $I_c - V_c$ characteristics.

Fig. 9. The current in the LR combination, i.e. the output current of the active device, is the sum of *abcde* and *a'b'c'd'e'*. If we take the datum line *ace* as representing zero current, the sum of *a* and *a'* is at *a'*. Similarly the sum of *b* and *b'* is at *b*. By continuing in this way we can deduce the shape of the waveform of the net current. It is shown in dashed lines *a'bc'de'* in Fig. 9 and is, of course, sinusoidal with a frequency equal to that of the voltage but phase retarded relative to the voltage. The amplitude of this current is in fact approximately 1.12 of that of the resistive current and is 26.5° retarded relative to it. We now know the waveform of the voltage across the LR combination and that of the net current through it. From this information we can deduce the form of the load line in the following manner. The current corresponding to voltage *A* is at *a'*: vertical and horizontal lines from these points meet at U which is therefore a point on the load line. Similarly the current corresponding to voltage *B* is at *b* giving point V on the load line. By continuing in this manner we obtain points X and Y and the next point is back again at U, showing that the load line has the form of an ellipse and that the operating point moves in a clockwise direction around the circumference of the ellipse at the rate of one revolution per cycle of signal.

The elliptical shape results from the interaction of two sinusoidal signals at the same frequency but with a phase displacement between them and can be demonstrated on an oscilliscope by applying the two signals to the X and Y plates: the ellipse is, in fact, one of the Lissajous figures.

The ellipse shown in Fig. 9 was for a parallel combination of resistance and inductance. For a parallel RC circuit the reactive current is phase advanced on the voltage but a similar elliptical load line results, the operating point this time moving anticlockwise around the perimeter.

In a series LR combination it is the current which is common to the two components. As shown in Fig. 11 the voltage across the resistor is in phase with the current; that across the inductor leads the current by 90°. The two voltages are added to obtain the net voltage across the combination and this, together with the current waveform, enables the shape of the load line to be deduced. It is again an ellipse and operating-point rotation is clockwise. A series RC combination gives a similar ellipse but the operating point moves anticlockwise around it.

The "fatness" of the ellipse, i.e. the ratio of the minor to major axis, depends on the phase displacement between the current and voltage in the load. If there is no displacement the ellipse becomes the linear load line VY in Fig. 9. If there is 90° phase displacement, as for a purely inductive or capacitive load, the ellipse has the form shown in Fig. 10. The major and minor axes are now vertical or horizontal and this is a true mathematical ellipse obeying the equation $x^2/a^2+y^2/b^2=1$.*. By suitable choice of scale for the current and voltage axes the major and minor axes can be made equal and the ellipse then becomes a circle. An elliptical load line such as that shown in Fig. 9 is a combination of a true ellipse (representing the reactive component of the load as in Fig. 10) and a linear load line (representing the resistive component of the load). An important point is that the ellipse is not symmetrical about the linear load line but is rotated slightly about the quiescent point in a clockwise direction for a parallel reactance/resistance combination and anti-clockwise for a series combination: thus the resistive load line does not coincide with the major axis of the ellipse.

The shaded areas in Fig. 9 represent the additional current which the active device has to deliver as a result of the reactive component of the load. The voltage swing is unaffected by the addition of the reactive component as would be expected for a parallel combination.

Fig. 11 applies to a series LR combination and the shaded areas here represent the additional voltage which the active device must deliver as a result of the addition of the reactance: the current swing is unaffected.

Curvature of load lines is usually associated with waveform distortion and it might therefore be expected that an elliptical load line (which has pronounced curvature) would also produce disortion. In fact, as shown in Fig. 9, it produces phase shift between the current and the voltage waveforms. This is perhaps clearer in Fig. 12 which shows the same elliptical load line superimposed on a set of I_c-V_c characteristics. For the particular reactance/resistance ratio chosen (2:1) the collector voltage is phase advanced on the antiphase condition by 26½°. If the load line for a parallel reactance/resistance combination is known only as an ellipse the position of the linear load line representing the resistive component can be found by drawing two vertical tangents to the ellipse at its left-hand and right-hand extremities and by joining their points of contact. (For a series reactance/resistance combination the tangents should be horizontal and touching the upper and lower extremities of the ellipse). The reciprocal of the slope of this line gives the value of the resistance. This construction has been carried out in Fig. 12 and the linear load line PGR corresponds to a resistance of 50 ohms. The shunt reactance is 100 ohms. An input (base) current swing from 13mA to 83mA gives a collector current swing from 0.15A to 1.25A. The corresponding collector voltage swing is from 60V to 10V. Although the current limits are 0.15A and 1.25A some of this is due to reactance (see Fig. 9) and the useful power output is provided by the swing between 0.2A and 1.2A, the current limits for the linear load line. The single-peak current and voltage values are thus 0.5A and 25V giving the power output as 6.25W.

This has been by no means a complete account of load lines: for example there has been no mention of load lines for push-pull amplifiers. It is hoped, however, that it has proved an interesting introduction to the subject.

* This equation applies when the centre of the ellipse is the origin of the rectangular co-ordinate system.

Wireless World amateur radio station

On January 29 *Wireless World*'s amateur radio station went on the air. This club station, call sign G8LWW, is licensed to operate in the amateur frequency bands from 144MHz and above (conditionally up to 24GHz). Under the recently-modified licensing conditions this means that *Wireless World* is permitted to operate the modes of fixed, mobile, pedestrian mobile, r.t.t.y. (radio-teletype), television, slow-scan television, facsimile, data and d.s.b.s.c. (double-sideband suppressed carrier). This will also include satellite communications through the amateur satellites Oscar 6 and Oscar 7.

The decision to have a permanent station was made in order that *Wireless World* can participate, in the practical sense, in communications in the same way that it does in the electronics field through constructional projects. This is the first time the journal has had a permanent amateur radio station; the only other time that an amateur station operated from its offices was when *Wireless World* celebrated its 60th anniversary in 1971 with the station GB3WW operating under a special short-term licence (see May 1971 issue).

The station, whose "main address" is at Dorset House, Stamford Street, London S.E.1, is situated at the top of a nine storey building at about 50m above-sea-level. In due course *Wireless World* intends to design and build its own equipment but until time can be found to carry out this project the station will continue to use tried and proven commercial equipment. Equipment presently in use in the 144 to 146MHz (2 metre) band is the Icom IC201 multi-mode transceiver which provides f.m., u.s.b., l.s.b. and c.w. modes. This 'rig', which uses a v.f.o. to give full 2-metre coverage, also has full facilities for repeater and reverse repeater, an automatic tone burst, break-in on c.w., and v.o.x. (voice-operated switching). The 10W output is fed into a ten-element crossed-yagi aerial mounted twenty feet above the roof of the building on a heavy-duty rotator, and connected for right-hand circular polarization (in preparation for satellite communication). The aerial apparatus and associated equipment was supplied by South Midlands Communications Limited. G8LWW is presently being operated by the licensee, Ray Ashmore, an assistant editor of *Wireless World*, whose own call sign is G8KYY. The station also has available an h.f. (3 to 30MHz) transceiver, the Yaesu Musen FT301, which has been operated from the *Wireless World* station by Ron Leath under his call sign G4ASE. This transceiver, which is capable of delivering the maximum permissible output of 400W, was used with a 40/80m trap-dipole and, after only three QSOs on 80 metres, made contact with SV4KS in Greece.

One disadvantage of the station location is a 31 storey building, part of the IPC complex, directly to the north and only about 100m away from the aerial. Although the effect that this building has on transmission and reception from and to the station has not yet been accurately determined, it represents a line-of-sight restriction of about 12 degrees, which will make contacts to the north of England and Scotland more difficult on 2-metres. However, it is hoped that the favourable "take-off" towards Europe will prove interesting, especially during the summer months when good v.h.f. propagation conditions will be more frequent.

Metal detector

B.f.o. circuit using fifth search oscillator harmonic for enhanced sensitivity

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

Metal detectors have fascinated people for a long time and a great many have been designed and built. Some work, but a high proportion have been abandoned as impractical by their disillusioned constructors. This article, in addition to giving the design for a practical metal detector, will explain some of the pitfalls and show how they may be circumvented.

All the metal detectors known to me use the modification of the magnetic field associated with one or more inductors to locate metal. Three main types are made commercially; b.f.o., induction balance and pulse induction. I will confine my description to the b.f.o., since this is the simplest to implement and, provided that due precautions are observed, it is adequate for most purposes.

Before proceeding any further, however, I think that it is as well to look at some of the legal aspects of metal detectors. Since, under the terms of the Wireless Telegraphy Act 1949 they have been deemed wireless telegraphy apparatus, they come under the jurisdiction of The Home Office who, at present, requires that a licence should be obtained for the use of the detector. Currently, this is £1.20 and permits the use of a "pipe finder" for a period of five years. In addition, the frequency of operation is limited to the range from 16 to 150kHz, with a forbidden band from 90 to 110kHz. In practice, the preferred bands are 85 to 90kHz and 110 to 144kHz. Before a detector may be used it must be "type approved" by the Home Office. Needless to say, the circuit to be described has approval.

With regard to the use of the detector for "treasure hunting" it is as well to observe a few rules:

- Never prospect a known archaeological site. If you do, you will incur the undying wrath of the archaeological fraternity in addition to possibly destroying historical information.
- Report unusual historical finds to your local museum.
- If you find any gold or silver, report the find immediately to the police, who will inform the local coroner. He will hold an inquest to decide to whom the find belongs. (A study of the laws relating to 'treasure trove' will help you to understand your rights.)
- If you find unexploded ammunition or a bomb, mark the place, leave well alone and inform the police.
- Do not leave a mess after excavating your finds.
- The issue of a licence does not absolve the licensee from obtaining any necessary consent before entering on any private property with any apparatus.

The principle of the b.f.o. detector is illustrated in Fig. 1. The outputs of two oscillators, tuned such that there is a small frequency difference between them, are mixed. The difference frequency is selected by a low-pass filter, amplified and fed to a loudspeaker or headphone. When a metallic object is brought near to the search coil, its inductance changes causing a change in the frequency of oscillator 1 and a corresponding change in the difference frequency. Non-ferrous metals will cause the frequency of the search oscillator to increase and ferrous metals should have the opposite effect. I use the word "should" since, in practice, both the shape of the object and its state of decomposition appear to affect the sense of the change. At first sight, it would appear a simple matter to apply this principle to a practical metal detector but there are a number of problems which need to be overcome before a satisfactory design can be achieved. The first of these concerns the search coil.

The frequency of oscillation will change if the reactance of the coil changes at all. Thus it is as susceptible to capacitance as to inductance changes. Indeed the change in coil capacitance caused by moving it relative to the ground may well exceed the inductance change caused by the object being sought. Fortunately, it is quite easy to minimize this effect by fitting a Faraday screen to the coil. This is done by wrapping the coil with a conductive foil, which is connected to the internal "earth" of the oscillator. There should be a break in the foil so that it does not constitute a short-circuited turn. When I first tried this out, I feared that it would reduce the sensitivity of the coil to metallic objects but measurements showed that the sensitivity was unchanged, while capacitive effects were reduced to negligible proportions. Another cause of spurious frequency change is heat: moving the coil from sunlight to shade can cause a large and fairly rapid frequency change. This effect can be reduced by suitable thermal insulation.

In order to select the best size of coil for the detector I made a series of tests plotting the frequency change caused

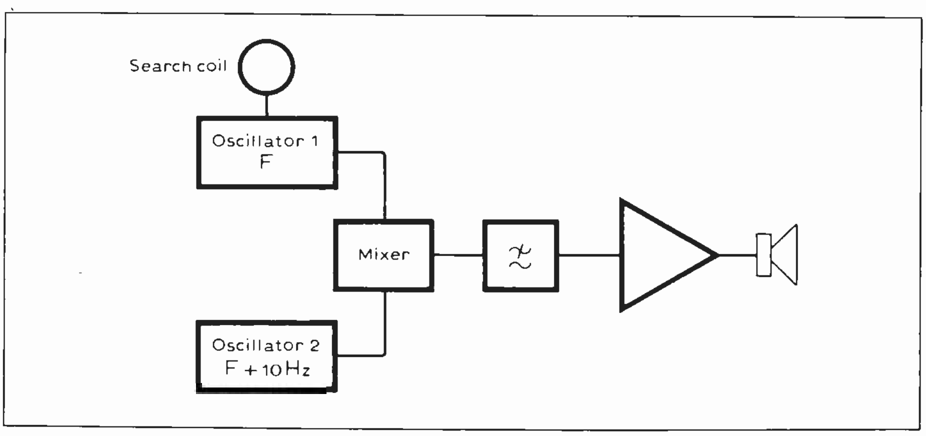


Fig. 1. Block diagram of a simple b.f.o. metal detector.

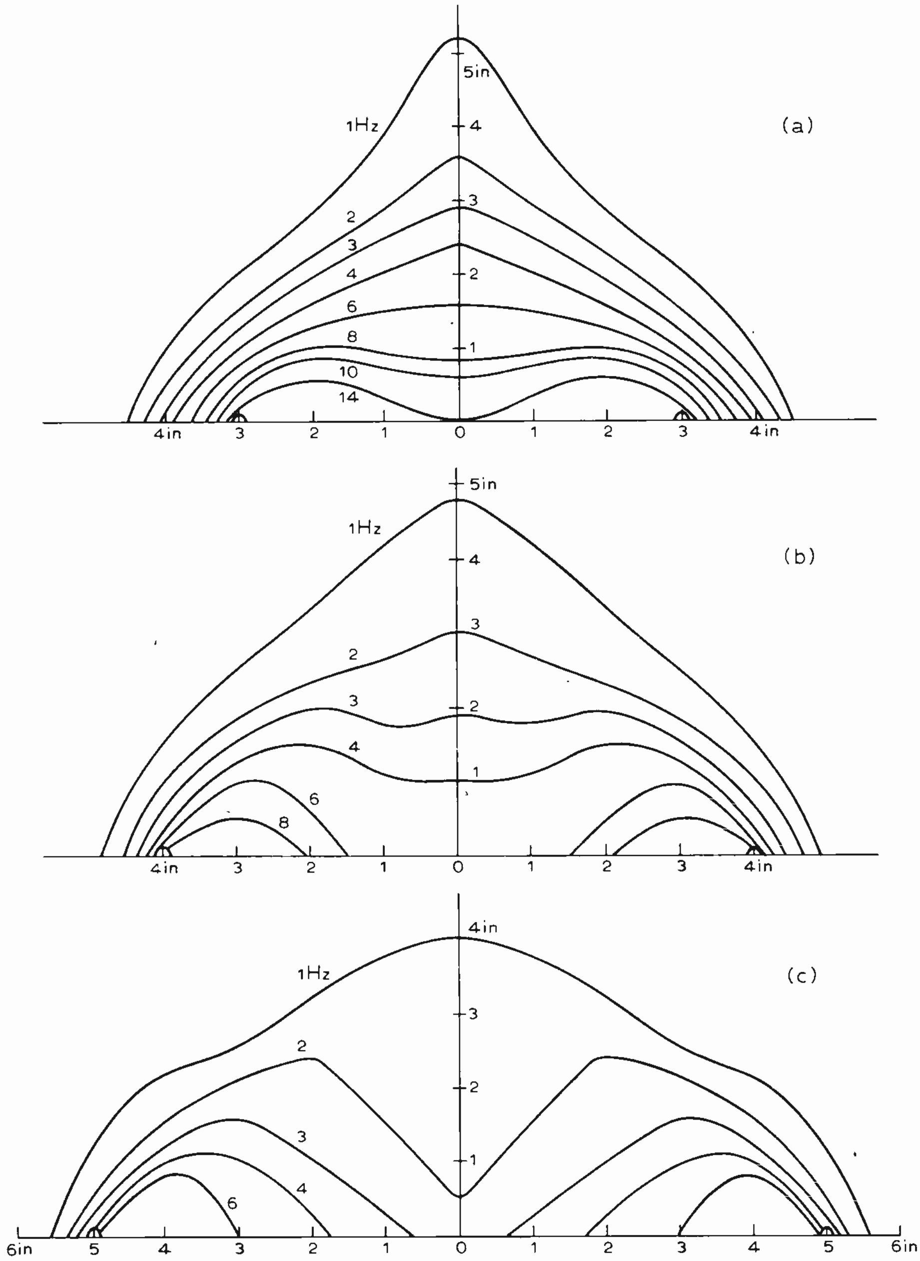


Fig. 2. The lines show the contours of equal frequency change for a ½p coin at a frequency of 100kHz with various coil sizes (a) 6" (b) 8" (c) 10"

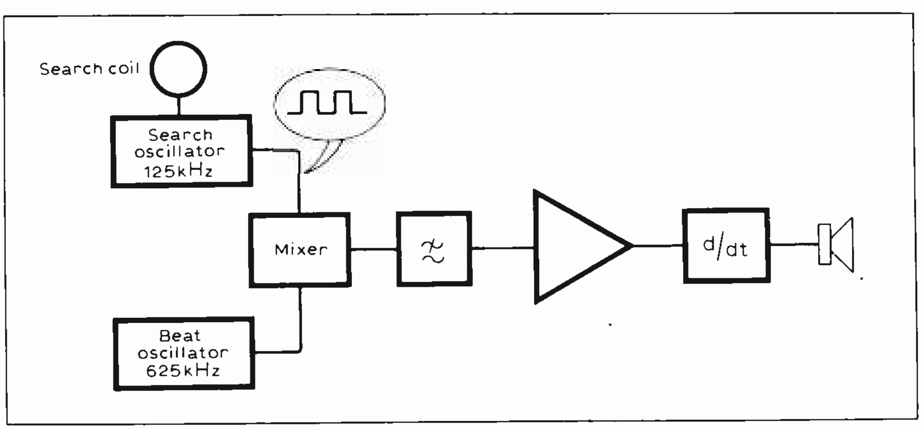
by a ½p coin with various coils. The inductance of the coil does not appear to be an important factor, but the diameter is. The results for 6in, 8in and 10in coils are shown in Fig. 2. They may not be strictly accurate, since the measurement is a very tedious one, but they do show what is to be expected. The important points are:

- The frequency change is very small.
- The sensitivity at the centre of the smaller coils is much the same, while the 10in coil is less sensitive.
- The larger the coil, the larger the sensitive area. However, this is not alw... an advantage, since it is still necessary to pin point the article being sought and the smaller coil gives a much better "focus". For my own design I have chosen the 6in coil.

The magnitude (or should I say smallness), of the frequency change is one of the main problems in using a b.f.o. metal detector. One very practical solution is to set the oscillator frequencies such that the frequency difference is very small <10Hz. When this is done a change of one or two hertz is readily discernible. If the frequency difference were of the order of 250Hz this change could only be heard by a trained listener. Since a normal loudspeaker or headphone does not reproduce low-frequency tones, the low frequency waveform can be converted into a pulse train, which is then easily reproduced.

The sensitivity of the b.f.o. can be increased as shown in Fig. 3. Here the search coil oscillator is operated at a frequency of 125kHz and its output is converted to a square wave, which is rich in harmonics. The beat oscillator runs at a frequency of 625kHz, i.e. five times the search oscillator frequency. Thus, the beat oscillator is mixed with the 5th harmonic of the search oscillator so that any frequency change is multiplied by five. This makes it very much easier to hear a change in frequency, although the susceptibility to drift is much greater. A higher harmonic could be used but it should be remembered that, with a square wave, only odd harmonics are present and the amplitude of the harmonic will be equal to the amplitude of the fundamental divided by the harmonic number. The rather odd choice of frequencies has been dictated by the fact that most constructors will only have a medium-wave radio receiver for setting up purposes and will have no simple means of checking the frequencies. If the beat oscillator is set to 625kHz, the beat note will only be heard strongly if the search oscillator is tuned to an odd sub-harmonic (625/5 = 125 or 625/7 = 89.286) and the forbidden band from 90-110kHz will be avoided. This precaution is necessary as it is difficult to control all the stray capacities associated with the search coil.

Fig. 3. Block diagram of an improved metal detector.



Design

The circuit of a metal detector based on the above considerations is shown in Fig. 4. I chose the "long-tailed-pair" oscillator for this application because it is easy to design, the tuned circuit needs only two connexions and the output is isolated from the tuned circuit so that the frequency of oscillation is virtually unaffected by loading or signals fed to the output. This last is particularly important for this application, in which it is essential that the oscillators do not lock to each other when the frequency, or in this case, harmonic frequency

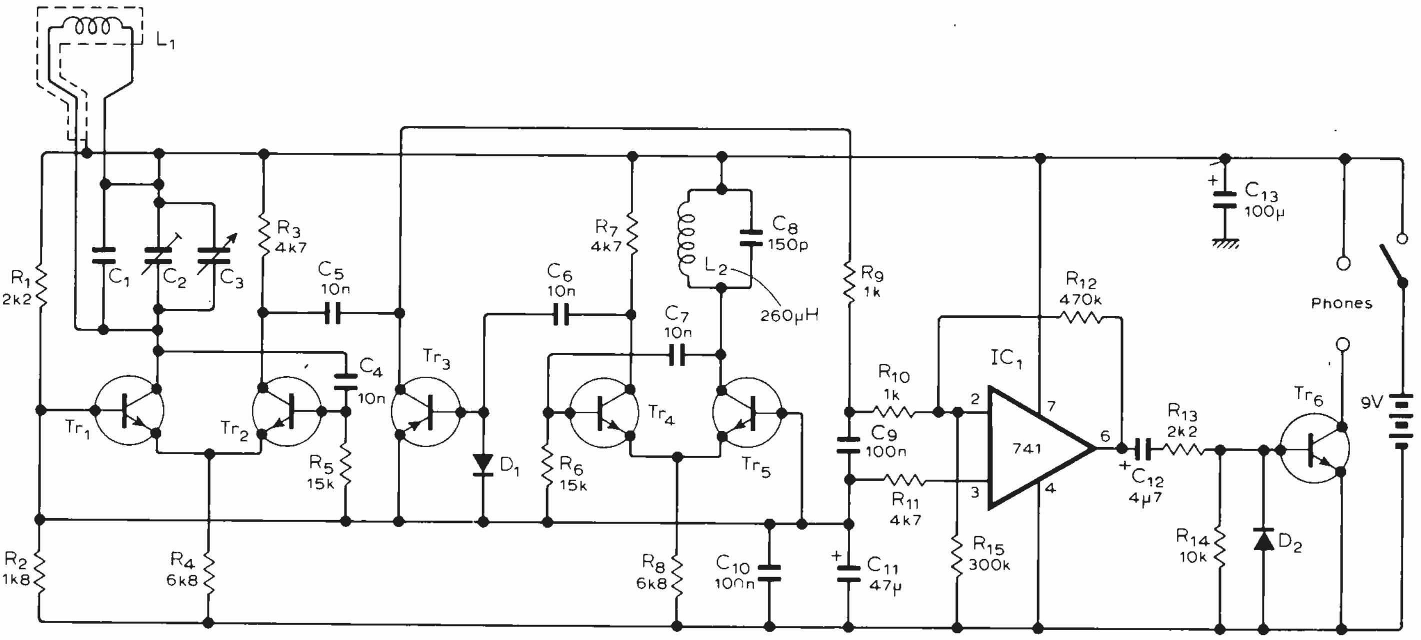


Fig. 4. Circuit diagram for metal detector.

difference is small. The search oscillator uses Tr_1 and Tr_2 with L_1, C_1, C_2 and C_3 forming the tuned circuit. It will probably be necessary to select C_1 to give the correct frequency, since the Faraday screen and the screened lead add an indeterminate amount of capacitance in parallel with the coil. This capacitance depends upon the physical construction of the coil and the materials used and is rather variable. Coarse tuning is carried out by C_2, while C_3 is used for fine adjustment. The search oscillator output is taken from the collector of Tr_2 to the mixer Tr_3. The beat oscillator uses Tr_4 and Tr_5; L_2 and C_8 form the tuned circuit, which resonates at 625kHz. The drive to the shunt gate mixer Tr_3 is taken from the collector of Tr_4. The difference frequency is selected by the low-pass filter, formed by R_9 and C_9 and is amplified by IC_1, differentiated and then fed to Tr_6, which drives the 'phones or loudspeaker. The volume can be controlled by connecting a variable resistor in series with the output.

Construction

The layout of the circuit does not appear to be critical – a practical version using matrix board is shown in Fig. 5. Mount the circuit inside a screened box so that hand capacitance does not affect the tuning.

The construction of the search coil is very important. It should be sufficiently robust to withstand rough handling, light, so as to be portable and adequately insulated against temperature change and moisture. I found that the construction shown in Fig. 6 works very well. First cut a ring of about ⅜in plywood as shown. To wind the coil, draw a 6¼in diameter circle on a piece of wood. Hammer ¾in panel pins at about 1in intervals around this circle and then wind 45 turns of 26 s.w.g. (0.46mm) wire around the pins. Tape the coil in four places to stop it springing undone. Remove the pins. Tape the coil tightly to the underside of the wooden ring, taking care that the ends of the winding come opposite to the tab for the handle. Cover the coil with a second layer of tape. Cut a strip of aluminium cooking foil about 1in wide and tape the coil with it, starting on one side of the tab and finishing at the other. It will probably be necessary to use more than one length of foil, in which case the ends should be overlapped. However take care that the start and finish of the coil do not short to each other. Bind the finish of the coil with 22 s.w.g. tinned copper wire and connect it to one end of the coil and to the screened lead. The other end of the coil is connected to the centre conductor of the screened lead. Cover the coil with a layer of tape. Cut a 1in wide strip of ⅛in thick expanded polystyrene sheet and wind this around the coil. Cover the whole with another layer of tape. Assemble the coil to the handle and paint it with white waterproof paint.

Setting up

The first step is to set the beat oscillator to the correct frequency.

- Short the search coil to disable the search oscillator.
- Switch on and adjust the core of L_2 so that the frequency of the beat oscillator is set to 625kHz. If you have no access to a frequency counter, a medium wave radio receiver may be used. Set the dial of the receiver to 625kHz (480m). If the receiver has an aerial connection, place the aerial lead close to the oscillator, but if it only has a ferrite rod aerial it will be necessary to place the receiver close to the oscillator. This setting up must be carried out with the detector circuit mounted in its screened box with the lid off. Tune for maximum signal. Remember that you will be looking for an

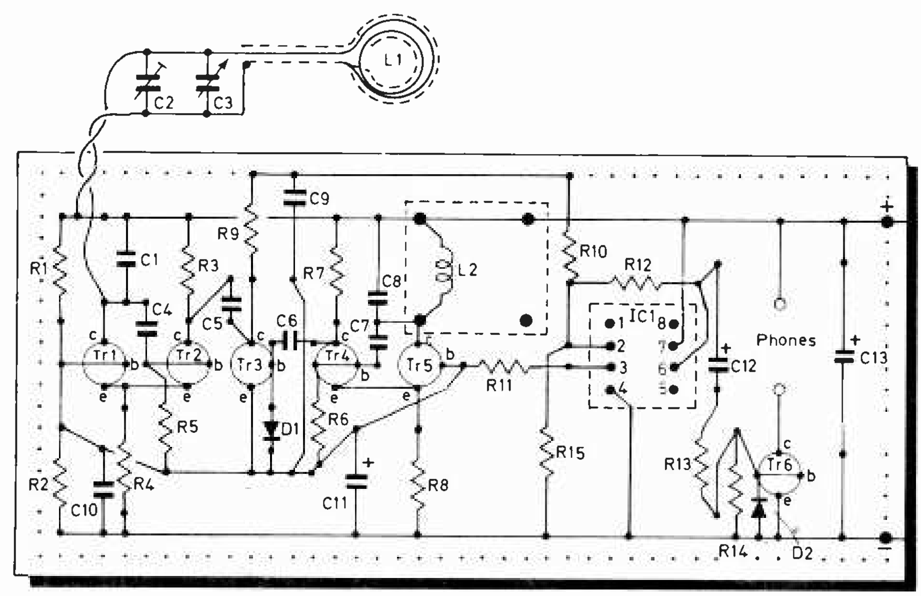


Fig. 5. Layout of circuit, using pin board (no copper tracks).

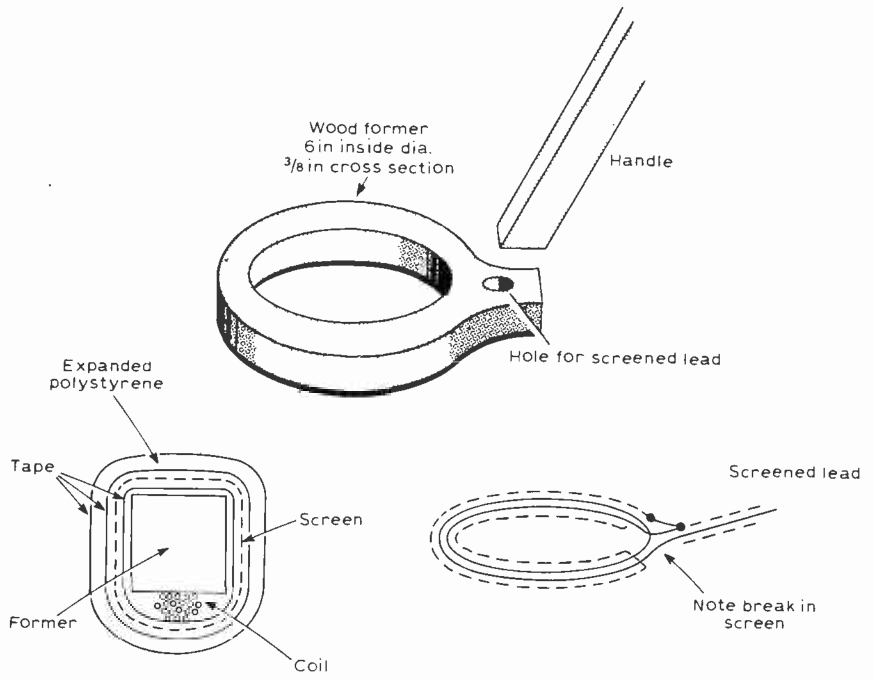


Fig. 6. Coil construction.

unmodulated carrier, so that only hiss will be heard. However, you can check whether you have the correct carrier by shorting the coil. The next step is to set the search oscillator to the correct frequency.

- Remove the short from the search coil.
- Set both the coarse and fine controls to mid-travel.
- Fit a 470pF capacitor for C_1.
- Adjust C_2 and check that a beat note can be obtained. If necessary increase the value of C_2 by 100pF.
- When a beat note is heard, check the frequency of the search oscillator as follows:

(*a*) Short the beat oscillator tuning coil.
(*b*) Using the receiver near the search coil, look for the harmonics of the search oscillator which should be as shown in Table 1. It is very probable that you will only be able to identify the odd harmonic frequencies.
(*c*) If the frequencies are too close together, the search oscillator will probably be running at 89.3kHz. Reduce the value of C_1 and repeat the procedure. If possible it is a good idea to select a value of C_1 which gives the correct frequency with C_2 set to mid travel. This will allow for any drift which may occur during the life of the detector.

Table 1

Harmonic Number	*Frequency*	*Wavelength*
5	625 kHz	480 m
6	750 kHz	400 m
7	875 kHz	342.85 m
8	1000 kHz	300 m
9	1125 kHz	266.67 m
10	1250 kHz	240 m
11	1375 kHz	218.18 m
12	1500 kHz	200 m
13	1625 kHz	184.615 m

PARTS LIST

Resistors

1	2k2	All resistors 1/4W ±5%
2	1k8	
3	1k	
4	6k8	
5	15k	
6	15k	
7	1k	
8	6k8	
9	1k	
10	1k	
11	4k7	
12	470k	
13	2k2	
14	10k	
15	300k	

Capacitors

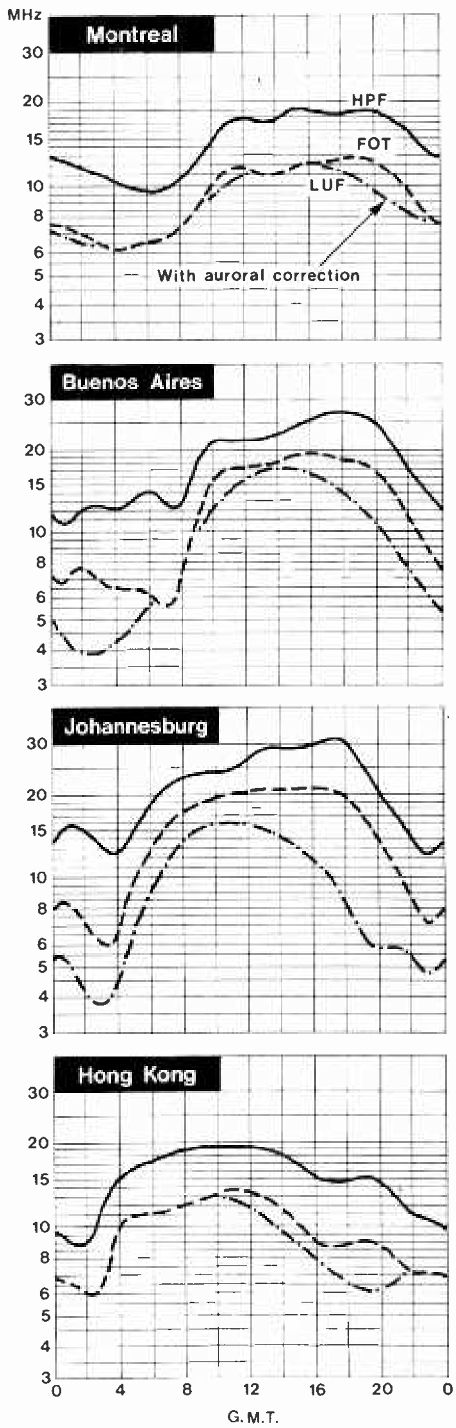
1	560pF polystyrene (see text)
2	150pF variable
3	10pF variable
4	0.01μF disc ceramic
5	0.01μF disc ceramic
6	0.01μF disc ceramic
7	0.01μF disc ceramic
8	150pF polystyrene
9	0.1μF 100V P.E.T.
10	0.1μF 100V P.E.T.
11	47μF 10V electrolytic
12	4.7μF 10V electrolytic
13	100μF 10V electrolytic

$Tr_{1,2,4,5,6}$	BF238, BC108 or equivalent
Tr_3	BC308, BCY72 or equivalent
$D_{1,2}$	1N4148
IC_1	μA741C
L_1	see text
L_2	49t 0.28mm wire or Mullard Vinkor LA1157 (260μH)

HF predictions

Predicted disturbed days are 1st to 3rd and 17th to 24th of the month.

Seasonable trend and low solar activity combine to produce FOTs and LUFs which give a restricted choice of time and frequency for reliable day to day communication. The charts show that this restriction is particularly severe for circuits having both terminals in the northern hemisphere.



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WW-005 for further details.

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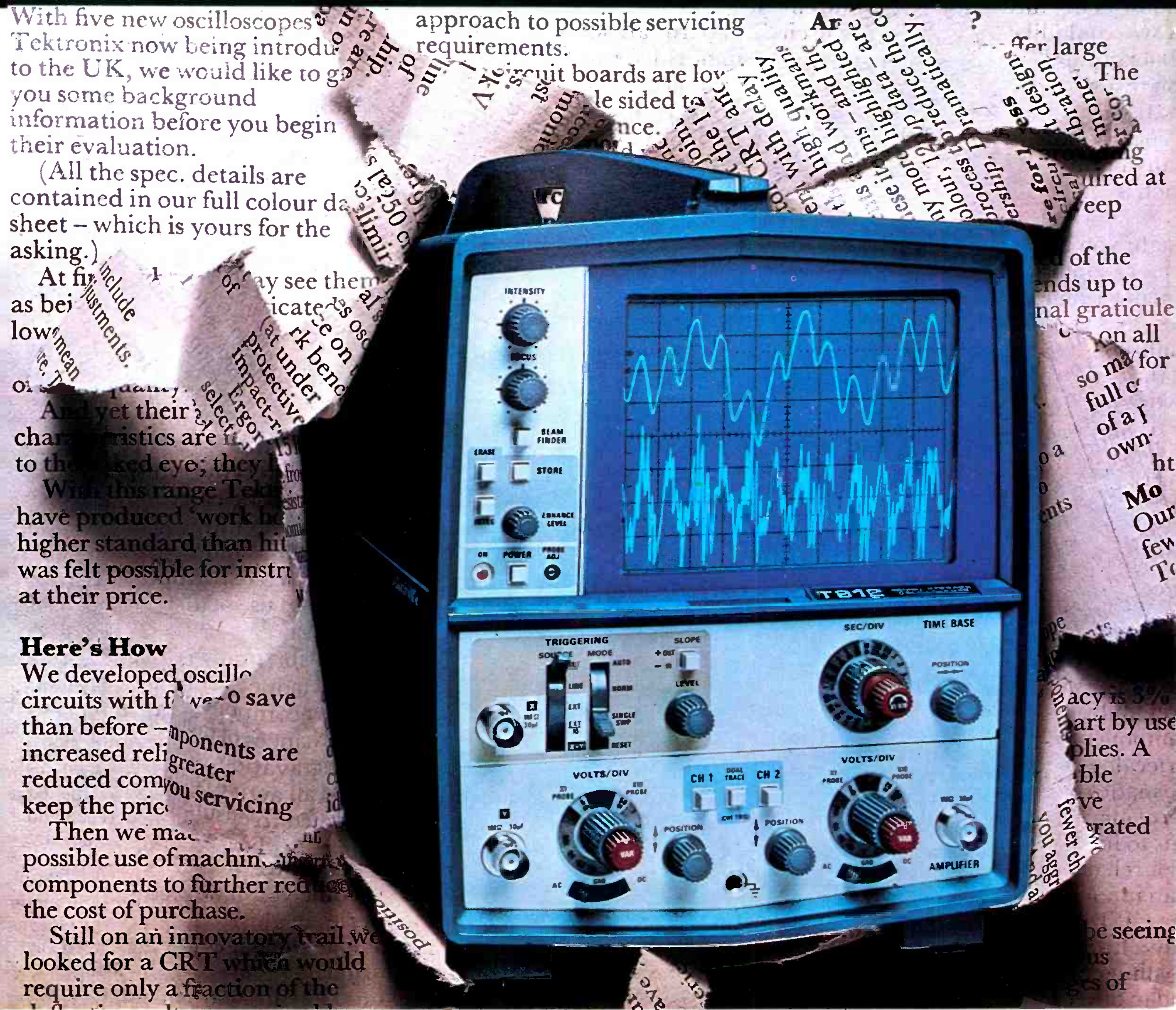

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News of the Month

CEI split again

The Council of Engineering Institutions has attacked the government's believed intention to hold an enquiry into the engineering profession. Sir Charles Pringle, the chairman, has told the Prime Minister in effect that such an enquiry would cause a further period of uncertainty just as the CEI was sorting itself out after its two years of dissension. But although at least half a dozen of the CEI's 15 members are said to share Sir Charles Pringle's objections to an inquiry, among the larger institutions there is a feeling that Sir Charles has spoken out of turn. All the signs are that yet another big row is brewing.

The CEI reached their attitude after a council meeting on February 10. They say that in opposing the enquiry they were reflecting the IEE and the IMechE though these bodies had also said that if there were an enquiry they would want it to include certain topics. The CEI say their attitude is that an enquiry is unnecessary but that they would co-operate if one were held.

It appears, however, that the two senior institutions take a more positive attitude to the putative inquiry. On 27th January they wrote to Mr Eric Varley saying that they would welcome it, and that it should cover: the education and training of engineers; how that education met the needs of industry; a study of compulsory registration in other countries; a study of how compulsory registration might be applied in the UK, and the allocation of certain jobs in industry to professional engineers.

The CEI say publicly there is merely a difference of emphasis between themselves and the IEE and IMechE, but we are told reliably that the CEI sent a letter to the two institutions, after they sent their letter to Varley, asking for an open apology for putting forward their point of view outside the auspices of the Council. From the other side, the dissenting Institutions have been so angered by the CEI's public pronouncements that they would now like the enquiry to review the CEI itself.

Radar simulator for the RAF

A simulated timebase and echo generator (STEG) is to be added to the airborne early warning mission trainer at RAF Lossiemouth. The STEG will generate fifteen controllable radar targets on the AEW trainer displays as well as "own" aircraft movement, sea clutter, Indicate Friend or Foe, thermal noise and a blind arc. The simulator, which is portable, can also superimpose radar echoes on to a background picture derived from a video recording of an actual mission. Operators learn to spot unidentified radar echoes and to guide interceptor aircraft on to the intruders.

Four hand-held keyboards are connected to the simulator by flexible leads. The keyboards first set the STEG to match the radar parameters and then to set up and control the targets and other effects. Marconi, who make the device, say the system is one of many applications of STEG, which can be coupled to any continuously rotating pulse position indicator radar display via an interface.

Components helped again

Electronic components is one of the five industrial sectors singled out by the Chancellor of the Exchequer, Denis Healey, and the Industry Secretary, Mr Eric Varley, for special help as part of an experiment "to see whether there is scope for the government to act as a catalyst in bringing about, in concert with both sides of the industries concerned, a more rapid improvement in performance . . ."

Because each industry sector is different the approach will be different in each case, but Healey and Varley say in their memorandum to the National Economic Development Council, responsible for bringing together the necessary elements to the working of the Government's industrial strategy, that "One possible approach would be to begin in the case of each sector with a general wide-ranging meeting with both management and trade unions in that sector together with the members of the Sector Working Party, under the chairmanship of the appropriate minister. This meeting would identify the main issues to be tackled. Thereafter, we envisage that it would be useful to hold discussions with individual firms or, if particular subjects lend themselves to more broadly based consultations, with groups of firms, to pursue these issues." Companies would be asked for their views, particularly on the sector working party reports but also on the whole range of Government policies.

An element of the Government's as yet vague proposals especially welcome to the components chiefs will be that although in the current economic circumstances resources are limited, "to the extent that public money is needed to solve the problems of the five sectors set out above (or those of other sectors) or, indeed to push forward the work on industrial strategy generally, the resources will within reason be available."

The proposals also follow news of a £20 million aid scheme for the components industry, which *Wireless World* reported last month. Still further help is expected from the European Commission (see WW News, March p48).

Students for industry

Sponsored students may get an extra £500 a year from their employers without a reduction in the local authority grant under a scheme outlined by the Education Secretary, Mrs Shirley Williams, in the Commons on February 3. From September 1977, she said in a written reply, "payments by employers to students whom they wish to sponsor, or by institutions who wish to give scholarships of up to £500 per annum will not be taken into account in the assessment of mandatory awards by local education authorities. This will be in addition to the amount of income disregarded under the present arrangements which is £185 per annum and now under review for the academic year 1977/8."

At present a local authority, in assessing a student's income for making a grant, does not take into account the first £185 per annum of income, any holiday earnings, or various pensions and benefits. Later in the year changes in the rates and conditions applying to mandatory awards, including the £185, will also be announced.

Currently about 7,200 undergraduate students and 2,600 postgraduates are fully supported by employers rather than by a grant. About a third are supported by industrial or commercial concerns and the rest by Government departments. Normally an employer makes a choice between giving a student £185 on top of his grant or paying him a salary greater than the grant would have been. About 400,000 students in Britain receive grants totalling £382 million, according to the Department of Education and Science. though this includes a controversial £107 million supplied by parents or spouses. In 1974-75 a Department survey showed that about half the students on mandatory grants did not get all the parental contribution, or £90 for each student underpaid.

Bullock's boardroom and the engineer

Lord Bullock himself has acknowledged that the proposals the majority of his committee agreed after a year's work may never be carried out. But he is not discouraged. The vigour of the debate since his report was published on January 26 has shown that the call for greater involvement of workers in company policy decisions which affect them has suddenly become a political issue. It is likely to remain so.

Among those who gave evidence were the Association of Professional Scientists and Technologists, the Business Equipment Trade Association, the CEI, the Electrical, Electronic, Telecommunication & Plumbing Union, EMI, GEC, Philips Electronic and Associated Industries, and the United Kingdom Association of Professional Engineers. The EETPU expressed the strongest opposition to the representation of trade unions on the board because they saw a conflict between collective bargaining and such representation: "It is not the responsibility of work people to manage the enterprise . . . It is essential that trade unions retain their independence." The EETPU thought that the job of the trade unions was, through collective bargaining, to "consider, contest and oppose, if necessary, the exercise of managerial prerogatives," but Bullock, unimpressed, says unions and management "have the same objective: to enable employees to participate in decision-making in the enterprise in which they work."

Reading the report makes you no wiser about the future role of the engineer, the scientist or the technician in the proposed new democratic boardroom. It is a fact of modern industrial organisation, however, that their skills and experience are badly needed.

Most of what Bullock says that is relevant to engineers is about middle management.

Staff associations count

"Some people have suggested to us that managers and other professional groups play a particularly important role in the running of companies and often occupy a unique position between the board and other employees – at one point representing the company in discussions with employees and at another being employees themselves – and they have argued that a special seat on the board should be reserved for these groups. Provided that professional and managerial employees are organised collectively, as increasingly many of them are, we can see no reason why they should not be represented on the board amongst the employee representatives. But we do not think that a special seat should be reserved for them on the board by law." Bullock explains that it would be unfortunate to give the impression that some employees had a special, and therefore higher, status in the eyes of the law.

Bullock adds that there is no objection to a staff association or professional association or any other employee organisation not affiliated to the TUC from being represented on the board provided it is independent of the company but recognised by it.

Trade Unions

So if the Bullock proposals are implemented the degree to which technicians and engineers will be able to contribute to the better running of their companies will be largely dependent on the extent to which they are involved in trade unions. The Confederation of British Industry has made clear its bitter opposition to Bullock on just these grounds, saying that trade unions speak for only half the workforce. The true picture is, however, a great deal more complicated than the CBI makes out. Trade union membership is not distributed evenly throughout industry, and the smaller the firm the less likely it is to be unionised.

Of the total workforce, it is true, 50.4% are members of a union. But in manufacturing industry membership is 62%, and if enterprises with less than 200 workers are left out of account the proportion jumps to 89%. in the Post Office and telecommunications the figure is 87.9% and in metals and engineering 69.4%. Bullock's proposals, if adopted, would only affect enterprises employing more than 2,000. In the others, according to Bullock, trade unions represent only 20% of the workforce, and it is *because* of this that these firms have been excluded from the proposals.

Against that, these smaller companies represent 11 million of the 18 million people employed in the private sector, and two thirds of the total number of enterprises. It seems true that small firms are becoming less important – the 1968 census of production showed that firms with over 2,000 employees then represented only 21% of the enterprises – but it also seems that the Bullock idea is not to extend industrial democracy to workers in the small firms, where the majority of work is done. The CBI has not been heard to complain about that.

Unionised engineers

On the other hand, trade unionism is still a more potent force among the wearers of blue than white collars. The qualified engineer is generally regarded as a white collar worker and as such if he is a member of a union, he is one of 4.3 million, whereas his manual union colleague is one of 7.5 million. Engineers, therefore, stand less chance than manual workers of getting into the boardroom if Bullock is adopted. But the report also notes the increasing rate at which white collar workers have joined trade unions. Since 1948, union membership among white collar workers has increased 117%, while manual union membership has increased 0.1%. In the four years to 1974 union membership among manual workers actually fell 1.3% but rose 19% among those off the shop floor.

The 'Y' element

For the moment, a much more likely opening for engineers lies in the proposal that a third element should balance the shareholder and union representatives. This third element, the Y in the now famous $2X+Y$ formula, has to be an uneven number greater than one, must be less than a third of the whole board and its membership must be agreed by the other two elements. The system, says the report "will provide an important means by which special experience and expertise can be brought into the boardroom from *inside and outside the company* . . . It may be, for example, that there will be someone in the company itself – among senior or middle management – who both sides agree could be a useful addition to the board."

The industry view

The electronics industry has identified itself with the CBI's view of Bullock. The Electronic Engineering Association told *Wireless World:* "Our input on that will be done through the CBI." Latest figures are not available but a quick check of 39 of the companies in the EEA shows an average number of employees of around 9,6700. Many of these are companies with a large number of subsidiaries with activities across the whole range of electronics. A council meeting of the British Radio Equipment Manufacturers' Association on February 10 decided that the attitude of many of their members would be decided by parent companies here or abroad, many of them in the EEA.

Size of firms

According to figures for the third quarter of 1976 at the Business Statistics Office at Newport, 48 enterprises in telegraph and telephone equipment employ 73,100 people; 252 enterprises in radio and electronic components employ 126,700; 37 computer firms employ 44,300; and 132 firms in radio, radar and electronic capital goods employ 90,400. No figures are available for the number of employees in the broadcast receiving and sound reproducing equipment sector.

Does it matter?

Membership of the EEC, for which the CBI must hold itself largely responsible, commits us to some form of worker participation in the boardroom. However, the National Enterprise Board has, since the report was published, dropped its commitment to putting worker directors on its board, and the Prime Minister agreed with the CBI in February that the Bullock proposals need not be implemented as long as there is greater consultation below board level.

V.m.o.s. devices "middle of this year"

American Microsystems (AMI) say devices which use their patented v.m.o.s. technique will be available commercially around the middle of 1977. "We are currently in the process of bringing them into production," said AMI's president and chief executive Glenn E. Penisten at a press conference in February.

He described the device as a "short channel n.m.o.s. structure fabricated in v-shaped grooves which entered the silicon surface." Advantages included vertical current paths, higher current density, and higher gain bandwidth than was possible with other devices. It was possible to get 285 dies from each 3in wafer of silicon with a side length of 145 mils each. In line with the general tendency for a reduction in the memory cell area per bit, such devices could be used to store 16kbits of information and this could be increased to 65k "before 1980". Mr Penisten told *Wireless World* that the speed of the devices was "approaching bipolar speeds, the 40ns kind of category." AMI also say the speed is less dependent on temperature change, and could work well at "enhanced ambient temperatures of 70°C." Although others might be producing discrete products using the technique AMI were further ahead, they say, in optimising "the speed/power relationships." It had been thought that v.m.o.s. was a dead-end technology because it could not be scaled (reduced in size to lower silicon consumption), but, said Penisten, that was wrong. "Our product is a product that has been scaled and scaled again." The first commercial product, a 1K static memory would be available "probably by mid-year."

Goldring falls with the pound

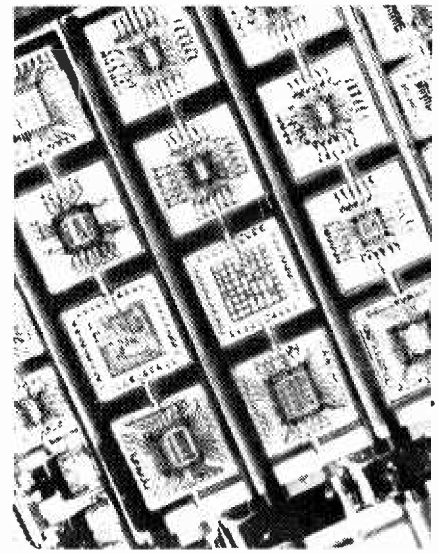
A receiver was appointed on February 3 for Goldring, which in 1973 was trading so strongly that it offered 1.5 million 10p shares at £1.17 each and closed the offer oversubscribed. The day before the receiver, Mr Christopher Morris of Touche Ross, was appointed they were down to 8p.

Goldring was heavily dependent on the home market. About 85% of it's business was in the UK, according to the *Financial Times*, and this had a number of effects. The first was that when VAT was increased to 25% they suffered more than firms like Garrard, which now exports something like 70% of its output. At one time Goldring stopped producing almost completely and relied on selling Swiss Lenco turntables, for which they had an agency. Another effect was that when the pound started to fall this Lenco equipment became uncompetitive in the market they relied on.

Another blow was that Lasky's stopped selling Goldring equipment when the Japanese put the marketing pressure on direct-drive turntables. While a belt-driven model might have withstood this, Goldring's rim-driven turntables were too far behind the times. They could not rely on the kind of business BSR had so successfully built up, supplying turntables for fitting to other sound systems. BSR turntables can even be found in audio systems imported from Japan, as in the case of Crown, now imported by York Electronics. Goldring also imported Toa public address equipment, which had been affected by import restrictions.

To add to everything else Goldring's premises at Leytonstone were compulsorily purchased by Walthamstow council, and they were faced with the disruption and cost of moving to Bury St Edmunds, still a matter of dispute with Walthamstow council. Cost control was not too strict, and they spent £100,000 there in offices alone, according to one account. Although staff had been reduced from 298 to 179 during 1975, effecting a reduction in the wage bill from £466,772 to £427,622, directors fees went up around £200 to £46,629. In the same year, the Barclay's bank overdraft jumped from £3,650 to £160,746, and the company borrowed a further £200,000 from the family of Mr E. Sharf, the president.

According to an informed source the receiver has now recovered the money owing to Barclay's and it now remains to get back the Sharf money, after which the future of the company seems grim indeed. Most of the money so far obtained has been won by selling off the considerable stock at a low price and keeping staff on while there are enough parts in the store to make more. The main value of the Goldring name will rest on the pickup cartridges and styli, and it has been suggested that Sharf will eventually buy the goodwill of the possibly liquidated firm. Toa have wasted no time in setting up Toa (UK) Ltd, and C. E. Hammond have already taken over the Lenco agency.



Liquid-cooled logic. *Current mode logic circuits used in Honeywell's new 66/85 computers. Honeywell say the elimination of transistor storage time makes each chip five to seven times as fast as t.t.l., using half the power. One 3in square micropackage there are up to 110 chips, "almost as much circuitry as a standard 12in square circuit board." At the back of each micropackage a liquid cooled heat exchanger eliminates the need for system air cooling. The exchanger is an oxidised copper diaphragm which, when pressurised by liquid flowing behind it, conforms to the surface of the micropack. Each board has 12 micropacks arranged in four columns of three. The coolant is pumped in parallel through each column. The liquid is cooled in an air-cooled radiator cabinet with an air blower. If the cooling system fails the computer shuts down automatically.*

"Britain pioneered the integrated circuit"

Mr G. W. A. Dummer, formerly superintendent of applied physics at the Royal Signals and Radar Establishment, has no doubt that Britain was the pioneer in the invention of the integrated circuit, though not the inventor in the full sense of the word. In a letter to the American journal *IEE Spectrum* (December 1976) he distinguishes between the pioneer "who thinks of it," the experimenter "who makes a working model" and the exploiter "who develops and produces it." He writes: "The pioneering stage was certainly that of the Royal Radar Establishment (RRE) in Great Britain. It must be remembered that the "solid circuit" idea was no flash in the pan, but the result of six years' work on miniaturization. The model shown to US military and other visitors at the United Kingdom Symposium in 1957 was intended to indicate my views on the logical future of component miniaturization techniques." The real inventors of the integrated circuit, in Dummer's opinion, were "Noyce and his dedicated team at Fairchild."

As a result of reporting the 1957 UK symposium under the title "Solid Circuits," *Wireless World* (Nov. 1957 issue) subsequently ran into a spot of bother with the lawyers of Texas Instruments because TI, at a date somewhat later than the report, had decided to use "Solid Circuits" as a trade name for their devices (before the term "integrated

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Binaural broadcast

First announced BBC programme

From a preliminary analysis of listeners' letters, a large majority of respondents got a sound sensation outside of the head when listening to "Oil Rig" on headphones, says the producer, Richard Imison. The Radio 3 programme was made with "binaural" microphones intended for headphone listening and was the first announced broadcast of its kind in the UK. After reading the first 500 letters, Mr Imison said about a third had experienced good all-round perception, but of the remaining two-thirds, a majority had good sound except within an arc of around ±45° of centre front, and a significant minority found everything in front and nothing behind. The programme, auditioned for the press six days before transmission on 8th February, was a 75-minute distillation of 37 hours of interviews and sound effects from a North Sea oil rig.

An interesting choice of location, this, for while life on an oil rig may possibly make for good journalism, its remoteness from everyday life did perhaps make it a little difficult to relate it to reality, acoustically. But it wasn't difficult to discover the weak point of the technique, that is, in portraying frontal sound images, a widely recognised problem with such binaural techniques.

One found the background sensation to be good and generally located outside the head, though almost always taking place behind. Three kinds of speech were heard. Studio-produced mono narration which, as it was fed to both channels equally, appeared in the head. On location, speech was either in the head or out of the head and elevated but never in front (for those at the audition anyway).

The two sensations were produced with two different microphone techniques. One used a 10-in diameter perspex disc with two forward-pointing eccentric omnidirectional microphones mounted either side to correspond with ear-to-ear spacing. This was used in the interview of the cook, but gave too much ambient noise on most interviews. The alternative was to mount microphones on the head of the speaker in "stethoscope" fashion — hence an in-head image.

One sometimes found it disconcerting when the out-of-head speech, clearly directed at the listener, didn't come from in front where one would have liked it to come from. This lack of centre front speech is not so upsetting on special demonstrations that are intended to startle, such as on the Sennheiser dummy head recording, but it can spoil the illusion where a speaker is addressing you constantly from behind or the sides — in real life one would quickly turn to face the speaker.

Why dummy heads weren't used

This disc baffle arrangement came about after three years of experiments by BBC Radio using first the Neumann artificial head and then the Sennheiser (both pictured on page 336 September 1974 issue). They say the heads were subject to countless tests involving hundreds of tapes, starting with a large, dead studio and going on to other studios and the open air, with different kinds of material including test sequences, plays, outside broadcasts, music.

They found that while the Neumann head was "convincing" and impressive on headphones, it had quality shortcomings on loudspeakers, in particular a steep roll off at 5kHz. The Sennheiser head and "stethoscope"-type microphone arrangement brought a response up to 15kHz, but the top was "edgy" and "rather hard" and the quality was not the best. Results with this arrangement on a real head were "a little better with the 'stethoscope' mikes but not good enough," commented Richard Imison. "Not really up to broadcast standards".

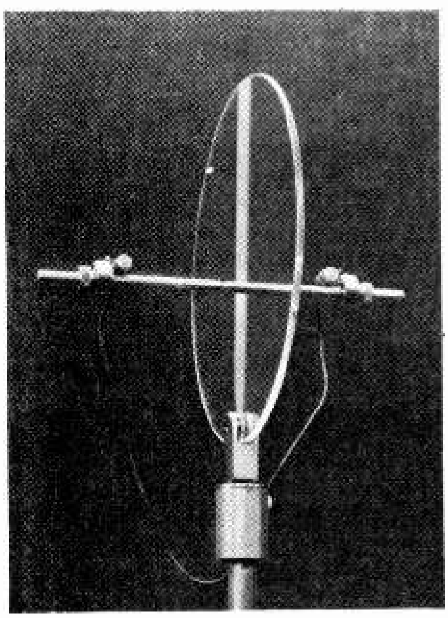
This was the point where an alternative had to be found; in fact the project was nearly abandoned, recalls Richard Imison. Derek Taylor of programme operations then found that good results could be obtained using better quality microphones in stethoscope fashion — Sony omnidirectional ECM50's were mounted on a headband with windshield and worn at the ears.

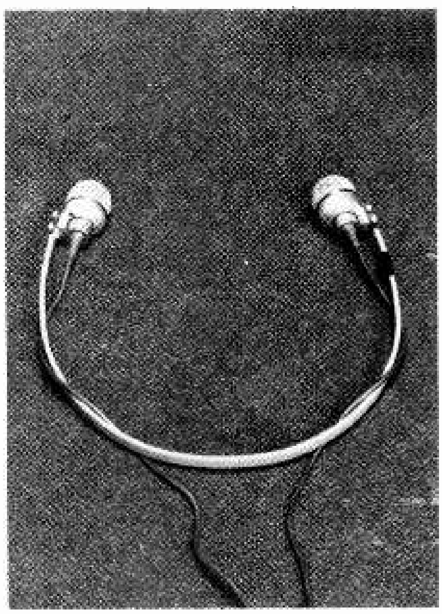
Because of the obvious limitations of this technique, checks were then made to see how much an artificial head actually contributed, starting with a head-sized carpet baffle between ear-spaced microphones (with and without plasticine pinnae!). Directional properties of the set up didn't seem any worse. In Derek Taylor's words "As long as the mics were about ear distance apart, with a baffle between to give the correct path length, the directional effects were not significantly different. Model ears or baffles behind the mics did not seem to help in resolving front-to-back confusion." Richard Imison agrees: there is "no significant difference" between the techniques tried as far as front localization is concerned. (They also agree that there isn't much difference in results between closed and open-type headphones either.)

Front-to-back ambiguity, it is argued, occurs with single, transient live sounds anyway. For continuous or longer live sounds one's head has more of a chance at assessing direction, either by unconscious minute head movements or by conscious larger movements, and the poor frontal localization with headphones is thought to be due to loss of such clues.

The BBC have obviously reached a point where they want to experiment with a large audience. But the data from listeners will have to be carefully interpreted as it seems far more likely that those who were impressed with the technique — say on account of well-defined images — would respond more readily than those for whom the technique was disappointing.

The ear-spaced microphone with baffle arrangement was made into more permanent form, as in the photograph, and used for the Oil Rig programme, as well as on other occasions including a proms recording. The prom recording, as with others, was not nearly so effective on loudspeakers though BBC personnel found it as good as the conventional stereo recordings, in some cases better. In simple informal preference tests between conventional and binaural stereo over loudspeakers, the binaural version was the preferred one. — **GBS.**





The baffle and (right) "stethoscope" microphone pairs described in the text.

Education by radio in Honduras

A case study in electronics technology in a developing country

by Michael K. Bates* B.A. (Eng. Tripos, Cambridge)

Electronics technology is at such a level of sophistication that few countries can sustain their own electronics industry. Nevertheless radio is an effective means of communication the world over and it has had a significant impact on developing countries. In studying a particular application in Honduras, the author draws lessons about the suitability of present technology for use in other developing countries.

Honduras, Central America, is reputedly the second poorest country in the Western Hemisphere. Although Honduras is less than half the size of the UK, its population density is low since the total population is only three million, of whom nearly all are Spanish-speaking Catholics; over two million eke out a subsistence living in rural areas and are known as *campesinos*, or peasant farmers. Most of the land is mountainous, containing small but fertile valleys. The wide strip of highly productive land on the Caribbean seaboard is mostly owned by foreign banana companies.

Communications systems within the country are on the whole ineffective: not even all the major towns are linked by paved roads, many villages are accessible only on foot or horseback, telephone links are over-subscribed and unreliable, and both the circulation of newspapers and the coverage of television are mostly confined to the cities. But radio has proved to be highly suitable and is the dominant medium for mass entertainment, dissemination of information and passing of messages. The success of radio broadcasting is largely due to an influx of cheap portable transistor radios, ownership of which is often regarded as an indication of social status, and this may account for the range at which the average transistor set is audible. Most broadcasting is on a private commercial basis from nearly one hundred local radio stations transmitting in the 540 to 1600kHz band, although use is also made of the 60m short-wave band and the standard v.h.f. f.m. band.

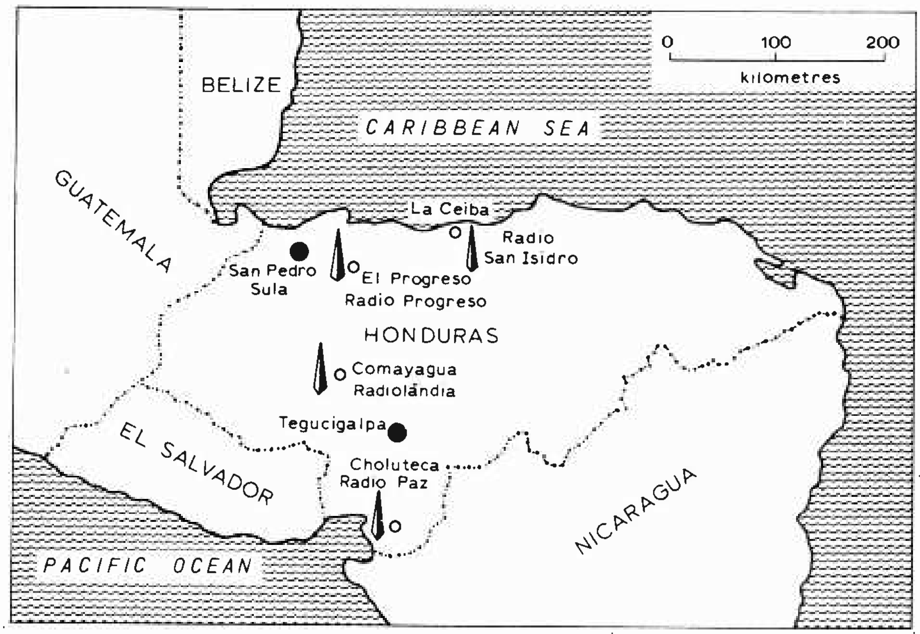


Fig. 1. Map of Honduras showing locations of radio stations mentioned in the text.

Radio schools

Although education is free in Honduras and primary school is, in theory, compulsory it is evident that few *compesinos* benefit from it: most have been to school for perhaps only a year or two and over 65% are illiterate. There are obvious difficulties in sparsely populated areas in bringing together enough pupils to make a conventional school viable, especially if the aim is education of working adults. Use of radio can, however, offer a solution to problems like these.

The system of radio schooling prevalent in Latin America originated in Colombia in 1947, when Radio Sutatenza went on the air with a 100W transmitter and just forty-five pupils. The idea proved successful and the organization grew rapidly, until today the station controls four transmitters with a combined output of over 750kW. Meanwhile radio schools were started in fifteen other Latin American countries, including Honduras.

The radio schools of Honduras have grown up under the auspices of Acción Cultural Popular Hondureña (ACPH), a non-government independent development agency which is financed from voluntary sources. There have been considerable problems in achieving autonomy from the influences of commercial enterprise, political forces and more recently a sector of the Catholic Church, partly because ACPH relies on agreements with sympathetic radio stations to buy air-time for transmission of the schools classes: hence, its effectiveness is closely linked to the progress of these stations.

Experimental education of adults by radio began in 1959 with broadcasts from Radio Católica in Tegucigalpa, the capital, and grew successful to encompass 700 school groups by 1964. After several years of organizational problems, the system was re-vitalised in 1969 with the opening by foreign priests of

*Volunteer radio engineer with the Catholic Institute for International Relations from September 1974 to December 1975 as part of the British volunteer programme.

Radio Paz, in southern Honduras, and the acquisition the following year of Radio Progreso in the north by Jesuits. As well as transmitting schools programmes, then as now recorded in the ACPH offices in Tegucigalpa, both stations followed normal commercial schedules. Plans for more comprehensive coverage of the country developed, and in 1974 surplus equipment was bought in the USA and shipped to Honduras for in-country construction of transmitters and studio facilities with local help. However this scheme has not reached fruition due to diverging aims of ACPH and the Catholic Church, a situation which has also caused Radio Católica to cease passing schools classes. Some expansion of the network was nevertheless achieved in 1975 with a low power short-wave installation at Radio San Isidro, La Ceiba, and complete new studios and transmitters for medium and short wavebands at Radiolándia, Comayagua. But these gains were offset by the closure of Radio Paz in June 1975 by the military government, following struggles over land tenancy in the east of the country, and attempts to regain the broadcast licence have so far only brought prevaricative responses.

The current disposition of facilities illustrates the wide spread of techniques which occurs in any technology in Honduras, ranging from the relatively sophisticated to the unbelievably crude. At the more impressive end of the spectrum, Radio Progreso broadcasts via a new Gates/Harris 5kW pulse-width modulated transmitter on 1110kHz, with a modified 10kW Collins on 4920kHz; on both frequencies there are back-up transmitters, a rare achievement for a Honduran station. Radio Paz transmitted on 990kHz using a modified Contel unit with 4-1000 tetrodes in the modulator and 3-1000 triodes in the final, and the locally constructed transmitter for Radiolándia draws from the same series of valves but with a single anode-modulated zero grid bias 4-1000 on the r.f. side to deliver 1.5kW on 1460kHz. For short-wave broadcasting at both Radiolándia and Radio San Isidro BC610 transmitters are in use, boosted to 500W with a final 833, a good robust valve which has been known to withstand accidental use as a light bulb. Even surplus equipment like this looks elegant alongside some home-made transmitters, which have been seen to use wood blocks to support and isolate transformers and domestic light switches on the control panel. It will be noticed that transmitter powers are all fairly low: 10kW is the legal upper limit and Honduran stations are at the moment spared the spiral of ever-rising powers. Despite the higher radio noise levels under tropical conditions, most areas are served well by their local transmitters and there is little adjacent or co-channel interference even at night.

On the studio side, there is such a range of equipment in use as to prohibit more than a mention here. The radio schools central recording studio is well equipped with a double turntable sound mixing desk, two Magnecord professional recorders, three Ampex series 600 machines and two high-speed tape duplicators. So too Radio Progreso has an impressive line up of Ampex 351 recorders in two fully interchangeable control rooms serving three studios, However, at the other end of the scale, the type of station with "mic and two decks" (one of them probably non-operational) is common.

Broadcasting policy

Radio Schools classes are broadcast from 4 p.m. to 6 p.m. Monday to Friday with supplementary material on Saturday including news and current affairs for *campesinos*. These programmes are followed by some 1200 community school groups involving about 22,000 students which means that, with their families included, the broadcasts affect some 100,000 people, around 5% of the rural population. Each group is guided by a *monitor* who will be a local *campesino* with approximately one month's training at one of a number of regional centres. The *monitor* also plays an important part in a feedback path of opinion via a regional co-ordinator to the production team in the capital. Instruction is given in reading, writing and basic arithmetic, progressing to geographical and cultural knowledge, but at all stages there is practical advice on agriculture, health and home management. However it is the teaching method which is significant. Education follows the idea, originated in Latin America, of "conscientization", a very pragmatic philosophy intended to create a critical awareness of one's environment and capabilities within it, with emphasis on democratic and co-operative processes as means of achieving communal aims. Hence it is not so much a "handing downwards" of information but rather a combined search by students and teachers in the context of a localized community to find solutions to very real practical problems.

The importance of employing local radio stations is noteworthy. Firstly the schedules of classes need to differ in various parts of the country to accommodate variations in the tending of crops. Secondly there is a chance for the local radio station to become the focal point in a community and give a sense of identification to those living around it, through their knowing personally the announcers, being able to participate in discussion programmes, or merely by hearing their own record dedications.

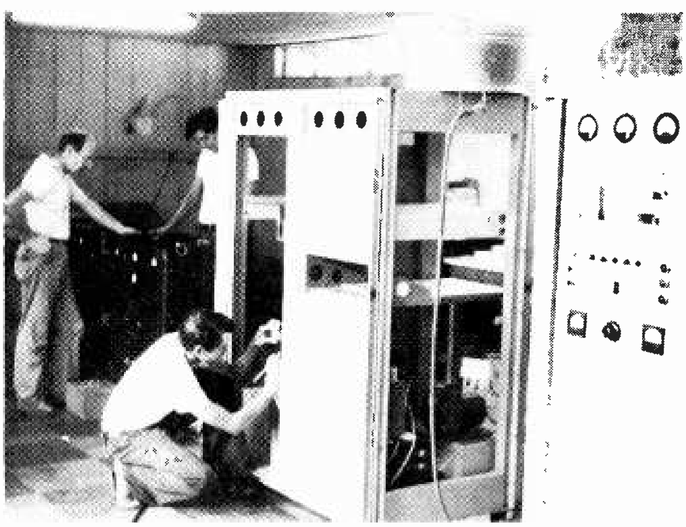


Fig. 2. Transmitter construction in workshops at Radio Paz, Cháuteca. On the right is the completed transmitter for Radiolándia; in the centre is a copy of it under construction; on the left is a BC610 US surplus being converted for short wave broadcasting. Note the tin bath, used to supply cooling water for a dummy load during necessarily brief transmitter tests at full power.

Fig. 3. A typical radio schools class, making use of a primary school out of normal school hours.

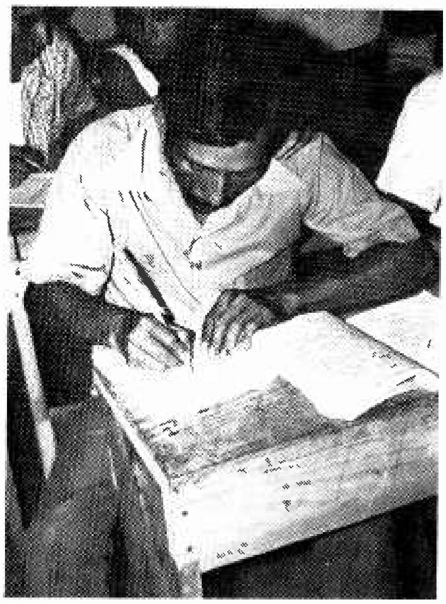


Fig. 4. An exercise in Handwriting for a Honduran campesino.

Operational problems

Operation of a radio network in a developing tropical country brings its own special difficulties not normally encountered here. There are frequent troubles with the *campesino* transistor radios which are often subjected to extreme conditions of heat or mechanical abuse, such as use as a temporary seat in a bus with doubtful suspension driven along a rocky dirt road. Sometimes a little "home servicing" is attempted too, with the aid of the first implement which comes to hand, normally a machete, and often the back of the set is lost and the loudspeaker cone is eaten by cockroaches.

Broadcasting stations also suffer from the climatic conditions. Ventilation can be a major difficulty: at the Radio Paz transmitter in Choluteca, admittedly one of the warmest parts of the country, shade temperatures in March and April regularly exceed 40°C, and even after increasing the size of blowers it was necessary to run the transmitter without sides and play a domestic fan on the modulator chassis. Concurrent with temperature problems are often those of high humidity: a particuarly bad case is in La Ceiba, where the damp salt-air has affected even the BC610, designed for military and tropical use. During the wet season, lightning strikes cause frequent disruption of service and damage to transmitters and for this reason a folded unipole (caged) aerial configuration, in which the base of the tower is earthed, has been adopted for m.w. radiation at both Radio Progreso and Radiolándia.

The studio equipment is not normally subjected to such extreme conditions, but in studios without air conditioning there are problems of overheating in turntable and tape-recorder motors, and much valve equipment such as line amplifiers and compressors has to be blown. Fluctuations in mains voltage can also be troublesome; for example the Radiolándia transmitter shows a tendency to trip out on the surge caused by a local factory shutting down at the end of the day.

Many stations have no technical staff and hence no regular maintenance, repairs being effected only when breakdown occurs. In a country dependent on agriculture rather than industry and technology, the whole environment is non-scientific and there are few technicians and engineers of any description. There appear to be several reasons for this. The social circumstances of most families tend to inhibit rather than encourage a child's natural curiosity; the education system, for those who benefit from it at all, is biased towards learning by rote rather than from exploratory and logical deducation processes, and Honduran technicians experience particular difficulty in fault diagnosis. For those few privileged enough to go on to higher education, most seeking technical studies would travel to the U.S.A. or Mexico, and perhaps not return. Latin American technicians encounter additional problems with language, as a large proportion of service manuals and specification sheets are in English only. Nevertheless, the enthusiasm and capacity for hard work of those trying to better themselves is an inspiration. Moreover most Hondurans are capable with their hands and adept at improvisation with what materials and knowledge they possess.

Electronics technology for developing countries

One of the dilemmas which developing countries face is whether to accept certain totally imported technologies, such as electronics, or to manage without them. The extent of radio ownership leaves no doubt that radio broadcasting is both desirable and successful in Honduras, yet even an organization like the radio schools, trying to go its own way to suit the needs of its own people, has to accept the technology of the industrialized countries and the way in which it is administered.

Furthermore, there is no half-way stage in radio, no "intermediate" technology. Other branches of engineering, for example transport, can be upgraded by better techniques while remaining within the framework of traditional styles: the wooden wheels and axles of an ox-cart can be replaced by pneumatic tyres and a suspension system without a complete changeover to use of a tractor and trailer. But there is no parallel process in radio, which is not a development of a traditional method of communication but a totally new science. It is hard to simplify a transmitter beyond a basic valve-driven anode-modulated circuit, yet at present this remains as incomprehensible to most Hondurans as ampliphase, Doherty or pulse amplitude systems: it is just another proverbial "black box".

So how suitable is present day electronics technology for developing countries such as Honduras? Despite the extent and importance of radio systems in such countries, little equipment is manufactured specifically for their needs and often standard equipment is unsuitable without modifications such as tropicalized components or additional cooling. At times equipment cannot be set up correctly or maintained through lack of test gear and spares: an example is an ampliphase transmitter imported into Honduras which has never given optimum performance. On the other hand, confusion is caused when a range of test equipment is specified which is not normally used

Fig. 5. Radio schools classes are often held in ordinary campesino *houses such as this one near Choluteca.*

outside a laboratory; the list of "required equipment" for tape-head alignment on one model of recorder included a valve voltmeter, a low-distortion oscillator and a spectrum analyser. The station concerned did not possess even a multimeter.

Nevertheless, the Latin American broadcast equipment market is booming; a periodical is produced, in English and Spanish, for free distribution to any radio personnel requesting it, and many of the larger electronics companies now have agencies in Central and South America.

Bearing in mind the possible size of the market for electronic and radio goods in developing countries, it seems appropriate to consider some of their basic requirements. It would indeed be a noteworthy advance if there were available a cheap, simple, foolproof transistor radio, in a tough impact-resistant case with firmly secured back and control knobs, with reliable battery contacts and protection against incorrect battery insertion. Suitable circuitry might include integrated circuit i.f. and a.f. stages and ceramic filters, with servicing simplified to the level of quick circuit-block replacement or perhaps even a complete change of encapsulated, throwaway electronics. The criteria of low cost, robustness under exacting conditions and misuse, reliability and ease of servicing by non-expert personnel also apply to broadcasting equipment, appearing more important than high performance and sophistication of design. Such ideas as solid-state relays, ball-race bearings lubricated for life, modular construction but with far more attention given to connectors, and generously rated components immediately suggest themselves. A plea might well be added for VU meters with flexible pointers and unbreakable end-stops.

Current technology can adequately satisfy these requirements if suitable production and marketing policies are adopted. Future demands from developing countries are likely to be for television as well as radio equipment in ever-increasing quantities, but understanding and ability to use the technology can only come slowly. In the meantime, these countries require the sort of equipment which can be used successfully in the present environment. The Honduran *campesino* needs his indestructible transistor radio for entertainment and for education, and must hope that progress in electronics technology will move towards providing it. And there might even be something in it for us.

Acknowledgements

Thanks are due for the considerable assistance provided by R. J. Levey, engineer for ACPH; P. G. Nairne, now with the British Council; and the Catholic Institute for International Relations.

One hundred years ago

No, *Wireless World* was yet a thing of the future in 1877, but the groundwork for the development of the electronic twentieth century was being laid and already, a hundred years ago, an impressive list of theoretical and practical invention was in existence. Computers, relays, transformers, diaphragm microphones, motors, fuel cells had all been made and the theory of wave propagation was well advanced.

In April 1877, Thomas Alva Edison filed a U.S. patent application for the design of the carbon microphone, which immediately took precedence over the efforts of Reis (diaphragm type — 1860) and Bell (magnetic — 1875). The "other end" of a speech communication system was attacked by E. W. Siemens, who applied for a German patent on the moving-coil loudspeaker in December, 1877. The device used the now-familiar motor with a circular coil moving in a radial field.

A rather more publicized centenary this year is the invention by Edison of the phonograph (or gramophone) using tin foil wrapped round a hand-cranked cylinder. This patent was applied for in December, 1877.

Moving on to fifty years ago, 1927 was an important date in the history of the cinema when the first really effective "talkie" film, "The Jazz Singer", with Al Jolson, was a tremendous success. The Western Electric sound system — the Vitaphone — used 16in disc turntables driven at 33⅓ r.p.m. from the same constant speed motor system as the film projectors. But this method of synchronism was soon to be supplanted by the "sound track" (sound-on-film system) introduced in the same year by Fox Movietone News. On a quieter and somewhat less distorted note, but highly significant to audio engineering, was the invention in 1927 of the negative feedback amplifier by H. S. Black of Bell Laboratories.

These are just a few of the significant inventions described in a new book "Electronic Inventions 1745-1976" by G. W. A. Dummer just published by Pergamon Press at £4.00. This contains mainly brief accounts of important inventions in electronics but also has some interesting graphs showing historical trends. For example, it shows that in the 200 years from 1745 to 1945 some 106 electronic inventions originated in Europe against 66 in the same period in the USA; but in the mere 31 years from 1945 to 1976 the situation was reversed with 32 inventions for Europe and 85 for the USA.

Literature Received

Power supply price list is now available from Weir, including bench types, a unit for use with microprocessors and a range of card supplies. Weir Instrumentation Ltd, Durban Road, Bognor Regis, Sussex WW401

Video cassette recorder control unit is made by Crow of Reading for use with the Ampex ACR-25. A leaflet describes the function of the unit, which is designed for remote control of the programmed recorder. Crow of Reading Ltd, PO Box 36, Reading, RG1 2NB WW402

Demonstration panels for teaching electronics are produced by Taran International. The panels take the form of large mimic diagrams with the circuit printed on the front, the components being plugged in. A leaflet can be obtained from Raynham Road, Bishop's Stortford, Herts CM23 5PG WW403

Component lead forming machinery from Eraser International is described in a "Wyber" catalogue. Hand-operated and automatic forming and cropping tools are illustrated and several implements for cleaning printed boards are described. Eraser International Ltd, 2/3 Hampton Court Parade, East Molesey, Surrey KT8 9HB WW404

Prices of measuring instruments in the Electroplan catalogue are brought up to date in their February 77 list, which briefly describes additions to the range from Advance, Solartron, Weston, Bryans, Telequipment and Systron-Donner. Electroplan Ltd, PO Box 19, Orchard Road, Royston, Herts SG8 5HH WW405

Printed-circuit manufacture by the Nevin group is the subject of a new brochure, which includes a wall-chart of board design information, protective finishes and metric conversions. Nevin Electric (Holdings) Ltd, Arkwright Road, Poyle Trading Estate, Colnbrook, Bucks SL3 0HJ WW406

Connectors in the Amphenol range include the r.f. types to DEF standards — the 27GB Subminax, the 31GB series quick disconnecting connectors and the 82GB 'C' weatherproof type. A set of data sheets covering all these is now obtainable from Amphenol Ltd, Thanet Way, Whitstable, Kent CT5 3JF WW407

Distance measurement techniques over a period of 5000 years are illustrated on a new wall-chart from Tellurometer, which has been involved in only the later, microwave methods of measurement. Tellurometer, Oakcroft Road, Chessington, Surrey KT9 1RQ WW408

Capacitors and semiconductor devices by RIFA are fully described in a catalogue, now available. A very full range of capacitors is offered and the semiconductors are rectifiers, timers and driver/interface circuits. Rifa, Fac, S-161 11 Bromma, Sweden WW409

Power supplies by Gardners are detailed in a series of recently published leaflets. Chargers for nickel-cadmium cells, 50Hz d.c.-to-a.c. inverters, regulators and d.c.-to-d.c. converters are all described and the leaflets can be obtained from Gardners Transformers Ltd, Christchurch, Dorset, BH23 3PN WW410

Speaker drive units, crossovers, materials and accessories for loudspeaker construction are listed in a new catalogue, obtainable from Badger Sound Services Ltd, 38(a) St Andrews Road South, St Annes, Lytham St Annes, Lancs FY8 1PS at 10p per copy.

Pressure transducers of various types are made by Bell & Howell who describe them in four bulletins. Types covered are: thin-film types, high-output versions with amplifiers, marine and industrial transducers with electronics in a bulkhead-mounting case and flameproof transducers. Bell & Howell Ltd, Electronics and Instruments Division, Lennox Road, Basingstoke, Hants RG22 4AW..... WW411

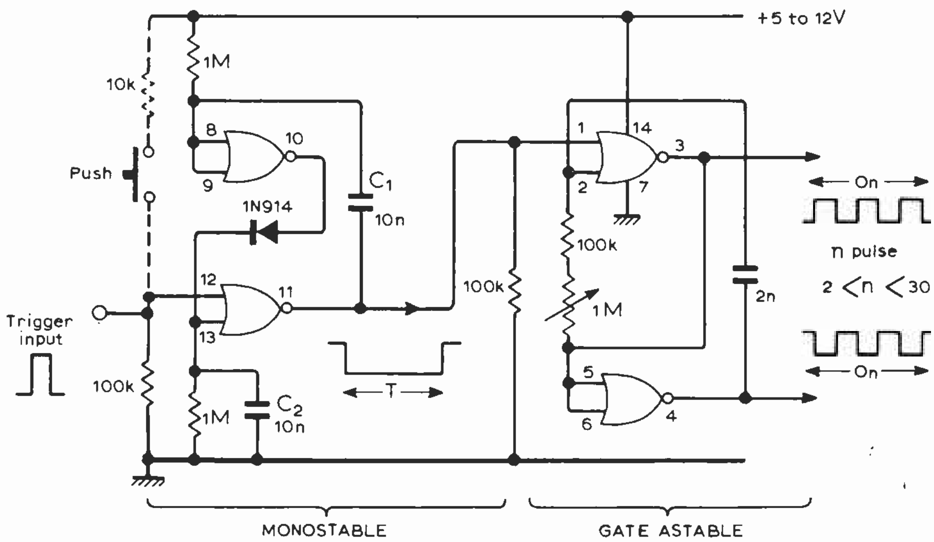
General electronic components, instruments, kits and books are all listed in the Maplin 1977 catalogue, available at 50p from Maplin Electronic Supplies, PO Box 3, Rayleigh, Essex SS6 8LR.

Circuit Ideas

N-stable multivibrator

This circuit produces a fixed number of pulses when triggered. Applications include number indicators, frequency multiplication, and number loaders. A monostable feeds a gated astable and, by adjusting the frequency control of the last mentioned, between two and thirty pulses can be obtained. This has been realised using a single CD4001 i.c. A pushbutton can be used instead of a trigger pulse for manual circuits.

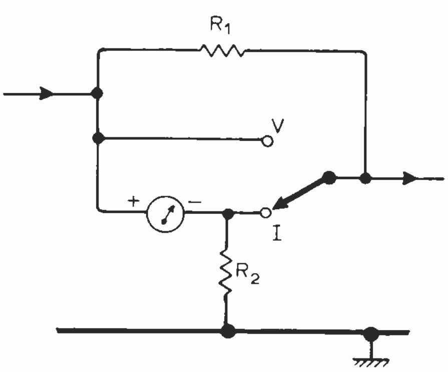
Dr K. Padmanabhan,
University of Madras,
India.



Voltage/current meter switch

The circuit arrangement shown enables a single pole two way switch to be used in place of the two pole, two way type which is usually required when one meter indicates both current and voltage. Resistors R_1 and R_2 are the meter shunt and series resistances respectively. The change of output voltage due to R_1 being switched in and out will usually be negligible if the circuit is included in the feedback loop of a stabilised power supply.

S. V. Essex,
London W.14.



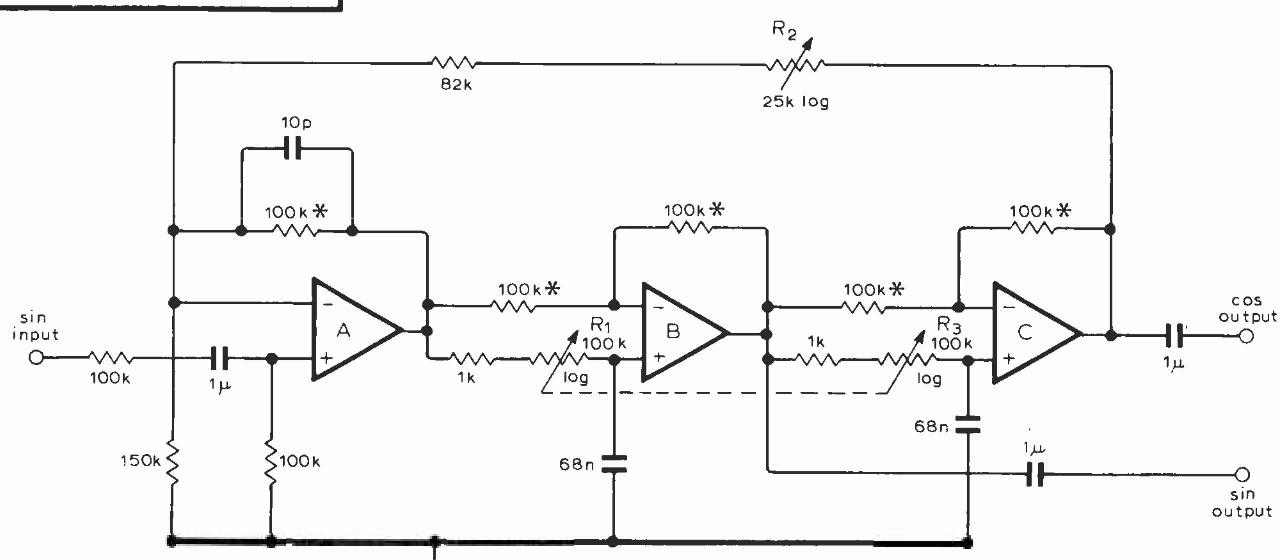
Variable band-pass filter

Sometimes it is required to have a high-Q, bandpass filter which is adjustable over a wide frequency range without an appreciable change in Q, or more particularly, without the loop-gain becoming greater than unity which causes oscillation. With this circuit the centre frequency can be adjusted over a 100:1 range whilst maintaining $Q>100$, and over smaller frequency ranges, a Q of up to 10^4. In addition, a two-phase output is also available.

Two cascaded all-pass networks, B and C, each have a 0° to 180° phase variation, and unity gain at all frequencies. This cascade is driven from a third operational amplifier whose feedback signal is the sum of the input and output of the all-pass network. The sum becomes zero when there is exactly 180° phase shift over the cascade, and thus the overall gain approaches half the open-loop gain of amplifier A. At other frequencies the gain tends towards unity.

Because the frequency determining components only affect the overall phase-shift and not the gain, there is a no danger of having a loop-gain greater than unity. If the two-phase output or large frequency range is not required one R can be fixed. The Q is adjusted by R_2, and with the values shown gives the circuit a 20Hz to 2kHz range.

J. M. Worley,
Colchester,
Essex.

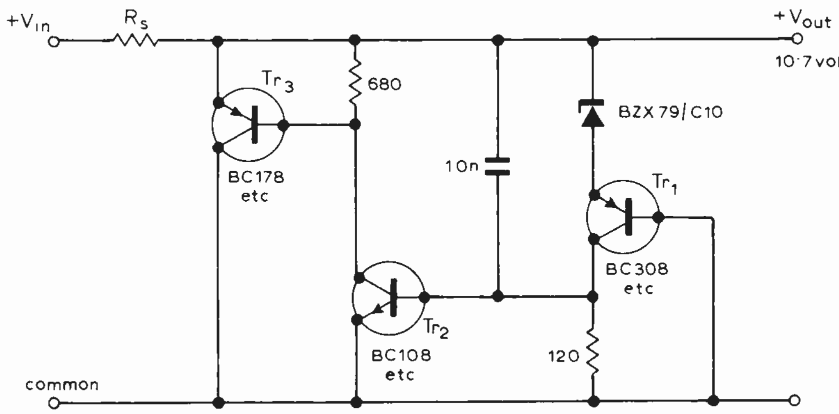


* denotes close tolerance

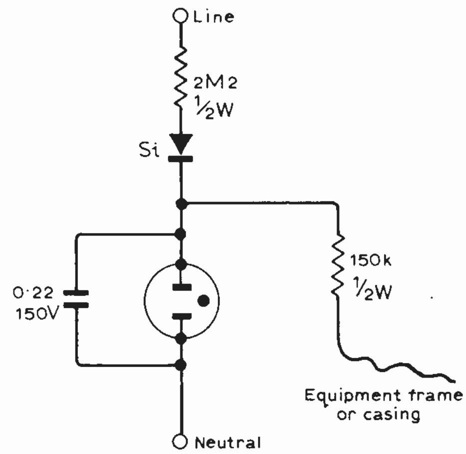
Ripple eliminator

This shunt regulator circuit virtually removes all mains ripple without using a large capacitor, and is inherently short-circuit proof. The regulator is ideal as a stabilized supply line for audio preamplifiers and other applications where a precise voltage level is not important but freedom from ripple is. The circuit's simplicity is due to silicon transistors which can operate at very low levels of collector-emitter voltage. The zener diode should be operated with enough current to make its dynamic resistance significantly less than R_1. Transistor Tr_3 may be a power type or a Darlington. The Miller capacitor should be large enough to stop high frequency oscillations.

P. S. Bright,
Christchurch, New Zealand.



Earth warning indicator



This simple circuit gives a warning if the earth wire is disconnected from the chassis of an instrument. It is particularly useful for oscilloscopes which may be left in a hazardous state when the earth wire is purposely disconnected to avoid hum loops etc.

The neon is normally extinguished, and flashes if the earth is not connected.

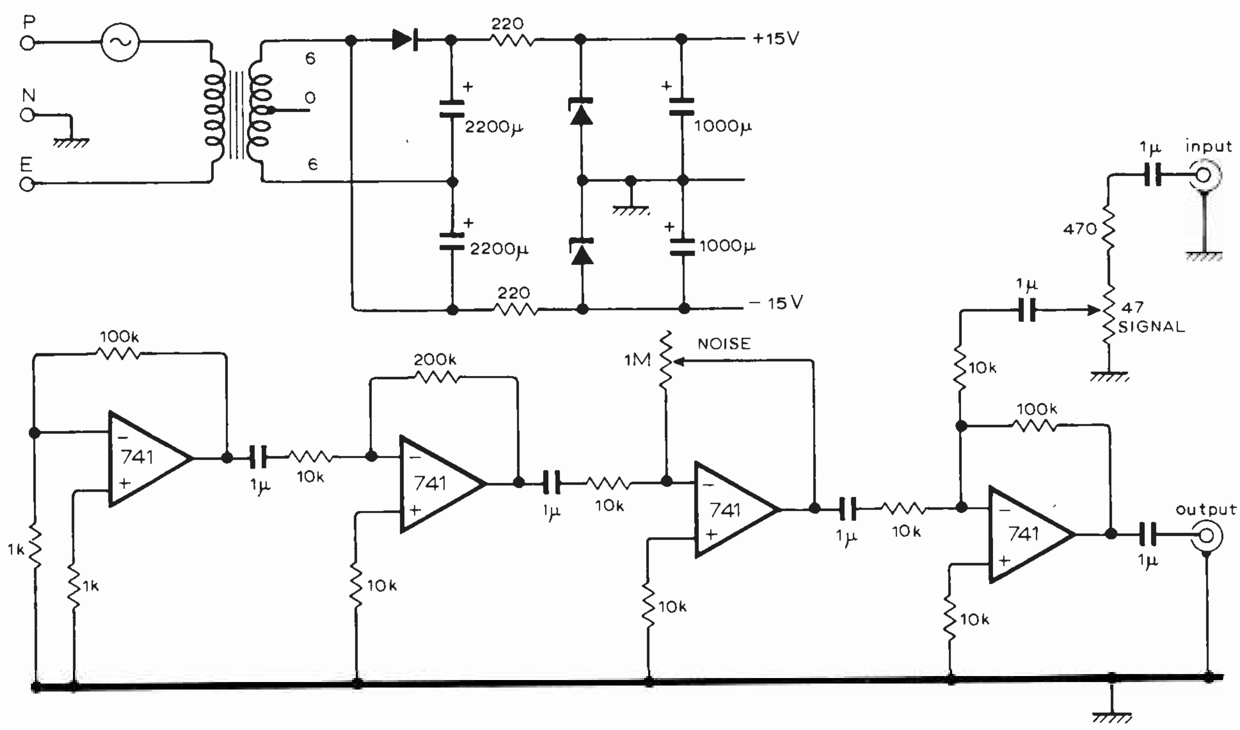
R. H. Troughton,
Gatwick Airport, Surrey.

Simple noise generator

Phase-lock loop techniques, for the recovery of low level information from noisy signals, have become increasingly important. This note describes a simple noise generator in which both signal and noise levels are continuously and independently variable from zero to maximum. The only point requiring care is the positioning of the transformer to avoid 50Hz hum. The voltage doubler supply may be replaced by any convenient configuration. The input impedance is approximately 500Ω. Four stages of gain have been used to minimize instabilities and provide the maximum noise amplitude without reaching the limits of output excursion. The a.c. coupling between stages eliminates offset compensation and provides low frequency roll-off. High frequency roll-off is determined by the gain of each stage and varies slightly with the noise level control. Output noise is essentially "white" from below 50Hz to above 5kHz. This range was selected as appropriate to demonstrate the recovery of a 500Hz signal from noise of similar frequencies. The circuit will operate at maximum noise output into a load of 1.5kΩ. For smaller load impedances, the noise level must be reduced or the 1000μF power supply capacitors increased to prevent oscillation.

The author wishes to acknowledge the contributions of Dr T. G. L. Shirtcliffe, Mr J. E. Nixon and Mr P. D. Turner to the project.

J. E. Morris,
University of Wellington,
New Zealand.



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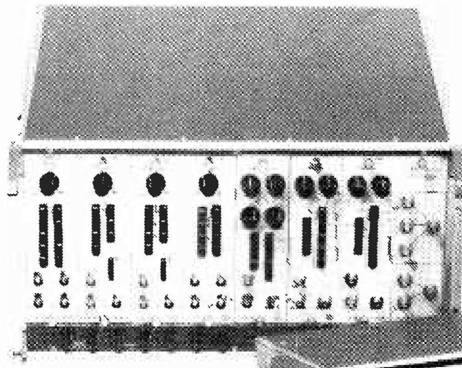
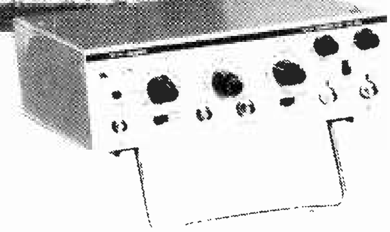
Then there's the SG200 RF Signal Generator, offering 7 ranges from 160 kHz to 230 MHz, and excellent frequency stability with fine setting to within 1 kHz.



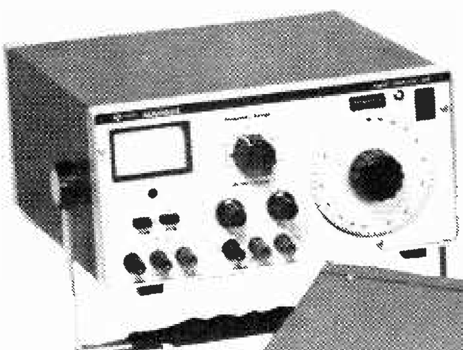
PG52B



PG58A

The Generation Game

There are Pulse Generators too. The PG58A, for instance: an inexpensive general-purpose instrument providing single or double pulses as well as square waves. And the PG52B; not really one instrument, but up to eight modular units in one Main Frame. There are twelve modules to choose from, enabling you to generate an extremely wide range of pulses and pulse patterns. And if you need still more versatility, there's a 16 bit Word Generator and a Gate Module to provide even more complex pulse patterns.



J3A

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WW—073 FOR FURTHER DETAILS

VIEWDATA

3 — Operation of the system: terminals and codes

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

Part 1 of this series, in the February issue, gave an introduction to Viewdata, with mentions of earlier systems. Part 2, in the March issue, dealt mainly with applications. This article now describes the overall arrangement of the system, the codes used and the Viewdata terminal.

Fig. 1 gives an overall view of a Viewdata connection. The home terminal, shown at the bottom left hand side, comprises a domestic television set, a telephone instrument, a Viewdata adaptor and a keypad. The actual assembly is shown in Fig. 2. Two types of keypads proposed are shown in Figs. 3 and 4. The basic keypad is Fig. 3; this provides the ten numerals, * and ≍ symbols and keys for automatic dialling, if installed. Fig. 4 is an alphanumeric keypad. This contains in addition to the above, the complete upper case alphabet, punctuation marks and symbols like £,%,/, arithmetic and algebraic symbols and cursor control characters. A typical Viewdata terminal for the office, the Viewdataphone, is shown schematically at the bottom right hand side of Fig. 1. This consists of a Viewdata terminal and a self-contained telephone instrument. A typical Viewdataphone was shown in the March issue. The Viewdata computer is shown at the top of Fig. 1, notionally connected to a variety of data banks, either direct or through the switched telephone network.

As mentioned in the February issue communication between the terminal and the Viewdata computer is at a rate of 1200 bits/s from computer to terminal and 75 bits/s in the opposite direction. More details of this arrangement will be given later.

In order to establish a connection to the Viewdata computer the user dials the telephone number of the computer as for a normal telephone call. When the connection is established the computer generates a high pitched tone (frequency 1300Hz) which is heard in the telephone receiver. The user then presses a button marked "data" on the telephone set, which switches the telephone line from the telephone set to a modem (modulator-demodulator). The telephone receiver is then set by the side of the cradle. Once contact is established, the computer transmits a first frame, which requires the user to enter a user number. When this has been done Viewdata offers the first index (shown in the February issue, p. 32).

The action is now transferred to the keypad. On this the user keys-in his user number and any further responses. Suppose the user wishes to obtain information about entertainment activities for a given day of the week. The user may enter the entertainment page direct by keying *3230≍. An example of one of the pages in the entertainment sequence was Fig. 6 in the February issue. In later models of the terminal, use is made of the calling key on the keypad. This calls the Viewdata computer automatically and switches over to the modem without the user's intervention. The keypad may then be used as previously.

The design philosophy of Viewdata which has been dealt with in the first

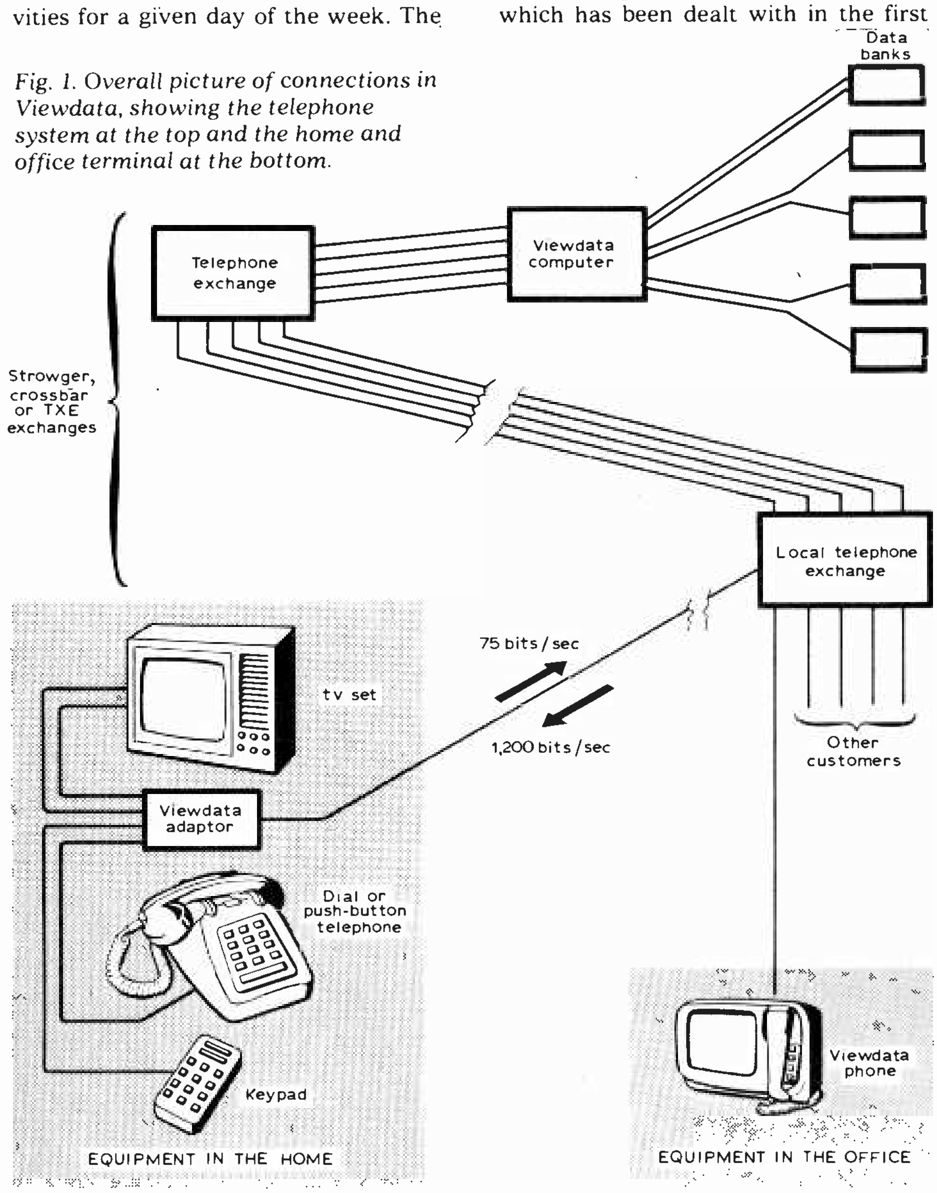
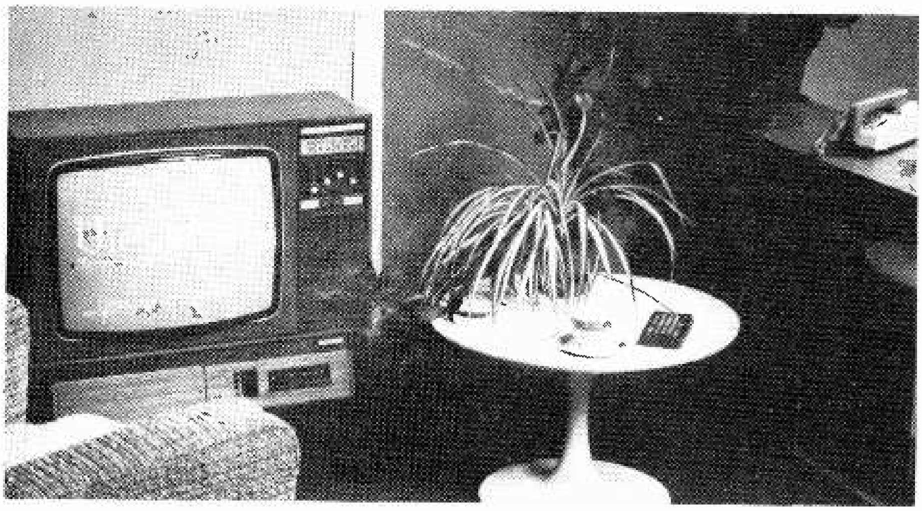


Fig. 1. Overall picture of connections in Viewdata, showing the telephone system at the top and the home and office terminal at the bottom.



▲ *Fig. 2. Home terminal for Viewdata, with television set, telephone (right) and keypad on the table.*

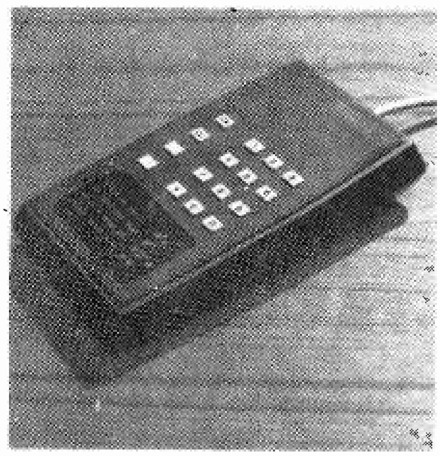
two parts of this article referred to the need to keep the cost of Viewdata down to very low levels, both on the terminal side and on the computer usage side. Indeed, unless the cost of using the computer facility is kept substantially below that of using current computer time-sharing systems, the whole project may not become viable. This therefore postulates the use of a distributed computer system, so arranged that the majority of users may have access to a nearby computer centre, at the cost of a local telephone call for the connection plus a correspondingly modest charge for the use of the computer and the information provided.

The resulting network is typically as shown in Fig. 5. Users are within a local call distance of their computer centres, shown as rectangles. A cluster of local computer centres is grouped under the control of a regional centre for the purpose of data gathering and distribution. A national data centre controls the operation of the whole system and distributes to each regional centre new information, news and data updates. Regional centres also accept information of regional or local interest and distribute this to the local centres.

The Viewdata terminal

Display format. The display format of Viewdata is identical with that of teletext, i.e. a page consists of 24 rows of 40 characters each, each character being generated by a 5 × 7 matrix with upper and lower case, character rounding, graphics symbols and colour. Thus a great deal of the electronics in a terminal may be common to Viewdata and teletext, the differences being primarily concerned with the additional functions needed in Viewdata, the different modes of transmission applicable to these two systems and the different contraints appertaining to the different communications media involved.

In the case of Viewdata the data enters the terminal via the telephone line at relatively low speed, and, as the probability of data corruption is quite low, little is needed for the purpose of error detection and correction. Indeed, extensive Viewdata tests have been



▲ *Fig. 3. Basic keypad used in a Viewdata terminal,providing ten numerals and a few other keys.*

carried out over the past two years from a large number of centres in the UK and on the Continent. In all these tests the public switched telephone network was used to connect up to the experimental Viewdata system based at Martlesham, near Ipswich, and transmission difficulties have been very rare.

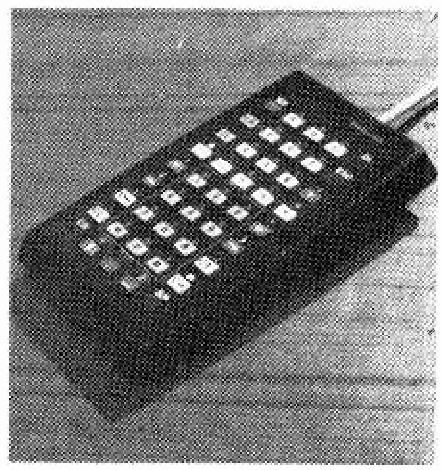
The character codes used for Viewdata and teletext are also identical, except for the actual codes transmitted over the line, where a slight change is made to comply with International Standards Organization recommendations.

The table of codes used for Viewdata is shown in Figs. 6, 7 and 8. Fig. 6 shows the joint Viewdata and teletext codes for alphanumeric characters only. This differs from earlier versions in the following characters:

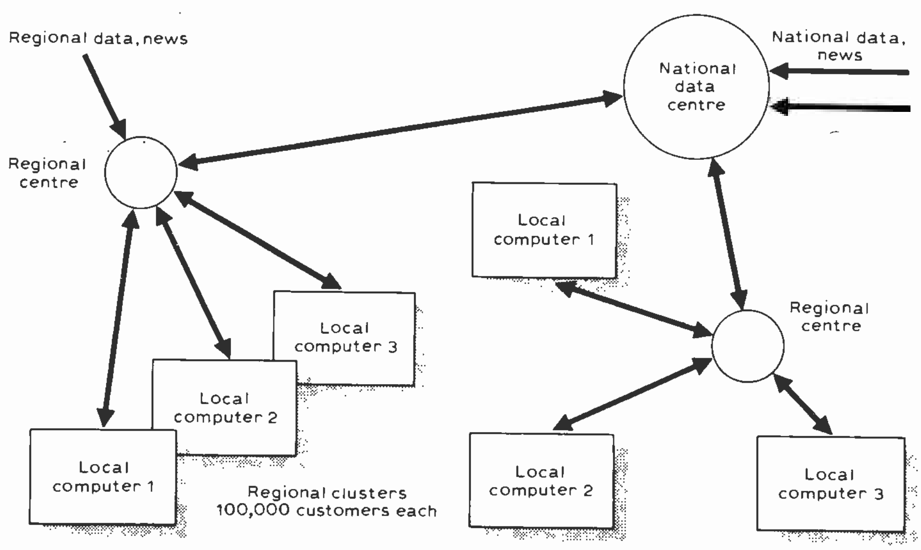
Column	Row	Was	Is now
5	11	[	←
5	12	\	½
5	13	]	→
5	15	–	#
6	0		—
7	11	¦	¼
7	12	¡	II
7	13	¦	¾
7	14	–	÷

Note: The top, left-pointing, arrow is used as an assignment statement; the lower, right-pointing, arrow means "go to"; and the sign # is used as a terminator and for special functions. Note also that the arithmetic operator × (multiply) used in Viewdata is shown as *x* (lower case *x*), while the minus sign (−) is code 2/13 and the exponentiation sign is code 5/14 shown as ↑.

Fig. 4. More elaborate, alphanumeric, ▼ *keypad with a variety of other symbols.*



▼ *Fig. 5. A distributed Viewdata network, showing local computers, regional centres and national data centre.*



		b_7	0	0	0	0	1	1	1	1
		b_6	0	0	1	1	0	0	1	1
		b_5	0	1	0	1	0	1	0	1
Bits	$b_7 b_6 b_5 b_4 b_3 b_2 b_1$	Col / Row	0	1	2	3	4	5	6	7
	0 0 0 0	0			SP	0	@	P	—	p
	0 0 0 1	1			!	1	A	Q	a	q
	0 0 1 0	2			"	2	B	R	b	r
	0 0 1 1	3			£	3	C	S	c	s
	0 1 0 0	4			$	4	D	T	d	t
	0 1 0 1	5			%	5	E	U	e	u
	0 1 1 0	6			&	6	F	V	f	v
	0 1 1 1	7			'	7	G	W	g	w
	1 0 0 0	8			(	8	H	X	h	x
	1 0 0 1	9			)	9	I	Y	i	y
	1 0 1 0	10			*	:	J	Z	j	z
	1 0 1 1	11			+	;	K	←	k	¼
	1 1 0 0	12			,	<	L	½	l	‖
	1 1 0 1	13			—	=	M	→	m	¾
	1 1 1 0	14			.	>	N	↑	n	÷
	1 1 1 1	15	S1		/	?	O	#	o	■

▲ *Fig. 6. Codes for alphanumeric characters only, as used in both Viewdata and teletext.*

		b_7	0	0	0	0	1	1	1	1
		b_6	0	0	1	1	0	0	1	1
		b_5	0	1	0	1	0	1	0	1
Bits	$b_7 b_6 b_5 b_4 b_3 b_2 b_1$	Col / Row	0a	1a	2a	3a			6a	7a
	0 0 0 0	0	(NUL)	(DLE)						
	0 0 0 1	1	alpha^n red	graphics red						
	0 0 1 0	2	alpha^n green	graphics green						
	0 0 1 1	3	alpha^n yellow	graphics yellow						
	0 1 0 0	4	alpha^n blue	graphics blue						
	0 1 0 1	5	alpha^n magenta	graphics magenta						
	0 1 1 0	6	alpha^n cyan	graphics cyan						
	0 1 1 1	7	alpha^n white	graphics white						
	1 0 0 0	8	flash	conceal display						
	1 0 0 1	9	steady	contiguous graphics						
	1 0 1 0	10	end box	separated graphics						
	1 0 1 1	11	start box	(ESC)						
	1 1 0 0	12	normal height	black background						
	1 1 0 1	13	double height	new background						
	1 1 1 0	14	(SO)	hold graphics						
	1 1 1 1	15	(S1)	release graphics						

Fig. 7. Codes for graphics used in teletext.

Fig. 7 shows the graphics and control characters use in teletext, as at September 1976*, the conventions being as before, that is:

1. All character rows start in the "steady", "alphanumeric white" and "unboxed" condition without control characters.
2. Control characters shown are displayed as spaces, but control whether alphanumeric or graphic characters are displayed and what colour is used.
3. Alphanumeric characters in columns 4 and 5, i.e. all of the upper case letters and a few others, may be displayed next to graphic symbols without an intervening space.

While the intervening space convention following a control character is essential in teletext, it has been accepted in Viewdata for the sake of uniformity, although it is not really essential and imposes undesirable constraints on the page format.

Additional control characters have recently been added to teletext to provide enhanced display facilities. The "intervening space" convention is somewhat modified and made less onerous, although not all its undesirable effects are eliminated.

The new control characters, which may be applied equally in Viewdata are in four groups:

Contiguous/separate graphics. Codes 1/9 and 1/10 in teletext, 5a/9 and 5a/10 in Viewdata. This provides the choice of graphics symbols filling the whole of a character rectangle, or only six discrete and separate dots.

Normal height/double height. Codes 0/12 and 0/13 in teletext, 4a/12 and 4a/13 in Viewdata. This provides for the optional display of alphanumeric characters in the standard size, i.e. within the normal char-

*Broadcast Teletext Specification. Published jointly by the Broadcasting Corporation, Independent Broadcasting Authority and British Radio Equipment Manufacturers Association.

		b_7	0	0	0	0	1	1	1	1
		b_6	0	0	1	1	0	0	1	1
		b_5	0	1	0	1	0	1	0	1
Bits	$b_7 b_6 b_5 b_4 b_3 b_2 b_1$	Col / Row	0	1	2a	3a	4a	5a	6a	7a
	0 0 0 0	0	NUL							
	0 0 0 1	1		DC_1			alpha^n red	graphics red		
	0 0 1 0	2		DC_2			alpha^n green	graphics green		
	0 0 1 1	3		DC_3			alpha^n yellow	graphics yellow		
	0 1 0 0	4		DC_4			alpha^n blue	graphics blue		
	0 1 0 1	5	ENQ				alpha^n magenta	graphics magenta		
	0 1 1 0	6					alpha^n cyan	graphics cyan		
	0 1 1 1	7					alpha^n white	graphics white		
	1 0 0 0	8	BS	CAN			flash	conceal display		
	1 0 0 1	9	HT				steady	contiguous graphics		
	1 0 1 0	10	LF				end box	separated graphics		
	1 0 1 1	11	VT	ESC			start box			
	1 1 0 0	12	FF				normal height	black background		
	1 1 0 1	13	CR				double height	new background		
	1 1 1 0	14		cursor home				hold graphics		
	1 1 1 1	15		IS_2				release graphics		

Fig. 8. Control and graphics codes used in Viewdata.

acter rectangle or stretched vertically to double height, the width of each character and the intervening spaces between characters remaining the same.

Black background/new background. The background colour of the character rectangle is normally black. Whenever the new background control character 1/13 in teletext or 5a/13 in Viewdata occurs, the display colour then obtaining is adopted as the new background colour.

Hold graphics/Release graphics. Codes 1/14 and 1/15 in teletext, 5a/14 and 5a/15 in Viewdata. This allows a limited range of abrupt display colour changes in a row whereas normally there is at least one space between rectangles with different display colours in the same row.

The graphics and control characters in Viewdata are show in Fig 8, but before these are looked at in detail, the use of a cursor in Viewdata should first be explained.

Cursor. The cursor in Viewdata is a symbol which shows up on the display as a bright rectangle, filling the space of an upper case alphabetic character. It may be switched on and off, as required. by a switch on the terminal or on the keypad, or by remote control from the computer. It may also be moved anywhere over the display either manually by using special keys on the keypad or by remote control from the computer.

The cursor has many functions.

b_7 b_6 b_5		0 0 0	0 0 1	0 1 0		0 1 1		1 0 0		1 0 1		1 1 0		1 1 1	
Bits $b_7b_6b_5b_4b_3b_2b_1$	Col / Row	0	1	2	2a	3	3a	4	4a	5	5a	6	6a	7	7a
0 0 0 0	0	NUL		SP		0		@		P		–		p	
0 0 0 1	1		DC_1	!		1		A	alpha^n red	Q	graphics red	a		q	
0 0 1 0	2		DC_2	"		2		B	alpha^n green	R	graphics green	b		r	
0 0 1 1	3		DC_3	£		3		C	alpha^n yellow	S	graphics yellow	c		s	
0 1 0 0	4		DC_4	$		4		D	alpha^n blue	T	graphics blue	d		t	
0 1 0 1	5	ENQ		%		5		E	alpha^n magenta	U	graphics magenta	e		u	
0 1 1 0	6			&		6		F	alpha^n cyan	V	graphics cyan	f		v	
0 1 1 1	7			'		7		G	alpha^n white	W	graphics white	g		w	
1 0 0 0	8	BS	CAN	(		8		H	flash	X	conceal display	h		x	
1 0 0 1	9	HT		)		9		I	steady	Y	contiguous graphics	i		y	
1 0 1 0	10	LF		*		:		J	end box	Z	separated graphics	j		z	
1 0 1 1	11	VT	ESC	+		;		K	start box	←		k		¼	
1 1 0 0	12	FF		,		<		L	normal height	½	black background	l		‖	
1 1 0 1	13	CR		–		=		M	double height	→	new background	m		¾	
1 1 1 0	14		cursor home	.		>		N		↑	hold graphics	n		÷	
1 1 1 1	15			/		?		O		#	release graphics	o		■	

Fig. 9. Complete set of Viewdata codes. columns 2a, 3a, 6a and 7a for graphics and columns 4a and 5a for the controls.

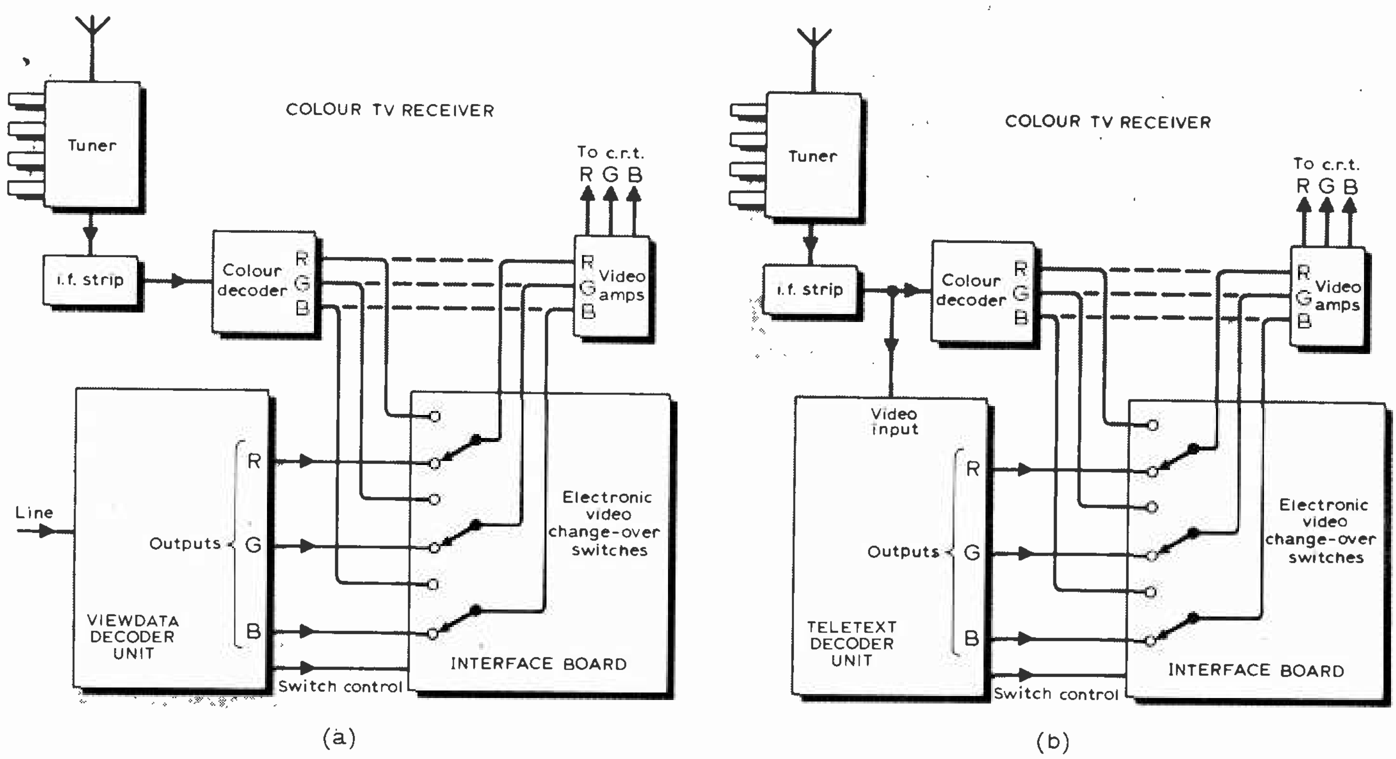


Fig. 10. Block diagrams of (a) a Viewdata terminal and (b) a teletext terminal, showing video connections to the television set.

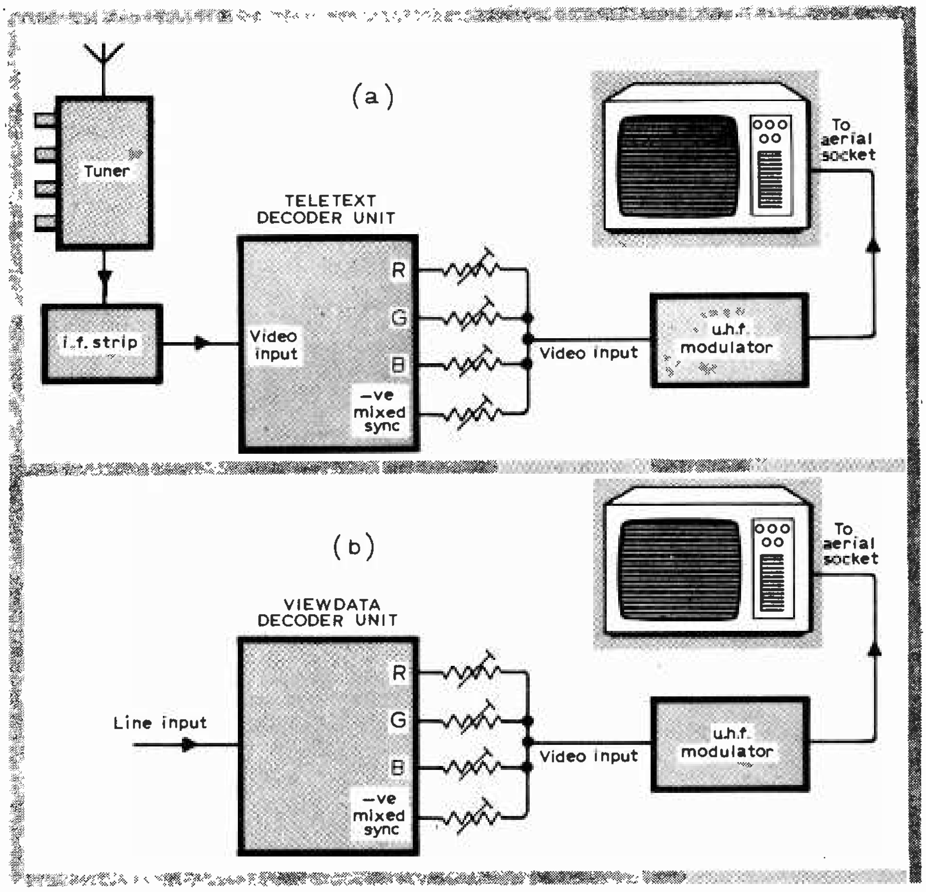


Fig. 11. Block diagrams of (a) a teletext terminal and (b) a Viewdata terminal, showing r.f. (u.h.f.) connections to the television set.

Basically it gives a visual indication of the position on the screen at which the next character sent by the computer will be displayed. When the computer sends a new page of information to the terminal, it first sends a code which returns the cursor, whether visible or not on the display, to the "home" position which is at the top left-hand side of the display. Thereafter, as each character is entered, the cursor is moved one character position to the right. The position of the cursor, whether this is switched on or off, is recorded by two counters, a character counter and a row counter, which maintain at all times a knowledge of the position at which the next character is to be displayed (and entered on memory). Thus we talk of the cursor as it it were a real entity, whether or not it is displayed.

By moving the cursor by means of the controls available (see below), the computer may position it to where the next character is to be entered. Thus it is not necessary to send a series of spaces where one or more blank lines are required, or where a row of characters is shorter than the full length of the line. The cursor also enables the computer to overwrite a portion of a display without having to first erase and retransmit the whole page.

The cursor may also be used at the terminal for editing purposes, e.g. when composing messages or doing calculations, or to point at a feature of the display it is desired to manipulate. In this context the cursor is a powerful communication channel between computer and user which resembles a pointer (but more about this later).

Control characters in columns 0 and 1 must comply with ISO7 for line transmission and so far 15 have been allocated. Additional characters in the same columns may be allocated in future as more facilities are included.

The control characters which have so far been allocated in the experimental system undergoing pilot trials are:

Col/row	Name	Function
0/1	NUL	None-used for timing purposes
0/5	ENQ	Code sent by computer to terminal to initiate automatic terminal identification
0/8	BS	Back-space. Moves cursor one character position to left
0/9	HT	Horizontal tab. Moves cursor one character position to right
0/10	LF	Line feed. Moves cursor one line position down
0/11	VT	Vertical tab. Moves cursor one line position up
0/12	FF	Form feed. Erases screen and moves cursor to top left hand side of screen (position 1)
0/13	CR	Carriage return. Moves cursor to first position on same line
1/1	DC1	Device control 1 } Combinations of these characters will be used to switch on tape recorders and hard copy devices remotely
1/2	DC2	Device control 2
13	DC3	Device control 3
1/4	DC4	Device control 4. Used to switch off both tape recorder and hard copy unit
1/8	CAN	Cancel. Used to delete line of character. This code is used only from terminal to computer
1/9	ESC	Escape. Used to indicate to terminal that the character following is from another set of control codes (in this case the control code set 2a to 7a of colours or graphics)
1/10	IS2	Home. Returns cursor to character position 1 on screen (top left hand side)

Graphics characters. The graphics and colour control characters for Viewdata are shown in Fig. 8 columns 2a, 3a, 6a, 7a for graphics and 4a and 5a for the controls. For line transmission the control characters of 4a and 5a are always preceded with ESC (code 1/11). On receipt of this code the terminal reverses the polarity of bit 7 from 1 to 0, thus restoring compatibility with teletext and places the characters in store.

The graphics characters in columns 2a, 3a, 6a and 7a are fully compatible with teletext and are treated in the same way when displayed. The complete set of Viewdata codes is shown in Fig. 9.

Block diagram of terminal. A block diagram of a Viewdata terminal is shown in Fig 10 (b). This shows the interconnection between the Viewdata decoder and the video amplifier of the colour tv receiver. An interface board contains the electronic switch which provides the changeover from tv reception to Viewdata. The input to the Viewdata decoder unit is, of course, the telephone line. By contrast Fig 10 (a) shows the teletext decoder connections (*Wireless World*, December 1975, pp. 563–566). The input to the teletext decoder is obtained from the i.f. input.

Fig 11 shows a similar set of connections where the entry to the television set for display purposes is the aerial socket of the tv receiver. In Viewdata only (b) a u.h.f. modulator has to be added, whereas for teletext (a) an additional tuner and i.f. strip must be provided. Hence the considerably greater attraction of a built-in decoder in the case of teletext.

(To be continued)

The journal you like

Wireless World's average circulation last year was up 4,604 copies to 69,220 per month, according to the Audit Bureau of Circulations. Overseas readers, in countries from the USSR and USA to the Falklands and Seychelles, bought 21,000 of these. On average, for the past eight years 200 more readers have joined our circulation each month.

World of Amateur Radio

Space and propagation

Martin Sweeting, G3YJO, of the University of Surrey's Oscar telecommand station reports that early this year one of the NiCad cells in the upper half of the Oscar 6 spacecraft (launched in 1972) "took a turn for the worse" and may fail completely; if this happens it is likely that the battery will be irretrievably damaged. He appeals for strict adherence by all amateurs to the operating schedules if Oscar 6 is to survive the year. Additional telemetry information received from the satellite would be welcome and should be sent to: UOS-AMSAT, Department of Electronic Engineering, University of Surrey, Guildford, Surrey. Incidentally, the UK FM Group (London) state that many amateurs in the Thames Valley area have been puzzled by the 144.8MHz wideband transmissions from the UOS-AMSAT telecommand station, G4DVT, at Guildford. This station operates daily for up to 25 minutes at a time, repeating every 100 minutes between 0530 and 2300 GMT.

GB3LBH, the 10GHz beacon station at Romford, Essex recently increased power and now uses a 200mW Gunn oscillator on 10.1GHz; it is regularly received at distances up to 25km including some obstructed paths; this beacon may be used for studies being carried out by students at Imperial College. A 144MHz beacon (possibly 9H3ML) may be set up in Malta. The 1.3GHz beacon at Andover (GB3AND) with a power of 5 watts e.r.p. has been heard in Devon.

28MHz c.w. and s.s.b. activity periods are now being run by the RSGB on the first Sunday of each month (1200-1800 GMT, 28.0 to 28.1 and 28.5 to 28.6MHz). A new 28MHz beacon is expected to be set up at Lannion in Brittany, France, with the callsign F3THF on 28.227MHz; it also hoped that 50MHz beacons may be established at Lannion and also at Gibraltar as part of a new series of 50MHz transatlantic tests.

It is now thought likely that the minimum of Sunspot Cycle 20 was reached during July 1976 with a maximum for Cycle 21 predicted around 1981.

Licence totals

The Radio Regulatory Department of the Home Office are currently distributing (as renewals fall due) the new form of amateur licence (see February issue). Two reasons are given for the changes: "(1) To give you greater flexibility to pursue each aspect of amateur radio without having to apply to us each time for authority to do so; (2) we, in turn, expect to be able to keep within the Government's staff ceiling over the next few years while maintaining the issue of amateur licences without undue delays."

On January 1, 1977 the number of new-style Class A and B licences were: Class A 15,956; Class B 6202; total 22,158.

How the number of old-style licences built up to over 29,000 during the past few years is shown below:

	end-1968	end-1971	end-1974	end-1976
Class A	13.082	14.082	15.304	15 956
Class B	1 352	3 012	4 966	6.142
Class A/M	2.589	2.666	3 424	4 173
Class B/M	132	545	1 549	2.463
Class F/M	–	--	--	23
Television	186	214	277	318
Totals	17.341	20.502	25.520	29.075

Amateur TV News

Mr R. C. Hills, G3HRH, Chief Engineer (Transmitters) of the IBA, is the new President of the British Amateur Television Club. He succeeds Mr R. S. Roberts, G6NR, who recently completed his four-year term of office. BATC has recently published a new 110-page book "A guide to amateur television" (non-members £1.75 post paid from BATC, 64 Showell Lane, Penn, Wolverhampton, Staffordshire).

P. Blakeborough, G3PYB, is constructing a vision transmitter for 1296MHz in addition to his 100-watt 625-line transmissions in the 432MHz band. Alan Morris, G4ENS, of Luton is trying to raise interest in proposals for an amateur tv beacon on 432MHz and later a 1296MHz repeater capable of handling tv signals.

U.H.F. aerial gain

Des Clift, VK2AHC (formerly G3BAK) who has operated on every available band from 1.8MHz to 10GHz has commented in *Electronics Australia* on the problems of reproducing aerial designs from constructional articles, noting that the element dimensions given by different constructors for the same bands often show surprising differences. For 1296MHz he has attempted with only moderate success to build 8-over-8 skeleton slot array; 34-element long Yagi; four square helix; conical reflector with dipole feed, etc. Arrays for 5.8 and 10GHz which can more readily be based on dishes have proved more successful.

The problem of obtaining gains (reference dipole) of above about 14dB on 432MHz is underlined in the results of the 10th national antenna-gain measuring contest held in the United States last year. The leading designs were: eight times 16-element Yagi (K2CBA) 16.1dB; four times 13-element wooden-boom Yagi (K2UYH) 16dB; G3JBL-type 28-element long quad-loop Yagi (K1LOG) 15dB; 15-element W0EYE-type Yagi (K1LOG) 11.8dB. On 1296MHz a 7ft dish aerial (WA2FGK) registered a gain of 24.3dB; a G3JBL-type 28-element long quad-loop Yagi (K2UYH) 17.1dB.

Such events indicate that many amateurs have an inflated idea of the forward gain of their aerials, possibly due to high front/back ratios.

In Brief

The death has occurred of Austin Forsyth, OBE, G6FO, for many years editor of *Short Wave Magazine*. Before the war he operated from Newport, Monmouth and for a time from North Devon; more recently from Maids Morton, Buckinghamshire. . . . A working party is being set up by the RSGB "to study the whole Society in depth with a particular relation to the organisation of the Society's headquarters, the organisation of Council and its committees and the inter-relation between HQ, Council and Committees". . . . Seychelles now use the prefix S7, and the prefix S8 has been allotted to Transkei. . . . A mountain top in the Antarctic has been named "Cima Radioamatori" by a recent Italian expedition that kept in daily touch with northern Italy with the help of a number of Italian amateurs . . . Endorsements for five-band operation are now made by the RSGB for the British Commonwealth Radio Transmission Award, the British Commonwealth Radio Reception Award and the DX Listeners' Century Award. . . . The ARRL National Convention for 1977 is being held (June 3-5) in Canada at the Sheraton Centre Hotel, Toronto: special get-togethers are planned for visiting British and "ex-G" amateurs. . . . Attention was drawn last September to the attractions offered by crystal ladder filters for the home construction of s.s.b. filters. Now, after extensive investigation of this type of filter, J. A. Hardcastle, G3JIR, has reported: "If a single outstanding factor were to be chosen from all the measurements which have been made, it would be that it is almost impossible not to produce a filter of some sort, if guidelines are followed. This should be sufficient to encourage even the most hesitant to try to construct their own crystal filters."

PAT HAWKER, G3VA

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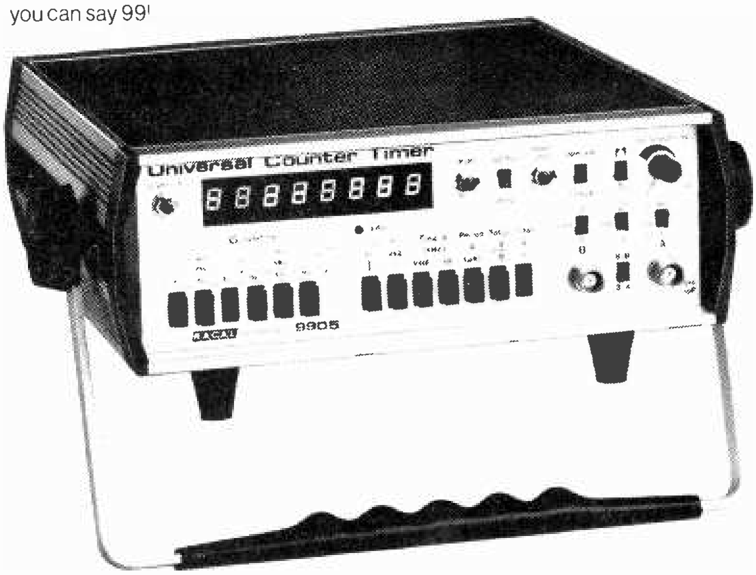


WW — 093 FOR FURTHER DETAILS

Electronic rhythm unit

Interfacing the M252 and M253 circuits, described in the March issue

by A. Battaiotto and G. Ronzi, *SGS-Ates Application Laboratory, Agrate, Italy*

So that the rhythm section may be inserted into an electronic organ, a signal must be available which indicates whether one or more keys on the organ key board have been played. This signal, which we call the key played, starts the rhythm section. When a key is played the rhythm section can be arranged to start at the beginning of the bar (touch or key operation), i.e. the playing of a key ,removes the reset from the clock and from the M 252 or M 253.

Alternatively it can be arranged to start at any point in the bar (continuous or silent operation) i.e. the rhythm generator runs continuously, but its output is enabled by the "key played" signal. In continuous operation, therefore, the down-beat indicator is indispensable as it allows the first key to be played when the bar begins.

A third method (continuous free running) allows the unit to operate without playing any of the keys. This is done simply by selecting a rhythm on the push button array of the rhythm section. Neither the touch key nor the continous silent key must be on when this method is used.

Fig. 11 illustrates the insertion of the electronic rhythm section into an organ. The two parts within dashed lines are details of the rhythm section, of interest for the connections to the keyboard of the organ.

Rhythm section with 15 rhythms and 9 instruments

This rhythm section, realized with the M 252AA, is programmed with 15 different rhythms in such a way that each rhythm can use up to a maximum of eight of the nine instruments available, Fig. 12. The 15 rhythms programmed are the waltz, jazz, waltz, tango, march, swing, foxtrot, slow rock, pop rock, shuffle, mambo, beguine, cha cha, bajon, samba and bossa nova, and can be brought in one at a time by means of the key board. The instruments available are the bassdrum, snare drum, claves, high bongo, low bongo, conga drum, long cymbals, short cymbals and maracas.

The three controls are volume, tone and tempo. In addition, a switch allows the rhythm to be started at the beginning of the bar or stops the rhythm. The assembly is carried out on two printed circuits, one contains the sound generators and preamplifier, and the other contains the supply, the M 252AA, the variable clock generator and the monostable circuit for driving the down-beat lamp.

The circuit can be divided into four parts, the sound generators, the variable clock generator, the down-beat monostable and the encoder. Operation of the M 252AA has already been described in the first part, but some further details will be given toward the end of this description.

Sound generators

The generators are designed to reproduce as faithfully as possible the sounds made by percussion instruments. They can be divided into two broad groups, namely, sounds consisting of damped, sinusoidal waves, like drums, and those consisting of damped white noise, like cymbals.

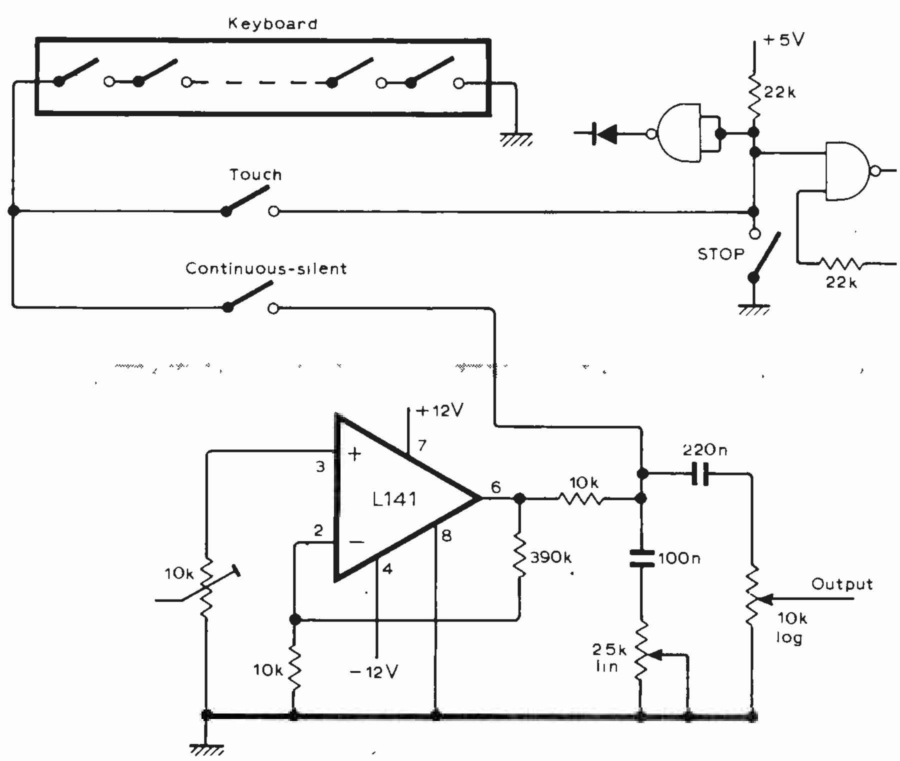
In the first category we can include the bass drum, high bongo, low bongo, conga drum and the claves, for which the basic circuit is shown around the twin-T parts of Fig. 13.

This circuit is a simple twin-T oscillator with active c.m.o.s.* element kept slightly below the point of oscillation by the pre-set resistor. To obtain the effect of different frequency instruments you only have to select the right values for the capacitors. The potentiometer also regulates the length of the damping, so that longer or shorter sounds can be obtained.

The command from the M252AA is applied at points BD, HB, etc. As the M252 produces a square wave, the RC

* A discrete-component oscillator circuit is available on request.

Fig. 11. Connections for incorporating into electronic organ. Rhythm unit parts are within shaded enclosures.



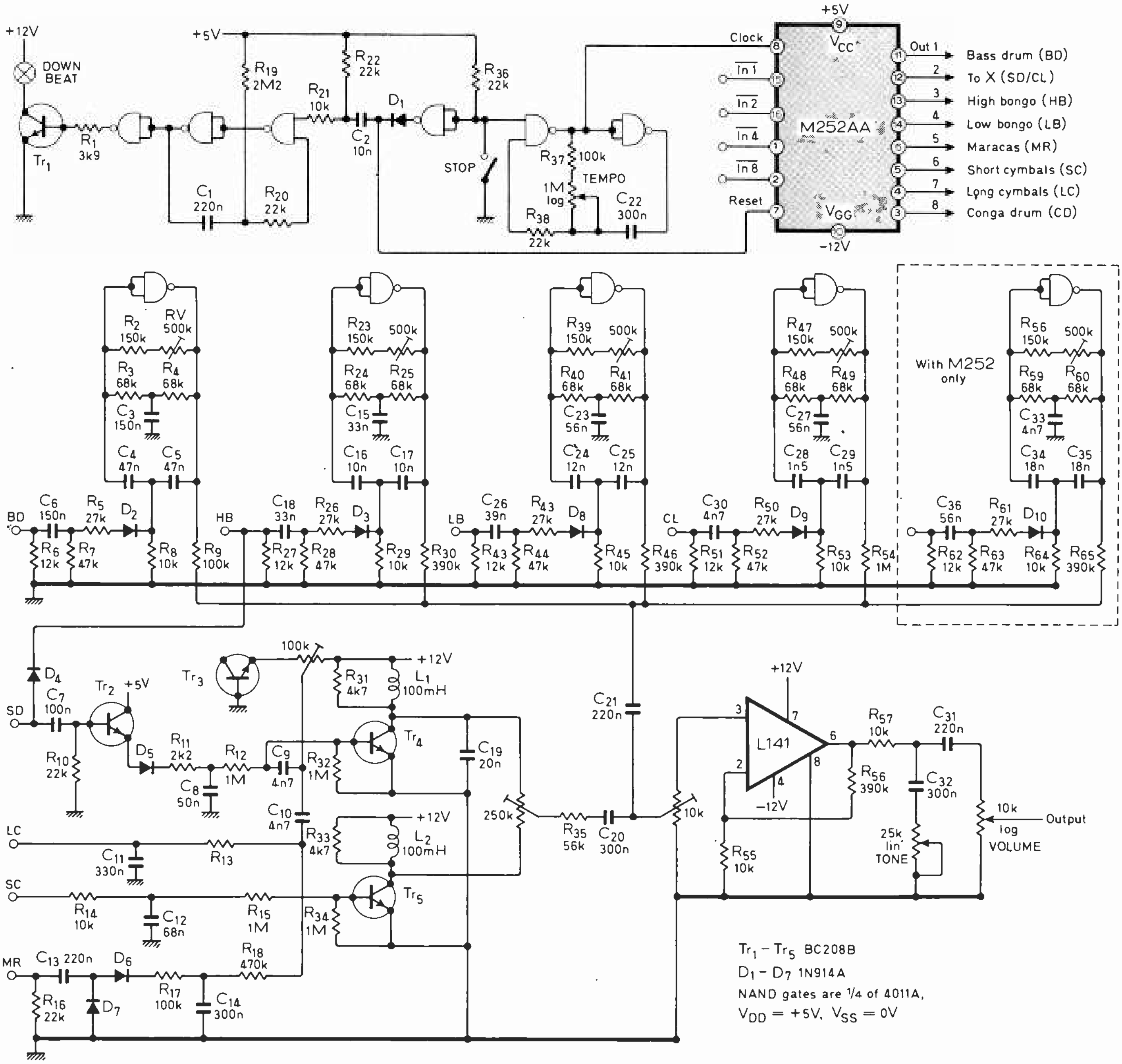
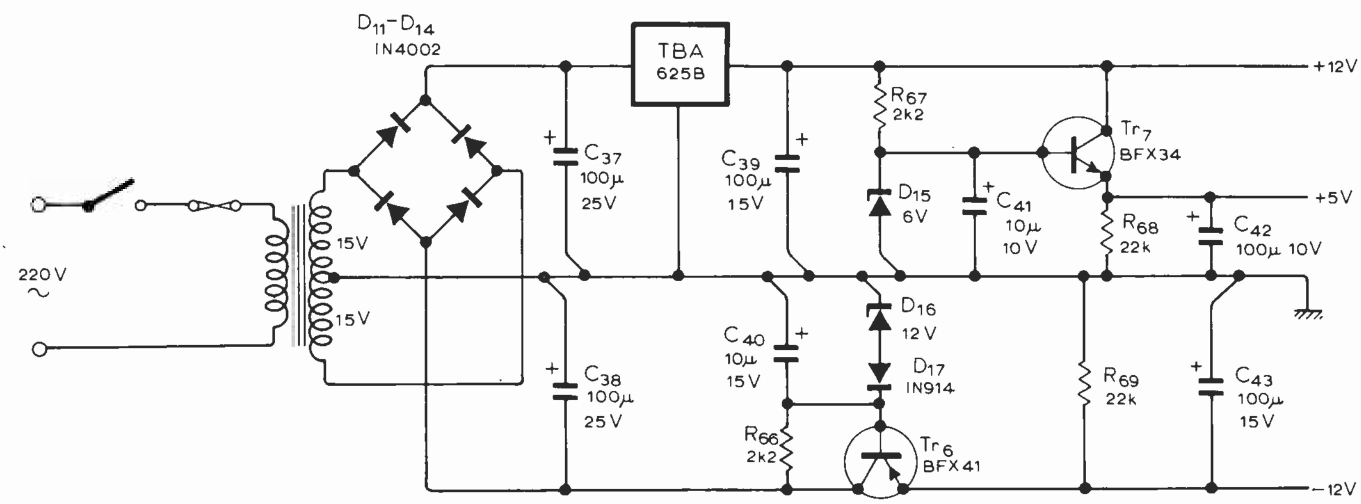


Fig. 12. Use encoder circuit of Fig. 13 with this M252 15-rhythm unit. (Rhythm selection details for M253 circuit will appear in part 3.) Circuit includes twin-T oscillators.

Below is show a conventional three-rail power supply circuit for rhythm generator.



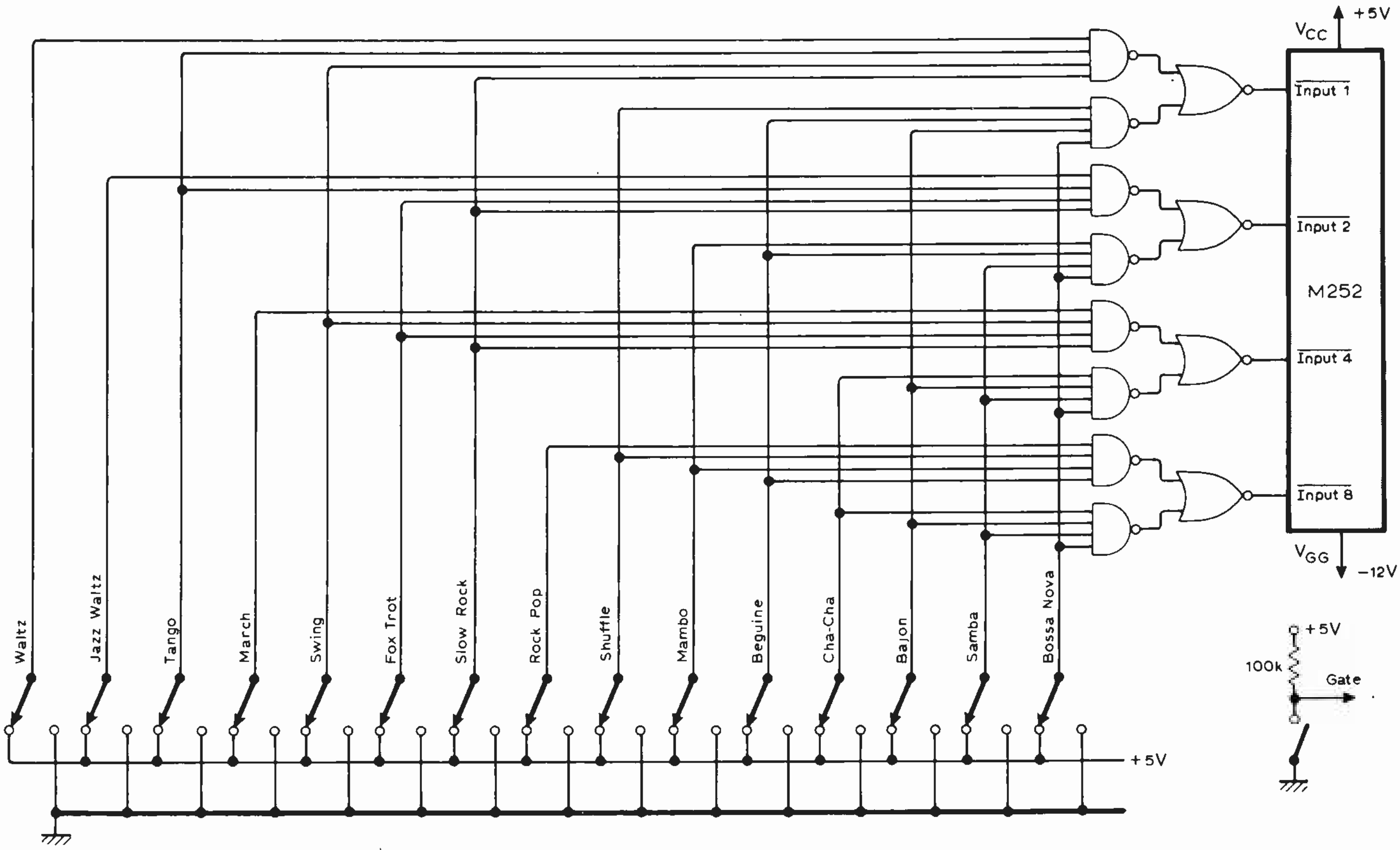


Fig. 13. In c.m.o.s. encoder for use with M252 rhythm unit single-pole switches can be used with resistors if desired. (See part 3 for M253 rhythm selection.)

differentiator (e.g. C_6, R_7) must be introduced so that a fairly short pulse arrives at the oscillator, which should not interfere with the damping of the oscillation but should be sufficient to activate the oscillator itself. Resistors R_{27}, etc, keeps the input at earth in the absence of a command, otherwise it would remain floating since the outputs of the M252AA are open-drain types.

In the second category are the long cymbals, short cymbals and maracas, for which the basic circuit is shown bottom left in Fig. 13. Transistor Tr_2 charges the capacitor C_8 during the short command pulse. This capacitor then discharges through R_{12} and the base of Tr_4.

The white noise produced by the zener effect of the base-emitter junction of a transistor is applied at the base of Tr_4. during the discharge of C_8, therefore, transistor Tr_4 can amplify this noise. The level of amplification, however, will follow the discharge curve of C_8 and therefore a damping effect of variable length will be obtained according to the values of C_8 and R_{12}.

The inductor and the capacitor at the collector of Tr_4 allow partially selective amplification to be obtained so that some harmonics can be boosted and an effect more similar to the instrument being simulated can be obtained.

Almost all the instruments used in this ryhthm section start immediately with maximum amplitude and decrease exponentially. The only exception is the maracas simulator,whose signal increases progressively and then decreases like the others. This effect was achieved by means of the integrator-differentiator circuit which allows controlled amplification of the white noise. The snare drum is obtained by adding a signal of the second type, i.e. a metellic sound, to a drum sound. Each sound starts on the positive edge of the control pulse.

Variable clock generator*

The clock generator is realized with two c.m.o.s. gates and the tempo regulated by means of a potentiometer. When closed, the switch sets the generator in such a way that the output remains at 1 and at the same time the M252AA is reset. By opening this switch the bar begins i.e. the output immediately goes to 0 so generating the negative edge necessary to cause the first command pulse or pulses to be produced by the M252AA, according to the rhythm selected.

Down-beat*

This too is made with two c.m.o.s. gates. The down-beat pulse supplied by the M252AA is too short to light a lamp. Also it occurs at the end of the bar whereas the lamp should be lit at the beginning. This monostable, Fig. 12 top, which starts on the negative edge i.e. at the beginning of the bar, operates with an auxiliary transistor in such a way that the lamp lights for a sufficient period of time to indicate the beginning of each bar.

* Alternative clock generator and downbeat circuits have been designed using t.t.l., h.l.l. and discrete components. Copies are available from editorial office.

Encoder†

Circuit, Fig. 13, uses HBF4012A four-input NAND gates, and HBF 4001A two-input NOR gates. If simple single-pole switches are to be used rather than an array of two-way switches, 15 resistors of 100kΩ must be inserted as indicated.

Rhythm section with 12 rhythms and 8 instruments

An alternative rhythm section was realized with the M253AA in which 12 different rhythms are programmed, each rhythm being able to drive simultaneously a maximum of seven out of the eight instruments available.

The 12 rhythms programmed are the tango, waltz, shuffle, march, slow rock, swing, pop rock, rumba, beguine, cha cha, samba and bossa nova. These rhythms can also be combined; two more can be selected simultaneously.

The instruments are the same as for the preceding unit with the exception of the conga. The adjustments too are equivalent, and the assembly is simply carried out on two printed circuit boards (£6 inclusive from M. R. Sagin, 23 Keyes Road, London NW2).

The sound generators, variable clock generator and monostable for the down-beat, are the same as for the M252 rhythm section.

The keyboard has the function of connecting the snare drum or the claves to the third output of the M253AA, according to the rhythm selected.

† Alternative encoder circuits are possible using mechanical switching, a diode matrix or t.t.l. gates Copies of circuits may be obtained from the editorial office.

To be concluded

Letters to the Editor

THE WARDEN REPORT

Having read your leading article "WARC talk" (December 1976) and the follow-up article "Who is warden over the Wardens" (January issue), we feel it might be informative to your readers to learn of the mobile radio industry's reaction to these two articles.

We should confirm that the EEA were given an opportunity to examine carefully the Warden report, an industry working party was set up and its view of the report was placed before the Home Office Mobile Radio Committee.

The industry was critical of many sections of the report but all companies supported, *inter alia*, that part of the Warden report which called for additional spectrum for land mobile services.

It should be emphasised that this report was probably the first of its kind with anything like its depth, and was a major contribution to the understanding of the many factors which affect the use of the spectrum by all mobile radio users.

Subsequently, one of our member companies has produced a report (the Pannell report) which presents a view supported in large measure by the industry and demonstrates that something like 100MHz, is required between now and 1999. [See leader in February issue — Editor.]

It is quite understandable for a regulating department to take a rather conservative attitude but, as they are aware of the views of the users and the industry, we have confidence that the Home Office strategy at WARC will result in these views carrying considerable weight.

In conclusion, we ought to point out that your "Warden" article is misleading in three matters. Mr Warden has not, as far as we are aware, (a) completed a report on broadcasting; (b) reached the conclusion that there was "no further need for any allocation to mobile radio above what it had already got"; (c) said that "any further channels which did become available should go to the Post Office" – indeed, we understand that the Post Office were asked to go to 12.5kHz channel spacing and to prove further need for more spectrum.

We trust this will be helpful in explaining the EEA view on this very important matter.

J. W. Carlton,
Chairman, Mobile Radio Committee,
Electronic Engineering Association,
London WC2.

CURRENT DUMPING AMPLIFIER

The recent controversy on the current dumping amplifier (December 1975 issue and subsequent letters) has not come up with any consensus as to whether it is just an elegant method of applying feedback or whether there is an element of feedforward in it. It can be shown quite easily that with an amplifier of finite open loop gain (and consequently finite feedback), the current dump trick achieves much more than feedback alone possibly could. An expression is derived below for the current dump configuration given by Mr Walker and Mr Albinson in *Wireless World* (Dec. 1975), but the amplifier considered has a finite open loop gain and a finite input impedance. With these constraints, and assuming an arbitrary non-linear transfer function for the current dump block, an expression can be derived wherein it can be shown that the error in the current through Z_4 is exactly compensated for by the current through Z_1 provided the conditions given in equation 4 are satisfied.

$$V_{01} = A(V_{in} - V_1) \quad (1)$$

$$V_1 = (Z_f \| Z_3 \| Z_{in})\left(\frac{V_{01}}{Z_3} + \frac{V_{in}}{Z_{in}} + \frac{N(V_{01})}{Z_2}\right) \quad (2)$$

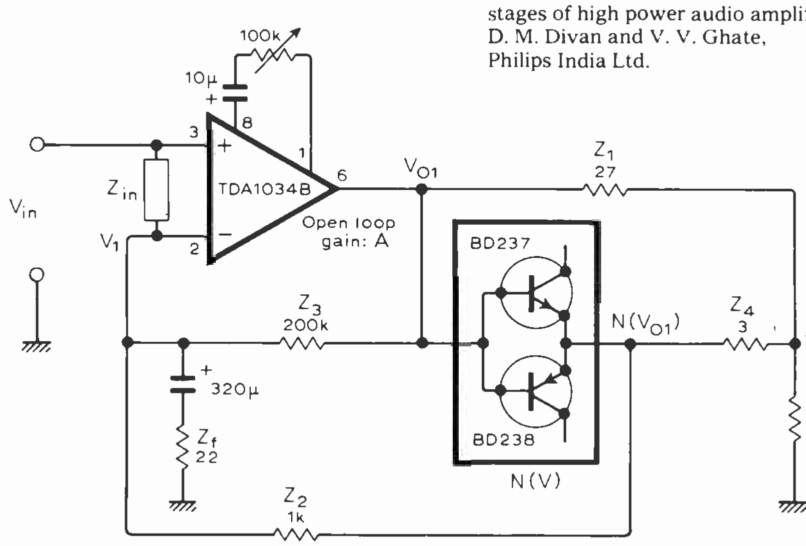


Fig. 1

$$V_L = (Z_L \| Z_1 \| Z_4)\left(\frac{V_{01}}{Z_1} + \frac{N(V_{01})}{Z_4}\right) \quad (3)$$

Simplification yields the combination required to make V_L independent of $N(V_{01})$

$$\text{i.e. } \frac{Z_1 Z_2}{Z_3 Z_4} = \frac{1}{1 + \dfrac{1}{A}\,\dfrac{Z_3}{Z_{in} \| Z_2 \| Z_3 \| Z_f}} \quad (4)$$

For an infinite gain op-amp, equation 4 reduces to Walker's original form. To confirm this result an amplifier was made with a variable open loop gain (A). This variation in open loop gain was obtained in an elegant manner by connecting a potentiometer across the compensating terminals of the operational amplifier used. The circuit was designed to have minimum distortion for an open loop gain of approximately 52dB, corresponding to 20dB of feedback. Fig. 2 shows the results which confirm that increasing feedback beyond a particular value makes the distortion figure worse. In fact with all the current dump elements removed and the same amount of feedback (20dB), the distortion measured 3.1% against the null reading of 0.4%. This should remove any doubt about the effectiveness of the method, and Mr Walker and Mr Albinson of the Acoustical Manufacturing Company should be congratulated on innovating a most elegant method for removing distortion and for eliminating thermal problems associated with the output stages of high power audio amplifiers.

D. M. Divan and V. V. Ghate,
Philips India Ltd.

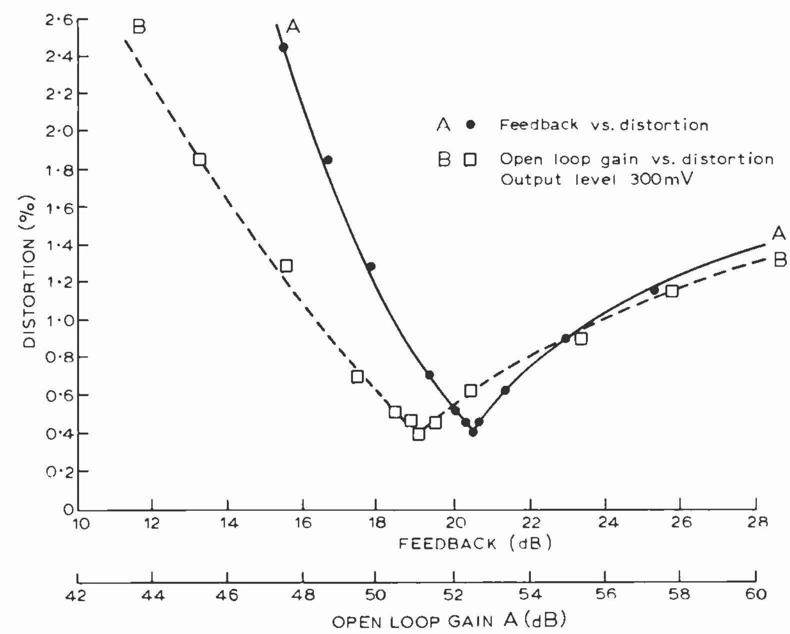


Fig. 2

ADVANCED PREAMPLIFIER DESIGN

The letter from Mr Watts in your February issue and the answer from Mr Self is notable for two factors — the abrasive language of the former's criticism and the surprisingly temperate reply from the latter. Frankly, I, too, could find much to fault in the design but, of course, there are ways of expressing it, aren't there?

My main criticism of Mr Self's design is that it is over-engineered, conceived by a hi-fi enthusiast who apparently has not been too involved in the costing process when putting together the elements of a circuit. The principle of Occam's Razor is also the essence of good design technique. He has also overlooked the simple facts of life — that despite the extremes to which one may go in designing equipment of this type, the aberrations that are inherent in all programme sources available to the domestic user are likely to be far greater than those introduced by even the most modestly designed reproducing equipment.

But Mr Watts is guilty of worse errors, in dealing with pure theory, opinion, and dressing it up as fact. Let me take one example — and since he seems to invite challenges, here's another from me. If he is able to produce for me a *high grade pickup cartridge* capable of the sort of amplitude linearity input when correctly loaded that he insists should be observed in the equalised input stage and will deliver consistently peaks in excess of 200mV, then there is £5 ready in my hand for any charity he cares to name.

Reg Williamson,
Norwich.

AURAL SENSITIVITY TO PHASE

As comment on the two letters in the February issue may I summarise some comment that I have made many times on the subject of the effects of phase shift in a monaural channel?

If a wideband speech or music signal is fed into a transmission system the system design must ensure that the low frequency components and the high frequency components arrive at the output end at about the same time. Clearly there will be some loss in sound quality if the low frequency components arrive today and the high frequency components arrive tomorrow. Thus there must be a limit to the differences in the transmission time that can be allowed. The CCIR standards define the permissible differential time delays for high quality systems, typically the 5kHz components may be delayed by around 5 milliseconds with respect to the 1kHz reference signal before a quality change is noticeable.

If we (mistakenly) choose to express this permissible time delay as a phase shift, it is some 9000 degrees, that is, the start of the 5kHz component can be delayed by about *twenty five cycles* before the shift is aurally noticeable. The wave shape at the system output then bears no relation to the waveshape at the system input.

If anybody has any evidence that time delays inside the CCIR values can result in obvious differences in sound quality then the data should be produced as a contribution to the art. Our own work appears to show that if a skilled listener has the opportunity to listen repeatedly to a signal while the time delay is switched in and out of circuit, he will eventually come to detect a shift of about 3 milliseconds (rather than 5 milliseconds quoted above) but these observations only serve to confirm that the delay limit specified by CCIR is a reasonable choice for the ordinary situation where repeated comparison is not possible.

James Moir,
James Moir & Associates,
Chipperfield,
Herts.

DISTORTION AND THE EAR

After reading D. Self's article, "Advanced preamplifier design" in your November issue, I feel obliged to comment on the general attitude to audio amplifier design taken by the majority of *WW* contributors. At the core of this approach is the assumption that any loss of realism, originating from amplification within the reproducing train, is a direct function of t.h.d. Consequently with each new design appears detailed analysis of t.h.d. performance but, from the user's point of view, the lack of any comparative listening test is painfully obvious.

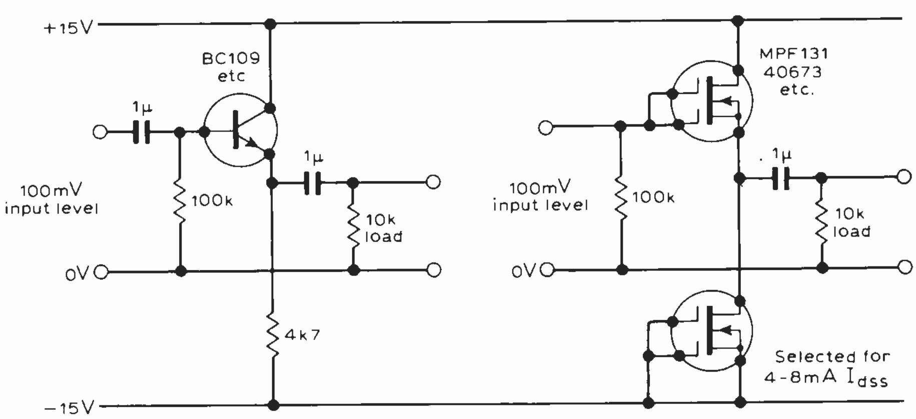
A striking example of the ear's dissimilarity to a t.h.d. meter would be the attempted measurement of distortion from an audibly inferior preamplifier of a sinewave signal recorded on disc. Wow and tracing distortion combine to swamp the amplifier's contribution by orders of magnitude, but the amplifier's imperfections are all too obvious through the reproduction of voice or music from the same source.

If an accurate model of the human audio processing path existed, it would be possible to design with confidence circuits that introduced the theoretical minimum of audible colouration. Unfortunately, this model does not exist and any major advancement in amplifier quality can only be achieved through extensive, practical listening comparisons of all types of active devices and circuit configurations.

After experimenting for several years in this direction and through the careful analysis of designs proved to be audibly superior, the one common factor to emerge is an appreciation of the ear's uncanny ability to detect high order distortion products under heavy masking by low order products and noise. In essence, the ear will react favourably to 1st order distortion products in the order of one per cent, provided all higher order products are virtually non existent. Although it has been long accepted that the ear does favour colouration derived from low order products, the relative weighting ratio (for a given degree of colouration) has never been established and I believe has been consistently under-estimated.

If one applies this theory to high quality amplifiers, the design rules are radically altered. Bipolar transistors become virtually useless in low level stages because of the complex exponential transfer characteristic. Negative feedback (even locally applied) tends to be a disadvantage because innocuous low order distortion products are converted to lower level, but audibly more apparent, higher order ones (Ref. Scroggie) and the output impedance of devices becomes a significant source of distortion. Space allows no further elaboration but a simple example of this alternative approach is given in the form of a unity gain buffer stage. Anyone interested in conducting a comparative listening test (on a high quality stereo system) between this circuit and the standard emitter-follower may find the lack of correlation between measured t.h.d. and audible colouration interesting.

A. King,
Glenroy,
Victoria, Australia.



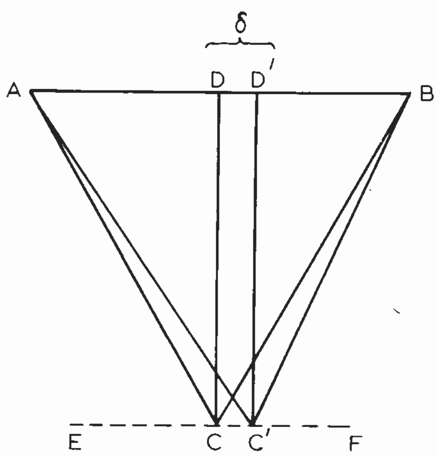
STANDARD BUFFER

ALTERNATIVE BUFFER

LINEAR PHASE LOUDSPEAKERS

As Mr Gorman pointed out in his letter in the February 1977 issue, the arguments arising from the advocacy of linear phase loudspeakers have generated much interest, heat and correspondence. May I be allowed to add to the last by enquiring of your other correspondents what importance should be attached to the position of the listener who has set up his linear phase loudspeakers in the normal stereophonic configuration?

In the diagram (overleaf) I shall assume that two linear phase loudspeakers (which I assume may be regarded as point or at most line sources) have been situated at points A and B of an equilateral triangle ABC of side, say, 2 metres. The listener being conscientous (and also being a point receiver) situates himself at C. Unfortunately before he can begin to appreciate the benefits of a linear



phase configuration, a malevolent deity displaces him a small distance δ metres along the line EF to C' Trivial geometry shows that in these circumstances there is a difference in path lengths AC'− BC' equal to

$$\sqrt{3+(1+\delta)^2} - \sqrt{3+(1-\delta)^2} \approx \delta \text{ metres.}$$

Thus, assuming a speed of sound of, say, 330m/s, a displacement of 10cm will produce approximate cancellation of a steady signal of wavelength 20cm, i.e. a frequency of 1.65kHz, and will do funny things to the phase of signals near that frequency.

Of course the listener should not have allowed himself to be displaced from point C, but the malevolent deity who is also cunning provided him with two ears placed about 20cm apart. Thus the poor listener (who, being conscientious has avoided the trap of inducing phase distortion by, say, waggling his head from side to side) is left in the position that the only way he can effectively enjoy the linear phase of the stereophonic set-up is to block-up one of his ears and locate the other at C.

N. G. Shipley,
London, EC4.

AMPLIFIER DESIGN

There is clearly an interesting disputation in the making regarding pre-amplifiers between Messrs Watts and Self (February letters). I particularly note that both seek upwards of 40dB overload margin. Why? There is no point in it unless the main amplifier and the loudspeakers could also handle 40dB overload. But in a real world what would happen? If such a sound level could be produced it is more than likely to permanently damage the ears, a fearful consequence of some such little *faux pas* as dropping the pickup.

Reality calls for a limitation of peak power and that limitation is best achieved by a means which minimises the resulting and inevitable distortion. More by accident than design valve amplifiers working in Class A had that useful property.

Mr Sundqvist (February issue) is now spelling out for us the details of i.m. distortion and it is becoming more generally apparent that transistor design needs far greater thought and attention to detail if i.m. and other distortion is to be kept at innocuous levels. In particular he is making us aware of the danger of feedback over several stages of undefined bandwidth in that a transitory condition will arise of a maximum signal at some point where feed back has failed, for an instant, to reduce the signal to its normal working level. Several cures were suggested including a generous overload margin.

May the current vogue and justifications for large overload margins arise from a possible subconscious reaction to hearing i.m. distortion which is then irrationally justified in terms of some supposed large transient output from the pickup? How in a practical world would this transient find its way on to the record, and if it could be present will not the normal mechanical constraints ensure it is never produced? Why in fact does virtually all discussion of high fidelity reproduction assume no significant defects in the recording amplifiers etc? Were this really true there are, and have long been, practical designs for near perfect reproduction amplifiers.

Be that as it may; the recordist does not, indeed he dare not, shrink back from some means of volume compression even if it be no more than simple manual control. That is his tool for avoiding the overload situation and if he has done his job properly may I ask what distressing signal, capable of upsetting a pre-amp, can come off a record via a pickup?

The truth of the situation is more likely that pre-amps are generally badly designed and, transistors being deceiving little beasts, they react in ways that are not expected. Mr Self would not have it that the first part of his pre-amp was, as Mr Watts claimed, a phase shift oscillator, but I can safely say from recent practical experience that similar arrangements are quite capable of oscillating at h.f. or l.f. and showing h.f. oscillation on part of an l.f. cycle when fed with a normal sine wave. They have in fact mutual conductances far beyond those of valves, and these increase more or less directly with current flow and have no clear inbuilt limiting mechanism as has a valve, which limits in most circuits just as soon as the grid becomes positive. Without limiting, a transistor may well start an h.f. oscillation; the circuit comprising *inter alia* stray reactances, in which its own widely variable capacitances will figure. This of course may establish a form of blocking oscillator. If the crucial reactances are within the transistor chip the designer has a fearsome problem on his hands.

Here Mr Watts chooses a policy of avoidance by using an i.c. in the no doubt well founded belief that these have been the subject of such exhaustive designing processes, so that they may be marketed as being vice free, that he needs fear no unwanted side effects. Mr Self attacks on the grounds that i.cs have greater noise, which seems to be yet another airing of the irrational oversight of the way in which noise in later stages is lost in the amplified noise from earlier stages.

However, the most intriguing feature of Mr Self's design and defence concerns the 1 n 5 capacitor from base to emitter of the input transistor. Why not to earth, if as claimed, it is an r.f. bypass? May the truth be that by some chance it is solving some instability problem? Certainly by trying out a number of preamp designs I have learnt to realise RIAA stages are exceedingly prone to strange problems. But then a warning was issued by J. Linsley Hood in the September 1971 issue of *Wireless World* concerning two, let alone three, transistor high gain circuits. Perhaps we do not learn and continue to fall into the same traps.

C. Streatfield,
Poole,
Dorset.

NORTH SEA COMMUNICATIONS

I have read with interest your report in the December 1976 issue (p.44) of Mr L. Buttriss's talk to the World Offshore Oil Conference.

How easy it is to knock those who are pace setting and breaking new ground and who occasionally fall short of the standards which Mr Buttriss sets. Considering that Mr Buttriss's organisation is only following along behind others who are in the front line, as it were, I suppose he is in a very good position to develop hindsight, which as we all know is a splendid quality.

If Mr Buttriss was a little nearer the front line action he might recognise the difficulties with which the British Post Office have had to cope, not to mention systems designers like my organisation whose clients found themselves at the mercy of a takeover exercise near to Mr Buttriss.

It is always easy to generalise on the failings of others, unspecified of course, but not always the wisest policy if your livelihood depends to a large extent on the said others.

W. T. Brown,
Macclesfield,
Cheshire.

TALKING BOOKS APPEAL

A few years ago you were good enough to publish an appeal for servicing volunteers for the British Talking Book Service for the Blind. As a result many new volunteers were enrolled.

As the service has expanded so has the need for servicing volunteers and I would ask anyone who can repair a simple tape recorder, and can spare a little time, to contact the address given below for further details.

These Talking Books mean a lot to the blind people who use them and their gratitude for the help given be servicing volunteers amply compensates for the loss of a few hours spare time.

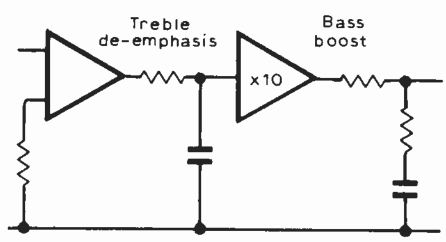
The address to contact is: British Talking Book Service for the Blind, Nuffield Library, Mount Pleasant, Wembley, Middx. HAA 1RR. Telephone: 01-903-6666

A. J. Smale,
London N21.

Corrections

The diagram below was inadvertently omitted from Mr Graham Nalty's letter in the February issue on the Advanced Pre-amplifier Design.

Also, the heading "Re-invention" was omitted from Mr K. H. Green's letter (top of page 60). Apologies to Mr Nalty, Mr Green and our readers.



Stereo coder

1—Choice of method/oscillator stability

by Trevor Brook

A practical design for a high quality coder suitable as a test instrument is described. Apart from the audio filtering, inductors have been avoided and a compact board layout produced. A v.h.f. unit for servicing checks on receiver performance could also be used by demonstration showrooms to feed programmes of their own choice to stereo tuners.

Part 1 examines the stereo multiplex system and establishes tolerance limits for signal components. Channel separation is considered as this would assume increased importance if a matrix system of surround sound broadcasting were adopted. Part 2 gives construction and alignment details for the coder and Part 3 gives modifications to the Portus and Haywood decoder to provide a low distortion reference decoder.

Work on this coder started originally out of curiosity as to whether an inductorless design would be possible. Early experiments were promising and the design has been pursued to give performance of broadcast quality.

The specifications of stereo coders now in use at both national and independent local radio transmitters are given in Table 1 and most existing coders have similar figures. Particular objects of this design are to improve crosstalk at the higher audio frequencies and achieve mid-frequency distortion better than 0.05%.

Stereo signal specification

The modulating signal in the Zenith-GE pilot tone system is defined as

$$0.9\left(\frac{A+B}{2}+\frac{A-B}{2}\sin 2\pi f_c t + 0.1\sin \pi f_c t\right),$$

where A is pre-emphasized left channel, B is the pre-emphasized right channel, and f_c is 38kHz. $\frac{1}{2}(A+B)$ is called the sum or M signal, and $\frac{1}{2}(A-B)\sin 2\pi f_c t$ is called the stereo difference or S signal, and is a double sideband suppressed-carrier signal. $0.1\sin\pi f_c t$ is the pilot signal at 19kHz.

Substituting the maximum values A = +1 and B = +1 or −1 gives the maximum amplitude of 90% for the M and S signals respectively. Monophonic receivers continue to produce only the M signal as audible output thus giving the system its compatibility.

Decoding

To retrieve the stereo information involves a decoder which can take the form in Fig. 1. The reduction in channel separation if a decoder adjusted to decode a perfect multiplex signal is presented with signals having the five following departures from ideal is shown in Fig 2:

– amplitude error between the M and S signals

–phase error between the M and S signals

–phase error in the pilot relative to the 38kHz suppressed carrier. The requirement for pilot phase accuracy is substantially less than for M/S phase accuracy

–amplitude error of one sideband only of the S signal, typical of the h.f. loss

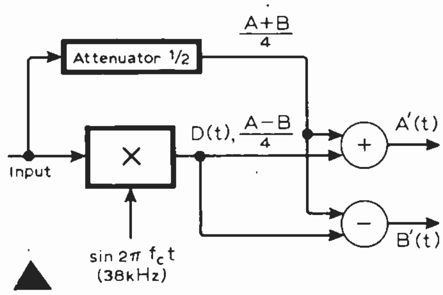


Fig. 1. How the stereo multiplex signal can be decoded. After de-emphasis the A′ and B′ outputs become left and right channels.

Fig. 2. Inherent crosstalk of the multiplex signal plotted against
1) Amplitude error between the M and S signals
2) Phase error between the M and S signals
3) Error in pilot phase
4) Amplitude imbalance between the sidebands of the S signal
5) Phase shift in a sideband of the S signal

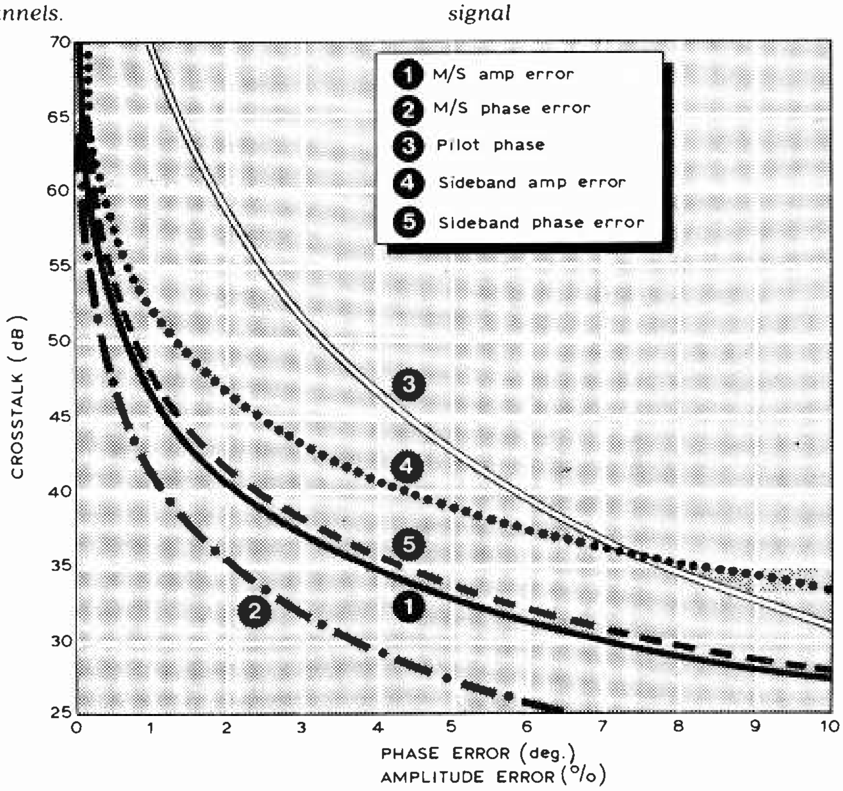


Table 1. Some parameters of the broadcast coders in use today.

	BBC	IBA
Amplitude response ±0.5dB	60Hz — 10kHz	50Hz — 15kHz
± 1dB	40Hz — 15kHz	—
Channel separation	100Hz — 10kHz ⩾40dB 10kHz – 15kHz⩾36dB	400Hz – 5kHz⩾48dB 30Hz – 15kHz⩾42dB
Harmonic distortion (1kHz)	0.3% at 2dB above peak level	0.5% at peak level
38kHz leakage	<40dB	⩽40dB

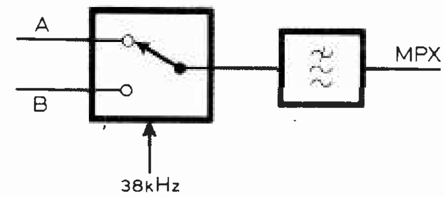


Fig. 4. Basic arrangement for the switch encoding method. Switch would typically be a ring of diodes or f.e.t. switch driven by the 38kHz square wave.

encountered in receivers
–phase error of one sideband only of the S signal.

For reasonably high channel separation, say better than 45dB, the above effects may be considered as algebraically additive. It is evident that extremely stringent amplitude and phase performance requirements are set for a coder intended to give high channel separation.

Another problem in the multiplex system is distortion. Apart from the usual harmonic and intermodulation distortions, spurious beat tones can be produced in the decoded outputs. This is the result of intermodulation between the various components of the stereo signal and, though predominantly a receiver problem, could also be caused in the signal generation method or in a coder's output amplifier. Beat tone distortion is worst at the higher audio frequencies and subjectively produces an unpleasant 'splashing' sound on sibiliants. Most stereo receivers will give clearly audible low- or mid-frequency beats on the 10 and 14kHz bursts during the BBC stereo test zone transmissions even though these tones are not at full level. On mono reception of a stereo signal the effect is not noticeable except on very poor receivers. Fig 3 shows the beat tone possibilities in both mono and stereo reception.

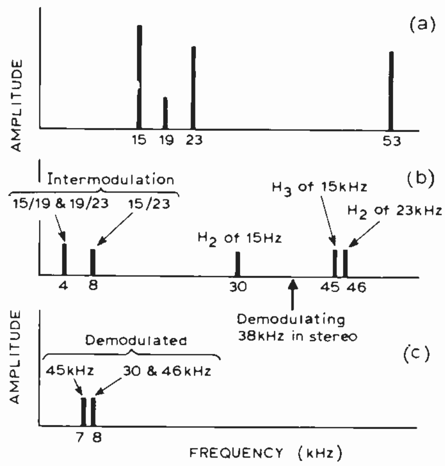


Fig. 3. Principal possibilities for production of beat tone distortion in any receiver (b) whenever a composite stereo signal (a) undergoes intermodulation distortion. Additional tones are produced in a stereo receiver (c).

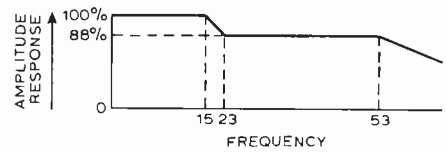


Fig. 5. Desired characteristic for the filter in the simple switch coder, Fig. 5. A linear phase response is required up to 53kHz.

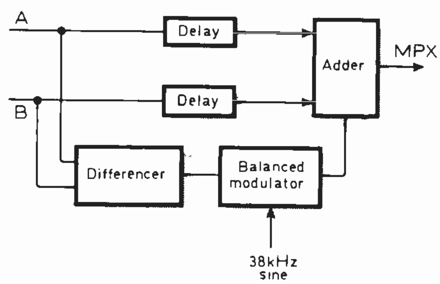


Fig. 6. Block diagram for the matrix coding method.

Generating multiplex signals

There are two principal ways of producing the coded stereo signal. The first and almost universal are switching methods, while the second is the matrix method where the individual signal components are generated separately and then added together.

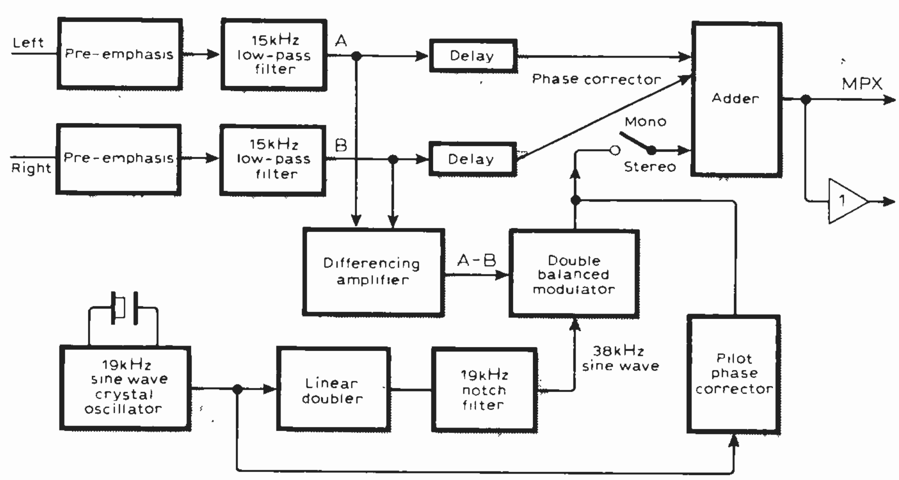
Conceptually the simplest and also a common way of switch encoding is to switch between the A and B signals with a diode ring or similar device driven by 38kHz, Fig 4. For a square wave switching signal the following output is produced

$$\frac{A+B}{2}+\frac{A-B}{2}\cdot\frac{4}{\pi}\Big|\sin 2\pi f_c t + \frac{1}{3}\sin 6\pi f_c t + \frac{1}{5}\sin 10\pi f_c t + \ldots\Big|$$

The snag is that sidebands around odd harmonics of the switching frequency are present in the output and, more difficult, the required difference signal has too high an amplitude. To remove the components above 53kHz as well as reduce the S amplitude by $\pi/4$ requires a filter with the amplitude characteristic shown in Fig 5, and a linear phase response at frequencies below 53kHz! Broadcast quality coders typically use ten or so inductors in such a filter. Other switching arrangements can avoid the necessity for S amplitude correction and in other respects switching coder performance is largely determined by switching time and 1:1 accuracy of the 38kHz square wave. Whatever low-pass filter is required practical realisations need careful alignment involving several interdependent adjustments and deficiences in the filter make such coders susceptible to all the forms of signal degradation listed earlier. A complete switching coder design has been published by Mack[1] and the virtues of diode cross modulator circuits for applications including coding stereo extolled by the same author[2].

The matrix form of coding is shown in Fig 6. A point to note is that the 38kHz fed to the multiplier in this case is a sine wave. Another alternative would be to use a conventional switching multiplier

Fig. 7. Complete block diagram of the coder described.



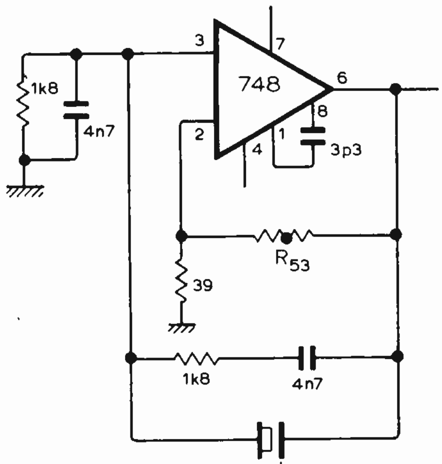


Fig. 8. Thermistor-controlled oscillator with the R53 bead running at 205°C, and a resistance of 82 ohms.

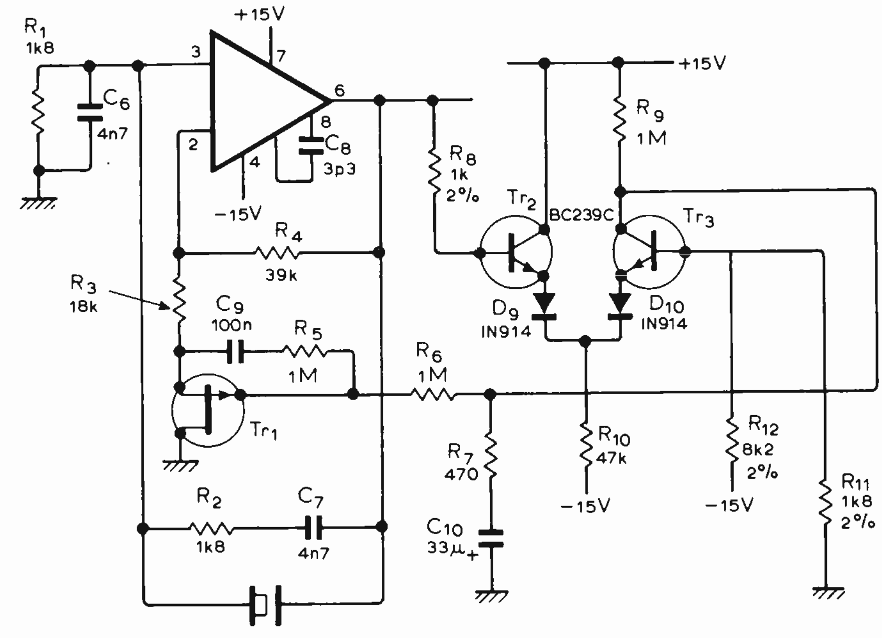


Fig. 9. Oscillator with improved amplitude/temperature drift. Tr_2 and Tr_3 form a long-tailed pair comparator and R_5, R_6 equalize the signal voltages across the f.e.t. to linearize it and reduce distortion of the sine wave output.

fed by a square wave, filter out the difference signal from the odd harmonic components, and then feed it to the adder. With the matrix arrangement in the diagram the last three degradations can be made negligible so crosstalk performance mainly rests on achieving good gain stability and phase matching between the sum and difference signal paths.

However, some new problems arise with this form of coder. The linearity of the multiplier to audio frequencies will have an effect on beat tone distortion performance and in a practical design there is the danger of impurities on the 38kHz producing further beat tone outputs. Common to all forms of coder is the need for a low distortion 19kHz pilot of correct phase and good stability, and audio pre-emphasis and filtering to limit the bandwidth of A and B signals to 15kHz.

Choice of matrix method

With an instinctive loathing of inductors and poor prospects at the time of realising a sensible active filter meeting the stringent phase and amplitude requirements while introducing negligible noise and distortion, the matrix approach looked more promising. Using the matrix principle only the first two signal degradations should be apparent and to meet a target channel separation of 55dB implies an M/S amplitude error of less than 0.18% and an M/S phase error better than 0.1°.

The block diagram of the coder is shown in Fig 7. Both 19 and 38kHz sine waves are required in this coder and starting with a 19kHz sine wave which is then doubled using a linear multiplier to square its input (a sine-wave squared equals a single wave of double frequency plus a d.c. term) and produce 38kHz of correct phase involves less filtering than starting with a square wave at a higher frequency (38, 76 or 152kHz) and dividing down.

If the coder is to be fed from any practical signal source other than a distortionless audio signal generator then the 15kHz filters are essential to prevent gross beat tone effects due to ultrasonic components on the audio inputs. It is desirable that rejection of frequencies of 19kHz and above be at least 45dB so this means that when pre-emphasis is in use, giving around 20dB boost at 19kHz, a filter attenuation of 65dB is required by 19kHz. If a passband ripple of only 1dB is allowed this implies the enormous attenuation rate of 200dB/octave between 15 and 19kHz.

Fortunately two cascaded Toko filter blocks can exceed the requirements in a very small space and at reasonable cost. The drawback of a filter with such violent attenuation so close to the passband is that there is little hope of achieving a linear phase characteristic and this is a deficiency common to all stereo coders. Part 2 includes a spectrum analyser photograph of the present filter response and a graph of measured phase shift.

The audio difference is derived and fed via the balanced modulator to the output adder while the sum signal is produced by feeding equal amounts of A and B directly to the output adder. The longer route of the difference signal means that it is slightly delayed at the adder compared to the A and B components and at the higher audio frequencies this would amount to a significant phase shift between the M and S components, hence the phase correctors inserted in the A and B lines to the adder.

Because the linear doubler used to produce 38kHz is not a perfect device some leakthrough of 19kHz may occur, particularly at extremes of the temperature range, so a 19kHz rejector is placed before the multiplier's carrier input. The pilot must also arrive at the output adder at the correct amplitude and phase and a small phase shift is required to equal the time delay through the doubler, amplifier, notch filter and balanced modulator. To provide balanced outputs a straightforward unity gain invertor is fed from the adder output.

Power supplies are entirely conventional, producing plus and minus 15 volts at around 100mA. Power take off points are provided for running the clipping amplifier and v.h.f. oscillator described later.

19kHz oscillator

The accepted frequency tolerance for the pilot tone is ±2Hz so crystal control, if not essential, is certainly desirable. As a sine wave is required anyway it seems sensible to start with a sine wave crystal oscillator. This is something which often gives circuit designers a problem but a reliable inductorless circuit is easily formed at low frequencies by building a Wien bridge oscillator around the correct frequency and then putting the crystal across the series element of the bridge. Easy starting with reliable crystal lock is the result.

The standard thermistor amplitude control method, Fig 8, proved adequate for an early prototype, but even running the bead as hot as permissible, 200 deg C, still means that its operating point is determined roughly 9 parts in 10 by the oscillation voltage and 1 part in 10 by the ambient temperature. With this circuit I measured an amplitude drift of −0.02dB/deg C over the range +10 to +40 deg C and distortion was below 0.05%. Evidently some form of amplified control was needed to improve this drift figure tenfold and allow maintenance of good channel separation over a wide temperature range.

The circuit evolved is in Fig. 9 where an f.e.t. replaces the thermistor as the gain control element but with linearizing components to maintain the distortion performance. Linearizing is achieved by equalizing the gate/drain and gate/source signal voltages and is done by R_5 and R_6. The f.e.t. is also only allowed to contribute a small amount of the total resistance between pin 2 of the i.c. and common, and this fraction is determined by R_3 in the source lead. Linearizing produces distortion better than 0.05% compared with around 0.4% without.

Transistors Tr_2 and Tr_3 form a long tailed pair which compares the oscillator amplitude with a direct reference voltage. Resistor 8 prevents loading of the oscillator output by changes in Tr_2 input impedance over each cycle. The direct error voltage feeds the f.e.t. gate after filtering (R_7, C_{10}) to remove oscillator components. The two transistors are identical types and mounted together so that their two base-emitter junctions provide temperature compensation; the use of a matched pair in a single can does not seem to be justified. Stability of the d.c. reference is assured by using low temperature coefficient resistors for R_{11} and R_{12} as well as a stabilized negative line.

Though a square wave oscillator followed by a filter could have produced similar amplitude stability simply by defining the voltage excursion of the square wave generator there is a unique advantage in the method described. Namely, the long-tailed pair comparator need not look at the oscillator output directly; it could look at the level of 38kHz which feeds into the multiplier and thus act as a servo, taking up gain drift in the doubler, amplifier and notch filter.

Printed boards (a total of three) are available for this encoder for £7.50 inclusive from M. R. Sagin, 23 Keyes Road, London NW2.

Appendix

Inherent crosstalk arising from deficiencies in the coded signal.
Crosstalk is expressed relative to the full level on the decoded channels when $A=B=1$ as this is the most convenient reference when making measurements.

Amplitude error between the M and S signals.
Ignoring the pilot signal and considering an error δ so that the composite signal becomes

$$\frac{A+B}{2}+\frac{A-B}{2+\delta}\sin 2f_c t$$

i.e. S is low in level if δ is positive.
After multiplication in the decoder, considering only the 38kHz component of the reinserted carrier waveform

$$D(t)=\left|\frac{A+B}{2}+\frac{A-B}{2+\delta}\sin 2\pi f_c t\right|\sin 2\pi f_c t$$

Adding $\frac{1}{4}(A+B)$ to give the decoded A signal, and considering only baseband components gives

$$\frac{A+B}{4}+\frac{A-B}{2(2+\delta)}.$$

Related to peak level, $\frac{1}{2}B$, fractional crosstalk is $\delta/2(2+\delta)$.

Phase error between M and S signals.
Suppose $A=0$, $B=1$ and $B(t)=\sin 2\pi f_B t$. If a delay of δt exists on the S signal, the composite signal is

$$\frac{\sin 2\pi f_B t}{2}-\left(\frac{\sin 2\pi f_B(t+\delta t)}{2}\right)\sin 2\pi f_c t.$$

After decoding, adding $\frac{1}{4}(A+B)$, i.e. $\frac{1}{4}\sin 2\pi f_B t$, and neglecting non-baseband components, the decoded A signal $\frac{1}{4}\sqrt{(1-\cos 2\pi f_B\delta t)^2+\sin^2 2\pi f_B\delta t}$ $=\frac{1}{2}\sin\pi f_B\delta t$, so that fractional crosstalk is $\sin\pi f_B\delta t$.

Error in pilot phase.
Suppose pilot is $0.1\sin f_c(t+\delta t)$, so in the decoder the regenerated 38kHz is $\sin 2\pi f_c(t+\delta t)$. $D(t)=$

$$\left|\frac{A+B}{2}+\frac{A-B}{2}\sin 2\pi f_c t\right|\sin 2\pi f_c(t+\delta t).$$

Add $\frac{1}{4}(A+B)$ and neglecting non-baseband terms the decoded A signal is

$$\frac{A}{4}(1+\cos 2\pi f_c\delta t)+\frac{B}{4}(1-\cos 2\pi f_c\delta t).$$

and fractional crosstalk is $\sin^2\pi f_c\delta t$.

Amplitude imbalance between the sidebands of the S signal.
If $A=0$, $B=1$ and $B(t)=\sin 2\pi f_B t$ and a sideband imbalance exists then the composite signal is

$$\frac{\sin 2\pi f_B t}{2}-\frac{\cos 2\pi(f_c-f_B)t}{4}+\frac{\cos 2\pi(f_c+f_B)t}{4+\delta} \qquad \text{A1}$$

Considering only baseband terms

$$D(t)=-\sin 2\pi f_B t.\left|\frac{8+\delta}{8(4+\delta)}\right|.$$

Adding $\frac{1}{4}(A+B)$ the decoded A signal is

$$\sin 2\pi f_B t\left|\frac{\delta}{8(4+\delta)}\right|.$$

and fractional crosstalk is therefore

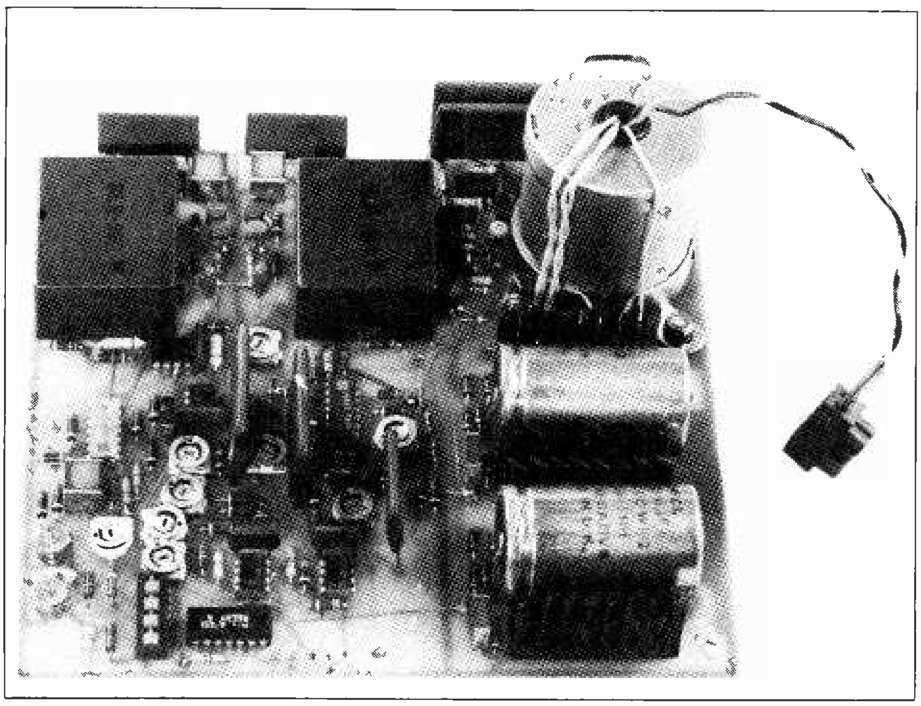
$$\frac{\delta}{4(4+\delta)}.$$

Phase shift in the upper sideband of the S signal.
Taking equation A1 but for a phase error in the (f_c+f_B) component, signal is

$$\frac{\sin 2\pi f_B t}{2}-\frac{\cos 2\pi(f_c-f_B)t}{4}+\frac{\cos 2\pi(f_c+f_B)(t+\delta t)}{4}.$$

$$D(t)=\tfrac{1}{8}\Big|\sin 2\pi f_B t.\cos 2\pi(f_c+f_B)\delta t+\cos 2\pi f_B t.\sin 2\pi(f_c+f_B)\delta t\Big|-\frac{\sin 2\pi f_B t}{8},$$

and the decoded A signal is $\frac{1}{4}\sin(f_c+f_B)\delta t$, giving a fractional crosstalk of $\frac{1}{2}\sin(f_c+f_B)\delta t$.



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2. Z. Mack, Comparison of transformerless ring-modulators and cross modulators. *Radio and Electronic Engineer* vol. 44 1974 p.407.

Power semiconductors— 2

A survey of devices, technologies and applications

by Mike Sagin, Assistant editor *Wireless World*

Over recent years much development has taken place in the power semiconductor field. Conventional devices are getting larger, quicker and more efficient, and several new devices have been introduced to the design engineer. These semiconductors allow far more freedom in the design of a power control system provided that they are used correctly. This article covers the various types of device currently available and outlines applications, together with future developments.

Thyristors

Thyristor is the generic name for a semiconductor bistable switch which has at least four semiconductor layers. The most common type, the silicon controlled rectifier, was first introduced in the 1950s and was used to replace thyratrons and mercury-arc rectifiers. Since then it has undergone much development to produce devices which can switch 1000A or 1000V in one microsecond, withstand voltages up to 4kV, handle r.m.s. currents up to 2.5kA, and operate at frequencies up to 5kHz. Several types of construction are now used, all of which have very definite advantages and corresponding disadvantages. Because designers have to "rob Peter to pay Paul" s.c.rs are designed for specific applications.

The basic s.c.r. as shown in Fig. 1(a) is a half way device whose bistable state depends on a positive feedback loop. When the s.c.r. is forward biased it can be switched from a high to low impedance state by making the gate positive with respect to the cathode. This action is analogous to a complementary pair of internally connected transistors as shown in Fig. 1(b). A regenerative situation exists when the positive feedback gain exceeds unity. Under reverse bias, the s.c.r. behaves like a p-n junction rectifier. The switching characteristics of a typical reverse blocking s.c.r. are shown in Fig. 2 and the important ratings and characteristics are shown in table 1.

In general, for high operating voltages, the p-n-p-n structure must be thicker and possess a higher resistivity. Unfortunately, this increases the voltage drop, which reduces the current rating. High frequency performance is also degraded because the rate of rise in current (di/dt) rating is reduced and the turn-off time increased, due to a larger stored charge in the structure. Another important factor which determines the voltage rating is the surface condition

Table 1
Important ratings and characteristics

Off-state	
V_{DRM}, V_{DSM}	Peak repetitive and non-repetitive voltages (V)
I_{DRM}	Peak current (mA)
On-state	
V_{TM}	On-state voltage (V)
$I_{T(AV)}$	Mean on-state current (A)
I_{TRM}, I_{TSM}	Repetitive and non-repetitive currents (A)
I_H	Holding current (mA)
Trigger	
V_{GT} I_{GT}	Gate trigger voltage (V) and current (mA)
Reverse bias	
V_{RRM}, V_{RSM}	Peak repetitive and non-repetitive voltages (V)
I_{RRM}	Peak current (mA)
Thermal	
R_{TH}	Thermal resistance (deg C/W)
T_j	Junction temperature (deg C)
Turn-on	
t_{gt}	Turn-on time
dI/dt on	Rate of rise of current (A/ s)
Turn-off	
t_q	Turn-off time (s)
dI/dt off; dV/dt off	Rate of fall of current and rise of reverse voltage in turn-off (A/ s, V/ s)
dV/dt	Rate of re-application of forward blocking voltage (V/ s)

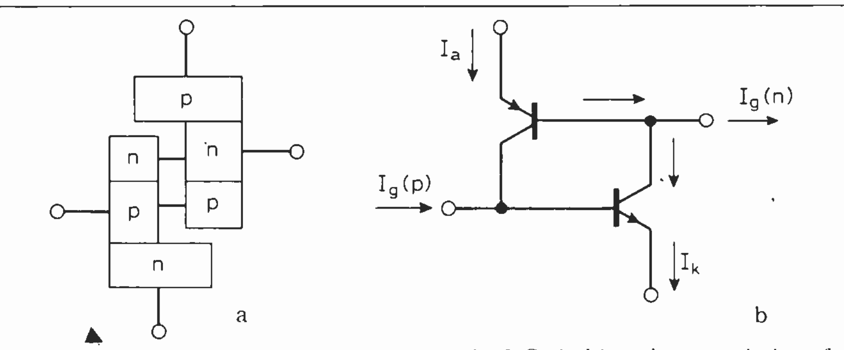
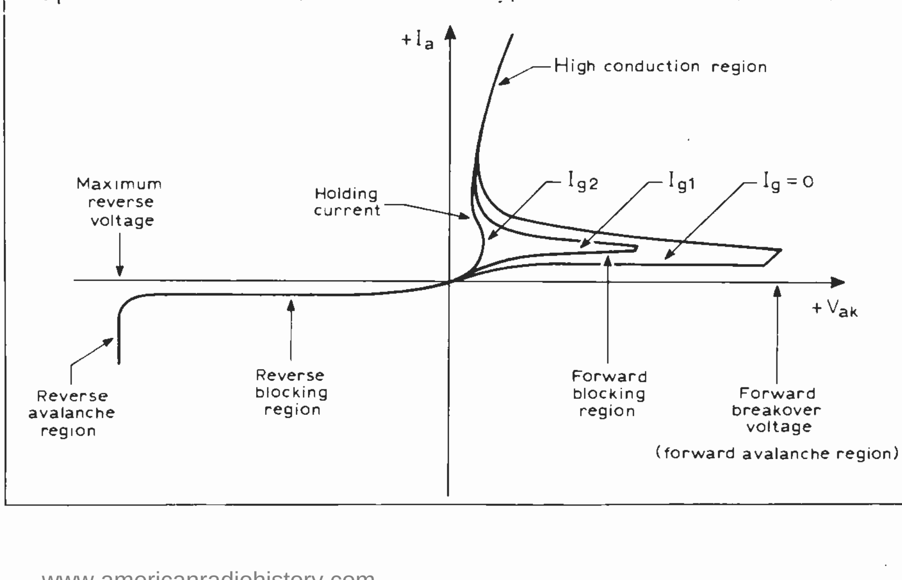


Fig. 1 (a) Basic s.c.r. structure, (b) Equivalent transistor circuit.

Fig. 2. Switching characteristics of a typical reverse blocking s.c.r.



where the p-n junction meets the silicon surface. Surface contouring or bevelling allows higher voltage operation by reducing the electric field in the depletion layer at the surface of the silicon pellet.

The allowable current through a device depends mainly on the conducting area. Silicon slices of 50mm diameter are now used in high power s.c.rs and larger devices are being produced in the laboratory.

Switching performance has received much attention because of the d*i*/d*t* problems which have been encountered. The turn-on process of a s.c.r. is two dimensional because the structure has an electrical resistance across the silicon wafer. Switching is initiated near to the gate electrode and the conducting area spreads outwards until a uniform current density is established. If the build-up of load current is too fast, localized "hot-spots" are created which can damage the device. This problem is most acute in the early point-gate structure, shown in Fig. 3. The area initially turned on is very small and is dependent upon the amplitude of the gate signal. An obvious progression was the centre gate, shown in Fig. 4. This type of construction is widely used in consumer and light industrial s.c.rs and allows d*i*/d*t* ratings up to 100A/μs when using gate pulses of 1-2A. The next development to improve the switching performance was the amplifying gate s.c.r. — see Fig 5. This type of structure may be considered as two radial s.c.rs with a common anode connection. When a positive gate signal is applied, current flows into the p region beneath the gate contact and across the p-n junction at the nearest point to the gate. This forward biases junction J4 and current flows into a metallized region which overlays the outside edge of this junction. The gate-pulse current then re-enters the p region and crosses the p-n junction J3 at the nearest point. Because the length of the auxiliary s.c.r. inner cathode edge is shorter than the main s.c.r. inner edge, the current density at J4 is higher than J3. This ensures that the auxiliary s.c.r. switches before the main section. When the auxiliary s.c.r. has switched, most of the anode current flows in the lowest impedance circuit to the cathode lead which includes the inside edge of the main s.c.r. The equivalent circuit is shown in Fig. 5(b).

Although this structure greatly improves the d*i*/d*t* ratings, further developments have produced the distributed amplifying gate s.c.r. shown in Fig. 6, and the interdigitated amplifying gate s.c.r. — Fig. 7. These are extensions of the basic amplifying gate device in which the length of the main s.c.r. cathode switching edge has been increased to reduce the spreading distance. Although this appears to be the answer to all power switching problems, "Peter" is effectively robbed again because as the surface area of the distributed gate increases, so the main cathode area, and hence, anode current carrying area decreases.

A second rating which effects the switching performance is the d*v*/d*t*. Rapidly rising voltage waveforms and high junction temperature can cause spurious triggering of an s.c.r., due to the capacitance of the p-n junction and the leakage current from the gate junction. The effect is one of increased gate sensitivity. This brought about the shorted-emitter structure which uses partial shorting links between the gate and cathode junction, to produce the same effect as placing a resistor

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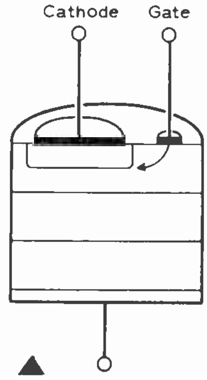


Fig. 3. Point gate s.c.r.

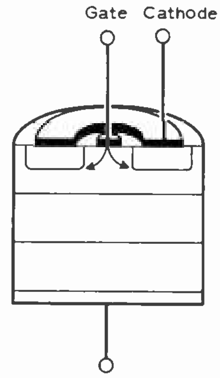
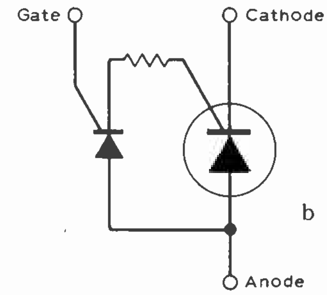


Fig. 4. Centre gate structure.



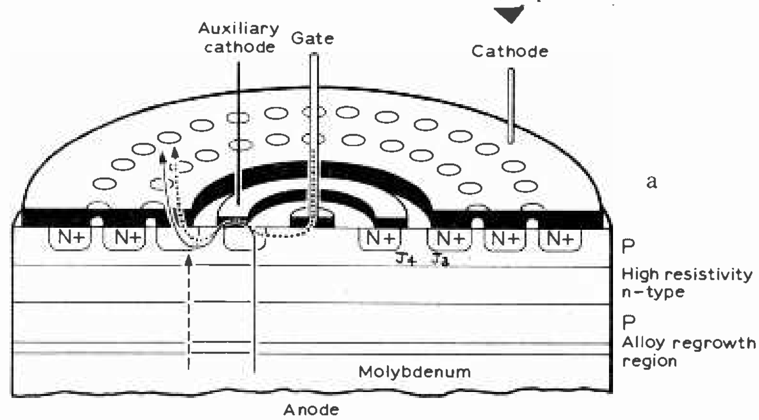


Fig. 5 (a) Amplifying gate structure, (b) Equivalent circuit.

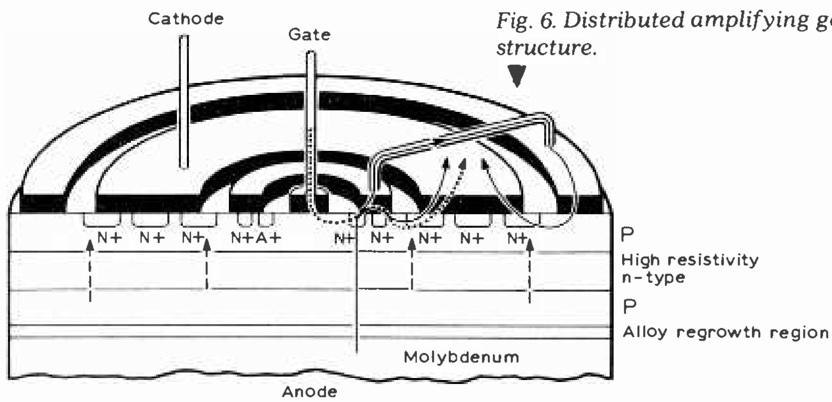


Fig. 6. Distributed amplifying gate structure.

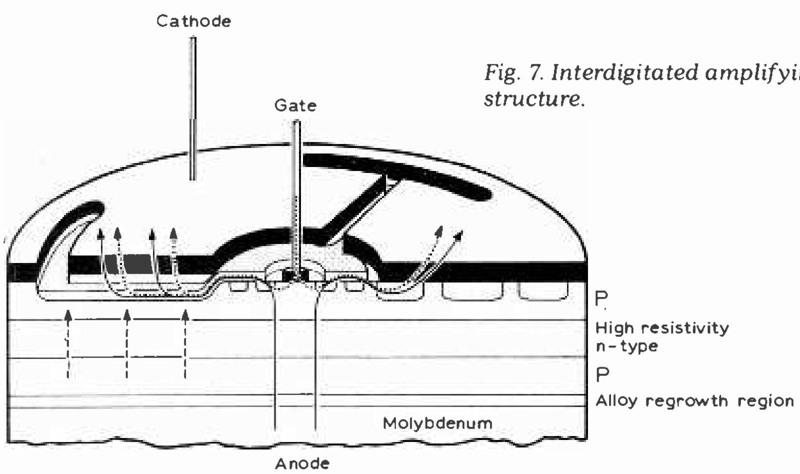
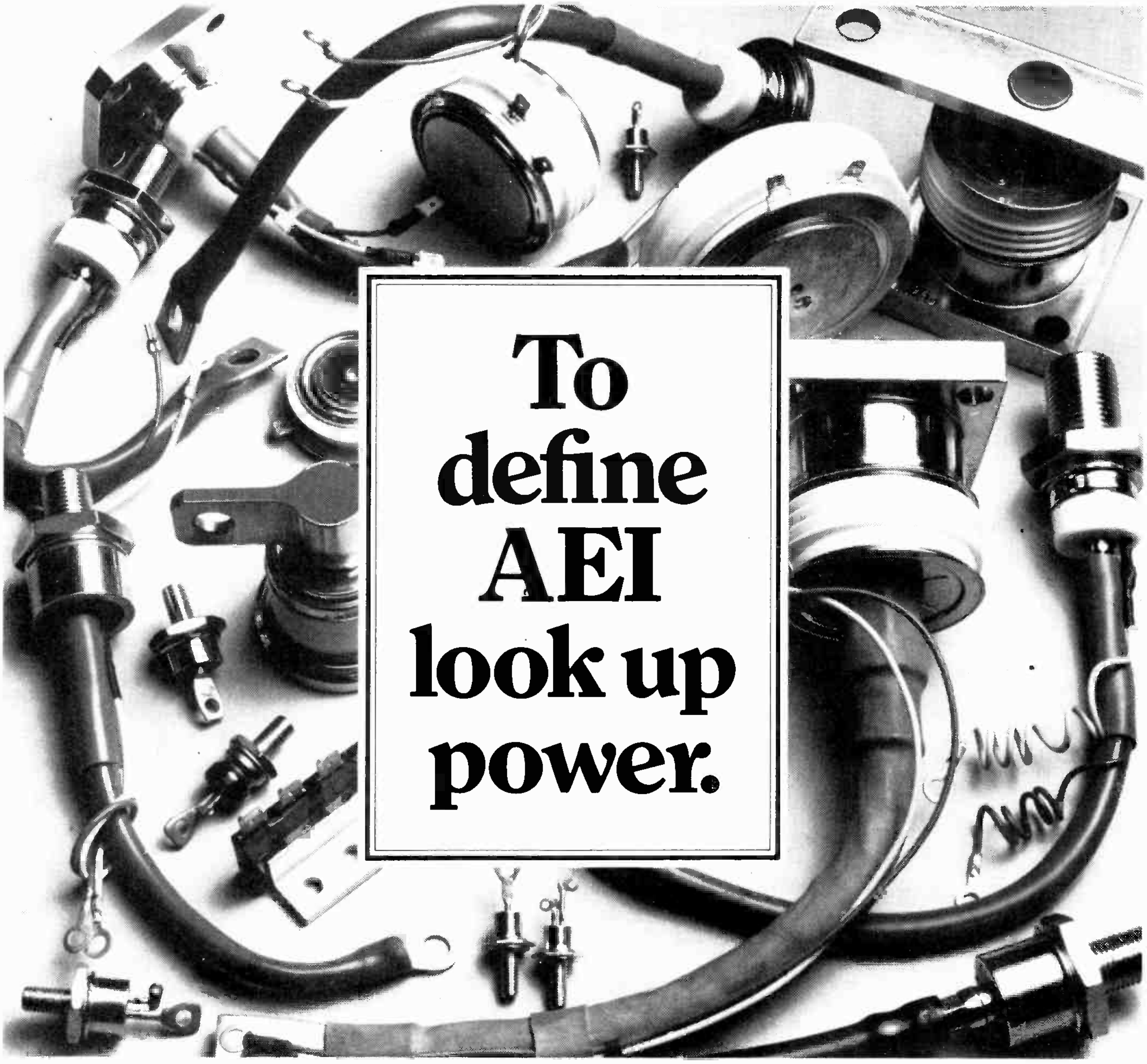


Fig. 7. Interdigitated amplifying gate structure.



POW'ER *n.* ability to do or act;

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between the gate and cathode. The only disadvantage of this type of construction is the slightly increased firing requirements.

The turn-off time for a s.c.r. will determine the maximum operating frequency of the device. During the turn-off period the excess minority charge must either be swept out by an electric field or must decay by recombination within the silicon before the s.c.r. will block a forward voltage. For rapid decay more recombination centres must be introduced. One method of achieving this is gold diffusion during fabrication. The introduction of gold impurities does, however, reduce the voltage and current ratings, and gate sensitivity.

Construction. The heart of a thyristor is its multi-layered pellet of alternate p and n-type semiconductor material. The pellet structure may be fabricated in several ways, depending on the characteristics and complexity of the device. The most popular fabrication methods are alloy diffusion, full diffusion and planar diffusion. The first two methods use large-area p-n-p wafers which are formed by gaseously diffusing p type impurities simultaneously into both faces of a thin n type wafer. Where specific device characteristics are required, a second diffusion step is used to complete the all-diffused p-n-p-n structure. To do this, each p-n-p wafer is selectively marked on one side and diffusion takes place through the windows in the mask. The finished wafers are then diced into individual pellets. In the manufacture of some higher power s.c.rs where only one pellet is available from the wafer, the original p-n-p wafer is converted into a pellet structure before the final n region is added. In this construction the alloying technique is used to fuse a gold-antimony layer into each p-n-p pellet — see Fig. 8.

Planar structure describes a type of device where all of the p-n junctions are on a single surface of the pellet. In this construction a thin layer of silicon dioxide is grown over the wafer before diffusion starts. This prevents contamination of the silicon surfaces. Because the planar construction requires more silicon per amp, the process is normally used for low current devices where many pellets can be cut from a single wafer.

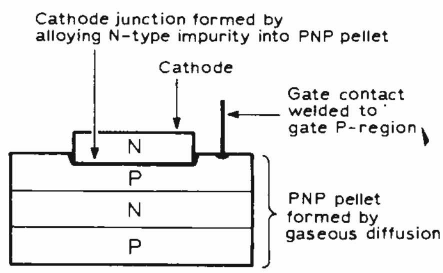
Encapsulation of the s.c.r. pellet has played an essential role in the progressive increase of power ratings. All s.c.r. characteristics are temperature sensitive and provision must be made to conduct away heat generated in the silicon. The older, more traditional method is to hard solder the pellet between a pair of thermally matched plates, one of which is then soldered to a copper stud. The stud serves as one terminal and the thermal conducting path. A newer method of encapsulation for devices rated at above about 150A is the pressure contact system. This replaces the solder joints between the silica pellet and the plates and, in turn, relieves much of the thermally induced stress on the pellet. This system is the only practical method for encapsulating pellets of more than 1 inch in diameter. An even more recent development in pellet encapsulation is glass passivation. A thin coating of low temperature glass is fused on to the silicon chip and performs the same function as the silicon dioxide layer used in the planar diffusion process. Glass passivation is a post-diffusion process and is superior to SiO_2 because it can be applied in thicker coatings, which also allow higher voltage ratings. Another advantage of glass passivation is the hermetic seal it produces which allows simple plastic packages to be used instead of the hermetic metal containers.

Future devices will no doubt have improved voltage and current ratings especially with the development of more uniformly doped silicon. As mentioned earlier, 50mm diameter silicon is now commonly used in high current s.c.rs. Larger diameter slices are already well advanced and will shortly be used in commercial devices.

Triacs

A bidirectional triode thyristor, commonly called the triac, is basically two s.c.rs connected back to back. These devices are mainly used for a.c. power control and are generally restricted to lower power applications. The structure of a typical glass passivated triac is shown in Fig. 9. Seven steps are necessary in the construction of such a device and the process begins with an n type high resistivity silicon wafer which has p layers deeply diffused into both sides. Silicon-dioxide diffusion masks are grown, and p^+ regions are defined and diffused into the wafer. A second diffusion mask is grown, and n^+ regions are defined and diffused into the wafer. A silicon-dioxide etch mask is grown and defined. Grids and gate moats are etched into the wafer and the glass passivated layer is then applied in these grids and moats. Finally, contact areas are opened on the wafer and nickel-lead-tin solder metallization is applied. The wafer is then separated into pellets.

The triac can be triggered by either a positive or negative gate signal regardless of the voltage polarity across the main terminals of the device. The triggering mechanism and current flow within the triac is shown in Fig.10. Gate trigger polarity is always referred to terminal 1, and the potential difference between the two terminals is such that gate current flows in the direction indicated by the dotted arrows. Because



◄ *Fig. 8. Alloy-diffused pellet formation.*

Fig. 9. Glass passivated centre gate triac structure. ▼

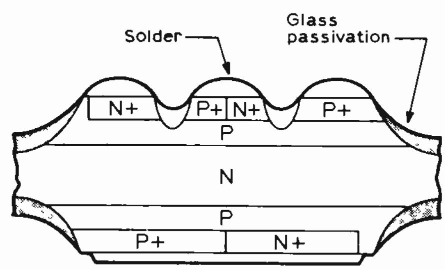
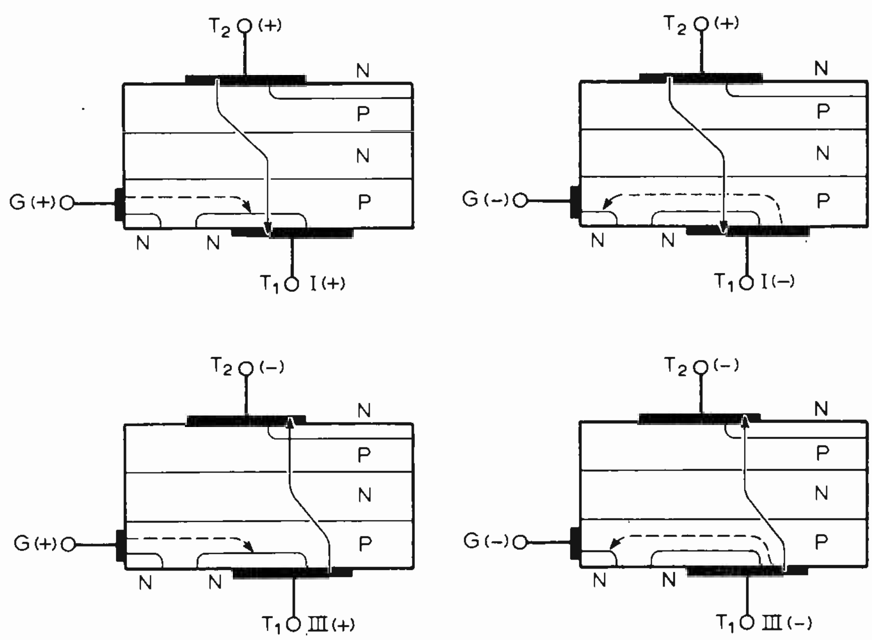


Fig. 10. Current flow in a triac. Dotted lines show the direction of gate current. ▼



the direction of current flow influences the gate trigger current, the gate requirements differ for each of the four modes. The operating modes in which the main current is in the same direction as the gate current require less trigger current than those in which the main current opposes the gate current.

Unlike s.c.rs, turn-off times are not associated with triacs because of the physical structure of the device. The ability of a triac to commutate a fixed value of current is an important characteristic, which is known as the commutating dv/dt capability of the device. In a.c. applications a triac must switch from the conducting state to the blocking state at each zero-current point. This action is called commutation. If the triac fails to block the circuit voltage, control of the load power is lost. Commutation for resistive loads presents no special problems because the voltage and current are in phase. For inductive loads, however, the current lag causes an applied voltage, opposite to the current and equal to the peak of the a.c. line voltage, across the triac after the zero current point. The maximum rate of rise of this voltage which can be blocked without the triac reverting to the on state is the commutating dv/dt capability of the device, and is specified in volts per microsecond for the following conditions. The maximum rated on-state current $I_{T(RMS)}$, the maximum case temperature for the rated value of on-state current, the maximum rated off-state voltage (V_{DROM}) and the maximum commutating di/dt.

The addition of a series capacitor and resistor "snubber" network across the triac reduces the commutating dv/dt of a circuit and is often used for inductive loads. The sizes of these components vary with the load but typical values are 100 ohms and 0.1μF. Table 2 shows

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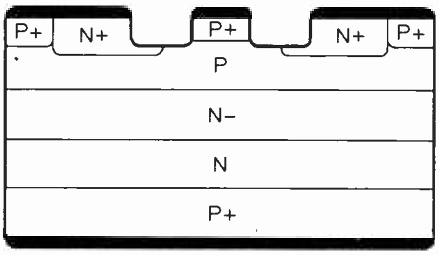
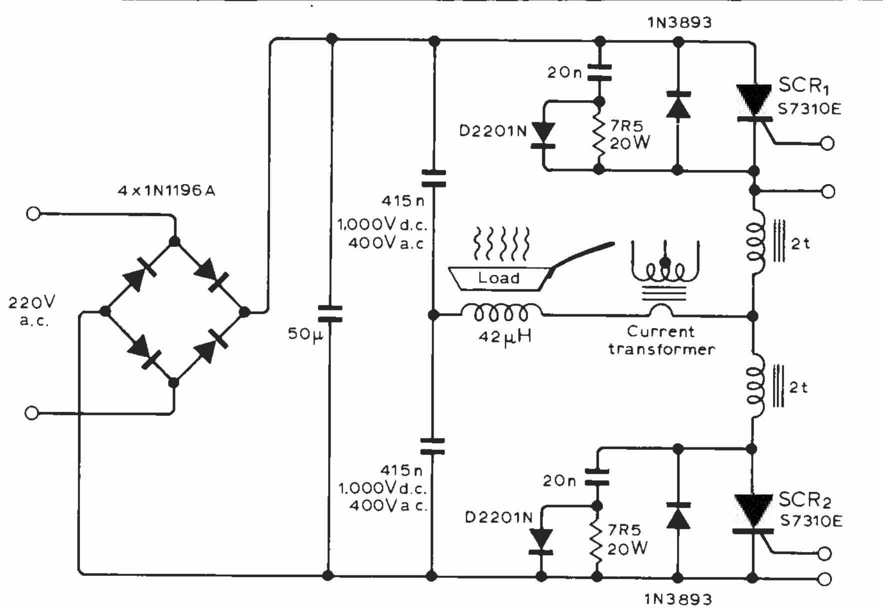


▲ *Fig. 11. Asymmetrical s.c.r. junction structure.*

Fig. 12. Practical circuit for an induction cooker hob. For further details see RCA application note number AN-6456. ▶ ▼



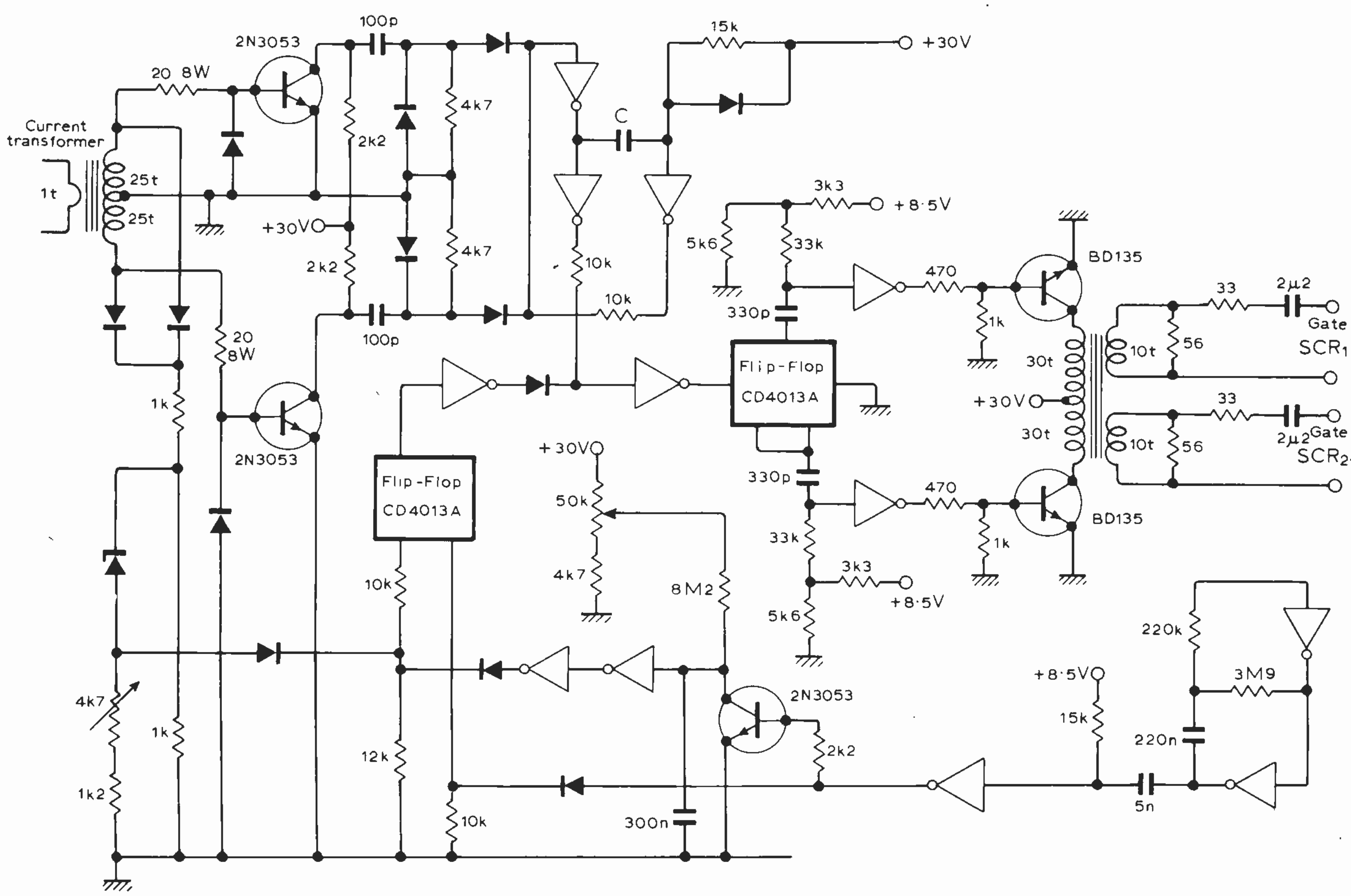


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Table 2

Commutating di/dt for various currents and frequencies.

Commutating di/dt A/μs	Sine wave Amperes r.m.s.	Operating Frequency Hz
141	40	400
88	25	400
21.1	40	60
13 2	25	60
17.6	40	50
11.0	25	50

commutating di/dt for various currents and frequencies.

Asymmetrical silicon controlled rectifier

A recently introduced device from RCA, known as an a.s.c.r., has been specially designed to achieve high dv/dt and di/dt capabilities. A gold dopant is diffused into the a.s.c.r. pellet to achieve fast turn-off capability but, as discussed earlier, gold doping tends to increase turn-on time and decrease di/dt capability. Special techniques are used to overcome this problem. The structure of an a.s.c.r. is shown in Fig. 11. It differs from a conventional s.c.r. in that an additional n-type layer is inserted between the p^+ and n^- regions. This new layer is doped so that it increases the forward blocking voltage of the device. The reverse blocking voltage, which is a function of the n^-/p^+ junction, is much lower than in conventional s.c.rs and is about 15V. The dv/dt capability of the a.s.c.r. is also increased with the introduction of a p^+ ring at the edge of the pellet.

Asymmetrical s.c.rs can be used in fast switching applications at frequencies up to 35kHz. A recently developed circuit uses these devices in an induction cooker hob. A high-frequency generator is used to supply an alternating current to a flat coil under a working surface. When an iron or steel utensil is placed above the induction coil, high-frequency currents are induced into the pan which generates heat. A functional circuit for such a unit is shown in Fig. 12. This design offers an output of 1275W, and a typical efficiency of 80%.

Gate turn-off s.c.r.

Gate turn-off devices (g.t.o.) are also four-layer, three-junction structures as shown in Fig. 13 but, unlike the s.c.r., they can be turned off by the application of a negative gate pulse. The g.t.o. can be turned on in a similar way to the conventional s.c.r. by making the gate positive with respect to the cathode. As positive current is applied to the gate, the voltage/current relationship resembles that of a forward-biased p-n junction until the point is reached where regeneration takes over to switch the structure on. The g.t.o. incorporates the regenerative properties of the two-transistor model of a

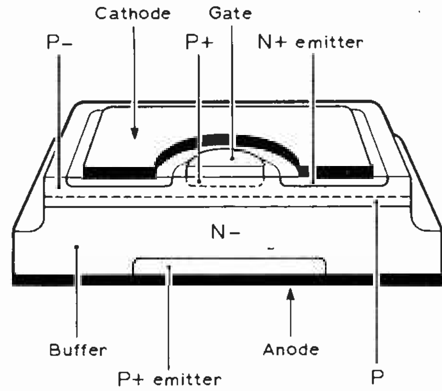


Fig. 13. Gate turn off s.c.r. structure showing centre gate and double p base layer.

Fig. 14. Anode current rise time versus gate drive current.

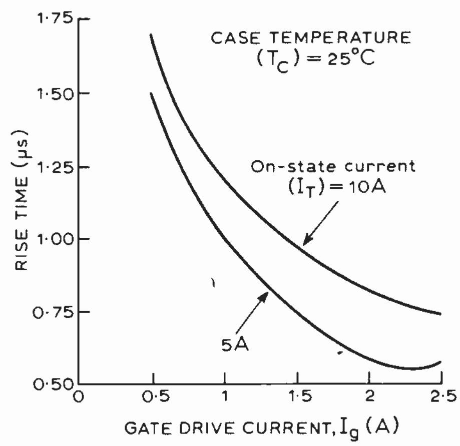
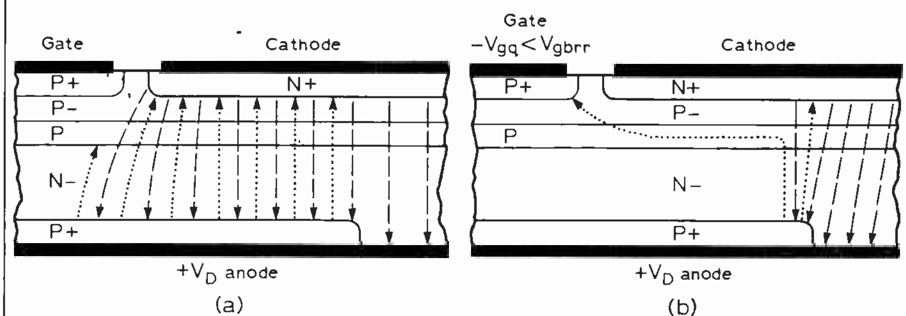


Fig. 15 (a) Gate turn off s.c.r. in the on-state and, (b) during turn off. The high density filament forms a non-regenerative region.



s.c.r., but the loop gain is reduced to allow turn-off control at the gate. In effect, turn-on in a g.t.o. is similar to that of a desensitized s.c.r. and, if sufficient gate drive is applied during turn-on, satisfactory performance can be achieved. The effect of increased values of gate-current on anode-current rise time for two values of on-state anode current, is shown in Fig. 14. The on-state voltage of the g.t.o. is a function of the regenerative properties of the device, so the transient on-state voltage drop can be reduced by the use of an increased gate drive.

During the turn-off process, the conducting electron/hole plasma is deflected from an area close to the gate, which has the highest negative potential, to the most remote area beneath the cathode, which has the least negative potential, see Fig. 15. In the on-state the device conducts uniformly over the entire cathode area. Upon application of a negative bias to the gate, the plasma is squeezed into a high-density filament. This filament is deflected into a non-regenerative three-layer section and cannot sustain itself.

The structure has a centre-gate geometry and a double-layer p base which allows a low lateral resistance. This low resistance causes a very small voltage drop from the negative gate current. The g.t.o. is surrounded by a non-regenerative section in which the final phase of the turn-off cycle takes place. Device dimensions are about 3 × 3mm and this size allows a continuous current operation up to 15A and a forward blocking voltage of above 600V.

Gate-drive techniques. For the best switch-on rise times a positive gate current of between 0.5 and 1A with at least a two microsecond pulse width is recommended by the manufacturers. Also, a pulse of −70V between the gate and cathode for the duration of the turn-off interval is advised. Fig. 16 shows gate drive systems that may be used when a negative voltage source of 70V is not available. In circuit (a) the resistor causes unnecessary dissipation during switching and in circuit (b) an inductor is substituted to reduce the dissipation. The configuration shown in (c) is the best method of switching the g.t.o. The peak value of the reverse gate current carried by the switch in Fig. 16 is approximately half the maximum

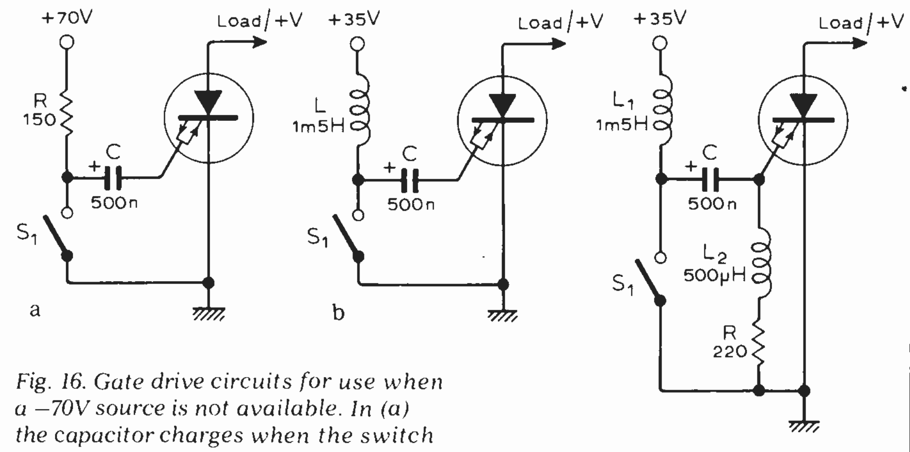


Fig. 16. Gate drive circuits for use when a −70V source is not available. In (a) the capacitor charges when the switch is opened and gate current turns the g.t.o. on. When the switch is closed the charged capacitor acts as a source of negative potential. In (b) when the switch is closed the g.t.o. is turned off by the capacitor and the extra energy stored in the inductor. In (c) when the switch is opened the g.t.o. is turned on because of stored energy from L_1 and the increased drive provided by the stored energy in L_2. When the switch is closed the g.t.o. turns off because of the negative voltage from the capacitor.

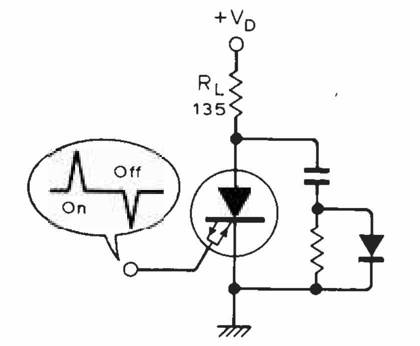


Fig. 17. Typical d.c. switch. The capacitor and resistor form a "snubber" network.

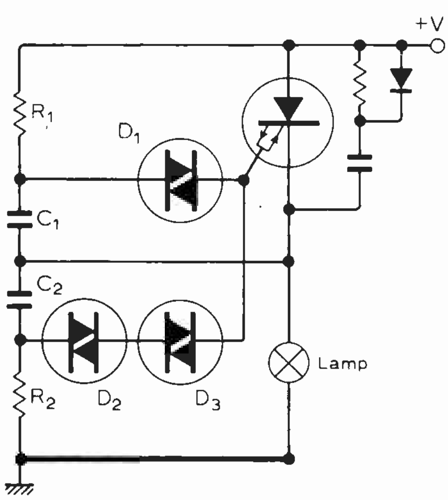


Fig. 18. Lamp flasher circuit. The on and off times can be adjusted by the time-constant networks R_1C_1 and R_2C_2 respectively.

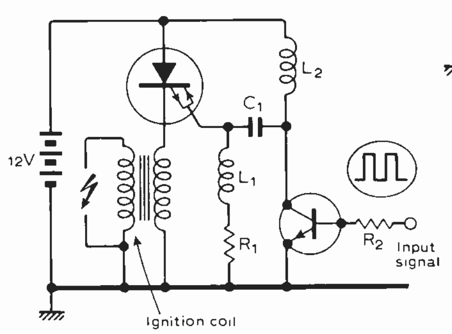


Fig. 19. Car ignition circuit.

anode current of the g.t.o. prior to turn off. This current lasts for about 400ns and then decreases to a value less than 0.7A for the rest of the turn-off interval. The switch may be an n-p-n transistor or low voltage s.c.r.

Applications of the g.t.o. are mainly in d.c. circuits, and use in cars will be popular. Particular devices can operate at frequencies up to 30kHz and Fig. 17 shows a circuit suitable for use as a d.c. switch. Fig. 18 shows a circuit breaker or lamp flasher. Diacs D_2 and D_3 are connected in series to provide a maximum peak negative gate voltage of −70V during the turn off period. The RC "snubber" network in parallel with the g.t.o., protects the device against high dv/dt. The circuit in Fig. 19 illustrates a typical use in a car ignition unit. The input signal can be obtained from the mechanical distributor or from an electronic generator.

In the near future it is expected that new devices will have much lower gate turn-off voltages of around −20V, higher current capabilities, and increased gate sensitivities. Because the g.t.o. can switch higher voltages at greater currents with a semiconductor pellet the same size as a conventional bi-polar transistor, these devices are likely to replace high power transistors in many d.c. switching applications.

To be continued.

Continued from page 55

circuits" had gained currency). Texas were anxious to establish that what we saw at the symposium was not in fact a working device but a model, and our reporter agreed to sign an affidavit to this effect. This incident demonstrates the Americans' awareness of the possibility of British priority in integrated circuits.

Mr Dummer is author of a new book "Electronic Inventions 1745-1976" just published by Pergamon Press at £4.00. This contains mainly brief descriptions of important inventions in electronics but also has some interesting graphs showing historical trends. For example, it shows that in the 200 years from 1745 to 1945 some 106 electronic inventions originated in Europe against 66 in the same period in the USA; but in the mere 31 years from 1945 to 1976 the situation was reversed, with 32 inventions in Europe and 85 in the USA.

Time by satellite

A digital clock controlled by a time code transmitted from a satellite has been developed by the US National Bureau of Standards (NBS). Once set by the time code the clock, which uses a simple and cheap microprocessor, continues to keep time in the presence or absence of the satellite signal. The clock was designed to use transmissions from the National Oceanic and Atmospheric Administration's meteorological satellites, which relay information from buoys, automatic weather stations, ships, aircraft and balloons. The time code used dates the information or organises its transmission into sequence.

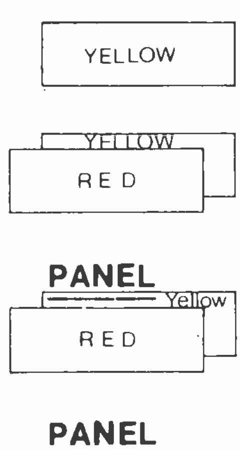
The clock receives a 100Hz pulse stream and time code information in 30s data frames. "Since each time code frame differs from the previous one by only 30s there is a high degree of redundancy in this data which can be used to improve the signal to noise ratio. The microprocessor stores the received time in random access memory and continually updates it by counting the 100Hz pulse stream." During every time code frame the r.a.m. time is compared with the new time message for errors. The r.a.m. time is assumed to be correct in the case of error in three consecutive comparisons. On the fourth the r.a.m. is assumed wrong and is reset in the next frame.

To counteract noise in the pulse stream the microprocessor crystal oscillator is divided down to 100Hz from 4.096MHz and phase locked to the received pulse stream. The adjustment of the crystal frequency is accomplished with varactor diodes.

New Products

Graphic transfers

P.c.b. and rub-down acid-resist graphic transfers, manufactured by E. R. Nicholls, includes space bars which enable users to lay transfers level and with the correct letter, word and line spacings. A yellow strip is first placed on to the artwork below the desired position of the wording, and a red straight edge is positioned over it. The space bar of the first character is then lined up on the visible yellow strip so that when rubbed down the character transfers to the artwork and the space bar transfers to the yellow strip. By lining up the space bars of adjacent characters, correct spacings will result. White line spacers are used in a similar way to give correct line spacings. Another important feature is that the transfers contain adhesive only on the character area and not on the surrounding area. Transfers include capitals and lower case letters and numerals in ⅛, ¼ and ½ inch sizes. Prices for complete kits are from £1.00, for the ⅛in set. E. R. Nicholls, 46 Lowfield Road, Stockport, Cheshire.
WW 302

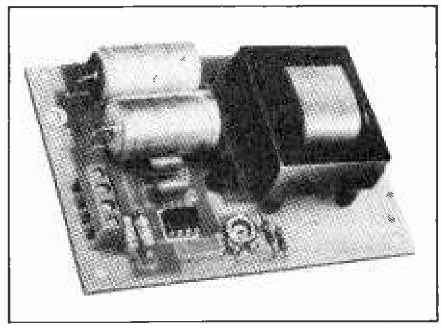


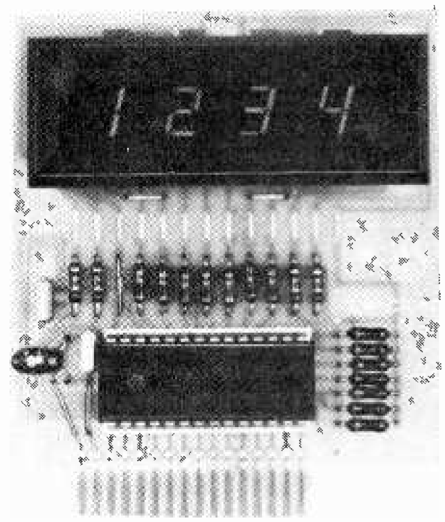
WW 302

Circuit module "time-savers" for development engineers

A range of circuit modules, called Cirblocs, includes power supplies, amplifiers, timers, comparators, count displays, waveform generators, relay drivers and switching and phase control units. All of the units are either ready to use or, by simple wire links and component programming, can be set up to provide desired operating characteristics. The manufacturers, Lascar Electronics Ltd, are a new organisation formed specifically to manufacture and market modules covering the most widely used electronic circuits so that engineers can produce many different electronic systems in the shortest possible time. The managing director of Lascars pointed out that all over the world engineers are spending time hard wiring the same basic types of circuits, during the development stage of their particular system. This range, he claims, offers these engineers a means of saving time by supplying basic, ready to use, circuits, leaving the engineer to devote more time to the development work. Also, he says, fault diagnosis and repair is simplified and complex systems may be constructed without specialised electronic knowledge.

Two of the modules, a power supply and a count-display unit, are illustrated below.





The ±15V, 100mA power supply is suitable for operational amplifiers, and has current, thermal shut-down and output short-circuit protection. Other features include a load regulation of 0.6%, line regulation of 0.13% and an output noise voltage of 0.06V; all of these parameters being typical and measured at 25°C. Five-, 12- and 24-V power supplies are also available.

The count-display module is a four-digit unit based on the Ferranti ZN1040E i.c. It has a 0.3in red (or green) l.e.d. display and may be supplied with a mounting bezel and filter. If the module is to be fitted in a low-profile instrument it may be divided in two and reconnected with ribbon cable. This unit, which has a t.t.l.-compatible input and requires a 5V supply, features up/down counting up to 5MHz, a reset zero, a display latch, and "unwanted zero" suppression. An add-on module is also available to convert this count-display into a digital frequency meter with ranges 0 to 9.999kHz and 0 to 99.99kHz.

Full details of the complete Cirbloc range, together with connection instructions and a selection of hand tools, are given in a catalogue which may be obtained from Lascars. All of these products are offered on a same-day basis, if orders are received before 4 p.m. and include no minimum order charges. Lascar Electronics Limited, P.O. Box 12, Second Avenue, Billericay, Essex CM12 9QA.
WW 301

Duplex muting unit

Full duplex operation requires the simultaneous operation of both a transmitter and receiver. In order to avoid breakthrough from the transmitter to the receiver the antennae are often geographically spaced, typically 30 miles apart in land-based installations. This is obviously impossible with shipboard installations. The Duplex Muting Unit, which is placed between the receiver and the antennae, eliminates breakthrough by monitoring the nature and level of the r.f. and introducing attenuation for the duration of the potential breakthrough — imitating the ear by automatically reducing sensitivity when the owner is talking. The unit requires no modifications to existing equipment, is compatible with all receivers without affecting the "type approval" and can represent, it is claimed, a saving of up to 90% against the costs of fitting feeders.

The frequency range of the unit is 0.1 to 30MHz and the insertion loss is typically 1dB. Callbuoy Marine Electronics Limited, 6 Somerset Road, Cwmbran, Gwent NP4 1QX.
WW 303

Polypropylene capacitors

Capacitors in the KP72 range have polypropylene dielectrics, instead of polystyrene, and use aluminium foil as electrodes. It is claimed that these capacitors offer a considerable improvement in heat resistance compared to polystyrene capacitors. Nickel silver terminals, welded to the foil electrodes, make the capacitors suitable for r.f. applications. Capacitances range from 100 to 33,000pF in tolerances of ±10%, ±5% and ±2.5% and are available with working voltages of 63, 160 and 630V. AEG-Telefunken UK Limited, Bath Road, Slough, Berks SL1 4AW.
WW 304

Miniature variable capacitors

Miniature trimmer capacitors in the Voltronics CP range, from ITT Components, are suitable for tuning circuits up to 5GHz. Two basic capacitance types 2.5 and 9pF, are available and these are tuned by sliding a shuttle from one end of the component to the other. They may be used to facilitate rough tuning of several stages before final tuning. The devices have contact resistances of 0.005Ω, voltage ratings of 15V d.c. (300V d.c. max. surge) and temperature coefficients of ±100 p.p.m./°C. Minimum life is quoted as 1000 cycles. ITT Components Group Europe, Capacitor Division, Brixham Road, Paignton, Devon TQ4 7BE.
WW 305

Stereo equalizer

The EQ2 stereo equalizer has eleven bands per channel and provides full equalization from 20Hz to 20kHz with a cut or boost of ±15dB on each band. Each filter has a control which allows an ±½ octave variation of the centre frequency, and tone controls are also provided allowing very low phase distortion equalisations. Balanced inputs provide either unity gain or switched 10dB gain. L.e.ds are provided to monitor and indicate overload. Frequency response is ±0.1dB from 20Hz to 20kHz and i.m. distortion is below 0.01% at the rated output of 2.5V r.m.s. Macinnes Laboratories Limited, Macinnes House, Carlton Park Industrial Estate, Saxmundham, Suffolk.
WW 306

Drive/stepping motors

A series of drive and stepping motors specifically designed for floppy disc drive applications has been introduced by Eastern Air Devices. The standard 1/100 h.p. a.c. drive motor has a high inertia ratio and output speeds of 1500rev/min at 50Hz or 1800 rev/min at 60Hz. This unit is a permanent-split-capacitor synchronous motor with an automatic-reset thermal overload protector.

The stepping motors, sizes 18 and 20, have single or multiple-start lead screws and are available with 15° step angles for 3 or 4 phase supplies. These variable reluctance motors are totally-enclosed bi-directional devices with permanently lubricated ball bearings. Computer Controls Limited, 19 Buckingham Street, London WC2N 6EQ.
WW 307

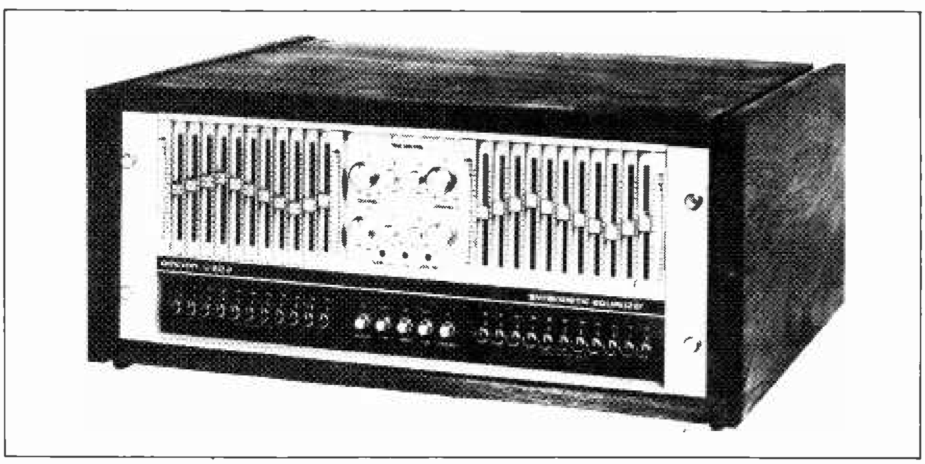
Rotary switch

A multi-wafer rotary switch, designated as Type 30, has ground, silicone treated h.f. ceramic wafers for high insulation resistance. The switch, which has a roller-type index mechanism allowing central bush or two-hole mounting, is available with up to 26 shorting and 13 non-shorting positions, with or without stops. Contacts are gold flash on silver plate as standard or hard gold plating as an option, and are protected from dust and solder vapour by transparent plastic covers. Operational life is quoted as 25,000 rotations and the temperature range is −40 to +85°C. Radiatron Components Limited, 76 Crown Road, Twickenham, Middlesex.
WW 308

Precision resistors

Wirewound resistors, available from G.E. Electronics Ltd, have standard tolerances of 0.1% and are rated at 0.3W (70°C). These resistors, in values from 10Ω to 1MΩ, have temperature coefficients of ±3 p.p.m. over the range 0 to 85°C and ±5 p.p.m. over the range −55 to 145°C. The components are also available in 0.025 and 0.01% tolerances

WW 305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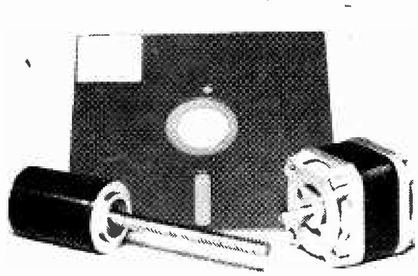
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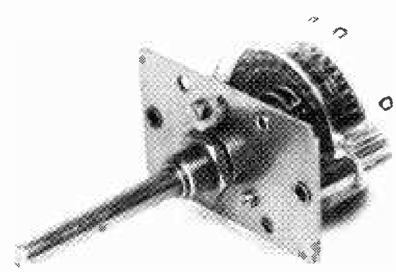

WW 308

and are manufactured and tested to MIL-R93, MIL-Std-202 and DIN40040. G.E. Electronics Limited, 182-184 Campden Hill Road, Kensington, London W8 7AS.
WW 309

Low-cost 5MHz oscilloscope

The S61 oscilloscope is a single trace 5MHz instrument featuring calibrated deflection factors from 5mV/div to 20V/div and sweep rates from 1 s/div to 500ms/div. Simple trigger controls provide a clear, jitter-free trace at all settings and levels over the entire bandwidth it is claimed. A trigger source may be switch selected from either an internal, external, or line frequency. An external X facility is provided for the X-Y display of Lissajous figures and other interactive signals, particularly useful in educational applications. The S61 has an 8 × 10cm screen and is priced at £125 + V.A.T. Electroplan Ltd, P.O. Box 19, Orchard Road, Royston, Herts.
WW 310

General purpose multimeter

The UM11 multimeter, from Poland, has 38 ranges and offers high sensitivities coupled with high input impedances. It has nine direct voltage ranges having input impedance of 100kΩ/V and covering full scale values from 150mV to 1500V. Eight alternating voltage ranges, with sensitivities of 31.6kΩ/V, cover the range 1.5 to 1500V. Other ranges cover direct and alternating current, resistance and dBm. The meter is supplied with a leather carrying case and is priced at £39.50. Electronic Brokers Limited, 49-53 Pancras Road, London NW1 2QB.
WW 311

Wheatstone bridge

A Wheatstone bridge, designated as type 2272, enables measurement of resistances from 0.001Ω to 1,000MΩ with an accuracy of ±0.002% between 22 and 24°C or ±0.005% between 18 and 28°C. The load on the unknown resistor is less than 50mW. The bridge, which is equipped with leakage current protection for improved accuracy, is supplied by a built-in power supply and has a zero-indicator having a sensitivity of 150nV/mm. Tettex AG Instruments, P.O. Box, CH 8042 Zurich, Switzerland.
WW 312

U.h.f. attenuators

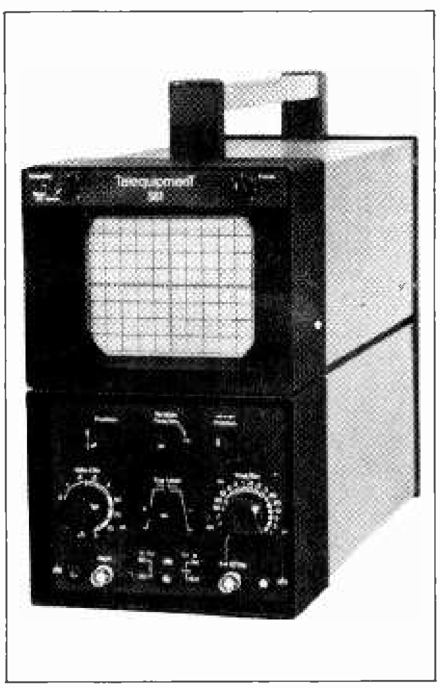
Variable attenuators in the 67DR range, from AEG-Telefunken, are constant impedance units suitable for use in broadband amplifiers — for example in distribution systems having frequencies 40 to 860MHz. The attenuators are available in three versions: 50, 60 and 75Ω with attenuations from 0 to 20dB. Four mechanical versions, with vertical or horizontal mountings, are also produced for p.c. or conventional wiring boards. AEG-Telefunken UK Limited, Bath Road, Slough, Berks SL1 4AW.
WW 313

V.h.f./u.h.f. amplifiers

A series of high dynamic range, wideband linear-amplifiers, from the Microwave Semiconductor Corporation, operate over the range 20 to 1000MHz. The amplifiers have outputs of about 25 to 29dBm at the 1dB compression point, with typical gains of 30dB at 1GHz. Typical noise figures are 7.5dB and operating temperatures range from −20 to +70°C. Tranchant Electronics UK Limited, 100a High Street, Hampton, Middlesex TWqw wST.
WW 314

Silent timers

A silent operating elapsed-time control, the Type ET from NSF Controls, is variable from 4 to 30 minutes and has a switch rating of 16A at 240V a.c. The unit has an eddy current brake mechanism and may be produced to customers' specifications for time cycles, mounting, shaft details and other characteristics. Switches are either s.p.s.t. or d.p.s.t. NSF Controls Ltd, Fence Houses, Houghton-le-Spring, Tyne & Wear DH4 5RG.
WW 315



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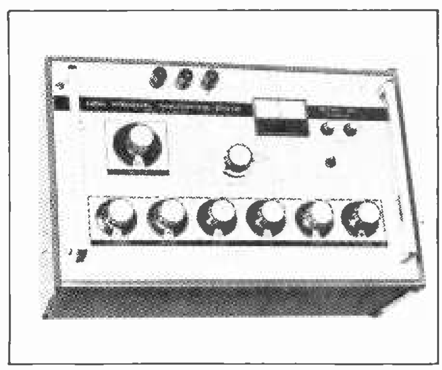

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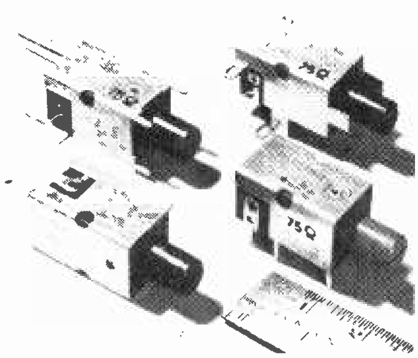

WW 313

Just for the record

Memories of the early years of recording

by Alan D. Foster

We have already been reminded that the year 1977 marks the centenary of the invention of sound recording. To me, this prompts the very sobering thought that I can clearly remember further than half way back over this period of time.

My earliest recollection of the wonders of recorded sound was at about the age of eight. An uncle of mine had an Edison phonograph and a large number of cylinder records. There may in fact have been less than 30 of them in all, but to me at the time it was a very impressive collection. The model of phonograph he had was a fine machine, all nickel plate and shining black, lavishly decorated in gold. It had two soundboxes, one for making and another for playing records, and must have cost about £10, with records in those days running at around one shilling.

Phonographs were made in a variety of models, the cheaper ones being very simple machines, driven by a key-wound clockwork motor with a fan governor rather like a musical box. These models had the unfortunate habit of slowing down during the run of the record. "Melody in 'F' " could well finish up "Melody in 'E'," and if the machine were not placed on a perfectly level table, the stylus was prone to jump a groove now and then.

I remember my uncle's bitter complaint that blank cylinders for making one's own records cost more than professionally-made ones but, of course, they could be used over and over again. The record was simply placed on the machine, and a special cutting tool would shave off a thin layer of wax, removing the previous recording. After the application of wax polish and a finish-off with a soft duster, the cylinder would gleam like new all ready to be re-used. About 20 or more recordings could be made before the record became too thin and had to be discarded. Cylinder records were fragile things, sold in flock-lined boxes to protect the relatively soft wax surface. Apart from being dropped on to the floor an untimely end could result simply by forgetfully leaving a record on the machine overnight. In the morning, there could be a gaping crack running right across the face of the record! With the usual overnight fall in room temperature the record would shrink on to the machine cylinder so tightly that it would simply burst.

Although he may have known a good deal about music, my uncle knew a good deal less about technical matters. I remember him one day standing by the window, closely inspecting a record through a pocket magnifier. "I just can't understand," he said, with a very puzzled expression, "how it is possible to record so many different notes all at the same time." "After all," he reasoned, "There is only one track of vibrations on the record and only one stylus to follow them so how on earth does it work!"

The disc record with which we are familiar today dates from the beginning of this century, yet so well established was the phonograph that both cylinder and disc records co-existed for many years. Edison and other manufacturers were producing cylinder records up to the 1920s until the demand fell off completely in favour of the disc record. The big breakthrough came after 1924, with what nowadays we call electronics. This had a dramatic effect on the recording industry. Technical know-how flourished at a healthy pace and, combined with a widening knowledge of acoustics, records were produced of such quality that some still bear comparison with today's high standard.

The heavy gang

In the late 20s, The H.M.V. Gramophone Company, as it was then, presented a demonstration of electrical recording at the premises of Rushworth & Dreaper, a leading, long established family music house in Liverpool. The demonstration was arranged in the large, ground floor showrooms, the handsome display of grand pianos and cases of musical instruments being put aside to make room for all the paraphernalia necessary to make a record. This consisted of an amplifier rack, control panel, two recording lathes and a large supply of thick, yellow, wax recording blanks. They even brought along their own power supply in the form of dozens of large lead acid accumulators. I was surprised to see that the record cutting lathes were powered not by an electric motor or even clockwork but by a huge iron block suspended like a clock weight under the cutting lathe. This, I suppose provided the smoothest possible source of power but, amongst the other sophisticated hardware, did look a bit primitive.

The advent of electrical recording gave voice to the silent films of the day. Sound accompanying some early films was recorded on 16in discs, running on a turntable directly coupled to the film projector. Projectionists of the day found this period in the development of the talkies to be a very tedious one indeed. In order to maintain synchronization between sound and picture, both the film in the projector and the disc on the turntable had to be set at precise starting points. Of course, the inevitable mistake had to happen. Everything was set, the projector and turntable started together. The sub-titles came on the screen, "World Boy Scout Jamboree" followed by the usual credit titles. Meanwhile background music came from the record on the turntable. Everything seemed OK. The projectionist was himself interested in the subject to settle down to watch the film. The music slowly faded as, on the screen, Lord Baden-Powell mounted the rostrum to make the opening speech — and then it happened.

As the chief scout's lips moved there came out, not inspiring words appropriate to the occasion, but the loud sound of a dog barking! Obviously something was radically wrong, but momentarily the projectionist was transfixed by the near perfect synchronization between the movement of Baden Powell's lips and the barking of the dog — "it was uncanny," he said. The record he had put on the turntable was intended to accompany a film of the "Down on the Farm" type. In haste, he had mis-read the film code mark S.O.F. (sound-on-film) for S.O.D. (sound-on-disc). The experience, he said, haunted him for weeks although he did admit to the satisfaction of having caused as big a laugh as Laurel and Hardy. Only the cinema manager wasn't amused.

This state of affairs was fortunately short-lived and ended with the exclusive use of the "Photophone" system. Thereafter, the sound to accompany a film was recorded photographically along the film itself.

As a result of well directed propaganda, I became the proud owner of my uncle's phonograph and what remained of his record collection. Inspired by the demonstration I had seen at Rushworth & Dreaper, I made an electrical recording head from an S. G. Brown Type A earphone. The old machine was given a new lease of life. Gone was the large horn and in its place was a hefty coil speaker, mounted on a large baffle board, driven by a push-pull amplifier. There was no end to my recordings, music and variety from the radio, piano duets with a friend and even the interval signals between programmes (who, I wonder, can remember those?). One day I found my father, glass in eye, closely studying the works of his watch. Its normally good timekeeping had gone completely crazy, he said. I remembered then I had made a record of the chimes of Big Ben which was wont to come booming out of my den at any time of day. Could the "old man" have been setting his watch to the recorded chimes? I often wondered but never asked.

Safe, tough, efficient and versatile – that's our new miniature CX iron.

Safe because it is virtually leak-free (leakage current less than 1μA). Earth it if you like – three core lead. It is made to conform with B.S. 3456 and has a breakdown voltage of more than 4000V.

Tough because the handle is almost unbreakable and the ceramic shaft is covered by a stainless steel shaft.

Efficient because the element is situated right inside the soldering bit and the heat generated by its 17 watts is not wasted.

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Available for 220-250 volts *or* 100-120 volts. *Weight* – 1$\frac{1}{2}$oz (40 gram). *Length* 7$\frac{1}{2}$" (19cm). *Price* – **£3.20** fitted with standard bit $\frac{3}{32}$" (2.3mm). *Spare bits* £0.46; £0.72; £0.84 exclusive of VAT.

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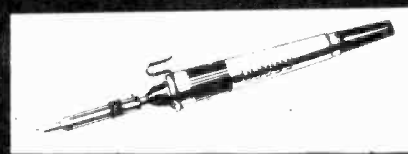

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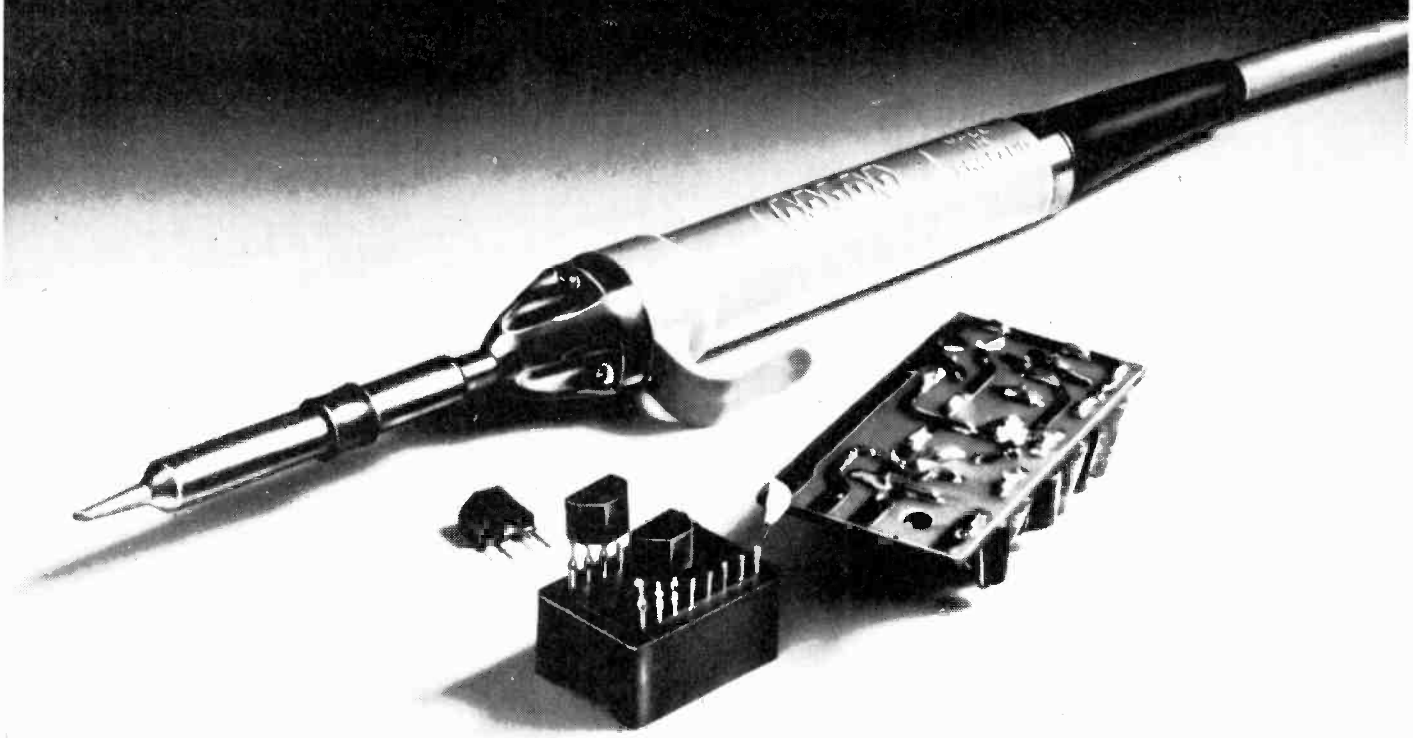

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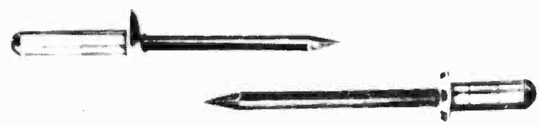

Interesting data and application notes on Blind Rivets — yours for the asking

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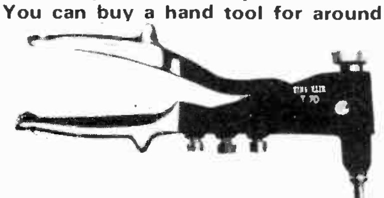

kit in a carrying case with a tool and an assortment of Anchor Nuts for about £22. Anchor Nuts cost around £2-£6 a hundred.

There are kits for all regular thread systems, BA, Metric, Whitworth, UNC, UNF.

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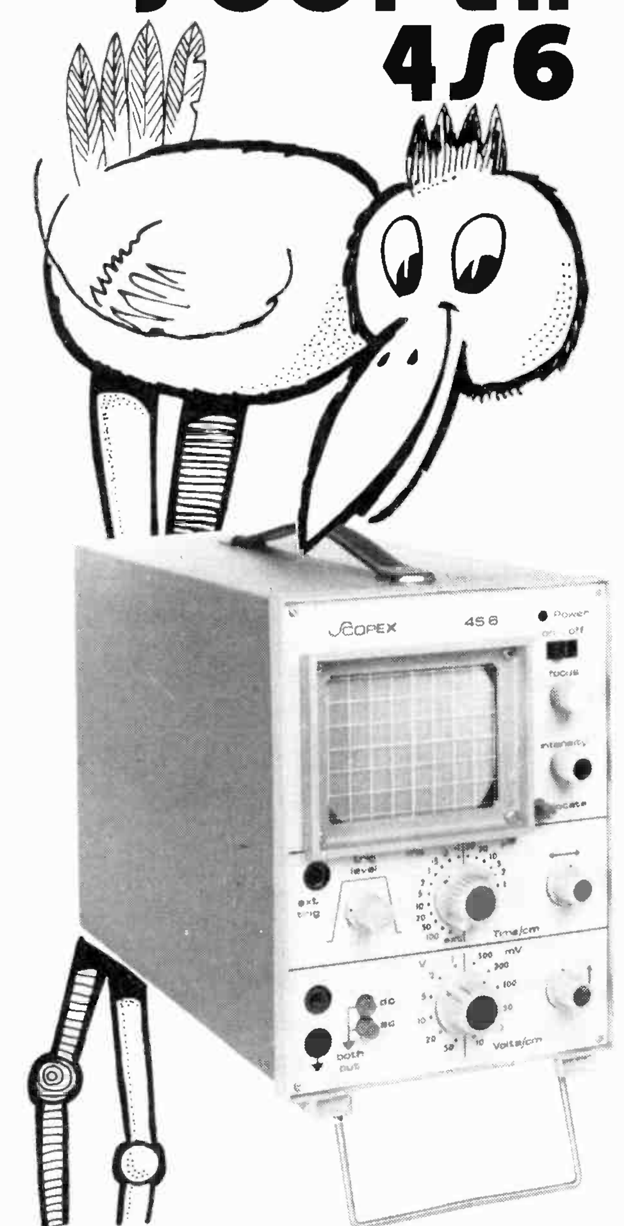

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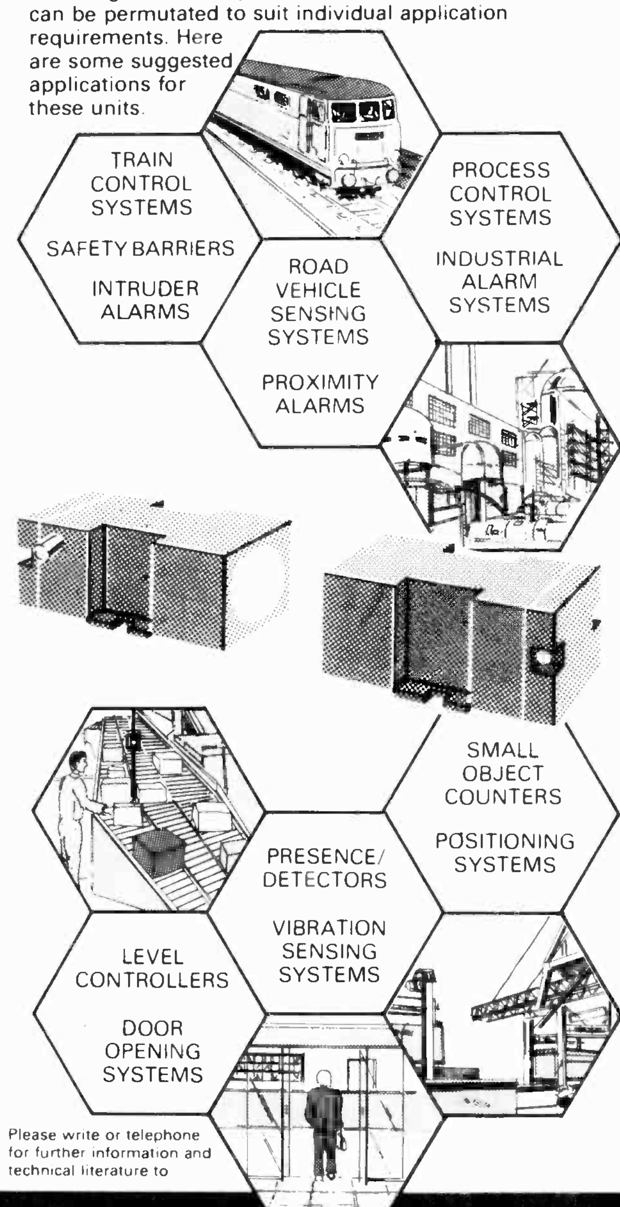

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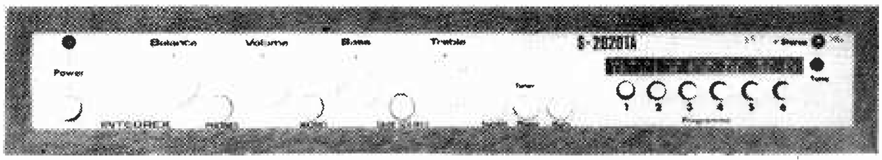

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PRICE: £53.95+VAT

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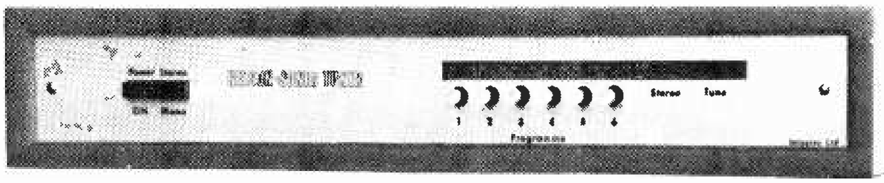

Brief Spec. Tuning range 88–104MHz. 20dB mono quieting @ 0.75μV. Image rejection – 70dB. IF rejection – 85dB. THD typically 0.4%.
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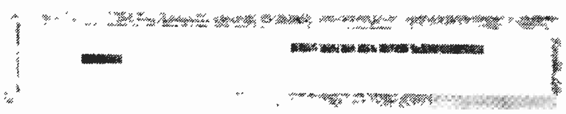

Sens. 30dB S/N mono @ 1.2μV
THD typically 0.3%
Tuning range 88–104MHz
LED sig. strength and stereo indicator

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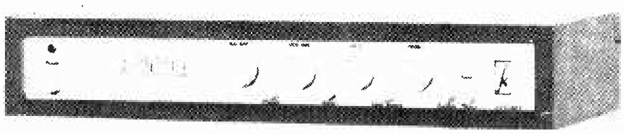

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PRI 120/240V SEC 120/240V
Centre Tapped and Screened

Ref.	VA (Watts)	£	
07★	20	3.57	66
149	60	5.39	80
150	100	6.13	95
151	200	9.82	1 25
152	250	11.87	1 53
153	350	14.34	1 53
154	500	16.48	1 79
155	750	25.23	OA
156	1000	35.16	OA
157	1500	40.12	OA
158	2000	44.76	OA
159	3000	70.70	OA

★115 or 240 sec only

12 and/or 24-VOLT

Separate 12v windings
Primary 220-240 Volts

Ref	Amps 12v	Amps 24v	£	P&P
111	0.5	.0 25	1.77	.36
213	1 0	0 5	2.14	.65
71	2	1	2.77	.65
18	4	2	3.42	.80
70	6	3	5.09	.80
108	8	4	5.85	.95
72	10	5	6.33	95
116	12	6	6.67	1 10
17	16	8	8.60	1 10
115	20	10	12.55	1 73
187	30	15	16.33	1 73
.226	60	30	20.32	OA

50 VOLT RANGE

Primary 220-240V
SEC. TAPS 0-19-25-33-40-50V

Ref.	Amps	£	P&P
102	0 5	3.12	65
103	1.0	4.08	80
104	2.0	5.69	95
105	3.0	7.02	1 10
106	4.0	9.18	1 25
107	6.0	14.62	1.37
118	8.0	15.56	1 73
119	10 0	20.41	OA

30 VOLT RANGE

Primary 220-240V
SEC TAPS 0-12-15-20-25-30V

Ref.	Amps	£	P&P
112	0 5	2.27	65
79	1 0	2.90	80
3	2.0	4.34	80
20	3.0	5.41	95
21	4.0	6.39	95
51	5.0	7.74	1 10
117	6 0	8.65	1 25
88	8 0	11.73	1 37
89	10.0	11.91	1 53

60 VOLT RANGE

Primary 220-240V
SEC TAPS 0 24 30 40 48-60V

Ref.	Amps	£	P&P
124	0 5	2.85	80
126	1 0	4.23	80
127	2 0	6.13	95
125	3 0	9.09	1 10
123	4.0	10.57	1 53
40	5.0	11.78	1 37
120	6 0	13.88	1 53
121	8.0	18.11	BRS
122	10 0	22.31	BRS
189	12 0	23.30	BRS

AUTO TRANSFORMERS

Ref.	VA (Watts)	TAPS	£	P&P
113	20	0-115-210-240V	2.01	59
64	75	0-115-210-240V	3.51	80
4	150	0-115-210-220-240V	4.98	80
66	300		7.03	95
67	500		10.76	1 37
84	1000		16.51	1 73
93	1500		21.87	BRS
95	2000		29.22	BRS
73	3000		42.37	BRS

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VA	Ref.	£	P&P
60	243	5.03	1 10
350	247	12.57	1 53
1000	250	30.26	BRS
2000	252	50.74	BRS

SCREENED MINIATURES Primary 240V

Ref.	mA	Volts	£	P&P
238	200	3-0-3	1.86	46
212	1A, 1A	0-6, 0-6	2.22	.65
13	100	9-0-9	1.79	.32
235	330,330	0-9, 0-9	1.89	.32
207	500, 500	0-8-9, 0-8-9	2.32	59
208	1A, 1A	0-8-9, 0-8-9	3.53	65
236	200, 200	0-15, 0-15	1.79	32
214	300, 300	0-20, 0-20	2.33	65
221	700 (DC)	20-12-0-12-20	2.74	65
206	1A, 1A	0-15-20, 0-15-20	4.17	80
203	500, 500	0-15-27, 0-15-27	3.62	80
204	1A, 1A	0-15-27, 0-15-27	4.76	80
S112	500	0-12-15-20-24-30	2.27	65

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S Dec 70 contacts	£1.98
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U Dec B IC s etc	£6.99

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240V cable input USA 2-pin outlets

20VA	£3.78.	P&P 80p	Ref	113W
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500VA	£12.62.	P&P £1 37	Ref	67W
750VA	£16.80.	P&P £1 53	Ref	83W
1000VA	£21.15.	OA	Ref	84W
2000VA	£33.02.	OA	Ref	95W

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200v	2A	45p
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500v	10A★	£2.35

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Pre-Amp for 25w	£13.75
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Power Supplies for 25w	£3.75
Transformer for 5 10w	£2.30
Transformer for 25w (one module)	£2.90
P&P Amps Pre-Amps/Power Supplies	18p
P&P Transformers	58p

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AVO TT169	£26.00
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STEREO 30

Complete chassis inc 7+7w r.m.s. amps. pre-amp. power supply front panel. knobs (needs mains trans.) £16.25. Mains trans £2.45. Teak veneered cab £3.65. P&P 88p VAT 12½%

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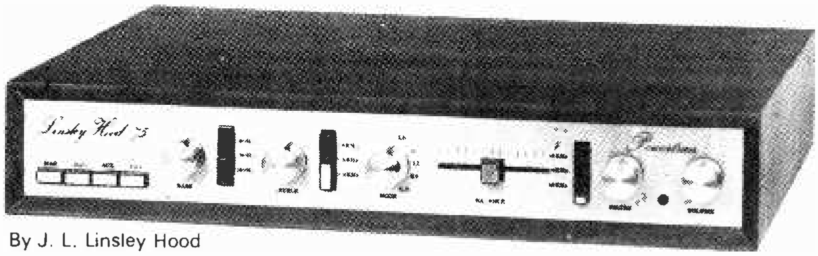
POWERTRAN ELECTRONICS

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.

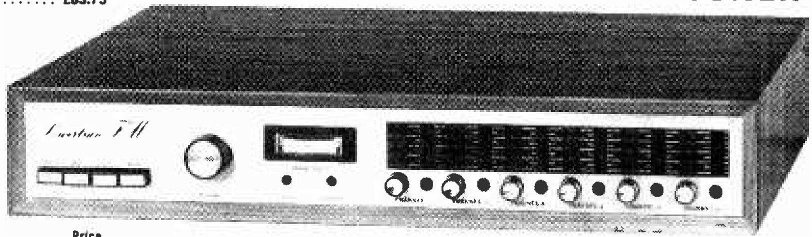
Pack	Price
1. Fibreglass printed-circuit board for power amp	£1.15
2. Set of resistors, capacitors, pre-sets for power amp	£2.15
3. Set of semiconductors for power amp	£6.50
4. Pair of 2 drilled, finned heat sinks	£1.10
5. Fibreglass printed-circuit board for pre-amp	£1.75
6. Set of low noise resistors, capacitors, pre-sets for pre-amp	£3.40
7. Set of low noise, high gain semiconductors for pre-amp	£2.40
8. Set of potentiometers (including mains switch)	£3.15
9. Set of 4 push-button switches, rotary mode switch	£4.50
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	£4.60
13. Set of miscellaneous parts including DIN skts, mains input skt, fuse holder, inter-connecting cable, control knobs	£5.35
14. Set of metalwork parts including silk screen printed fascia panel and all brackets, fixing parts, etc.	£7.30
15. Handbook	£0.30
16. Teak cabinet 18.3" x 12.7" x 3.1"	£9.85

2 each of packs 1-7 inclusive are required for complete stereo system. Total cost of individually purchased packs £83.75

FREE TEAK CASE WITH FULL KITS

KIT PRICE ONLY **£73.90**

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	£4.30
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.	£8.80
9. Function switch, 10 turn tuning potentiometer, knobs	£5.30
10. Frequency meter, meter drive components, fibreglass printed circuit board	£9.45
11. Toroidal transformer with electrostatic screen. Primary: 0—117V—234V	£4.45
12. Set of capacitors, rectifiers, voltage regulator for power supply	£2.95
13. Set of miscellaneous parts, including sockets, fuse holder, fuses, inter-connecting wire, etc.	£1.50
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.	£7.50
15. Construction notes (free with complete kit)	£0.25
16. Teak cabinet 18.3" x 12.7" x 3.1"	£9.85

One each of packs 1-16 inclusive are required for complete stereo FM tuner. Total cost of individually purchased packs £76.85

FREE TEAK CASE WITH FULL KITS

KIT PRICE only **£66.75**

NEW KIT!

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	£8.90
4. Miniature relay with socket	£2.45
5. PCB, all components for solenoid, speed control circuits	£3.20
6. Goldring Lenco mechanism as specified	£21.95
7. Function switch, knobs	£1.60
8. Dual VU meter with illuminating lamp	£7.20
9. Toroidal transformer with E.S. screen prim. 0-117V, 234V, Sec. 15V	£4.45
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.	£2.50
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"	£9.85

One each of packs 1-14 inclusive are required for compete stereo cassette deck. Total cost of individually purchased packs £85.40

SPECIAL PRICE FOR COMPLETE KITS £81.35

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.

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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	1.40	1.50
2. Set of small capacitors	2.20	2.80
3. Set of power supply capacitors	1.90	2.30
4. Set of miscellaneous parts	3.20	3.20
5. Set of slide, mains, P.B. switches	1.20	1.20
6. Set of pots, selector switch	2.80	2.80
7. Set of semiconductors, ICs, skts.	7.25	7.75
8. Toroidal transformer — 240V prim. e.s. screen	4.95	6.80
9. Fibreglass PCB	3.20	3.60
10. Set of metalwork, fixing parts	4.20	4.80
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 **£31.10**

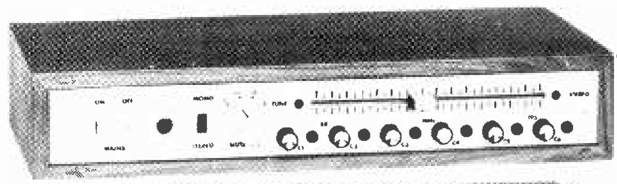
T30+30 KIT PRICE only **£35.90**

2 NEW 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

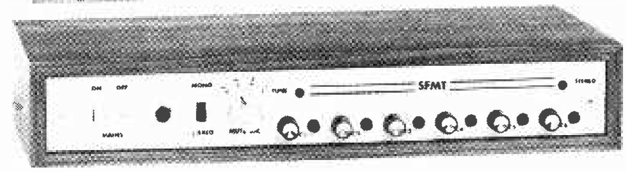
KIT PRICE **£45.50**



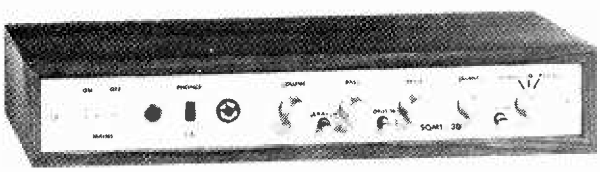
POWERTRAN SFMT

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 **£32.60**



CONVERT NOW TO QUADRAPHONICS!



SQM1 — 30 KIT PRICE £37.15

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 T2D + 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 list

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 Sypply	
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	£2.80
BBPA Pk 2 Resistor, capacitor semiconductor set	£6.70
BBPA Pk 3R Rotary Potentiometer set	£2.85
BBPA Pk 3S Slider Potentiometer set with knobs	£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	£2.30
Stuart Tape Recorder	
TRRP Pk 1 Replay Amp F/Glass PCB	£1.30
TRRC Pk 1 Record Amp F/Glass PCB	£1.70
TROS Pk 1 Bias/Erase/Stalilizer F/Glass PCB	£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

SEMICONDUCTORS as used in our range of quality audio equipment.

2N699	£0.20	40361	£0.40	BD530	£0.55	MJE521	£0.60	TIP29C	£0.55
2N1613	£0.20	40362	£0.45	BDY56	£1.60	MPSA05	£0.25	TIP30C	£0.60
2N2926G	£0.10	BC107	£0.10	BF257	£0.40	MPSA12	£0.35	TIP41A	£0.70
2N3055	£0.45	BC108	£0.10	BF259	£0.47	MPSA14	£0.30	TIP42A	£0.80
2N3442	£1.20	BC109	£0.10	BFR39	£0.30	MPSA55	£0.25	TIP41B	£0.75
2N3711	£0.09	BC109C	£0.12	BFR79	£0 30	MPSA65	£0.35	TIP42B	£0.90
2N3904	£0.17	BC125	£0.15	BFY51	£0.20	MPSA66	£0.40	1N914	£0.07
2N3906	£0.20	BC126	£0.15	BFY52	£0.20	MPSU05	£0.50	1N916	£0.07
2N4062	£0.11	BC182	£0.10	CA3046	£0.70	SBA750A	£1.90	1S920	£0.10
2N4302	£0.60	BC212	£0.12	LP1186	£6.50	SL301	£1.30		
2N5087	£0.25	BC182L	£0.10	MC1310	£2.20	SL3045	£1.20	FILTERS	
2N5210	£0.25	BC184L	£0.11	MC1351	£1.05	SN72741P	£0.40	FM4	£1.00
2N5457	£0.45	BC212L	£0.12	MC1741CG	£0.65	SN72748P	£0.40	SF.10 /MA	£1.50
2N5459	£0.45	BC214L	£0.14	MFC4010	£0.95	TIL209	£0.20		
2N5461	£0.50	BCY72	£0.13	MJ481	£1.20	TIP29A	£0.40		
2N5830	£0.35	BD529	£0.55	MJ491	£1.45	TIP30A	£0.45		

EXPORT NO PROBLEM

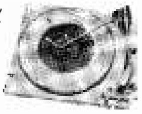
Our Export Department will be pleased to advise on postal costs to any country in the world Some of the countries to which we sent kits in 1976 are shown surrounding this advertisement

Sierra Leone Jamaica Holland Kenya Malta Windward Isles Austria Czechoslovakia South Africa Finland Nigeria Luxembourg

Tunisia Germany Nauru Hong Kong Australia Eire Gambia Denmark France Muscat & Oman

RETURN OF POST MAIL ORDER SERVICE

BSR HI-FI AUTOCHANGER
STEREO AND MONO £11.95 Post 75p
Plays 12", 10" or 7" records. Auto or Manual. A high quality unit backed by BSR reliability with 12 months' guarantee. A.C. 200/250V. Size 13½-11¼in. 3 speeds. Above motor board 3¾in. Below motor board 2½in. with STEREO and MONO CARTRIDGE

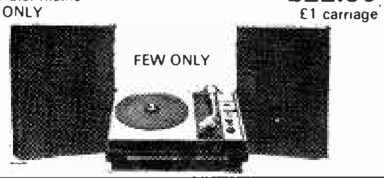


B.S.R. SINGLE PLAYER similar to above with stereo cartridge and cueing device, large turntable **£13.50**
B.S.R. P128 with magnetic cartridge. Balanced arm cueing device **£23.50.**

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

HEAVY METAL PLINTHS
With P.V.C. Cover. Cut out for most B S R or Garrard decks Silver grey finish. **£6.50** Post £1 50
Model "A" Size 12½ x 14¾ x 7½in.
Model "B" Size 16 x 13¾ x 7in. **£7.50.**
Extra large plinth & cover, teak wood base. Size 20"x 17½"x 9" **£19.50. Callers only.**

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



SPECIAL OFFER!
SMITH'S CLOCKWORK 15 AMP TIME SWITCH
0—60 MINUTES £2.95 Post 35p
Single pole two-way Surface mounting with fixing screws. Will replace existing wall switch to give light for return home, garage, automatic anti-burglar lights, etc. Variable knob. Turn on or off at full or intermediate settings. Brand new and fully guaranteed.
0-6 Hour version—**£3.30**

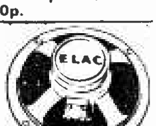
TEAKWOOD LOUDSPEAKER GRILLES will easily fit to baffle board. Size 10½ x 7⅞in—**45p.**

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

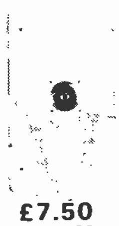
VOLUME CONTROLS
5kΩ to 2MΩ. LOG or LIN. L/S **35p.** D P **60p.** STEREO L/S **85p.** D.P. **£1.** Edge 5K. S.P. Transistor **30p.**

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

ELAC HI-FI SPEAKER 8in. TWIN CONE
Dual cone plasticised roll surround Large ceramic magnet. 50-16,000 c/s Bass resonance 55 c/s. 8 ohm impedance, 10 watts, music power. **£3.95** Post 35p



E.M.I. 13½ x 8in. SPEAKER SALE!
With tweeter and crossover. 10 watt. State 3 or 8 ohm. As illustrated. **£5.95** Post 45p
Ditto 15 watts. 8 or 15 ohm **£8.50** Post 65p



With tweeter and cross-over. 20 watt. Bass res. 25 c.p.s. Flux=11,000 gauss. 8 or 15 ohm. 20 to 20,000 c p s **£9.50** Post 75p

Bookshelf Cabinet **£7.50**
Teak finish. For EMI 13 x 8 speakers Post £1.00

THE "INSTANT" BULK TAPE ERASER AND HEAD DEMAGNETISER. Suitable for cassettes, and all sizes of tape reels. A C. mains 200/250V. Leaflet S A E. Will also demagnetise small tools. **£4.50** Post 50p

BLANK ALUMINIUM CHASSIS. 6 x 4—**70p;** 8 x 6—**90p;** 10 x 7—**£1.15;** 12 x 8—**£1.35;** 14 x 9—**£1.50;** 16 x 6—**£1.45;** 16 x 10—**£1.70. ANGLE ALI.** 6 x ¾ x ¾in—**15p.**
ALUMINIUM PANELS. 6 x 4—**17p;** 8 x 6—**24p;** 14 x 3—**25p;** 10 x 7—**35p;** 12 x 8—**43p;** 12 x 5—**30p;** 16 x 6—**43p;** 14 x 9—**52p;** 12 x 12—**68p;** 16 x 10—**75p.**
MANY ALI BOXES IN STOCK. MANY SIZES

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

R.C.S. LOW VOLTAGE STABILISED POWER PACK KITS
All parts and instructions with Zener diode, printed circuit rectifiers and double wound mains transformer Input 200/240V a.c Output voltages available, 6 or 7.5 or 9 or 12V d.c. up to 100mA or less Size 3 x 2½ x 1½in. Please state voltage required. **£2.95** Post 45p

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

R.C.S. GENERAL PURPOSE TRANSISTOR PRE-AMPLIFIER — BRITISH MADE
Ideal for Mike, Tape, P U, Guitar, etc Can be used with battery 9-12V or H T. line 200-300V d.c. operation. Size 1¾ x 1¼ x ¾in. Response 25 c/s to 25 kc/s. 26 dB gain For use with valve or transistor equipment. **£1.45**
Full instructions supplied. Details S.A.E. Post 30p

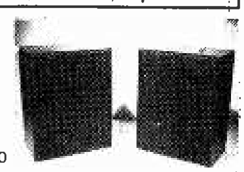
ELECTRO MAGNETIC PENDULUM MECHANISM
1.5V d.c. operation over 300 hours continuous on SP2 battery, fully adjustable swing and speed. Ideal displays, teaching electro magnetism or for metronome, strobe, etc. **95p** Post 30p

MAINS TRANSFORMERS
ALL POST 50p

250-0-250V 70mA, 6 5V, 2A	£3.45
250-0-250 80mA, 6 3V 3 5A, 6.3V 1A or 5V 2A	£4.60
350-0-350 80mA, 6 3V 3.5A, 6.3V 1A or 5V 2A	£5.80
300-0-300V 120mA, 6.3V 4A C.T ; 6.3V 2A	£7.00
MIDGET 220V 45mA, 6.3V 2A	£1.75
HEATED TRANS. 6.3V ½ amp £1; 3 amp	£1.40

GENERAL PURPOSE LOW VOLTAGE Tapped outputs at 2 amp 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 25 and 30V **£4.60.** 1 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 **£4.60.** 2 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 **£7.** 3 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 **£8.70.** 5 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 **£11.25.** 6.06V 500mA **£1,** 9V 1 amp. **£1,** 12V 300mA, **£1,** 12V 500mA, **£1,** 12V 750mA, **£1,** 10V, 30V, 40V, 2 amp., **£2.75,** 20V, 3 amp., **£2.45,** 40V, 2 amp., **£2.95,** 30V 5A and 34V 2ACT **£3.45,** 16V, 2 amp., **£2.20,** 0, 5, 8, 10, 16V, ½ amp., **£1.95,** 20V ½ amp., **£1.75,** 20V, 1 amp., **£2.20,** 20V 3 amp., **£2.50,** 20-0-20V 1 amp., **£2.95,** 30V 1½ amp., **£2.75;** 20V, 40V, 60V or 20-0-20V, 1 amp, **£3.50.**
AUTO TRANSFORMERS, 115V to 230V or 230V to 115V 150W **£5;** 250W **£6;** 400W **£7;** 500W **£8.**
FULL WAVE BRIDGE CHARGER RECTIFIERS.
6 or 12V outputs, 1½ amp **40p;** 2 amp **55p;** 4 amp **85p.**
CHARGER TRANSFORMERS 1½ amp **£2.75;** 4 amp **£4.60.**
12V. 1½A HALF WAVE Selenium Rectifier, **25p.**

R.C.S. BOOKSHELF SPEAKERS
Size 14½in. x 9¾in. x 6in
50 to 14,000 cps
8 watts rms 8 or 4 ohms
£16 pair Post £1.30



KUBA-KOPENHAGEN STEREO

TUNER-AMPLIFIER CHASSIS AM-FM 5+5 WATT
This Continental 4-band radiogram chassis uses first class quality components throughout. Features. Large facia panel with 7 push buttons for medium, long, short, VHF-FM, AFC, phono, mains on-off. 4-rotary controls, tuning, volume, tone, balance Facia size 17 × 4½ inches. Chassis size 17 × 4½ × 5½ inches DIN-connector sockets for tape record/playback, loudspeakers, phono pick-up, external FM-AM aerials Automatic stereo beacon light. Built-in ferrite rod aerial for medium/longwave A C 240V mains. Circuit supplied Above speakers are suitable **£33.50** Post £1 50

LOW VOLTAGE ELECTROLYTICS
1, 2, 4, 5, 8, 16, 25, 30, 50, 100, 200mF 15V **10p.**
500mF 12V **15p;** 25V **20p;** 50V **30p.**
1000mF 12V **17p;** 25V **35p;** 50V **47p;** 100V **70p.**
2000mF 6V **25p;** 25V **42p;** 50V **57p.**
2500mF 50V **62p;** 3000mF 25V **47p;** 50V **65p.**
3900mF 100V **£1.60.**
4700mF 63V **£1.20.**
5000mF 6V **25p;** 12V **42p;** 25V **75p;** 35V **85p.**

SHORT WAVE 100pF air spaced gangable tuner. **95p.**
TRIMMERS 10pF, 30pF, 50pF, **5p.** 100pF, 150pF, **15p.**
CERAMIC, 1pF to 0 01mF, **5p.** Silver Mica 2 to 5000pF, **5p.**
PAPER 350V-0 1 **7p;** 0.5 **13p;** 1mF 150V **15p;** 2mF 150V **15p;** 500V-0.001 to 0.05 **5p;** 0 1 **10p;** 0.25 **13p;** 0 47 **25p.**
MICRO SWITCH SINGLE POLE CHANGEOVER 20p.
SUB-MIN MICRO SWITCH, 25p. Single pole change over
TWIN GANG, 385 + 385pF **50p;** 500pF standard **75p;** 365 + 365 + 25 + 25pF, Slow motion drive **65p.**
120pF **TWIN GANG, 50p;** 365pF **TWIN GANG, 50p.**
NEON PANEL INDICATORS 250V. Amber or red **30p.**
RESISTORS. ¼W, ½W 1W 20% **2p;** 2W, **10p;** 10Ω to 10M.
HIGH STABILITY. ½W 2% 10 ohms to 6 meg , **12p.**
Ditto 5% Preferred values 10 ohms to 10 meg , **5p.**
WIRE-WOUND RESISTORS 5 watt. 10 watt, 15 watt, 10 ohms to 100K **12p** each
TAG STRIP 28-way **12p.**
TAPE OSCILLATOR COIL. Valve type. **35p.**
BRIDGE RECTIFIER 200V PIV ½ amp **50p.**
TOGGLE SWITCHES S P. **20p.** D.P.S T **25p.** D P D T **30p.**
MANY OTHER TOGGLES IN STOCK
PICK-UP CARTRIDGES ACOS GP91 **£1.50.** GP93 **£2.50.**
SONOTONE stereo **£2.00.**

BAKER MAJOR 12" £14.95
Post £1.00

30-14 500 c/s. 12in double cone woofer and tweeter cone together with a BAKER ceramic magnet assembly having a flux density of 14,000 gauss and a total flux of 145,000 Maxwells Bass resonance 40 c/s Rated 25W NOTE 4 or 8 or 16 ohms must be stated
Module kit. 30-17,000 c/s with tweeter crossover baffle and instructions. **£18.95** Post £1 60p each
Please state 3 or 8 or 15 ohms

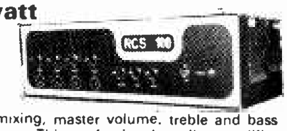
BAKER "BIG-SOUND" SPEAKERS. Post £1.00 each

'Group 25'	'Group 35'	'Group 50/15'
12in 30W **£11.95**	12in 40W **£13.95**	15in 75W **£24.95**
4 or 8 or 16 ohm	4 or 8 or 16 ohm	8 or 16 ohm

BAKER LOUDSPEAKER, 12 INCH. 60 WATT.
GROUP 50/12, 8 OR 15 OHM HIGH POWER
FULL RANGE PROFESSIONAL QUALITY
RESPONSE 30-16 000 CPS **£20.95**
MASSIVE CERAMIC MAGNET WITH Post £1 60
ALUMINIUM PRESENCE CENTRE DOME

TEAK VENEERED HI-FI SPEAKERS AND CABINETS
For 12in or 10in speaker 20x13x12in. **£14.50** Post £2
For 13x8in. or 8in speaker **£7.50** Post £1
For 8x5in speaker 12x8x6in **£5.80** Post 75p

R.C.S. 100 watt VALVE AMPLIFIER CHASSIS

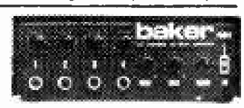


Four inputs Four way mixing, master volume, treble and bass controls. Suits all speakers. This professional quality amplifier chassis is suitable for all groups, disco, P.A , where high quality power is required. 5 speaker outputs. A/C mains operated. Slave output socket. Produced by demand for a quality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

SPEAKER COVERING MATERIALS. Samples Large S.A.E.
LOUDSPEAKER CABINET WADDING 18in. wide **20p** ft.
Horn Tweeters 2-16kc/s, 10W 8 ohm or 15 ohm **£3.60**
De Luxe Horn Tweeters 3-18kc/s, 30W, 8 ohm, **£7.50.**
CROSSOVERS. TWO-WAY 3000 c/s 3 or 8 or 15 ohm **£1.90.** 3-way 950 cps/3000 cps, **£2.20.**
LOUDSPEAKERS P.M. 3 OHM 7x4in. **£1.50;** 6½in , **£1.80;** 8x5in , **£1.90;** 8in , **£1.95.**
SPECIAL OFFER: 80 ohm, 2¼in., 2¾in., 35 ohm, 3in., 25 ohm, 2½in , 3in , 5x3in., 7x4in., 8 ohm, 2½in , 3in., 3½in., 5in , 15 ohm, 3½in dia. 6x4in., 7x4in., 5x3in., 3 ohm , 2½in., 2⅝in., 3½in., 5in. dia. **£1.25 each.**
PHILIPS LOUDSPEAKER, 8in., 4 ohms, 4 watts, **£1.95**
RICHARD ALLAN TWIN CONE LOUDSPEAKERS
8in. diameter 4W **£2.50.** 10in. diameter 5W **£2.95;** 12in. diameter 6W **£3.50.** 3/8/15 ohms, please state
PIEZO ELECTRIC HORN TWEETER. Handles up to 100 watts. No crossover required. **£10.95.**

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

BAKER 150 WATT PROFESSIONAL MIXER AMPLIFIER



All purpose transistorised. Ideal for Groups, Disco and P.A. 4 inputs speech and music. 4 way mixing Output 4 8/15 ohms. a.c Mains Separate treble and bass controls Master volume control Guaranteed Details S.A E. **£68** £1 50 carr
NEW MODEL MAJOR—50 watt, 4 input, 2 vol Treble and bass Ideal disco amplifier **£49** Carr £1

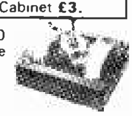
100 WATT DISCO AMPLIFIER CHASSIS
volume, treble, bass controls. 500 M V. or 1 volt input. Four loudspeaker outputs 4 to 16 ohm. All transistor **£52**

BARGAIN 4 CHANNEL TRANSISTOR MONO MIXER
Add musical highlights and sound effects to recordings Will mix Microphone, records, tape and tuner with separate controls into single output. 9V. **£5.95**
TWO STEREO CHANNEL VERSION **£7.50**
BARGAIN 3 WATT AMPLIFIER. 4 Transistor Push-Pull Ready Built, with volume, Treble and bass controls 18 volt d c **£3.95** Mains Power Pack **£3.45**

ALUMINIUM HEAT SINKS. Finned type Sizes 6½" × 4½" × 2¼" **95p.** 6½" × 2" × 2¼" **65p.**
BALANCED TWIN RIBBON FEEDER 300 ohms. 5p yd.
JACK SOCKET Std. open-circuit 20p, closed circuit 25p; Chrome Lead-Socket 45p. Mono or Stereo.
Phono Plugs 8p. Phono Socket 8p.
JACK PLUGS Std. Chrome 30p; Plastic 25p; 3.5mm 15p.
STEREO JACK PLUG 30p. SOCKET 25p.
DIN SOCKETS Chassis 3-pin 10p. 5-pin 10p.
DIN SOCKETS FREE 3-pin 25p; 5-pin 25p. DIN PLUGS 3-pin 25p; 5-pin 25p. VALVE HOLDERS, 10p; CANS 10p.

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

E.M.I. TAPE MOTORS. 240V a.c. 1,200 r p.m. 4 pole Spindle 0 187x0 75in Size 3¼ x 2½ x 2¼in **£2.** Post 50p
Collaro gram motor 120V **75p.**
E M.I. gram motor 240V **£1.25.**



RADIO COMPONENT SPECIALISTS
337 WHITEHORSE ROAD, CROYDON
Open 9-6. Wed. 9-1. Sat. 9-5 (Closed for lunch 1.15-2.30)

Radio Books and Components Lists 10p. (Minimum posting charge 30p.) All prices include VAT. (We accept Access or Barclaycard. Phone your Order) **Tel. 01-684 1665**

TRANSISTORISED 3cm RADAR AMPLIFIER SWITCH: with 24v waveguide switch, .9 x .4 cm ins. with crystal CV.2355 and spark gap VX.1046. **£16.20** + £1.00 post.

TRANSISTORISED VIDEO INDICATOR (used with above amplifier): 1½" C.R.T. **£10.80** + £1.00 post.

RADAR RECEIVING ANTENNA TYPE X443 Mk. D: Suitable for detecting signals on X, K, J and Q bands. 9gHz-60gHz. Complete with waveguide horns, associated crystals. Transistorised amplifier and geared motor, etc. **£135.00**, carr. approx. £5.00.

DIODES: CD.384 — **£2.00** per 100 + 20p post.

VACUUM & PRESSURE SEAL TEST EQUIPMENT: Complete with 3 x 4" gauges indicating 0-20lbs p.s.i., 0-30lbs vacuum. With stand, hand pump, etc., **£32.40** + £3.00 carr.

ASHCROFT DEADWEIGHT GAUGE TEST SET TYPE 1300: 0-25lbs **£64.80** + £3.00 carr.

E.A.L. ANALOGUE DIGITAL CONVERTER TYPE MPD. 120-0: 7-bit or 8-bit mode. **£70.00**, carr. £2.00.

PAIGNTON dB SWITCH: High quality instrument stud switch. 20-way, 2-pole. Dial marked 0-60dB. As new. **£3.78** + 60p post.

UNISELECTORS: Reversible action. Twin coils 120Ω 25-way 6-Bank. **£4.90** + 75p post.

FAMOUS 1154 TRANSMITTER as used in Lancasters in World War II (collector's item). **£12.50**, carr. £4.00.

RACAL RA-17 RECEIVER 50kHz-30mHz, s/hand, good condition. **£365.00** (including VAT 12½%).

CT.316 SOLARTRON OSCILLOSCOPE (CD-518): 3" tybe, d.c.-5mHz calibration marker 1mHz and 100kHz. 230v a.c. single beam. Excellent condition. **£35.00**, carr. £2.50.

EVERSHED SAFETY OHM METER: Max 10mA. Test pressure 30v. Complete in leather case. **£27.00**, post £1.00.

AVO TRANSISTOR ANALYSER CT.446: £37.80, carr. £2.20.

ADVANCE TCD.40 FREQUENCY DIVIDER: 0-40mHz. **£10.80** + £1.00 post.

MARCONI FREQUENCY METER 1026/4: 2000-4000mHz 'as new' condition **£32.40** or secondhand condition **£24.30.**

1026/2: 0-100mHz **£32.40** 'as new' or s/hand **£24.30.** Carriage for all type £2.00.

ANTENNA MAST 36ft: Aluminium, diameter at base 3", tapering to 2" at top, complete with red hazard lights, stays, guys, etc. Normally used with direction finding equipment. Approx. weight 3cwt. **£106.90** (including 12½% VAT), carriage rates on request. WITH rotating Antenna suitable for 200-400mHz **£16.90** extra (including 12½% VAT).

BURGLAR ALARM BELL: 6-8v. d.c. **£3.24** + £1.00 post.

MEGGER (Record): 500 volts **£21.60** £1.00 post.

R-216 RECEIVER MANUAL (Photostat copy): £1.50 inc. post.

MUIRHEAD ATTENUATORS: 75 ohms 0-8Mc/s 3V MAK 3 ranges 0-5, 0-25, 0-50dB. **£3.24** + 75p post.

POWER UNIT TYPE 234: 200-250v. a.c. input. 250-0-250v. d.c. at 100mA and 6 3v at 4 amps output. **£8.10**, carr. £2.50.

REDIFON TELEPRINTER RELAY UNIT NO. 12: ZA-41196 and power supply 200-250v. a.c. Polarised relay type 3SEITR 80-0-80v. 25mA. Two stabilised valves CV-286 Centre Zero Meter 10-0-10. Size 8" x 8" x 8". New condition. **£10.80**, carr. £2.50.

SOLARTRON PULSE GENERATOR TYPE G1101-2: £81.00, carr. £2.50.

TELEPRINTER TYPE 7B: Pageprinter 24v. d.c. power supply, speed 50 bauds per min. S/hand cond. (excellent order), no parts broken **£21.60**, carriage £3.50.

AUTO TRANSFORMER: 230v. 50c/s, 1000 watts. Mounted in strong steel case 5" x 6½" x 7". Bitumen impregnated. **£12.96**, carr. £2.00.

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FREQUENCY METER BC-221: 125-20,000kc/s complete with original calibration charts. Checked out, working order. **£22.70** + £2.00 carr.

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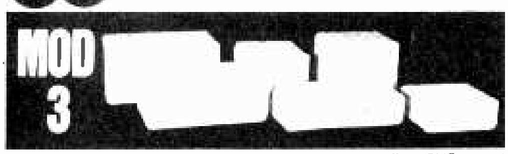
WEST HYDE — **Instrument cases** — **WEST HYDE**



Offer instrument manufacturers low cost cases ex stock. Blue PVC coated steel strength and rigidity. PVC aluminium grey front and rear panels are removable. PCB and PSU mounting system available. Also available in black, 301 price of 302, Bk 302 303, Bk 304 305

All dimensions are Width x Height x Depth

PRICES 1 off inc P & P but not VAT

MOD 3 (including chassis)		
301	7x3 x5¼	6.32
302	7x4½x5¼	6.78
303	7x6 x5¼	8.65
304	11x3 x5¼	7.78
305	11x4½x5¼	9.18
306	11x6 x5¼	10.98
CONTIL TEXTURED		
755	7x5x5'	8.77
867	8x7x6	10.42
975	9x5x7	10.42
1277	12x7x7'	12.01
1277	unpainted	8.92
16127	16x7x12	16.55
191010	19x10x10'	22.72
ELF CASES Grey (inc chassis)		
Elf	6x4x4	3.20
Bare Elf	(less ft ch pnl)	2.15
Giant Elf	8x5½x5'	4.50
Long Elf	9x4x3	3.60
Jumbo Elf	10¾x5¼x5⅛"	5.40
MOD 2 CASES (including chassis)		
A	4 5x 3x 6 5	6.65
B	4 5x 7x 6 5"	7.72

C	4 5x10x 6 5	9.44
D	9 x 3x 6 5	9.44
E	9 x 7x 6 5'	10.45
F	9 x10x 6 5	12.32
G	13 x 3x 6 5	10.45
H	13 x 7x 6 5'	12.32
I	13 x10x 6 5	13.91
J	18 x 3x 6 5	12.32
K	18 x 7x 6 5	16.97
L	18 x10x 6 5'	20.96
M	4 5x 3x13	7.72
N	4 5x 7x13	10.45
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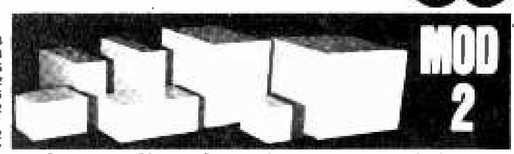
P	9 x 3x13	10.45
Q	9 x 7x13	13.91
R	9 x10x13	16.97
S	13 x 3x13	13.91
T	13 x 7x13	16.97
U	13 x10x13'	20.96
V	18 x 3x13	16.97
W	18 x 7x13	20.96
X	18 x10x13	24.62

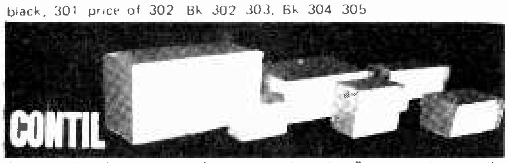
Please check with us prices are correct

Mod 2 in Woodgrain or Black finish in sizes A-L & N

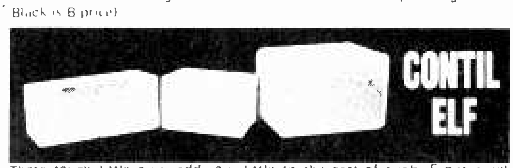
Prices as for one price up on Mod 2, e g Mod 2A Woodgrain or Black is as Mod 2B



Mod 2 cases over 24 sizes. Front and back panels grey PVC. Aluminium chassis included. Packed flat. Outer casing blue PVC steel or up to size L also available in wood grain and black. (Price as for next price higher ie A Black is B price)



A range of eyebrow cases in blue textured acrylic. Front panels normally white zintec or PVC aluminium, also available unpainted up to 1277 size. Aluminium panels 20p extra up to 16127 only



These tough little cases add very little to the cost of a job. Front panel aluminium with protective coat. Elf cases are available in 4 sizes, all dough moulded in grey glass polyester, all panels, feet and chassis included

All West Hyde cases are available with substantial discounts for quantities. Most cases have discounts at 5 off and 25 off with discounts up to 25 at 100 off. Prices include P & P and are less 10 if collected, on first three price breaks on cases only

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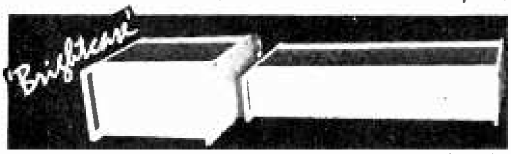
Instrument cases



A prestige anodised case, black PVC steel top and bottom which can be supplied louvred at no extra cost. Free standing or rack mounting available in rack or half width assembled in special polystyrene pack for safe postage

BRIGHTCASE MARK II		
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BC222 (3	Half Rack)	15.84
BC312 (5¼	Full Rack)	24.04
BC322 (5¼	Half Rack)	17.72
Rack Brackets available		
No extra for Louvres add L		
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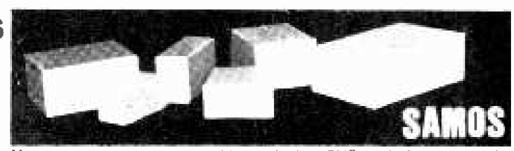
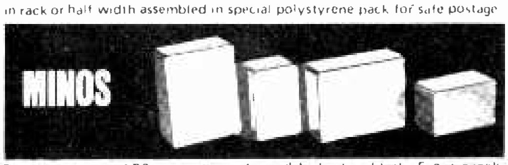
M2	65x100x50mm	.70
M3	100x130x50mm	.89
M2	Bare	.46
M3	Bare	.52

SAMOS		
S1	100x 50x50mm	1.36
S2	100x100x50mm	1.56
S3	100x150x50mm	1.73
S4	125x 50x75mm	1.95
S5	125x100x75mm	2.24
S6	125x150x75mm	2.62
S7	125x200x75mm	2.91
HEAVY DUTY CASE		
	8x 8x5	14.89
	10x10x7	16.54
	12x10x7	20.95



Miniature instrument cases in blue and white PVC steel. Assemble in the lower half clip in feet, 2 screws allow the cover to hinge off cases, 2 more to fix. PC feet are available to hold up to 4 PC boards horizontally in case



Smart miniature ABS cases in tough rigid high gloss black. Front panels either alu or PVC steel. Built in slots for PC cards dividers etc. Chassis or PC boards can be supported on 'P' clips from internal pillars

OVER 400 DIFFERENT CASES IN STOCK—SIZE RANGE OVER 5000:1 IN VOLUME

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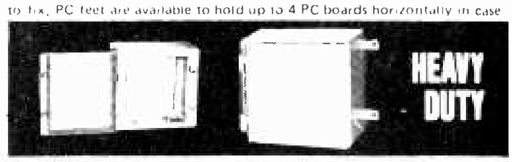

Available in 3 sizes. Heavily constructed in zintec steel, welded corners with heavy hinges, 2 screw fixings and foam round the door. In the base is a gland plate with gasket and a chassis with screws provided

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AC128	0.16	BC169	0.12*	BD135	0.36*	BFX30	0.30	OC139	1.30	2N3707	0.10*
AC128K	0.25	BC169C	0.14*	BD136	0.39*	BFX84	0.23	OC140	1.30	2N3708	0.09*
AC141	0.22	BC170B	0.12*	BD137	0.40*	BFX85	0.25	OC170	0.23	2N3709	0.09*
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AF114	0.20	BC212L	0.12*	BD410	0.60	BFY64	0.35	2N1131	0.15	2N4290	0.14*
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AF124	0.25	BC237	0.16*	BDY38	0.60	BSX21	0.20	2N1305	0.45	2N4870	0.35*
AF125	0.25	BC238	0.16*	BDY60	1.70	BSX76	0.30	2N1306	0.50	2N4871	0.35*
AF126	0.25	BC300	0.34	BDY61	1.65	BSX77	0.30	2N1307	0.50	2N4918	0.60*
AF139	0.35	BC301	0.32	BDY62	1.15	BSX78	0.35	2N1308	0.60	2N4919	0.70*
AF239	0.37	BC302	0.40	BDY95	2.14	BSY52	0.28	2N1309	0.60	2N4920	0.50*
AL102	1.45	BC303	0.46	BDY96	4.96	BSY53	0.39	2N1711	0.24	2N4922	0.58*
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BC108B	0.09	BC321	0.18*	BF181	0.30	BU105/02	1.90*	2N2711	0.20		
BC109	0.09	BC323	1.60*	BF182	0.30	BU108	3.00*	2N2712	0.15		
BC109B	0.09	BC327	0.18*	BF183	0.30	BU109	2.50*	2N2904A	0.20		
BC109C	0.12	BC328	0.16*	BF184	0.20	BU126	1.60*	2N2905	0.18		
BC117	0.19*	BC337	0.17*	BF185	0.20	BU133	1.60*	2N2905A	0.22		
BC119	0.25	BC338	0.17*	BF194	0.10*	BU204	1.60*	2N2906	0.18		
BC125	0.18*	BC407	0.22*	BF196	0.12*	BU205	1.90*	2N2925	0.14*		
BC126	0.20*	BC408	0.22*	BF197	0.12*	BU206	2.40*	2N2926O	0.09*		
BC140	0.32	BCY30	0.55	BF200	0.40	BU208	2.60*	2N2926R	0.10*		
BC141	0.28	BCY31	0.55	BF218	0.30	MJ480	0.80	2N2926Y	0.09*		
BC142	0.23	BCY32	0.60	BF219	0.30	MJ481	1.05	2N2926G	0.10*		
BC143	0.23	BCY33	0.55	BF220	0.28	MJ490	0.90	2N3053	0.20		
BC144	0.30	BCY34	0.55	BF224J	0.18*	MJ491	1.15	2N3055	0.50		
BC147	0.09*	BCY38	0.50	BF244	0.17*	MJE340	0.40*	2N3133	0.30		
BC148	0.09*	BCY39	1.15	BF257	0.30	MJE520	0.45	2N3134	0.30		
BC149	0.09*	BCY40	0.75	BF258	0.35	MJE521	0.55	2N3137	1.10		
BC152	0.25*	BCY42	0.30	BF259	0.48	OC43	0.95	2N3440	0.56		
BC153	0.18*	BCY54	1.60	BF336	0.35*	OC44	0.32	2N3442	1.20		
BC157	0.09*	BCY70	0.12	BF337	0.32*	OC45	0.32	2N3570	3.60		
BC158	0.09*	BCY71	0.18	BF338	0.45*	OC46	0.20	2N3702	0.10*		
BC159	0.09*	BCY72	0.12	BFW30	1.25	OC70	0.30	2N3703	0.10*		
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7412	0.25	7495	0.67
7413	0.25	7496	0.82
7414	0.72	74100	1.07
7417	0.43	74107	0.35
7420	0.16	74121	0.34
7425	0.30	74122	0.47
7427	0.48	74123	0.40
7430	0.16	74141	0.78
7432	0.37	74145	0.68
7437	0.35	74154	1.62
7441AN	0.76	74164	0.93
7442	0.65	74165	0.93
7445	1.50	74174	1.00
7447AN	0.81	74175	0.94
7448	0.81	74180	1.06
7470	0.32	74181	3.20
7472	0.26	74191	1.33
7473	0.30	74192	1.35
7474	0.32	74193	1.35
7475	0.47	74194	1.20
7476	0.36	74196	1.6?

LINEAR I.C.s

301A	0.40*	MC1310P	1.18*
307	0.55*	MC1351P	0.75*
380	0.90*	MC1352P	0.75*
381	1.60*	MC1353P	0.75
3900	0.70*	MC1458P	0.77
709	0.27	MC1496L	0.82*
741	0.28	TAA300	1.61
748	0.35	TAA310A	1.38
NE555	0.45	TAA550	0.45*
NE565	2.00*	TAA611B12	1.25*
NE566	1.50*		
NE567	2.00*	TAA861	0.65
CA3045	0.85*	TBA530	1.85*
CA3046	0.50*	TBA530Q	1.90*
CA3130	0.79	TBA560	2.80*
MC1303L	0.55*	TBA570	0.98
MC1304P	1.60*	TCA270SQ	1.95*
MC1307P	0.85*		

THYRISTORS

PIV	1A (T05)	3A (Stud)	A (C106)	4A (T0220)	6A (T0220)	8A (T0220)	10A (T0220)	15A (T048)
200	0.35	0.50	0.45	0.40	0.58	0.60	0.68	1.14
400	0.40	0.60	0.50	0.45	0.88	0.88	0.98	1.40
600	0.65	0.85	0.70	—	1.09	1.19	1.26	1.80

BT106 £1.00 BT107 £1.60 BT108 £1.60 BT109 £1.00 BT116 £1.00 2N3525 £0.50

TRIACS — Plastic TO-220 Package Isolated Tab

	4A		6.5A		8.5A		10A		15A	
	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
100V	0.60	0.60	0.70	0.70	0.78	0.78	0.83	0.83	1.01	1.01
200V	0.64	0.64	0.75	0.75	0.87	0.87	0.97	1.01	1.17	1.17
400V	0.77	0.78	0.80	0.83	0.97	1.01	1.13	1.19	1.70	1.74
600V	0.96	0.99	1.01	1.10	1.21	1.26	1.42	1.50	2.11	2.17

N.B. Column (a) without internal trigger (b) with internal trigger

★ ★ ★ SPECIAL OFFER SECTION ★ ★ ★

SG309K £1.25
NPN TO-3 POWER TRANSISTORS
Fully tested but unmarked. Similar to 2N3055 except BVCEO = 50+ HFE (gain) = 20+ at 3A VCE SAT<1.3V at 3A
5 pcs £1.00
25 pcs £4.00
50 pcs £7.50
100 pcs £13.00

TIL209 Red Led 0.12
ITT BRANDED TRANSISTORS
Medium Voltage High Gain Type BSY65
Similar to BC107/8/9
25 pcs £1.20
100 pcs £3.50
TO-3 HARDWARE
Mica Washers, Solder tag, Nuts, Bolts.
50 sets for 65p

OCP 71 £1.15
RECTIFIERS DO-4 PACKAGE
10A 50V 0.40.
Please specify
10A 100V 0.45.
Polarity
10A 200V 0.50.
Stud Cathode or
10A 400V 0.60.
Stud Anode
Ideal for Power Supplies, Inverters, etc.

★ ★ ★ ★ ★ ★

DIODES

BA145	0.14*
BA148	0.13*
BA155	0.13
BA156	0.12
BA157	0.22
BA158	0.22
BA159	0.25
BY206	0.15
BY207	0.20*

BYX36—
300 0.12
600 0.15
900 0.18
1200 0.21
BYX38—
300 0.50
600 0.55
900 0.60
1200 0.65
BZX61 Series 0.26

BZX83 Series 0.11
BZY88 Series 0.11

OA5	0.50*
OA10	0.40
OA85	0.12
OA90	0.08
OA91	0.08
OA200	0.09
IN914	0.04*
IN4001	0.04*
IN4002	0.05*
IN4003	0.06*
IN4004	0.07*
IN4005	0.08*
IN4006	0.09*
IN4007	0.10*
IN4148	0.04*

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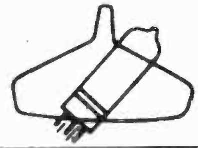

Diodes

Type	Price (p)	Type	Price (p)
BA115	10	OA90	7
BA145	18	OA95	6
BA148	18	OA202	11
BA154	12	IN60/OA91	7
BA155	15	IN914	6
BAX13	6	IN4001	6½
BAX16	10	IN4002	7
BY126	10½	IN4003	8
BY127	12	IN4004	8
BY133	17½	IN4005	9
BY199	25	IN4006	9½
BY206	17	IN4007	10
BYX10	16	IN4148	4½
OA47	8		

Semi Conductors

Type	Price (p)	Type	Price (p)
AC107	25	AF115	27
AC126	20	AF116	27
AC127	20	AF117	27
AC128	15	AF118	65
AC128K	30	AF124	40
AC141	24	AF125	32
AC141K	34	AF126	38
AC142	20	AF127	42
AC142K	36	AF139	45
AC151	28	AF178	69
AC154	18	AF180	69
AC155	18	AF181	69
AC156	28	AF239	45
AC176	22	AF240	20
AC176K	34	AL102	£1.40
AC187	20	AL103	£1.30
AC187K	36	AU107	£1.50
AC188	25	AU110	£1.30
AC188K	38	AU113	£1.30
AC193K	36	BC107	14
AC194K	35	BC107B	16
AD140	69	BC108	14
AD142	75	BC109	14
AD143	65	BC109C	14
AD149	70	BC113	15
AD161	50	BC114	15
AD161/2	£1.00	BC115	17½
AD162	50	BC116	17½
AF114	27	BC116A	30

Semi Conductors

Type	Price (p)	Type	Price (p)
BC117	14	BC237	12
BC118	15	BC238	12
BC119	27	BC301	30
BC125	17½	BC303	30
BC125B	18	BC327	13
BC126	16	BC328	13
BC132	15	BC337	12
BC135	20	BC338	12
BC136	16	BC546	13
BC137	25	BC547	12
BC138	33	BC548	12
BC139	28	BC549	13
BC140	32	BC550	14
BC141	28	BC557	13
BC142	25	BC558	12
BC143	28	BCY72	16
BC147	10	BD115	39
BC147A	11	BD116	65
BC147B	11	BD124	75
BC148	10	BD131/BD233	43
BC149	10	BD132	45
BC153	20	BD133	45
BC154	20	BD135	29
BC157	11	BD136	30
BC158	10	BD137	30
BC159	11	BD138	33
BC160	30	BD139	37
BC161	33	BD140	39
BC171	10	BD144	£1.99
BC172	10	BD160	£1.65
BC173	15	BD181	90
BC178	18	BD182	90
BC178B	20	BD183	80
BC179	24	BD184	£1.10
BC182	11	BD222	50
BC182L	12	BD225	47
BC183L	12	BD232	50
BC184	13	BD233	43
BC186	25	BD234	49
BC187	25	BD235	49
BC204	14	BD236	53
BC212	11	BD237	49
BC212L	12	BD238	55
BC213	12	BDX32	£2.75
BC213L	11	BDY20	80
BC214	13		
BC214L	15		

Semi Conductors

Type	Price (p)	Type	Price (p)
BF115	38	BFX88	25
BF123/T092	25	BFY50	20
BF152	20	BFY51	30
BF158	20	BFY52	20
BF160	35	BFY90	£1.10
BF167	28	BR100	32
BF173	32	BR101	38
BF178	33	BRC4443	80
BF179	38	BRY39	38
BF180	36	BSY52	30
BF181	36	BT106	£1.20
BF182	30	BT108	£1.50
BF183	30	BT116	£1.25
BF184	30	BU105/02	£1.90
BF185	30	BU108	£2.10
BF186	32	BU126	£1.49
BF194	10	BU204	£1.80
BF195	10	BU205	£1.67
BF196	10	BU206	£2.10
BF197	11	BU208/02	£2.75
BF197A/BF597A	17½	BUY69B	£2.50
BF198	30	BUY69A	£2.65
BF199	25	E1222	38
BF200	30	MJE340/BF459	48
BF218	56	MJE520	44
BF224	20	2N696	30
BF240	18	2N706	15
BF241	18	2N3053	20
BF257	28	2N3054	65
BF258	30	2N3055	60
BF259	30	2N3702	12
BF336	37	2N3703	12
BF337	35	2N3704	10
BF338	34	2N3705	10
BF355	50	2N3706	10
BF457	37	2N3819	38
BF458	37	2N5293	52
BF459	48	2N5294	52
BFT42	36	2N5295	52
BFT43	35	2N5296	46½
BFX29	29	2N5297	52
BFX84	29	2N5298/TIP31A	52
BFX85	30	2N5496	53
BFX86	28	OC71	29

Semi Conductors

Type	Price (p)	Type	Price (p)
OC72	38	TIP32A	62
R2008B	£2.10	TIP41A	70
R2010B	£2.10	TIP42A	75
RCA16334	80	TIS91	27
RCA16335	80	2SC1172A	£2.73
S.2802	2.99	2SC643A	£1.48
S.6080A	£4.90	4.43MHZ Crystal	£1.10
TIP31A/2N5298	52		

Integrated Circuits

MC1349	£1.02	SN76660N	66
ML231B	£4.20	SN76666N	£1.10
ML232B	£4.20	TAA550	39
SL414A	£1.68	TAA570	£1.30
SL415A	£2.20	TAA661B	81
SL1310	£1.54	TAA700	£2.56
SL1327	97	TBA120AS	69
SL3046	73	TBA120SQ	£1.14
SL76544	£1.50	TBA440	£3.00
SN76003N	£2.45	TBA480Q	£1.40
SN76013N	£1.65	TBA520Q	£2.06
SN76013ND	£1.40	TBA530Q	£1.30
SN76023N	£1.65	TBA540Q	£2.00
SN76023ND	£1.40	TBA550Q	£2.56
SN76033N	£2.45	TBA560CQ	£2.56
SN76110N	£1.75	TBA750Q	£1.43
SN76226N	£2.20	TBA800	£1.10
SN76227N	£1.65	TBA920Q	£2.64
SN76532N	£1.60	TBA990Q	£2.56
SN76533N	£1.60	TCA270Q	£2.64
SN76544N	£1.80	TCA800	£4.60
SN76650N	£1.50	TDA440	£3.00

Toshiba

Type	Equivalent		Price
TA7050P	CA3044	RCA	£1.13
TA7051P	CA3042	RCA	£1.45
TA7072P	MC1351	Motorola	£1.53
TA7074P	MC1352	Motorola	£1.34
TA7141AP	MC1327	Motorola	£1.40
TA7171P	SAS560S	Siemens	£1.65
TA7172P	SAS570S	Siemens	£1.65
TA7173P	TCA270	Philips	£2.20
TA7176P	CA3065	RCA	£1.30

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

NEW

PUSH-BUTTON STEREO FM TUNER

OUR PRICE ONLY

£20.45

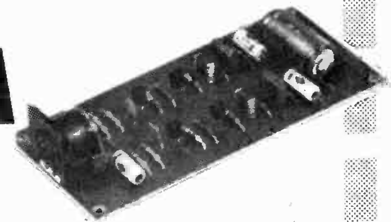
Fitted with Phase Lock-loop Decoder

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

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

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

MPA 30



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

£2.85

VAT ADD 12½%

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

STEREO PRE-AMPLIFIER PA100

OUR PRICE
£13.75

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

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

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

MK. 60 AUDIO KIT: Comprising 2 x AL60's, 1 x SPM80, 1 x BTM80, 1 x PA100, 1 front panel and knobs, 1 Kit of parts to include on/off switch, neon indicator, stereo headphone sockets plus instruction booklet. **COMPLETE PRICE £29.55** plus 85p postage.

TEAK 60 AUDIO KIT:
Comprising Teak veneered cabinet size 16¾"x11½"x3¾", other parts include aluminium chassis, heatsink and front panel bracket plus back panel and appropriate sockets etc. **KIT PRICE £10.70** plus 85p postage.

STEREO 30

COMPLETE AUDIO

7+7 WATTS R.M.S.

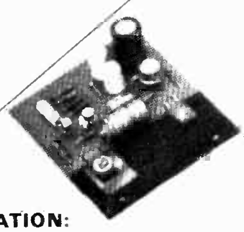
P & P 45p

£16.25

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

TRANSFORMER £2.45 plus 62p p &p
TEAK CASE £5.25 plus 62p p & p

AL-20-30 AUDIO AMPLIFIER MODULES

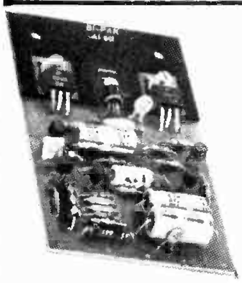


The AL20 and AL30 units are similar in their appearance and in their general specification. However, careful selection of the plastic power devices has resulted in a range of output powers from 5 to 10 watts R.M.S.
The versatility of their design makes them ideal for use in record players, tape recorders, stereo amplifiers and cassette and cartridge tape players in the home.

SPECIFICATION:
- **Harmonic Distortion Po=3 watts f=1KHz 02.5%**
- **Load Impedance 8-16ohm**
- **Size: 75mm x 63mm x 25mm**
- **Frequency response ±3dB Po=2 watts 50Hz 25Hz**
- **Sensitivity for Rated O/P — Vs=25v. RL=8ohm f=1KHz 75mV.RMS**

AL20 5w R.M.S. £2.95 AL30 10w R.M.S. £3.25

AL 60 25 Watts (RMS)



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

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

£4.35

NEW PA12

NEW PA12 Stereo Pre-Amplifier completely redesigned for use with AL 20/30 Amplifier Modules. Features include on/off volume, Balance, Bass and Treble controls. Complete with tape output.

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

£6.70

PS12

Power supply for **AL20/30, PA12, SA450** etc.

Input voltage 15-20v A.C. Output voltage 22-30v D.C. Output current 800 mA Max. Size 60mm x 43mm x 26mm.
Transformer T538 £2.30

OUR PRICE £1.30

Stabilised Power Supply Type SPM80

SPM80 is especially designed to power 2 of the AL60 Amplifiers, up to 15 watts (R.M.S.) per channel simultaneously. With the addition of the Mains Transformer **BMT80**, the unit will provide outputs of up to 1.5A at 35V. Size: 63mm. 105mm. 30mm. Incorporating short circuit protection.
Transformer BMT80
£2.60 + 62p postage

£3.75

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4 Ranges 0-5, 0-10, 0-15, 0-30.
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½ H.P. Motor 110V **£10 ea.**

MARCONI TF675F WIDE RANGE PULSE GENERATOR
+/− variable outputs up to 50V. Optional delay. Small compact unit **£18 ea.**

SPOOLS OF ½" MAG TAPE APPROX. 2000ft
50p ea. P&P £1 ea

AVO VALVE TESTER CT160 "THE SUITCASE"
Size approx. 15" wide x 10" high x 11" deep.
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TEKTRONIX OSCILLOSCOPE Type 561A
Complete with 3BI Time Base &
3AI Dual Trace Amplifier
£375 each

THE HONEYWELL KEYTAPE UNIT
is a multi-channel Keyboard to Magnetic Tape System recording Keyboard entered data on ½" tape in 80 or 120 character records in a form easily usable as a computer input/output and verifier. 240 Volt operation.

From the simple to understand electro mechanical / vacuum system to the +15 −15 +5 Power Supply and hinged wire wrapped card frame, the flexibility and reliability are outstanding, this coupled with the ease of interfacing to a VDU, Mini/Micro computer, etc. make all the Honeywell Keytapes on offer very fine value.

Honeywell Keytape Unit, checked, tested with Manual, **£215 ea.**
As above but less data boards. Tested forward / backward tape movement and control, etc. Data entry / exit via read / write boards. **£105 ea.**
Exactly as above but less keyboard and table. **£80 ea.**
All units carriage paid.
KEYBOARDS also available at **£20 each.** Carr. £2.50.

TEKTRONIX OSCILLOSCOPE Type 506
Complete with 3BI Time Base &
9AI Dual Trace Amplifier **£450 each.**

TEKTRONIX OSCILLOSCOPE Type 585A with type 82 plug-in. **£500.**
RHODE & SCHWARZ GENERATOR BN41022 300-1000MHZ **£185.**
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MARCONI DOUBLE PULSE GENERATOR. TF1400S with TM6600/S **£20.**
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TEKTRONIX 181 Time Marker Generator **£40.**
TELONIC Sweeper 0-200MHZ **£80.**
HEWLETT PACKARD Oscilloscope type 175 DC-50MHZ Double Beam **£180** with delay amplifier **£220.**
GENERAL RADIO PULSE SWEEP & Time Delay Generator type 1391B **£120.**
ROYAL INVERTORS manufactured USA. 28V DC Input. Output 115V AC 400HZ up to 2KVA. Brand new. Crated **£12.50** ea.

SPECTRUM ANALYSER by **NELSON ROSS.** Plug-in for TEKTRONIX 561/506 Oscilloscopes **£225.**

SOLARTRON CD1212 SB 40 meg **£85.** DB24meg twice. **£120.** Many other types available.
Ex-Ministry **OSCILLOSCOPE.** CT436 Double beam DC-6MHZ **£95** each.
★**TELEPHONES.** Post Office style 746. Black or two-tone grey **£6.50** ea. Modern style 706. Black or two-tone grey **£4.50** ea. P&P 75p ea. Old black style **£1.50** ea. P&P 75p.
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MODERN FANS. 4¾ x 4¾ x 1½" 240 Volts. Superbly quiet. 6 Blades **£4.50 ea.** P&P 75p.
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VARIACS 240V input 0-240V output 8A **£18** ea., 20A **£30** ea. Carr. £2.50
E.H.T. TRANSFORMERS 20KV 2KVA **£70** ea. Many other EHT transformers and EHT Capacitors available.
DON'T FORGET YOUR MANUALS. S.A.E. with requirements
TUBE type DB7/36 – Replacement for Telequipment S31 **£11 ea.** P&P £1.50.

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2N5879 with 2N5881 Motorola 150 Watt. Comp. pair **£2** pr. P&P 15p
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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.
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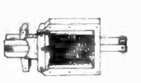
Shaded pole. Open frame 230V 50 Hz. Double ended 5/32" dia spindle, each 1¾" long. Ideal for fans, models, etc. Size 1¾" x 2⅜" x 1⅛" deep plus spindles. **£1.50** p & p 45p.

SOLENOIDS 240V A.C.



MAGNETIC DEVICES LTD No. 1) has 20lb pull for 50% duty. 1½" travel, push or pull. Shackle both ends. Size 1¾" wide x 3⅛" high x 4" long plus 3" arm travel **£6.75** plus p & p £1 00.
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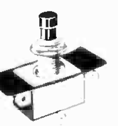

Press on/off. Single hole fixing SP/ST. Size 1⅞" x ⅞". Stud extends ½". Rated 1 amp at 240v 2½ amps at 125v. Price for 5 (min. qty) **£1.75** p & p 30p. 10 or more 30p each p & p 40p.

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Octal base 2 C/O 6 amp contacts. Following voltages 12V a.c. 48V d.c. 110 d.c. 230 a.c. all **£1.25** each plus base **15p** postage and packing 15p. 11-pin 3 C/O 6 amp contacts, following voltages 115 a.c. 48 d.c. 24 d.c. all at **£1.50** each, base **15p** plus 15p p. & p.

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Shaded pole. Open frame 115/230V 50HZ 1425 r.p.m. Size 2½" x 2¾" x 1⅜" deep plus ¾" long x 5/32" spindle. **£3.50** plus p. & p. 62p

SYLVANIA SWITCH

Complete with magnet normally closed. 3 amp vacuum sealed 1¼" x ¼" dia

10 for £2.50
50 for £11.00
100 for £18.00

Plus 50p p. & p. any quantity

NIXIE TUBES

ITT GN4 Red. Standard numerals 0-9. Complete with ceramic base for PCB mounting. 1 08" dia x 1 38" high plus ½" base depth inc. pins. Operating voltage 170v. DC min. Complete data and connections supplied. Brand new **£1.50.** p & p 20p. 10 off £1 00 each. 100 or more 85p each. p & p 40p any quantity.

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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.

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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 3¼" x 4¾". Also bargain at **£12.50.** Carr £2 00.
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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 1¼" 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

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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 10 rpm. Torque 14 5 Kg cm. 5/16" dia shaft. Brand new. Fantastic value at **£16.50,** p. & p. £1 50.
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B. Davis Electronics. Limited quantity only.

Type No.	CPS 40	SPS 5	SPS 7W	SPS 9(1)
Supply	Card Form	Fully encased	Fully encased	Fully encased
Form	logic	logic	op-amp.	logic
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 B C D E F G

Type	Size (Dia.)	Volt/Curr	Type	Size (Dia.)	Volt/Curr
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			

Price Types A-F £4 00 for 25. 50 and upwards **13p** each. Type G **45p** each. p. & p. 20p per order

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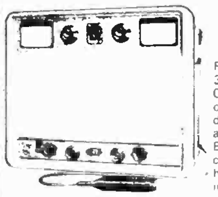

MARCONI TF 867 SIGNAL GENERATOR
Range 15KHz to 30MHz. Output 0 4 V to 4V at 13 or 75 ohms impedance with termination (supplied). Built in crystal check facility with handbook. **£138** including carriage

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HEWLETT-PACKARD

AUDIO GENERATOR MODEL 206-A. Freq 20c to 20,000c matching impedance 50, 150, 600 ohms. Price **£85.00** carriage £4 00

KAHN SSB ADAPTOR TYPE RSSB — 62 — 18. Designed for receivers with 455-500KHz IF at 100mV (max) input. Features electronic AFC carrier freq diversity to combat fading. 20 sce. R.C. memory to maintain tuning during severe fading. Individual carrier meters, nuvishers, IOW distortion production demodulator **£65** carriage £5 00

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RA98A Adaptor for above **£85**

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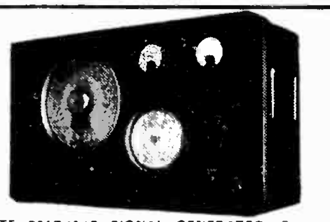

TF 801D/1/S SIGNAL GENERATOR. Range 10-485MHz in 5 ranges. R.F. output 0 1 V-1V. Source C.M. Dial calibrated in volts, decibels and power relative to thermal noise. Piston type attenuator 50Ω output impedance. Internal modulation at 1KHz at up to 90% depth also external sine and pulse modulation. Built in 5MHz crystal calibrator. Separate RF and mod. meters. P.O.A.

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PAMETRADA WAVE ANALYSER TYPE D-489-G. Freq range 19 c/s-21 Kc/s continuously variable in nine ranges 19-90 c/s, 79-150 c/s, 139-210 c/s (x 1, x 10, x 100). Freq accuracy x 1 and x 10 ranges ± 0 3%. Input voltage for full scale deflection of meter 1 mV minimum to 300V maximum. Maximum permissible input is 300V r.m.s.
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Frequency range 10MHz-6Hz. Full spec and price on request

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TF 1370 R.C. OSCILLATOR FOR SQUARE & SINE WAVE. Freq. -31 6V rms 10Hz-1MHz square wave 0-73 2pp 10Hz 100kHz. Attenuator range -50dB to + 10dB impedance 75, 100, 600Ω **£145** carriage £5 00

TF 6600 SECONDARY PULSE UNIT for testing radad nucleonics, scopes, counters, filters, etc.

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RADIOMETER TYPE MS111 SIGNAL GENERATOR. High quality Danish production 10kHz 110MHz **£200** carriage £5 00

REDIFON SSB TRANSISTORISED TRANSCEIVER GR410. 2-16 Mc/s 200 250V 4 channels 100W p.c.p.

TEKTRONIX OSCILLOSCOPES MAIN FRAME ONLY 535A. Bandwidth DC to 15MHz at 3dB depending on plug-in unit. Specification and price on request.
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551. 27MHz DUAL BEAM OSCILLOSCOPE. Accepts multi-trace differential sampling and spectrum analyser plug-in units. Specification and price on request.
PLUG-IN UNIT TYPE CA. For single or dual trace operation, each channel has its own input selector, attenuator, gain and polarity. Price **£65.00,** packing & carriage £1 90

WAYNE KERR NOISE GENERATOR CT 410
A portable instrument for measuring the noise factor of radio receiving equipment, metric radar receivers and radar wide-band i.f. amplifiers in the band 15kHz-160MHz. Output impedance 50 or 75 ohms. A built-in audio power meter has a switched input circuit giving impedances of 10, 15, 6,000 and 20,000 ohms and has a basic range of 10μW to 1W (-20db to +30db to 1W). Price **£85** carriage £5 00

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DIGITAL VOLTMETER. LM1426, LM1420 2BA, LM1420, LM1440 3

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SIGNAL GENERATOR TS. 497/URS 2-5Mz, 13MHz, 30MHz, 78MHz, 180MHz, 400MHz. 0 1v-1μv **£150** carriage £3 00.

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10 LINE MAGNETO SWITCHBOARDS
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RCA ET4336, 2 Mc/s-20Mc/s 350W also modified version of increased output to 700W
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H1 Audio Signal Generator 15Hz-50KHz Sine and Square **£35.00**
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H1E Audio Signal Generator. Sine & Square Wave 15Hz-50KHz, 200μV to 20V (Sine) Distortion 1% 1.4mV to 140V (square). Brand new condition £70.00

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Signal Generator Type 701 30 KHz-30 MHz (2 only) **£75.00**
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**
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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**
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PC88	0.62
PC92	0.55
PC95	0.70
PC97	0.75
PC900	0.40
PCC84	0.39
PCC85	0.47
PCC88	0.61
PCC89	0.49
PCC189	0.52
PCC805	0.75
PCC806	0.70
PCF80	0.40
PCF82	0.45
PCF84	0.70
PCF86	0.57
PCF87	0.77
PCF200	1.20
PCF201	1.00
PCF800	0.77
PCF801	0.49
PCF802	0.54
PCF806	0.53
PCH200	1.00
PCL82	0.40
PCL83	0.49
PCL84	0.46
PCL86	0.54
PCL88	1.29
PCL800	1.00
PCL805/85	0.60
PEN4DD	2.00
PEN25	1.00
PEN45	1.00
PEN45DD	1.00
PEN46	0.60
PEN453DD	2.00
PENA4	1.00
PENDD/4020	1.00
PFL200	0.70
PL33	1.00
PL36	0.60
PL81	0.49
PL81A	0.53
PL82	0.37
PL83	0.45
PL84	0.50
PL302	0.90
PL504/500	0.90
PL505	2.00
PL508	1.10
PL509	2.00
PL801	0.74
PM84	0.75
PY31	0.50
PY33/2	0.50
PY80	0.50
PY81	0.40
PY82	0.40
PY83	0.44

PY88	0.40
PY301	0.50
PY500	1.20
PY500A	1.20
PY800	0.40
PY801	0.40
PZ30	0.50
QP21	1.10
QQV03/10	2.00
QS75/20	1.00
QS95/10	1.00
QS150/15	1.80
QV03/12	1.65
QV04/7	3.00
QV06/20	3.50
R11	1.00
R16	2.00
R17	1.00
R18	1.20
R19	0.75
R20	0.60
R52	0.48
RK34	1.00
SP4	1.50
SP13C	0.75
TH/4B	1.00
TH233	1.00
TP2620	1.00
TP22	1.00
TP25	1.00
UABC80	0.45
UAF42	0.70
UBC41	0.50
UBC81	0.55
UBF80	0.50
UBF89	0.39
UBL21	2.00
UC92	0.50
UCC84	0.90
UCC85	0.45
UCF80	0.80
UCH21	2.00
UCH42	0.71
UCH81	0.45
UCL82	0.45
UCL83	0.57
UF41	0.70
UF42	0.80
UF80	0.40
UF85	0.50
UF89	0.45
UL41	0.70
UL46	0.70
UL84	0.54
UM80	0.60
UR1C	1.00
UU5	1.15
UU9	0.52
UU12	0.40
UY41	0.50
UY42	0.50
UY85	0.35
U10	1.00
U12/14	1.15
U16	1.00
U17	1.00

U18/20	1.80
U19	4.00
U22	0.85
U25	0.71
U26	0.60
U31	0.50
U33	1.75
U35	1.75
U37	2.00
U45	1.20
U47	0.71
U49	0.60
U50	0.55
U52	0.60
U76	0.70
U78	0.45
U81	0.80
U150	0.52
U153	0.40
U191	0.50
U192	0.40
U193	0.40
U251	1.00
U281	0.75
U282	0.70
U291	0.50
U301	0.55
U329	1.00
U339	0.50
U381	0.35
U403	0.90
U404	0.75
U709	0.40
U801	0.80
U4020	0.75
VLS492	9.50
VP2	1.50
VP4(5)	2.00
VP13C	0.60
VP23	0.65
VP41	0.90
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VT61A	0.75
VU111	1.00
VU120	1.00
VU120A	1.00
VU133	1.00
W76	0.50
W81M	1.20
W107	0.75
W719	0.36
W729	1.20
WD709	0.40
XE3	0.60
XFY12	0.60
XH15	0.60
XSG15	1.20
X41	1.00
X61	1.60
X63	1.40
X65	1.60
X66	1.60
X76M	0.75
X119	0.45
X142	0.71
X150	0.71
X719	0.40

Z145	0.67
Z152	0.29
Z329	0.70
Z719	0.29
Z729	0.45
Z749	0.65
Z759	5.85

Transistors and Diodes

1N1124A	0.61
1N4744A	0.16
1N4952	0.58
2N404	0.21
2N966	0.61
2N1756	0.58
2N2147	0.99
2N2297	0.26
2N2369	0.16
2N2613	0.45
2N3053	0.38
2N3121	2.90
2N3703	0.23
2N3709	0.23
2N3866	1.16
2N3988	0.58
2S323	0.58
AA119	0.18
AA120	0.18
AA129	0.18
AAZ13	0.21
AC107	0.18
AC113	0.30
AC114	0.47
AC126	0.14
AC127	0.20
AC128	0.23
AC132	0.23
AC154	0.30
AC156	0.23
AC157	0.30
AC165	0.30
AC166	0.30
AC167	0.69
AC168	0.44
AC169	0.38
AC176	0.64
AC177	0.32
ACY17	0.30
ACY18	0.23
ACY19	0.23
ACY20	0.21
ACY21	0.23
ACY22	0.18
ACY28	0.21
AD140	0.42
AD149	0.58
AD161	0.53
AD162	0.53

AF102	1.04
AF106	0.58
AF114	0.30
AF115	0.30
AF117	0.23
AF121	0.35
AF124	0.36
AF125	0.50
AF139	0.76
AF178	0.79
AF180	0.56
AF186	0.64
AF239	0.44
ASY27	0.50
ASY28	0.38
ASY29	0.58
BA102	0.53
BA115	0.16
BA116	0.21
BA129	0.14
BA130	0.12
BA153	0.18
BCY10	0.53
BCY12	0.58
BCY33	0.23
BCY34	0.26
BCY38	0.26
BC107	0.14
BC108	0.14
BC109	0.14
BC113	0.30
BC115	0.18
BC116	0.30
BC118	0.26
BF154	0.30
BF158	0.21
BF159	0.30
BF163	0.23
BF173	0.44
BF180	0.35
BF181	0.47
BF185	0.47
BFY50	0.26
BFY51	0.23
BFY52	0.23
BTX34/400	2.31
BY100	0.21
BY101	0.18
BY105	0.21
BY114	0.21
BY126	0.18
BY127	0.21
BYY23	1.16
BYZ10	0.30
BYZ11	0.30
BYZ12	0.30
BYZ13	0.30
BYZ15	2.03

CG12E	0.23
CG64H	0.23
FSY11A	0.26
FSY41A	0.26
GD4	0.38
GD5	0.32
GD6	0.32
GD8	0.23
GD9	0.23
GD11	0.23
GD12	0.23
GD14	0.58
GD15	0.47
GD16	0.23
GET113	0.23
GET118	0.23
GET119	0.30
GET573	0.44
GET587	0.50
GET872	1.11
GET873	0.18
GET882	0.58
GET887	0.26
GET889	0.26
GET896	0.26
GET897	0.26
GET898	0.26
GEX113	0.21
GEX36	0.58
GEX45	0.38
GEX55	0.87
GT3	0.30
M1	0.18
MAT100	0.45
MAT101	0.50
MAT120	0.45
OA9	0.14
OA47	0.12
OA70	0.18
OA73	0.18
OA79	0.11
OA81	0.11
OA85	0.11
OA86	0.23
OA90	0.14
OA91	0.11
OA95	0.11
OA200	0.11
OA202	0.12
OC19	1.46
OC22	0.44
OC23	0.44
OC24	0.44
OC25	0.44
OC28	0.69
OC29	0.73
OC36	0.50
OC38	0.50
OC41	0.58

OC42	0.73
OC43	1.37
OC44	0.12
OC45	0.13
OC46	0.18
OC65	1.31
OC70	0.14
OC71	0.13
OC72	0.13
OC74	0.26
OC75	0.13
OC76	0.18
OC77	0.32
OC78	0.18
OC78D	0.18
OC79	0.47
OC81	0.13
OC81D	0.13
OC82	0.13
OC82D	0.13
OC83	0.23
OC84	0.28
OC123	0.26
OC139	0.50
OC140	1.11
OC169	0.50
OC171	0.40
OC172	0.41
OC200	0.55
OC201	0.53
OC204	0.50
OC205	0.50
OC206	1.05
ORP12	0.61
SFT237	0.50
SM1036	0.58
ST1276	0.58
SX1/6	0.21
U14706	0.30
XZ30	0.30
Y543	0.21
Y728	0.21

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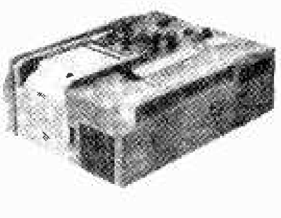
Made in USSR

Series H3020



Basic error: 2.5%
Sensitivity: 8mA F.S.D
Response: 0.2 sec
Width of each channel
Single and three-pen recorders: 80mm
Five-pen recorders: 50mm

Chart speeds, selected by push buttons: 0.1-0.2-0.5-1.0-2.5-5.0-12.5-25 mm/sec
Chart drive: 200-250V 50Hz
Recording: Syphon pen directly attached to moving coil frames
Curvilinear co-ordinates
Equipment: Marker pen, timer pen, paper footage indicator, 10 rolls of paper, connectors, etc

H3020-1 (Single pen): 285mm wide x 384mm deep x 165mm high **PRICE £108.00**
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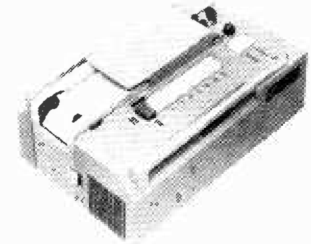
Series H327



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Basic error 4%. Frequency response from DC to 100Hz 2dB

Sensitivity: 0.02 - 0.05 - 0.1 - 0.2 - 0.5 - 1 - 2 - 5 volts/cm
Width of each recording channel: 40mm
Chart drive: 220-250V 50Hz
Chart speeds: 1-2-5-10-50-125-250mm/sec

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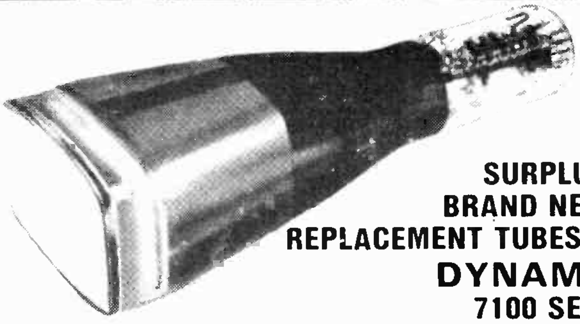

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CD4025AE	22p
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CD4028AE	98p
CD4029AE	120p
CD4030AE	55p
CD4040AE	120p
CD4042AE	90p
CD4043AE	100p
CD4046AE	140p
CD4047AE	100p
CD4049AE	63p
CD4050AE	57p
CD4054AE	120p
CD4055AE	140p
CD4056AE	135p
CD4060AE	130p
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709	Ext. Comp	8/14 pin DIL	30p
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ICA3046	5 Transistor Array	14 pin DIL	80p
★CA3048	Quad Low Noise Amp.	16 pin DIL	200p
★CA3053	Diff Cascade Amp	TO5	70p
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★CA3089E	FM IF System	16 pin DIL	225p
★CA3090	FM stereo Multi Dec	16 pin DIL	400p
ICL8038CC	VCO Fun Gen	14 pin DIL	340p
★LM380	2W Audio Amp	14 pin DIL	99p
★LM381	Stereo Preamp	14 pin DIL	175p
★LM389N	Aud Amp + 3 Trs Array	18 pin DIL	160p
★M252	Rhythm Generator	16 pin DIL	800p
★MC1310P	FM Stereo Dec	14 pin DIL	190p
★MC1351P	Lim/Det Aud Preamp	14 pin DIL	97p
MC1495	Multiplier	14 pin DIL	300p
★MC1496L	Bal Mod/Demod	14 pin DIL	100p
★MC1596	Bal Mod /Demond	TO/DIL	300p
★MC3340P	Electronic Attenuator	8 pin DIL	160p
★MFC4000B	1/4W Audio Amp.	PCB	90p
★NE540L	Audio Pwr driver	TO99	140p
NE555	Timer	8 pin DIL	40p
NE556	Dual 555	14 pin DIL	100p
NE561	PLL with AM Demod.	16 pin DIL	425p
NE562	PLL with VCO	16 pin DIL	425p
NE565	PLL	14 pin DIL	200p
NE566	PLL Fun Gen	8 pin DIL	200p
NE567	PLL Tone Dec	8 pin DIL	200p
2567	Dual 567	16 pin DIL	370p
SN72710	Diff Comparator	14 pin DIL	50p
★SN72733	Video Amp	14 pin DIL	120p
★SN76003N	Pwr Aud Amp with int HS	16 pin DIL	245p
★SN76008	10W Amp in 4 ohms	5 pin Plastic	250p
★SN76013N	Pwr Aud Amp with int HS	16 pin DIL	140p
★SN76018	10W Amp in 8 ohms	5 pin Plastic	250p
★SN76023N	Pwr Aud Amp with int HS	16 pin DIL	140p
★SN76033N	Pwr Aud Amp with int HS	16 pin DIL	230p
★TAA621A	Aud Amp for TV	QIL	225p
★TAA661B	FM IF Amp-Limiter/Det	QIL	120p
★TBA641B	Audio Amp.	QIL	250p
★TBA651	Tuner & IF Amp	16 pin QIL	200p
★TBA800	5W Audio Amp	QIL	90p
★TBA810	7W Audio Amp	QIL	100p
★TBA820	2W Audio Amp	QIL	80p
★TDA2020	20W Audio Amp	QIL/QIL	325p
XR2240	Prog Timer/Counter	16 pin DIL	370p
★ZN414	TRF Radio Receiver	TO-18	110p

Basic data sheets on above at **20p** each + S A E

OPTO-ELECTRONICS

Phototransistors		L D Ro	
OCP70	75p	ORP12	70p
OCP71	120p	ORP60	75p
2N5777	45p	ORP61	75p

LEDS

TIL209 Red	16p	0 2" Red	18p
TIL211 Green	36p	Green	36p
TIL32 Infrared	75p	Yellow	36p
		Tri-state Red/Green/Off	160p

SEVEN SEGMENT DISPLAYS

3015F 0.3"	160p	Xciton:	
DL704 0.3" Red	140p	0 3" Green	160p
DL707 0.3" Red	140p	0 3" Green	160p
DL747 0 3" Red	225p	0 6" Green	225p
Drivers: 75491	84p	75492	96p

TRANSISTORS

AC125	25p	BFY90	120p	★2N3702	12p
AC126	20p	BRY39	45p	★2N3703	12p
AC127	20p	BSX19	20p	★2N3704	12p
AC128	18p	BSX20	20p	★2N3705	12p
AC141	20p	★BU105	140p	★2N3706	12p
AC142	20p	BU108	250p	★2N3707	12p
AC176	20p	★MJE340	45p	★2N3708	12p
AC187	20p	MJ2955	120p	★2N3709	12p
AC187K	25p	MJE2955	130p	2N3773	250p
AC188	20p	MJE3055	70p	2N3866	90p
AC188K	25p	★MPSA06	30p	★2N3903	18p
AD149	49p	★MPSA12	50p	★2N3904	16p
AD161	36p	★MPSA56	32p	★2N3905	20p
AD162	36p	★MPSU06	62p	★2N3906	16p
AF114	20p	★MPSU56	78p	★2N4058	15p
AF115	20p	OC28	75p	★2N4059	10p
AF116	20p	OC35	75p	★2N4060	13p
AF117	20p	OC36	75p	★2N4123	22p
AF127	25p	★OC71	20p	★2N4124	22p
AF139	43p	★R2008B	200p	★2N4125	22p
AF239	48p	★R2010B	200p	★2N4126	22p
BC107/B	9p	★TIP29A	40p	★2N4289	20p
BC108/B	9p	★TIP29C	55p	★2N4401	27p
BC109/B	10p	★TIP30A	48p	★2N4403	27p
BC109C	12p	★TIP30C	60p	2N4427	90p
★BC117	22p	TIP31A	52p	★2N5089	27p
★BC147	9p	TIP31C	52p	2N5296	55p
★BC148	9p	TIP32A	58p	★2N5401	50p
★BC149C	10p	TIP32C	82p	2N6034	160p
★BC157	11p	TIP33A	90p	2N6107	55p
★BC158	10p	TIP33C	115p	2N6247	190p
★BC159	11p	TIP34A	115p	(Comp to 2N3055)	
★BC169C	12p	TIP34C	160p	2N6254	130p
★BC172	11p	TIP35A	225p	2N6292	65p
BC177	18p	TIP35C	290p	40360	40p
BC178	17p	TIP36A	270p	40361	45p
BC179	18p	TIP36C	340p	40362	45p
★BC182	12p	TIP41A	65p	40364	120p
★BC183	12p	TIP41B	70p	40409	65p
★BC184	13p	TIP41C	78p	40410	65p
BC187	30p	TIP42A	70p	40411	300p
★BC212	11p	TIP42B	76p	40594	88p
★BC213	10p	TIP42C	82p	40595	97p
★BC214	14p	TIP2955	78p		
BC478	30p	★TIS93	30p		
BCY70	18p	★ZTX108	10p		
BCY71	22p	★ZTX300	13p		
BD124	130p	★ZTX500	15p	**FETs**	
BD131	36p	★ZTX502	18p	★BF244	25p
BD132	40p	2N457A	190p	★MPF102	40p
★BD135	48p	2N697	22p	★MPF103	40p
★BD136	50p	2N698	45p	★MPF104	40p
★BD139	52p	2N706	20p	★MPF105	40p
★BD140	58p	2N708	20p	★2N3819	25p
BDY20	125p	2N918	40p	★2N3820	50p
BDY56	200p	2N930	18p	2N3823	57p
BF115	22p	2N1131	18p	★2N5457	40p
BF167	23p	2N1132	18p	★2N5458	40p
BF170	23p	2N1304	45p	★2N5459	40p
BF173	25p	2N1305	45p	★2N5485	40p
BF177	26p	2N1306	45p		
BF178	28p	2N1307	45p		
BF179	33p	2N1308	40p		
BF180	33p	2N1309	40p		
BF184	22p	2N1613	25p	**MOSFETs**	
★BF194	10p	2N1711	25p	3N128	96p
★BF195	9p	2N1893	30p	3N140	95p
★BF196	14p	2N2102	55p	3N141	95p
★BF197	15p	2N2219	20p	3N187	180p
BF200	32p	2N2222	20p	40603	63p
BF257	32p	2N2369	14p	40673	63p
BF258	36p	2N2484	30p		
★BFR39	30p	2N2904/A	25p		
★BFR40	30p	2N2905/A	25p		
★BFR41	30p	2N2906/A	24p		
★BFR79	30p	★2N2926R	7p	**UJTs**	
★BFR80	30p	★2N2926B	7p	★TIS43	34p
★BFR88	30p	★2N2926O	10p	2N2160	95p
BFX30	34p	★2N2926Y	12p	2N2646	45p
BFX84	30p	★2N2926G	12p	★2N4871	54p
BFX85	30p	2N3053	18p		
BFX86	30p	2N3054	50p		
BFX87	30p	2N3055	50p		
BFX88	30p	2N3439	67p		
BFY50	16p	2N3442	140p	**PUJT**	
BFY51	15p	★2N3565	30p	★2N6027	48p
BFY52	16p				

DIODES

★SIGNAL	
OA47	9p
OA70	9p
OA81	15p
OA85	15p
OA90	7p
OA91	7p
OA95	7p
OA200	8p
OA202	10p
IN914	4p
IN916	9p
IN4148	4p
RECTIFIER	
★BY100	25p
★BY126	12p
★BY127	10p
IN4001	5p
IN4002	5p
IN4004	6p
IN4005	6p
IN4007	7p
IN5401	13p
IN5404	18p
IN5407	23p
ZENER	
2 7V to 33V★	
★400mW	9p
★1W	18p
NOISE	
★Z5J	110p

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★1A 50V	22p
★1A 100V	24p
★1A 200V	28p
★1A 400V	30p
★1A 600V	36p
★2A 50V	30p
★2A 100V	35p
★2A 200V	40p
★2A 400V	45p
★3A 200V	60p
★3A 600V	72p
★4A 100V	84p
★4A 400V	90p
6A 50V	90p
6A 100V	96p
6A 200V	108p
6A 400V	120p
10A 400V	270p
25A 400V	400p

TRIACS

Plastic

Amp	Volts	
3	400	85p
6	400	99p
6	500	107p
10	400	120p
10	500	140p
15	400	160p
15	500	180p
40430		130p
40669		130p
DIAC		
BR100		30p

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5V	7805	140p	5V	7905	200p
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15V	7815	140p	15V	7915	200p
18V	7818	140p	18V	7918	200p
24V	7824	140p	24V	7924	200p

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LM309H 100mA 5V TO5 **75p**
TBA625B 12V 0 5A TO5 **120p**

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1A100V	TO5	42p	C106D 4A/400V	Plastic	63p
1A400V	TO5	45p	★MCR101 0 5A/15V	TO-92	25p
1A600V	TO5	70p	2N3525 5A/400V	TO-66	120p
3A100V	Stud	65p	2N4444 8A/600V	Plastic	185p
3A400V	Stud	75p	★2N5060 0 8A/30V	TO-92	34p
7A100V	TO5+HS	84p	★2N5062 0.8A/100V	TO-92	37p
7A400V	TO5+HS	90p	★2N5064 0 8A/200V	TO-92	40p
8A 50V	Plastic	130p			
12A400V	Plastic	160p			
16A100V	Plastic	160p			
16A400V	Plastic	180p			
16A600V	Plastic	220p			

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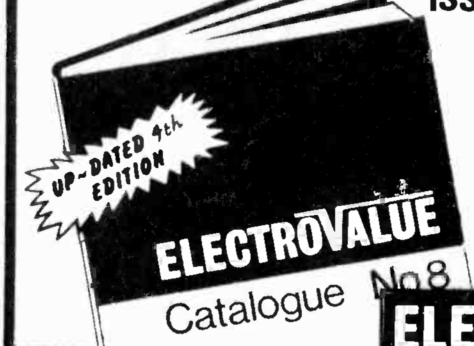

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Longacres, St. Albans, Herts. Tel : St. Albans 59292
A GEC-Marconi Electronics Company

(7085)

UNIVERSITY OF SOUTHAMPTON
Department of Chemistry

INSTRUMENT TECHNICIAN

required to join a section carrying out the maintenance and repair of scientific, electronic and optical instruments.
Applicants should have a technical qualification of HNC or ONC or equivalent with several years' relevant experience in electronics and/or scientific instruments.
The appointment will be made at grade 5 on salary scale £2889-£3367 (which includes two supplements under Government pay policy).
Applications giving details of age, qualifications and experience and the names and addresses of two referees should be sent to Mr D A S Copland, The University, Southampton SO9 5NH, quoting reference 217/T/WW.

(7060)

Oxfordshire AREA HEALTH AUTHORITY (TEACHING)

Churchill Hospital

Medical Physics Technician

Grade III (Electronics)
£2961.00-£3834.00 + £312.00

To work in the Department of Radiotherapy and Oncology on the design and building of new circuits and the maintenance and updating of existing radiotherapy equipment. HNC or equivalent in electronics necessary.

Enquiries to Mr R J Thorne, Chief Technician, Department of Radiotherapy & Oncology, Churchill Hospital, Oxford OX3 7LJ. Closing date 25th February, 1977.

UNIVERSITY OF ABERDEEN

ELECTRONICS TECHNICIAN

required for Department of Medical Physics for duties concerned mainly with the development of digital and analogue circuitry for prototype equipment used in clinical/research projects and the maintenance/repair of medical electronic equipment.

Applicants should hold ONC or equivalent qualification and have had previous experience in electronics.

For suitably qualified candidate, salary on scale £2455-£2788 (inclusive of supplements under Stages 1 & 2 of incomes policy).

Applications giving details of age, qualifications and experience should reach the Secretary, University Office, Regent Walk, Aberdeen AB9 1FX by 31st March and quote Ref. No. 36/77.

(7095)

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The work is varied and involves the calibration and maintenance of electronic and electro-mechanical test equipment, covering a wide range of test and measuring techniques such as optical, thermal, digital and computer.

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**For further details and an application form, please telephone or write to: Barry Page, Personnel Department, EMI Limited, 135 Blyth Road, Hayes, Middlesex.
Tel: 01-573 3888 ext. 639 or Record-a-Call anytime on 01-573 5524.**

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7098

LONDON COLLEGE OF PRINTING
Faculty of Visual Communications
Department of Photography Film and Television

TELEVISION TECHNICIAN/ ENGINEER

Applications are invited for the above post in the expanding Television Department of Photography, Film and Television.

Candidates should be conversant with ½", ¾" and 1" black and white and colour equipment and be capable of electronic maintenance. Experience in professional broadcasting would be an advantage, as well as an interest in experimental video work. The successful applicant will be expected to assist in running studio productions, and video tape editing. Salary scale £3190-£4702 inclusive (ST1/2).

Application forms, returnable within 14 days, obtainable from the Senior Administrative Officer at the college.
(7050)

ITN
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£5,712 p.a.

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A broad base of experience, gained either with a broadcaster or a manufacturer is essential.

In addition to practical experience, academic achievements will be taken into account.

Candidates should telephone the Personnel Department of Independent Television News Ltd. on 01-637 3144 quoting reference 3217.

(7088)

Re-advertisement

UNIVERSITY COLLEGE OF NORTH WALES BANGOR
School of Physical and Molecular Sciences

ELECTRONICS TECHNICIAN GRADE 5

Applications are invited for the post of Electronics Technician Grade 5 in the above mentioned School.

The successful applicant would be concerned with the development, construction and maintenance of specialised electronic equipment for a wide range of research work and teaching in the School.

Applicants should have had several years' relevant practical experience coupled with theoretical knowledge, preferably to H.N.C. standard or equivalent.

Salary at an appropriate point on scale: £2,889-£3,367 per annum. Pension Scheme.

Applications (two copies), giving details of age, education and experience, together with the names and addresses of two referees should be submitted to the Assistant Registrar (Personnel), University College of North Wales, Bangor, Gwynedd LL57 2DG.
(7053)

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Ferranti Limited,
Ferry Road,
EDINBURGH, EH5 2XS.
Please quote Ref. WW/1.

FERRANTI

(7000)

Electronic Test Technicians- put your skills to the test!

Here at Havant where we currently manufacture large systems we're looking for Technicians, male or female, with experience of sophisticated electronics, and the ability to diagnose and rectify malfunctions on a complex computer system.

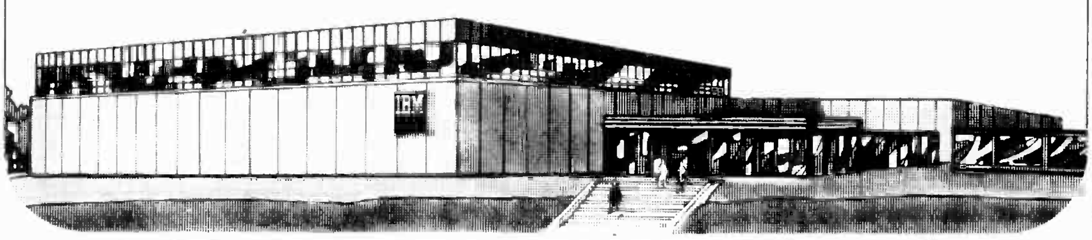
You're probably an experienced Technician with ONC/HNC in electronics or relevant Service experience in digital equipment.

Starting salaries are very competitive, together with first-class working conditions. You may be expected to work on a double shift basis for which an attractive premium will be paid.

As well as a wide range of fringe benefits we also offer generous relocation expenses to this attractive part of the south coast which provides outstanding social and recreational facilities.

If you feel this opportunity is suited to your ability and experience phone or write for an application form to: Marjorie Menereau, Personnel Officer, IBM United Kingdom Limited, Langstone Road, Havant, Hants. Tel: Havant 6363. Quoting ref: WW/92838

IBM



Thames Polytechnic

School of Materials Science and Physics

Electronics Technician (Grade 4)

Applications are invited for a technician for the electronics workshop who will be required to construct, maintain and repair a variety of electronic equipment for teaching and research. A good understanding and a flair for electronics is needed. Candidates should have an ONC or OND or equivalent qualification and at least seven years relevant experience.

Salary scale:
£2835-£3216 including London weighting plus personal allowance (i.e. 5% of gross pay; min. £2.50 max. £4.00).

Further particulars and form of application may be obtained from the Staffing Officer, Thames Polytechnic, Wellington Street, London, SE18 6PF, to whom completed applications should be returned by 22 March, 1977.

Join the leaders in Telecine Development

Rank Cintel — a division of Rank Precision Industries — has developed the world's most sophisticated telecine machine, and is currently engaged in a vast export programme. These achievements result from concentration on technical superiority and excellence of quality, and demand the highest standards of engineering at all levels. In order to maintain and develop our technical advantages, we now have a number of progressive positions for the following specialists:

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To apply their expertise to circuit design, using analogue and digital techniques in audio, video and servos. Candidates, men or women, should have good practical experience and be qualified to at least HNC level.

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To test and fault-find sub-units and PCB's using test specifications and a traditional range of test equipment. Candidates, men or women, should be qualified to T4 level, and preferably will have some work experience in electronics testing.

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To design and develop film and tape transports and associated instruments. Candidates, men or women, should be qualified to at least HNC Mech Eng., and have a number of years' experience in designing precise and dynamic devices.

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To apply please contact
Ian Waterhouse
Personnel Manager
Rank Cintel
Watton Road
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Tel. 0920 3939

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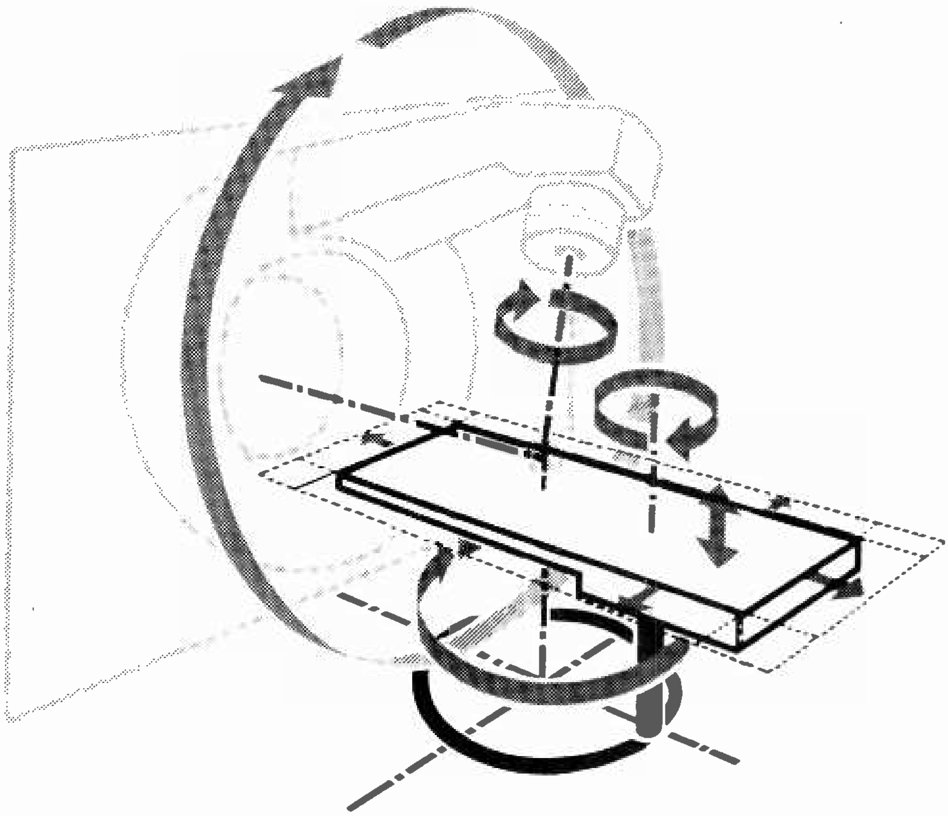
* Assistance, where appropriate, in moving to this pleasant, socially attractive, healthy coastal area, where housing is available and more reasonably priced, yet the amenities of the "big city" are within easy reach.

Sounds good? Then, if you have a degree or HNC, plus experience in a relevant speciality, write giving brief personal and career details (or phone for Application Form) to:—George Greaves, Personnel Officer, ITT Consumer Products (UK) Ltd., Theaklen Drive, Hastings, E. Sussex. Tel: Hastings (0424) 437061.

7080

TV • Radio • Stereo ITT



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The MEL Equipment Company Limited, the professional electronic division of the International Philips Group produce the advanced linear accelerators used in many of the major hospitals throughout the world for the treatment of cancer.

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We offer excellent progressive salaries with full expenses and allowances, an annual bonus, Pension and Life Assurance schemes and at least 4 weeks and 3 days annual holiday entitlement. Where candidates do not live in the Crawley area relocation will be necessary. Assistance will be given, including nomination for rented accommodation from Crawley New Town Commission. Crawley is an established New Town situated on the Surrey/Sussex borders offering excellent educational and recreational facilities, including a local sports centre and swimming pool.

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MEL

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Applicants should be practical, innovatory electronics engineers with experience in r.f., and precision analogue circuit design. A knowledge of digital techniques, would be useful, but is not a prime requirement.

The successful applicant will be a key member of a small new group with multidisciplinary interests. He or she will primarily supply the electronics expertise required for the development of sophisticated new instruments, but will also be expected to become involved in other aspects of innovation. The ability to work with minimal supervision and to be self-motivated is essential.

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Contact Dr. Peter Hanley, telephone Oxford 41456 or write to The Oxford Instrument Co., Osney Mead, Oxford OX2 0DX, to arrange an interview.

(7064)

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CANADA

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Canadian Cablesystems is a company with ten C.A.T.V. Systems in Ontario with over 400,000 Subscribers.
Salary will be in the range of $20,000 per annum.
If you wish to pursue this position within our organisation please send your résumé in confidence to

G. F. Stone
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Interviews will be held in London, England.

(7113)

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Applicants (male or female), aged 21- , should have a Degree or HNC and experience of Analogue/Digital Circuit Design. A knowledge of Microprocessors, Hydraulic Systems or Scientific Programming would be an advantage.

The posts carry a good basic salary and other "big company" benefits. In addition, there are excellent opportunities for promotion on merit within an expanding organisation.

For further information, please contact Mike Gernat.

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Erith 39121

(7062)

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TOWN CLERK & CHIEF EXECUTIVES DEPARTMENT

Administrative Officer (Telecommunications)

£4836-£5142

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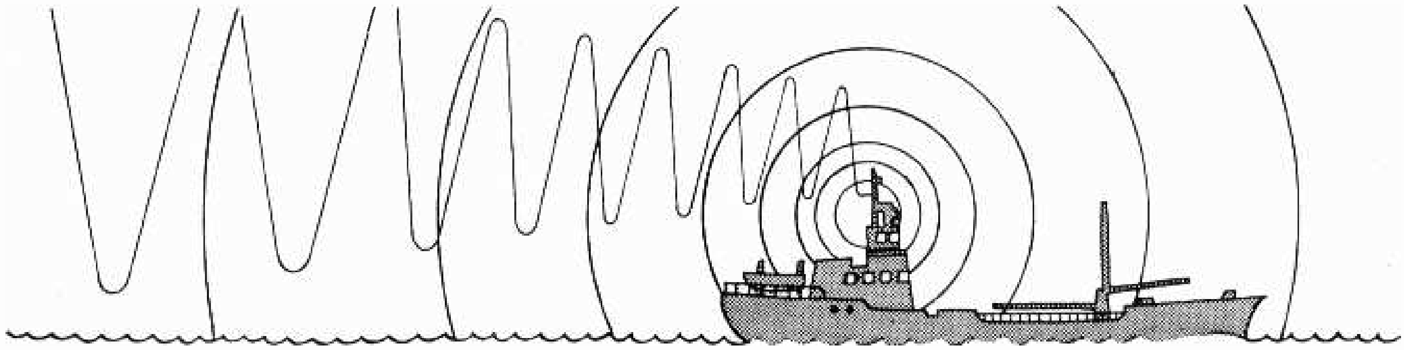
Applicants must have a wide knowledge of Post Office and commercial communication installations.

Application form, returnable by 1st April, and detailed job description from Chief Personnel Officer, Town Hall, Catford, London SE6 4RU, or telephone 01-690 7666 (24-hour Ansafone service) quoting reference CE 78 and job title.

(7052)



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

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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:
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ET 17.1.1.2., Room 643, Union House,
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Dolby Laboratories manufacture and market professional audio noise reduction equipment which is widely used by major recording companies, recording studios and broadcasting authorities throughout the world. Established in London, the Company has enjoyed successful growth since incorporation in 1968.

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Reporting to and working closely with the International Marketing Manager the person appointed will be involved in all aspects of sales, eg providing technical information to distributors and customers, giving demonstrations and training courses, and visiting recording studios and broadcasting organisations in the UK and abroad.

The successful applicant will be an electronics engineer who enjoys dealing with people and problems. Aged between 25 and 35 he, or she, will probably have a degree and may well have experience of recording studio or broadcasting practice. European languages would be a distinct advantage.

Production Engineer c.£4,000
The person appointed will join a small team which provides the technical support to the production department. Working under the Production Technical Manager this section is responsible for establishing assembly and testing procedures, quality control and interfacing with sales and design engineers on product improvements and new product introductions.

The successful applicant will be an electro-mechanical engineer who enjoys using his specialist knowledge to resolve day-to-day problems as much as the more theoretical aspect of the job. He, or she, will probably have a degree and experience in electronic equipment manufacturing.

Write or telephone:
Gary Holt, General Manager
Dolby Laboratories Inc
346 Clapham Road, London SW9
Telephone 01-720 1111

Dolby
Dolby Laboratories
(7094)

THE OPEN UNIVERSITY
Faculty of Technology

ELECTRONIC TECHNICIAN

An Electronic Technician (Calibration) is required to join the general electronic facilities of the Open University.
Main duties of the post are to provide a 95% in-house calibration and maintenance service for all measuring equipment using mainly electronic techniques
To assist all O U staff (academic, research, technicians and maintenance) with electronic problems and the use of their equipment
To set up and maintain the necessary record system to operate such a service.
Experience: Ten years in electronics, five years of which should be relevant to the above duties
Qualifications: HNC or C and G in an appropriate subject
Salary: Technician Grade 5 £2889-£3367 per annum
Holidays: 20 working days, plus 6 university closed days plus 7 national days
The post is within the New City of Milton Keynes
There is a university office to assist with housing The applicant may be eligible for development housing and part removal expenses from the Open University
Application forms and further particulars are available, by postcard request please, from the Personnel Manager (ET2) The Open University, P O Box 75, Walton Hall, Milton Keynes, MK7 6AL Telephone Milton Keynes 63868
Closing date for applications 31st March 1977
(7065)

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Good basic knowledge and German Language required by active Company Interesting position with variety
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DEVELOPMENT ENGINEER

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Personnel Officer,
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P.O. Box 41,
Coldhams Lane,
Cambridge CB1 3JU.
Tel: Cambridge 45115 7074

Pye TVT Limited
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(*4190 Saudi Riyals per month)

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London W1M 0AA.
Tel: (01)-491 3211**

HOSPITAL CORPORATION INTERNATIONAL

7079

SALOP AREA HEALTH AUTHORITY

Electronic and Bio-medical Engineering Department

TECHNICIAN IV

required for the Area Works Department based initially at Copthorne Hospital South

Qualifications	O N C / H N C Electronics
Responsible to	Area Engineer
Salary scale	£2 346-£3 267 p a + £312 p a supplement

A technician is required for the above department to be responsible for the maintenance of medical mechanical and electronic apparatus used in the Area

The Technician will join a team who carry out a continuous servicing and overhauling programme to ensure that the equipment in their charge will run at the peak of its available efficiency at all times

Application form and job description to be obtained from the Area Engineer Shrewsbury Hospai. Copthorne South Mytton Oak Road Shrewsbury Salop Tel Shrewsbury 52244 Ext 3273 Competed appliction forms to be returned by 14 days after insertion date

71: :

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637 5551 day, 550 0836eve.

ELECTRONICS TECHNICIAN (Grade 6) required by Physiology Dept. for the design and construction of biophysical instrumentation to be used in muscle research. Experience in analog, digital and computer interfacing circuitry desirable. This is a three-year grant supported post. Salary in range £3.802-£4.435 inc. of London Weighting. Application form from Personnel Officer (Technical Staff FF5) University College London Gower Street London WC1E 6BT (7106)

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BOOKS

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APPOINTMENTS

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£5,000 to £6,000 per annum

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Duties will include responsibility for provision of HF prediction services, propagation studies, advice on technical characteristics of antennae and modulation methods.

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Application forms may be obtained from:—
Recruitment Manager,
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Theobalds Road, London WC1X 8RX.
(01-242 4433 ext. 211)

(7066)

Cable & Wireless

Electronics Engineers

Cheltenham

The Scanner Division of Linotype-Paul is world renowned for the design and production of sophisticated systems used in the colour printing industry.

The Division now requires top-class electronics engineers to carry out complex testing operations during sub-assembly and final test stages.

Applicants, male or female, must have wide experience of analogue and digital circuitry, preferably gained in a test environment, and should be educated to ONC. An understanding of precision mechanical engineering and associated materials, as well as the principal processes in colour photography, would be advantageous.

We can offer top salaries and excellent conditions of employment. Assistance with relocation will be provided in appropriate cases.

Please write with career details to:

Barrie Witt, Personnel Officer
Linotype-Paul Limited
Block 22, Lansdown Industrial Estate
Cheltenham, Glos.

1974

(7103)

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60KHz MSF Rugby Receiver. BCD TIME OF DAY OUTPUT. High performance, phase locked loop radio receiver. 5V operation with 1 second LED indication. Kit complete with tuned ferrite rod aerial £14.08 (including postage and VAT). Assembled circuit and cased-up version also available. Send for details Toolex, Sherborne (4359), Dorset. (21)

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40p ea + 10p P&P
6 for **£2.20** + 20p P&P
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(6792)

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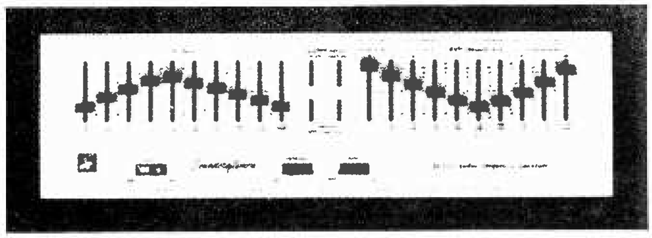

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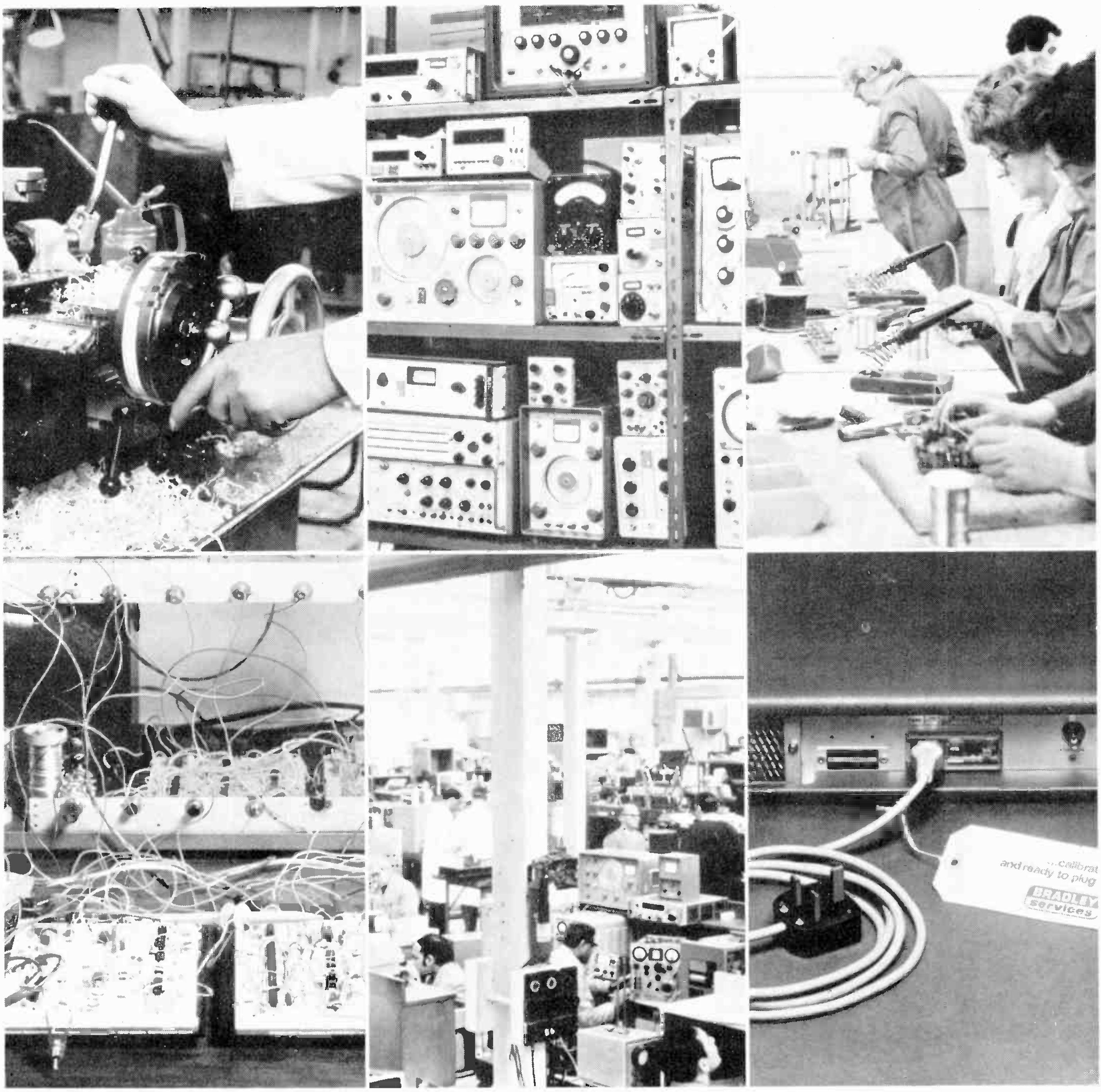
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Ersin Multicore 5-Core Solder

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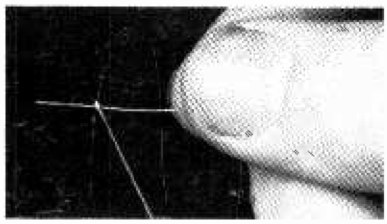
Our unsurpassed ERSIN flux is rigorously tested before and after it is incorporated in the solder wire. Our five separate cores of flux ensure flux continuity, leave only an ultra-thin layer of solder separating flux from work for instant wetting and provide a more accurate ratio of flux to solder. It is therefore possible to use less solder and obtain greater reliability.

Our Quality Control at all stages of manufacture is guaranteed and recorded by the batch number on every reel.

Needle fine gauges



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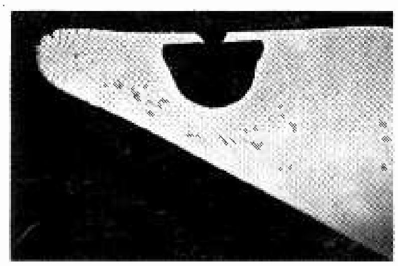
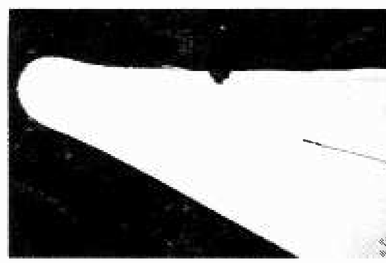
One of our most popular special ERSIN Multicore Solder alloys is SAVBIT alloy. Compared with ordinary tin/lead solders it dramatically reduces the erosion of soldering iron bits, copper wires and printed circuit conductors. It also saves costs and increases reliability. SAVBIT alloy containing 5-Cores ERSIN 362 flux has received special Ministry approval—under DTD. 900/4535 for Military applications.



Sectioned iron-plated bit, after 40,000 simulated operations using 60/40 Solder.



Sectioned iron-plated bit, after 40,000 simulated operations using SAVBIT Solder.

ALLOY

Composition (nominal major elements)	Grade	Melting Temperature Solidus °C	Melting Temperature Liquidus °C	Specification
50/33/17 Sn/Pb/Cd	TLC	145	145	DIN 1707
62/36/2 Sn/Pb/Ag	LMP	179	179	DIN 1707
62/35.7/2/0.3 Sn/Pb/Ag/Sb	Sn62	179	179	QQ-S-57 1E
63/36.7/0.3 Sn/Pb/Sb	Sn63	183	183	QQ-S-57 1E
60/40 Sn/Pb	K	183	188	B.S. 219
~~60/39.7/0.3 Sn/Pb/Sb~~	Sn60	183	188	QQ-S-57 1E
50/50 Sn/Pb	F	183	212	B.S.219
50/49.7/0.3 Sn/Pb/Sb	Sn50	183	212	QQ-S-57 1E
50/48.5/1.5 Sn/Pb/Cu	Savbit 1	183	215	DTD 900/4535 DIN 1707
45/55 Sn/Pb	R	183	224	B.S.219
40/60 Sn/Pb	G	183	234	B.S.219
40/59.7/0.3 Sn/Pb/Sb	Sn40	183	234	QQ-S-57 1E
30/70 Sn/Pb	J	183	255	B.S.219
20/80 Sn/Pb	V	183	275	B.S.219
15/85 Sn/Pb	—	225	290	—
Pure Tin	P.T.	232	232	B.S.3252
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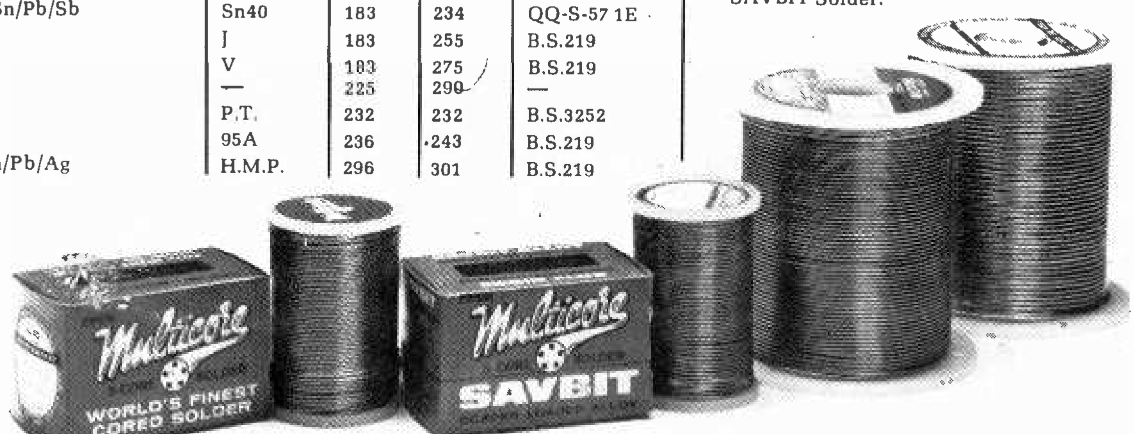

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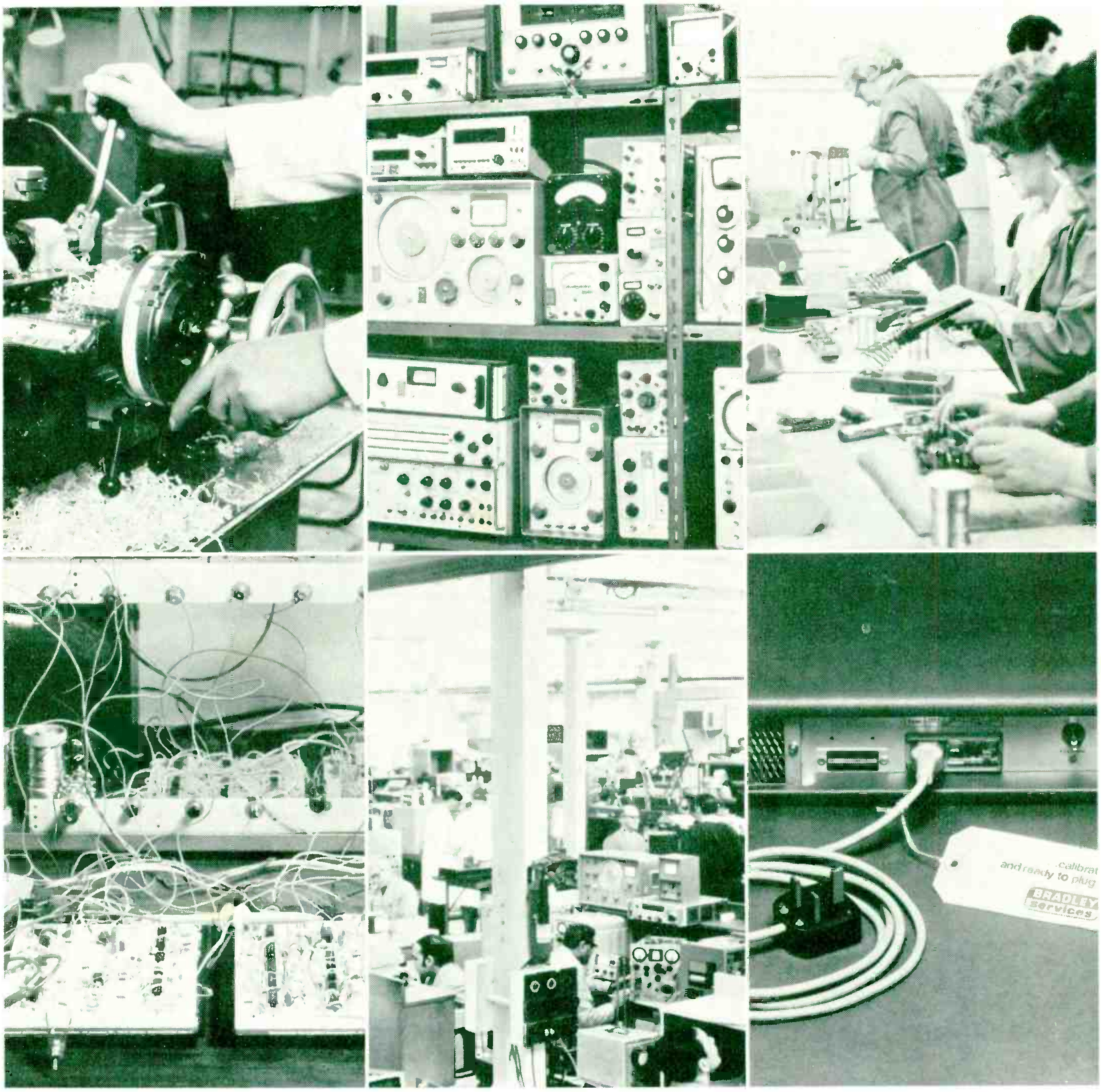
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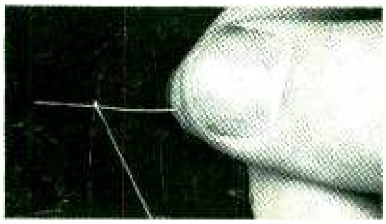

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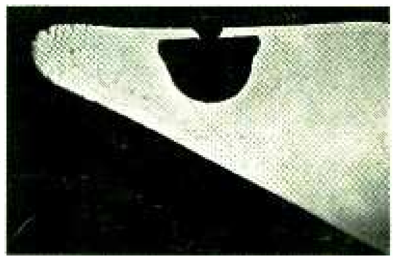
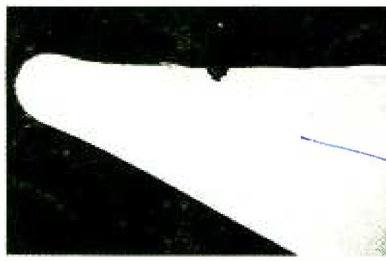


Sectioned iron-plated bit, after 40,000 simulated operations using 60/40 Solder.



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20/80 Sn/Pb	V	183	275	B.S.219
15/85 Sn/Pb	—	225	290	—
Pure Tin	P.T.	232	232	B.S.3252
95/5 Sn/Sb	95A	236	243	B.S.219
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