wireless world

DECEMBER 1974 25p

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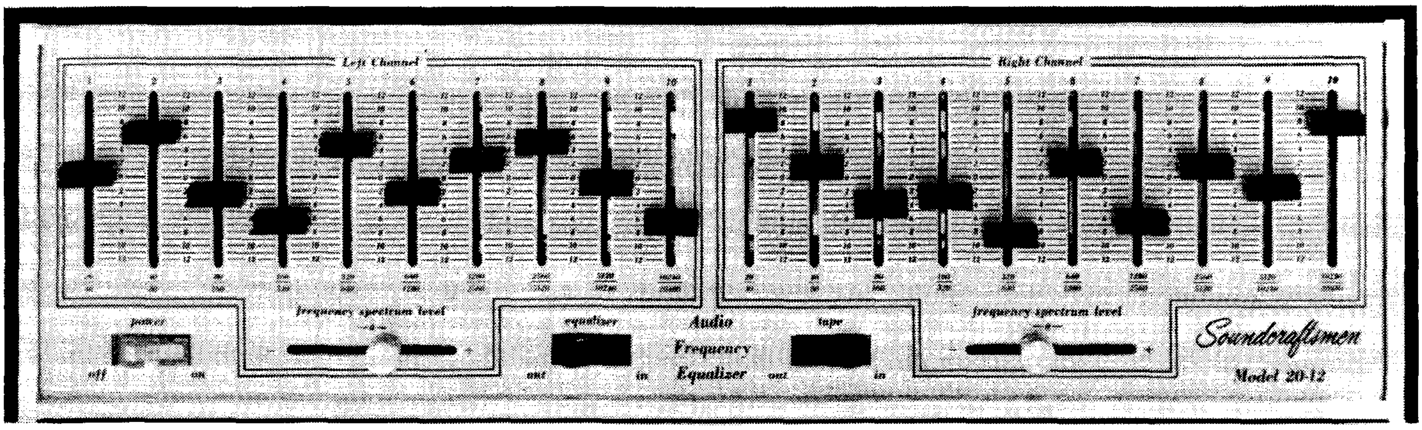

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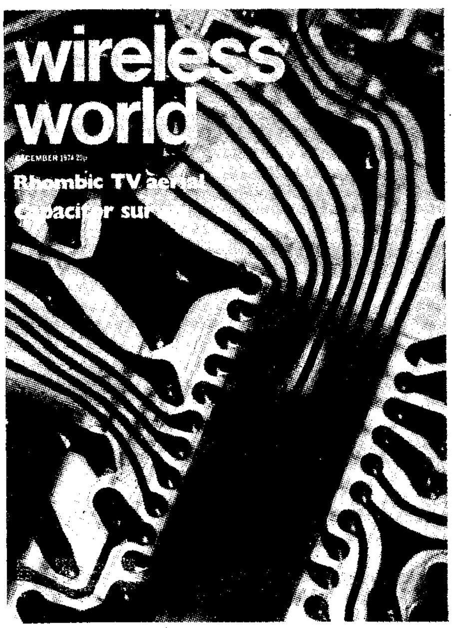

This month's front cover shows part of a printed circuit of Sphericall, a Pye TMC l.s.i. device for push-button telephone dialling.
(Photographer Paul Brierley)

IN OUR NEXT ISSUE
(published December 18)

Electronics and oil. An inside view of the communications, telemetry and navigational aids used in drilling for North Sea oil

Silent switch for stereo-pair comparisons. Construction of an f.e.t. electronic switch that meets stringent requirements

Contents

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New directions in sound

In the April 1958 issue we commented that the results of demonstrations of the new stereo discs were "practically indistinguishable from the master . . .". Such a test has been applied on numerous occasions when demonstrating two-channel quadraphonic (which we take to mean surround sound using four loudspeakers) systems. Inventors of these systems deserve credit for their technical achievement in being able to mount A-B comparisons between four-track master tapes and their two-channel-processed versions; some of them are very effective. But is comparison with the master tape the best test of a system's capabilities?

Two things suggest it isn't. One is the relative inability of the master to do a good job in the first place. Acute sensitivity to listener position and—as Michael Gerzon points out in this issue—the instability of phantom images make one query the use of pan-potted masters as the starting point.

Possibly more important is compatibility. Whatever the quality of quadraphonic performance, records must have stereo and mono compatibility. Differences between two-channel systems, for instance, really amount to differing priorities as to the relative quality of mono, stereo and quadraphonic reproduction. And much of the current debate on the relative merits of systems could be settled once it has been agreed whose interests to give what weight to. No one body in the record industry appears to have accepted responsibility for doing this.

This issue may well be settled by the broadcasters. Weighing the interests of a minority against those of a majority is something broadcast authorities ought to be used to. Given that a two-channel quadraphonic system must be perfectly mono compatible (not only because the majority of receivers in use are mono, but imperfect mono compatibility is a much more serious thing than stereo compatibility), one problem that poses itself is: how much degradation of the stereo image is going to be acceptable, in the interests of a limited quadraphonic audience?

This question is implicit in the detailed NQRC study*, now in progress. Another question being studied, fundamental to choosing a surround-sound system, is the effect of the number of transmission channels on quadraphonic performance—"directional fidelity" in particular. This is clearly of utmost importance in broadcasting, if only because it affects the magnitude of quality loss that must occur in delivering a compatible service.

What engineers should concern themselves with, it seems to us, is providing the best possible method of conveying sound direction, within the constraint of a limited number of channels, commensurate with agreed priorities in compatibility. (Given such a means, decisions about whether to use the medium for drama, ambience portrayal, pan-potted material or special effects such as "overhead" sound, then become the province of others.)

This is basically what Nippon Columbia Co have been doing in developing their new UD-4 system, with Peter Fellgett's NRDC-backed UK group thinking along the same lines but emphasizing a microphone technique that collects ambience in a uniform way.

It will be interesting to see how the NQRC weigh the various priorities and how relevant their priority mix, and hence their conclusion, is to other countries.

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*See page 458, November issue.

Charge-coupled devices

1—Introduction, early device structure and operation

by Ted Williams
Royal Radar Establishment

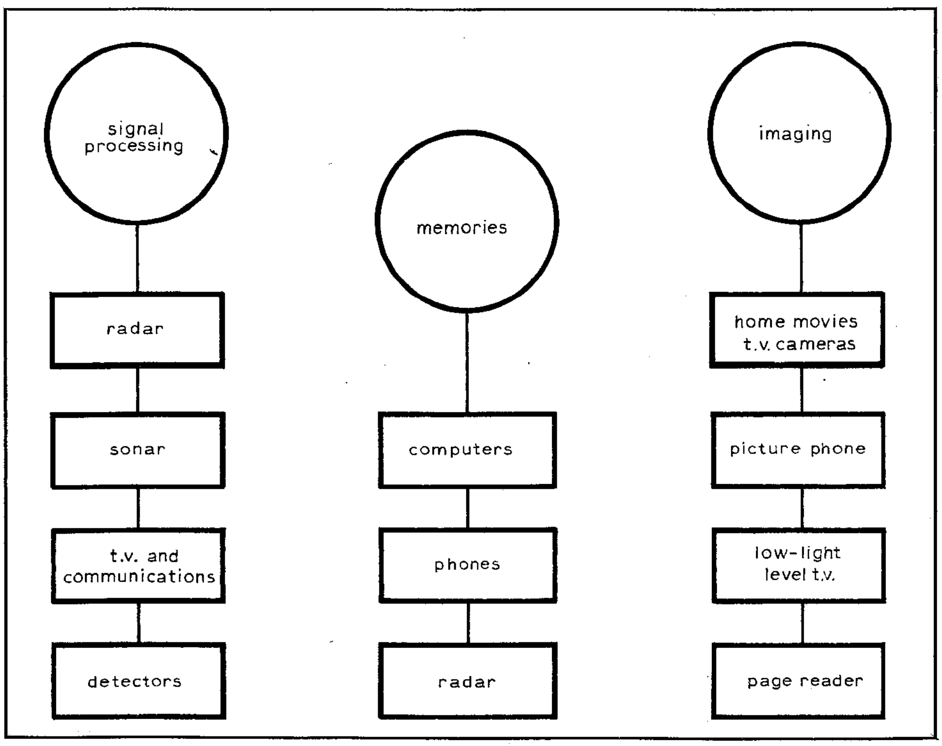
Charge-coupled devices, which consist of chains of charge-storage elements along which charge packets are transferred, are already turning out to be the most significant advance in electronics since development of m.o.s. circuits. Usually associated with imaging in solid-state cameras, their unique performance characteristics, small size and high yield will produce far-reaching effects on signal processing techniques and in digital memories. After the four or five years since inception, advanced signal processors and memories are about to leave the drawing board. What gives the c.c.d. this position is discussed in a series of articles written by two leading authorities in the UK. This article describes operation of simple devices; a second article will outline fabrication processes and modifications to improve performance. Later articles will discuss applications.

The charge-coupled device has aroused considerable interest ever since it was first conceived and tested in 1970.[1] Since then the interest has never slackened. This is borne out by the rapid commercial development of the c.c.d.

1973—first device offered for sale by Fairchild
1973—successfully built into simulated radar systems
1974—c.c.d. TV camera became available; and
1974—first complete signal processing system expected on the market.

Complete systems rather than individual devices will be offered for sale because of their much higher profit potential. Nowadays, many products, of which the pocket calculator is one example, are being built as complete systems by one manufacturer. Selling devices no longer makes big profits unless you have cheap labour; and in Europe and America labour is not cheap. The profit expected from the c.c.d. systems business is enormous. One American estimate[2] predicts that the annual systems business will be worth over £100 million.

This optimism explains why the Americans have put so much effort into c.c.ds. In 1973, for example, the manpower effort at companies like Texas Instruments and Fairchild was built up to an extremely large team of scientists and engineers. With so many people working on c.c.ds the chances of success are very high. There is little doubt that in the seventies the way to succeed with a promising new device is to put big teams to work on it.



There are three reasons why there has been so much interest in c.c.ds:

- Cheap technology makes them very competitive.
- Flexibility: analogue, digital, and optical signals can be handled.
- Applications are extensive (see chart).

Fig. 1 compares the c.c.d. shift register element to the previous generations of m.o.s. and bipolar devices. From this it is clear that the c.c.d. *element* is much simpler and consequently much cheaper because no diffusions are required. This absence of diffusions also makes integrated circuit design much easier and, in particular, very cheap high area density arrays can be produced.

A second article will show how this basic technology does have some disadvantages, and how some process innovations have been adopted which overcome these problems. But to understand the basic operation this article is restricted to the first technology that was developed for the c.c.d. In spite of its limitations, this is still used for some of the simpler applications.

These basic applications, together with some of the more sophisticated systems applications, especially imaging, signal processing and memories, will form the subject of further articles.

Device structure

Anyone who is familiar with the metal-oxide-silicon transistor will have no difficulty in understanding the device structure and operation of a c.c.d., because

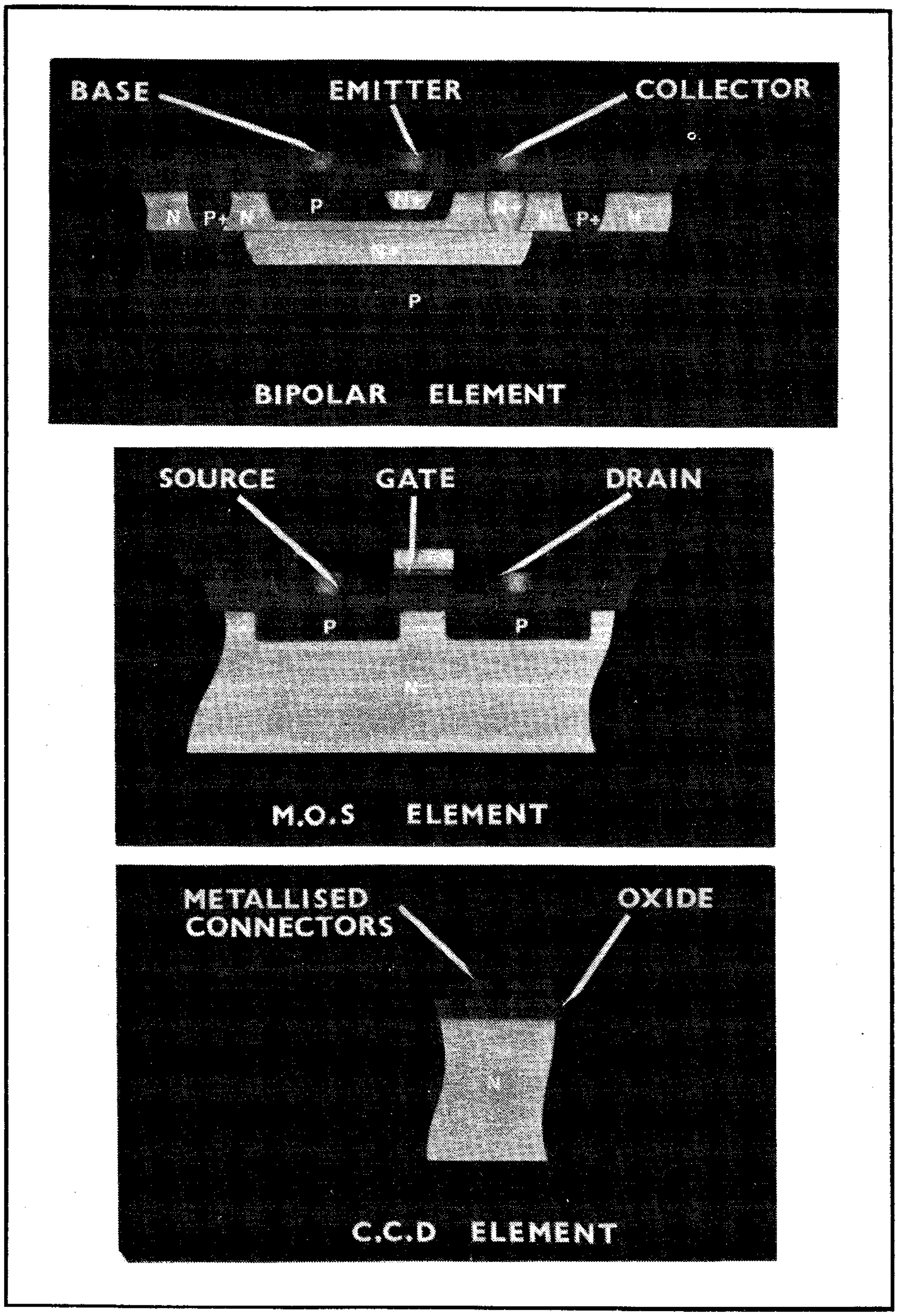


Fig. 1. Comparison of the c.c.d. shift register element with m.o.s. and bipolar elements.

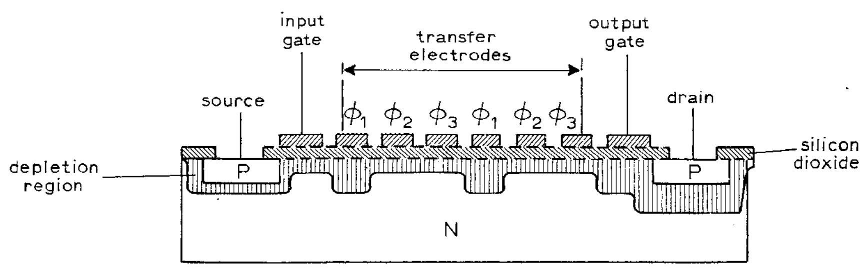


Fig. 2. Cross-section of a complete two-bit p-channel c.c.d.

it can be thought of as a multi-gate m.o.s. transistor.

Fig. 2 shows the structure of a basic two-bit, p-channel, c.c.d. shift register. The silicon semiconductor substrate is doped n-type (with electrons as the majority carriers and holes as the minority carriers), whereas the source and drain diffusions are p-type (with holes as the majority carriers and electrons as the minority carriers). The oxide, or more correctly the silicon dioxide, which is grown on top of the silicon substrate is about 150nm thick; and the aluminium, which makes up the contacts to the source, drain, the input gate, output gate, and the transfer electrodes, is 200nm thick.

A negative-voltage reverse bias is applied via a load resistor to the drain diffusion. This bias makes the drain a sink for holes and a barrier to electrons. Holes are injected from the earthed source diffusion to the surface under the first transfer electrode ϕ_1 by switching on the negative input gate voltage at the same time as the first clock transfer electrode negative voltage pulse. The time sequence of the input gate pulse and the clock pulses is shown in Fig. 3. This shows that as soon as the second phase voltage is switched on, ϕ_1 is reduced to zero in a time defined as the overlap time t.

During t, the charge under ϕ_1 will be transferred to the surface under ϕ_2. Similarly when ϕ_2 begins to turn off, ϕ_3 is turned on and the charge is transferred under ϕ_3. Then ϕ_1 is switched on again and the charge moves under ϕ_1 for the second time. At this point in time the charge has now shifted through one bit or three phases of the device. Referring back to Fig. 2, at the end of the second complete shift, or bit, the charge is transferred into the drain—the output of the device. The final charge transfer is accomplished either by switching on the output gate in phase with ϕ_3 or by leaving a permanent negative d.c. bias on the output gate.

Fig. 4 shows a top-view photograph of a complete eight-bit p-channel c.c.d. made at the Royal Radar Establishment. Comparing this with Fig. 2 makes it easy to identify the source and drain diffusions, the input and output gate, and the transfer gates. The three-phase clock lines are linked together to minimize the number of contact pads and to facilitate the production of a complete depletion region right across the device as shown in Fig. 2. (Production of a depletion region is discussed later.) The oblong-shaped, heavily doped n-type channel stop diffusion prevents holes diffusing out from the transfer electrodes to the contact pads. Total device area or chip size was $1mm^2$, and the transfer electrode size was 12µm long (in the transfer directions) by 300µm wide with a gap between the electrodes of 2.5µm.

Digital operation

Digital operation of a p-channel device is illustrated in Fig. 5. This shows the input signal applied as a square pulse to the input gate with the source earthed. The pulse generator which provides the input pulse is triggered by the clock generator through a divider board to give a "one" pulse in phase with ϕ_1 followed by a series of n zeros. The output is studied by connecting an oscilloscope to the drain. The accompanying table shows typical operating voltages for a p-channel device.

Fig. 6(a) shows the digital output from a 64-bit device. The value of n used for

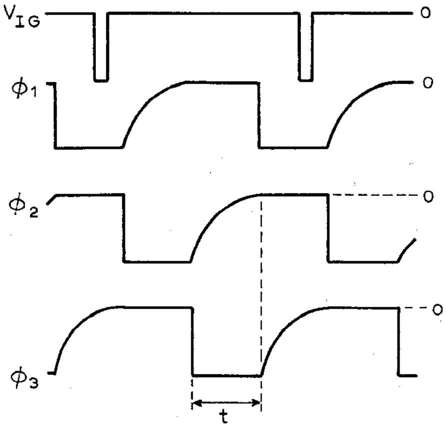
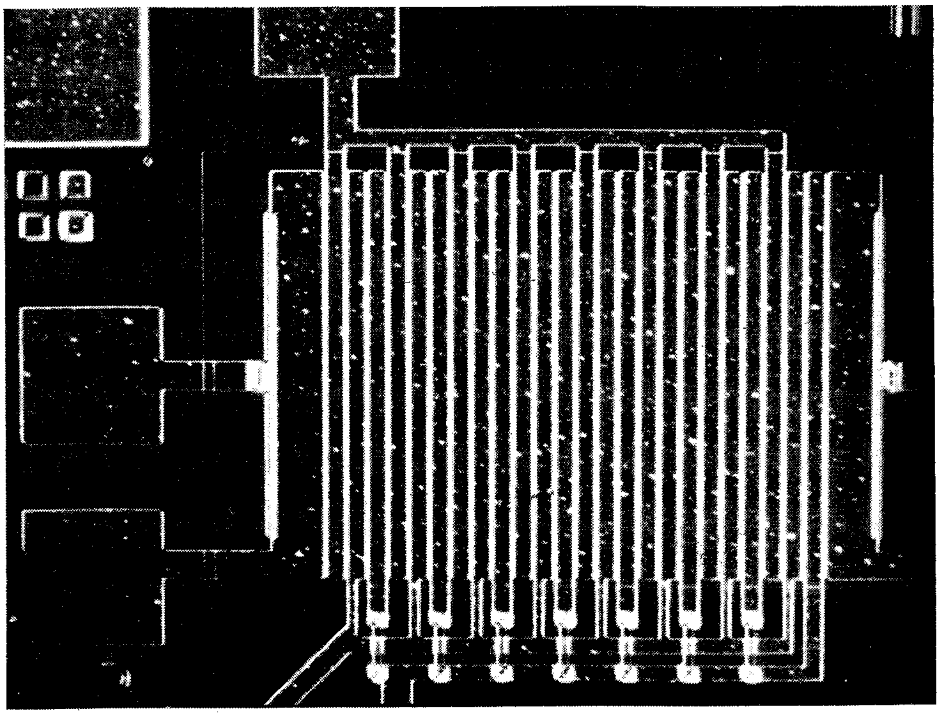
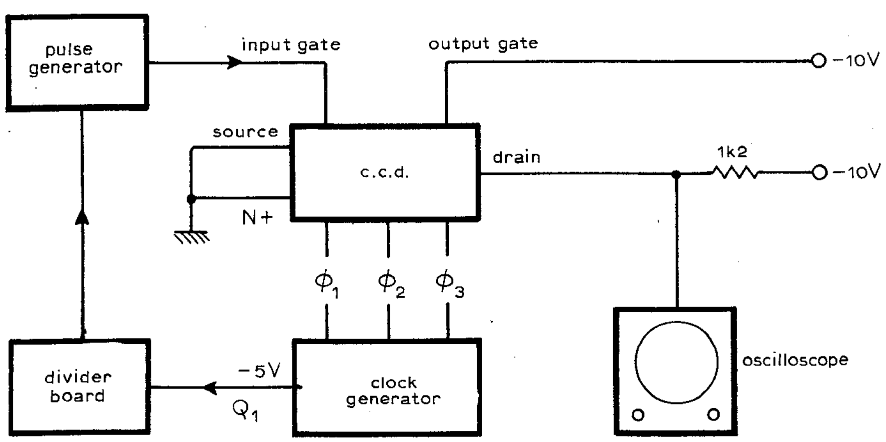


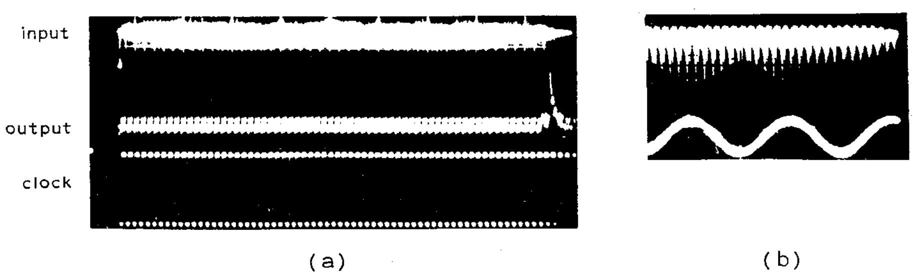
TABLE Digital operating conditions for an eight-bit p-channel c.c.d*

Clock frequency	20kHz to 5MHz
Source	earthed
Input gate, V_{IG}	−4.4V
Output gate, V_{OG}	−6V
Clock voltages ϕ_1, ϕ_2, ϕ_3	−30V
Drain bias	−10V
Drain load	1.2kΩ

*Silicon substrate, *n*-type, 50 ohm cm, and <100> orientation







the input gate pulse was 128 and equal to twice the number of bits in the device. The clock phase voltage pulse is also shown. The output pulse is shown delayed by 64 time intervals—bits ("range bins" in radar terminology)—from the input gate, square wave digital pulse.

Analogue operation

Fig. 6(b) top shows a sinusoidal analogue signal input that was applied to the same 64-bit p-channel device whose digital operation was shown in Fig. 6(a). In this case the analogue signal is applied via a capacitor to a negatively biased source diffusion as illustrated in Fig. 7. As with digital operation shown in Fig. 5, the channel stop diffusion is earthed. But in the analogue case the input gate has a d.c. bias of about −5V. The output is observed on an oscilloscope connected via a capacitor to the drain. The bottom part of Fig. 6(b) shows the delayed time quantized output of the analogue signal.

More details will be given about the operation and the use of the c.c.d. as an analogue delay line in a later article when radar applications are discussed.

Digital testing

Testing new devices for c.c.d. action is normally carried out digitally. The same circuit that was used in Fig. 5 to show digital operation can also be used for digital testing. Using this test set-up the digital characteristic of the device can be rapidly obtained by plotting the output from the drain, V_{OUT}, as a function of the input gate voltage, V_{IG}, for a series of constant values of the d.c. voltage applied to the output gate, V_{OG}. Fig 8 shows the transfer characteristic for the eight-bit device pictured in Fig. 3. As the input gate voltage is gradually increased a critical voltage is reached at which the devices switch on and this critical voltage is called V_T, the threshold voltage of the device. For the device shown in Fig. 8 V_T was −3.8V; V_{OG} must also be set above this voltage, V_T, or the device will not operate. As V_{IG} is increased above V_T the output increases until V_S, the saturation voltage, is reached. Above V_S no further increase in output occurs; V_S does not vary for output gate voltages above V_T. The output from the drain does vary with the output gate voltage and for

Fig. 3. Input gate and the clock pulse time sequence; t is the overlap between clock phases.

Fig. 4. Eight-bit p-channel c.c.d. made at RRE.

Fig. 5. Digital test set-up for a p-channel c.c.d.

Fig. 6. Digital input and delayed output from a 64-bit c.c.d. compared to clock waveform, (a). Analogue input and output for the same device, (b). Note that analogue output is quantized in time.

the device shown it reaches a maximum for output gate voltages in the range −6 to −8V.

Understanding the threshold voltage

To understand the threshold voltage consider what happens when a voltage is applied to the metal gate electrode of an m.o.s. structure, Fig. 9(a) shows a plot of the charge density $\rho(x)$ against distance x through a cross-section of an m.o.s. structure without any voltage applied to the gate, that is $V_G = 0$. The semiconductor is n-type and the interface between the semiconductor and the oxide occurs at $x=0$ on the diagram. The charge trapped at the surface states, Q_{SS}, is shown schematically as a block of positive charge of density, $\rho(x)$, lying on the oxide side of the semiconductor-oxide interface. This is because the majority of these surface states come from positive ions in the oxide and the maximum number of these ions are found just inside the oxide. Just as in a capacitor, when you apply a positive voltage or charge to one plate of the capacitor, an equal and opposite charge is induced on the other plate, so when a positive charge is present on one side of the semiconductor–oxide interface an equal and opposite negative charge must balance it on the other side of the interface. In the last case, as shown in Fig. 7(a), Q_{SS} is balanced by Q_A, a contribution of negative charge (electrons) from the *n*-type semiconductor in which the electrons are the majority carrier. The Q_A charge is referred to as the accumulation layer because it builds up or accumulates as the surface state charge increases in the oxide during and just after the growth of the oxide on the semiconductor. Under accumulation conditions:

$$Q_{SS} + Q_A = 0, (\text{for } V_G = 0).$$

Now, to move on to what happens when a negative voltage is applied to the gate. As this negative voltage increases, the electrons in the accumulation layer are repelled and gradually the accumulation layer is lost. Further increase in negative gate voltage after the disappearance of the accumulation layer results in further negative charge being repelled from the semiconductor-oxide interface. This produces a depletion region, as shown in Fig. 9(b). Charge Q_D due to the depletion region is shown as positive because it has resulted from the removal of electron majority carriers. The depletion region is depleted of all charge —both electrons and holes. (The depletion region in an operating c.c.d. normally extends all the way from the source to the drain, see Fig. 2.)

Further increase in the negative gate voltage results in attraction of positive holes to the interface. The surface of the silicon has now changed from being dominated by electrons as in Fig. 9(a) to one dominated by holes and is therefore said to have inverted from an n-type surface to a p-type one. Holes can now pass along this p surface channel. Hence an m.o.s. device, or in particular a c.c.d., that is produced on an n-type semiconductor is called a p-channel device. The size of the gate voltage determines the hole density in the channel region and so this means that the gate voltage controls or gates the channel current.

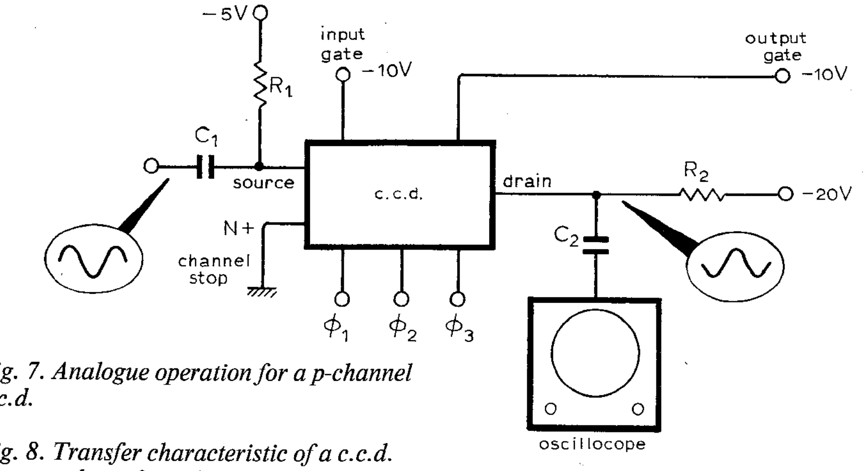


Fig. 7. Analogue operation for a p-channel c.c.d.

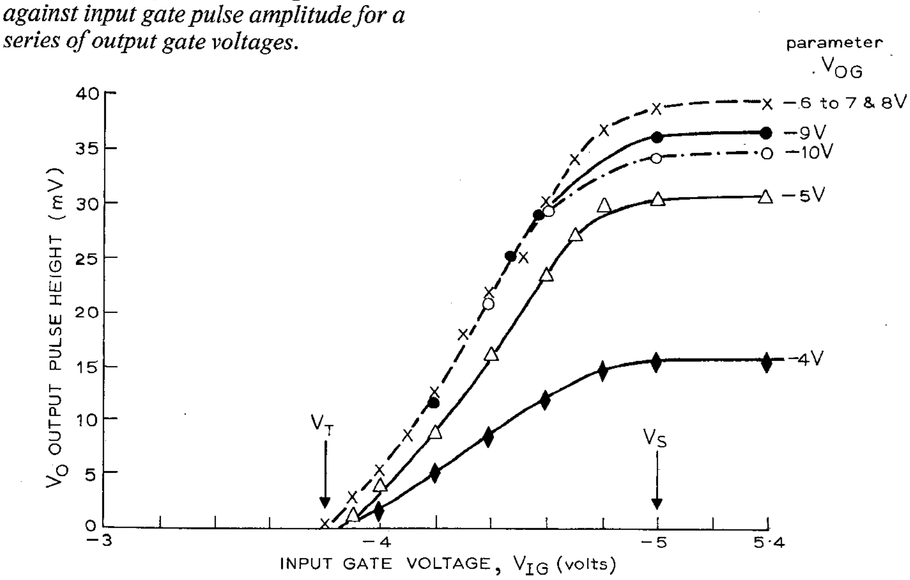


Fig. 8. Transfer characteristic of a c.c.d. Output voltage from drain is plotted against input gate pulse amplitude for a series of output gate voltages.

The threshold voltage, V_T, is the voltage required to produce inversion or current flow in the channel. It is usually defined as the voltage required to produce a current flow of 1μA, because it is well above the leakage current (or noise) levels which are usually of the order of nanoamperes. V_T for a p-channel c.c.d. normally lies in the region of 1.8 to 4.0V. For n-channel devices, however, the threshold is usually below a volt and a second article will show how the properties of n- and p-channel c.c.ds compare.

Surface states

Surface states act as traps for electrons and holes travelling along the surface of the semiconductor and they have a large effect on the operation of a surface channel c.c.d., such as the one described previously.

Surface states arise in many different ways. Some of the major causes of surface states are:

—impurity ions in the oxide

—defects at the semiconductor surface due to impurities, or defects in the crystal structure of the semiconductor, or a combination of both

—absorbed impurities on the surface of the semiconductor.

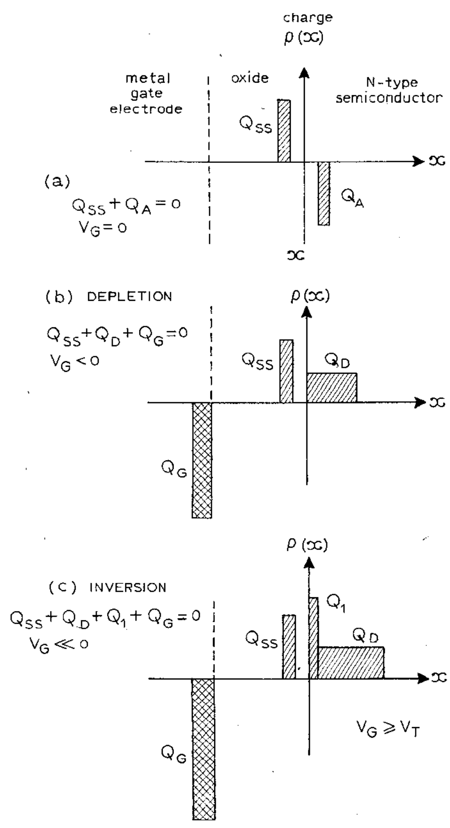


Fig. 9. Schematic diagram of the charge distribution in an m.o.s. structure for three cases: (a) zero volts on the gate, (b) depletion, and (c) inversion.

The surface states which arise from positively charged impurity ions such as sodium in the oxide are known to be the major cause of surface states in the case of c.c.d. Some of these ions are trapped at the surface when the oxide is grown on the semiconductor during c.c.d. manufacture. Others remain in the oxide very close to the interface, and then the charges trapped on these states drift to the surface when the device is switched on. The negative voltage that is applied to the gate drives the positive charge to the interface, and the time taken by the charge to move to the interface is usually seconds or minutes so these surface states are referred to as slow states. Slow surface states can often be observed in poor-quality devices. A certain warm-up time of a few minutes is required before the device reaches a maximum due to the electron trapping of these slow states. Once the trapping slows down to its equilibrium level the device reaches a maximum.

Fast surface states are those which can trap charge in a few milliseconds or less. These fast states arise from all the three sources discussed above and they control to a large extent the high frequency limit of operation of the device.

Charge transfer efficiency

The transfer efficiency gives a measure of the efficiency of charge transfer in c.c.d. It is the most critical parameter and much more important than the threshold voltage.

The charge transfer efficiency is defined as the fraction of the charge transferred when a charge packet moves from under one clock transfer gate electrode to the next. Charge loss can be considered as having two contributions:

—the fractional charge lost during the transfer across the gap between the electrodes, q_T (or α)
the fractional charge left behind under the electrode, the so-called residual charge, q_R (or ϵ).

The charge transfer efficiency, η_T, can therefore be written as

$$\eta_T = (q_n/q_{n-1})100 = (1-q_T-q_R), 100\%,$$

where q_n is the charge under the nth electrode and q_{n-1} is the charge under the $n-1$ electrode. The fractional charge lost during transfer, q_T, depends on

—surface state density
—width of the gap between the transfer electrodes
—strength of the input signal; that is, the amount of charge injected into the device from the source
—speed of transfer or the frequency of operation of the device.

The residual charge, q_R, is a function of the above and also on the length of the transfer electrode.

For optimum transfer efficiency q_R and q_T must be minimized. Only when the transfer efficiency is high enough will the c.c.d. meet the stringent requirements of most of the systems applications for imaging and radar.

To minimize both q_R and q_T the surface state density must be kept as small as possible by using careful selection of the silicon material that is used for the devices and the silicon processing that is carried out. A second article will outline some of these processing techniques and also discuss the buried-channel c.c.d. in which the charge transfer is carried out under the surface of the silicon so that surface states are avoided altogether.

For the surface-channel device, the gap width must be kept to 3μm or below to give a reasonable transfer efficiency and must be maintained across the device. In addition, if the gap can be made less than 1μm and the electrode size can be kept to 10μm or below, operation in the frequency range 1 to 10MHz becomes very efficient. New surface-channel technologies have been developed to produce very-small-gap and gapless devices and will be discussed in a later article.

The input signal strength is very important when considering operating efficiencies. If it is too small, the transfer efficiency is very low because surface state trapping dominates. For this reason most c.c.ds are operated in the fat zero mode.

In this mode a constant trickle of charge or level of channel current is maintained either by not allowing the input gate voltage to go below V_T, or by exposure of the whole of the device to a constant light level so that a small number of carriers are optically generated in the channel. Of these two, the first is most commonly used where the signal is superposed on the small channel current provided by the offset d.c. bias on the input gate.

Signal strength must also not be too large and should be kept well away from output level saturation. This is because near saturation, thermally generated carriers and any fluctuations in device geometry, can result in the overflow of carriers from a potential well under one transfer electrode to an adjoining well. As a result the signal is smeared out and, in the case of analogue operation in particular, vital information can be lost.

Dependence of transfer efficiency on signal strength is clearly illustrated in Fig. 10 where the full line shows the transfer efficiency plotted against the voltage on the input gate. (The dashed line shows the output voltage seen on the oscilloscope using the circuit shown in Fig. 5, also plotted against the input gate voltage.) The centre of the flat plateau of constant transfer efficiency coincides with half the maximum output signal and this represents the optimum working condition.

Transfer efficiency values shown in Fig. 10 were measured with a scanning light-spot technique[3]. This method is only one of several different measurement techniques[3,4] that have been used for measuring transfer efficiency. The trailing pulse technique is the simplest of these. In this case the ratio of output pulse to the next ϕ_1 trailing pulse is used to calculate the transfer efficiency. This technique has the advantage that it needs no extra equipment and can be easily calculated at the same time as a new device is being tested.

In the same way, none of the sophisticated technologies that have been developed for the c.c.d. is perfect for a wide range of conditions. But the currently available technologies to be described in another article do improve the potential of the c.c.d. and make it look a very attractive proposition for many applications.

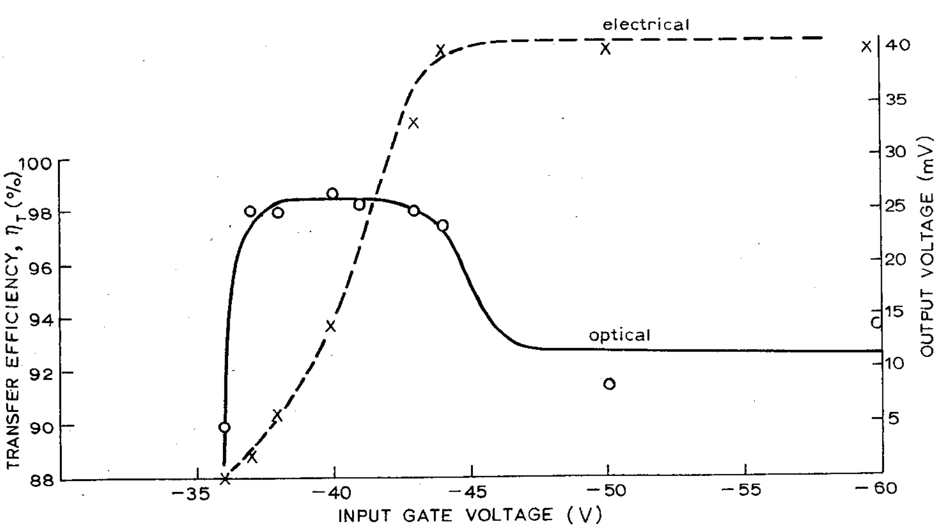


Fig. 10. Variation of optical transfer efficiency with voltage on input gate for an eight-bit p-channel device. Dashed line shows electrical transfer characteristic for the same device.

Acknowledgement This article is published with the permission of the director of RRE. Figs. 2, 3, 4 and 8 appeared in an article published by the Institute of Physics in *J Phy D*, August 1974.

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2. Gilder, J. H., *Electronic Design*, vol 25, December 6, 1973, p. 32.
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Rhombic u.h.f. TV aerial

Design for loft installation uses coaxial-to-wire impedance conversion device

by A. B. Starks-Field, B.Sc., M.I.E.E.

The account which follows was triggered by a chain of circumstances that originated in the motor industry. Because of the increasing level of ignition interference from many of the modern cars (manufacturers, please note!) the time came when I had to do something about the picture on my 17-year-old home-constructed 45MHz television receiver.

A preliminary examination showed that the flywheel synchronizer locking was no longer able to cope. Because of the set's age I decided to pension it off in favour of a 600MHz receiver, and this in turn raised the question of whether to build or to buy. Being preoccupied with other matters, I decided to buy and put up with the inferior sound reproduction.

The choice of aerial was the next query to raise its ugly head, and I say "ugly" advisedly, because a roof-top Yagi is not a thing of beauty; neither is it cheap, particularly if one has to pay someone to erect it. The alternative was a loft antenna of some kind; this was attractive, for although I have reached the years of discretion when roof-clambering has lost its savour, I am still agile enough to reach the loft where I have a power point and can work in comparative comfort. The indoor aerial has the further advantages of being protected from wind and weather and there are no swaying feeders ultimately to break.

The next question was, which type to use? My local (booster) BBC station radiates a horizontally polarized signal and (according to a field-strength contour map) provides better than 10mV per metre in my area. There are, however, notorious "holes" in the district and, taking this and the opacity of the roof into consideration, I judged that I should need an aerial of some significant gain and directivity; but what?

In my amateur days (G6YG) in the late 1930s my particular pipedream was to have a shack at the hub of a set of rhombics all pointing in the most useful directions. This remained only a dream because of the relatively small garden space available, but the desire to use a rhombic has always remained. Well, why not do so? The loft is large enough to accommodate one about 11 wavelengths long and pointing towards the local BBC and IBA stations.

According to Terman[1], if a rhombic has legs of six wavelengths each it has a gain of 65 times (approximately 18dB) and a horizontal beamwidth null-to-null of about 22°, and about twice this in the vertical direction. Yes, this should be satisfactory for my requirement and because of its lack of resonant components it performs reasonably well to less than half its optimum frequency, so there is no bandwidth limitation.

However, we are not there yet. We always thought of rhombics as terminated with a 600Ω resistor and using a parallel wire feeder of 600Ω characteristic impedance (c.i.). The television receiver would be required to work with a 70Ω c.i. cable and in any case a 600Ω c.i. feeder would be a difficult one to accommodate up the walls and into the loft. A further point is that at this impedance, using 18swg wire, the required spacing is of the order of four inches which is a significant part of a wavelength and so the feeder is likely to receive or radiate. No, some form of coaxial-to-wire impedance conversion was required.

The first thing which came to mind, rather reluctantly because of its resonant quality, was a quarter-wave matching section. Calculation indicates that if one wishes to match 70Ω to 600Ω the c.i. of the matching section has to be about 200Ω. Looking up the spacing indicated in the *W.W.* Radio Charts for this impedance one finds that it is very small, as shown roughly to scale in Fig. 1.

Now at 600Ω c.i. the spacing of 18swg wires (as has already been said) is of the order of four inches and the quarter-wave matching section requires to be about 6¾in long, with the result shown in Fig. 2. The wires connecting the matching section to the 600Ω line—which may, in fact, be the start of the rhombic aerial—are a significant length in terms of a wavelength, so that this scheme clearly will not work. Are there then any other ways of achieving this transition?

Going back to amateur days again, Fig. 3 shows a very popular aerial which we used to call a Y-matched dipole. The significant feature about this one is that the 600Ω feeder was brought to a point below the aerial where it then spread out to two points A and B, where connection was made to a half-wave radiator.

The selection of points A and B are such that the aerial presents an impedance which corresponds to the c.i. of the feeder wires at the spacing of AB, probably something of the order of 1000Ω. The Y section is thus a flared transition between the 600Ω line and 1000Ω and because of the continuous gradation of c.i. does not produce a mismatch and therefore no standing waves. As this form of matching works from 600Ω to 1000Ω, then it seemed to me that in principle it should also be effective from 70Ω to 600Ω.

I have no doubt that some of my mathematically minded colleagues could produce a rigorous proof, but for the moment let me suggest a mechanism whereby a true impedance transformation is effected and at least gives an approach for the mathematician. Fig. 4 shows a series of lumped elements of part of the transition where C_1 represents the capacitance per unit length and L_1 the inductance per unit length before the flare. C_2, L_2, C_3, L_3, etc., are all parts of the flare where C_n progressively becomes less as the flare progresses while L_n pro-

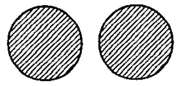


Fig. 1. Wire spacing for 200Ω characteristic impedance.

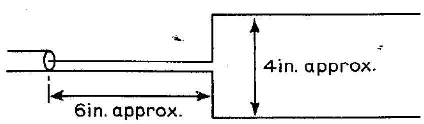


Fig. 2. Matching a 70Ω coaxial cable to a 600Ω wire feeder; the spread is significant compared with the wavelength.

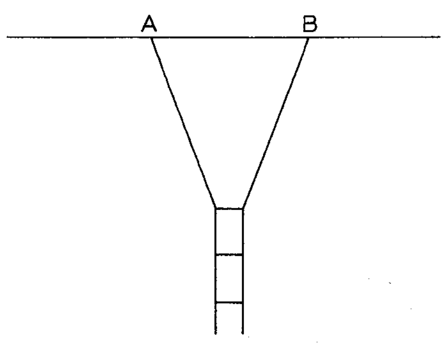


Fig. 3. The Y-matched dipole.

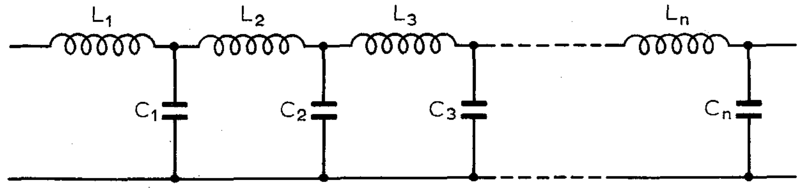


Fig. 4. Lumped constant representation of a transmission line.

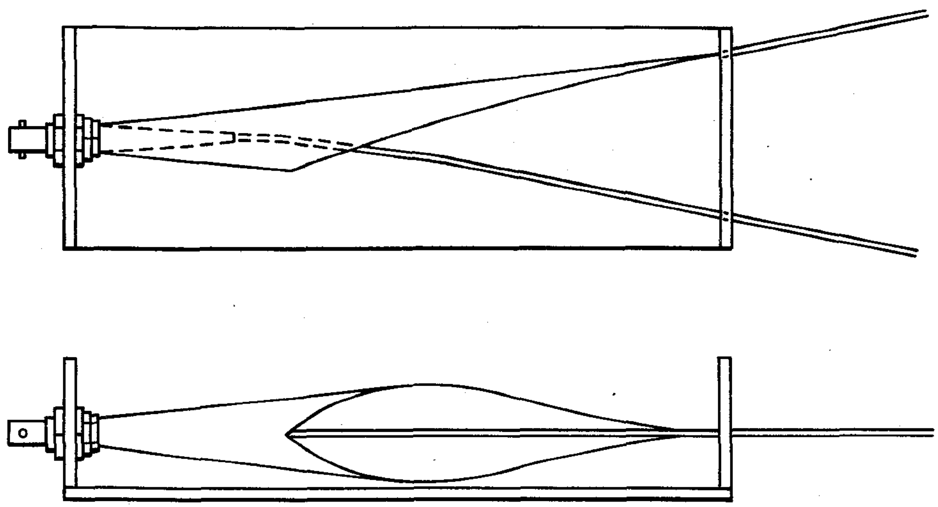


Fig. 5. Coaxial to open-wire flare.

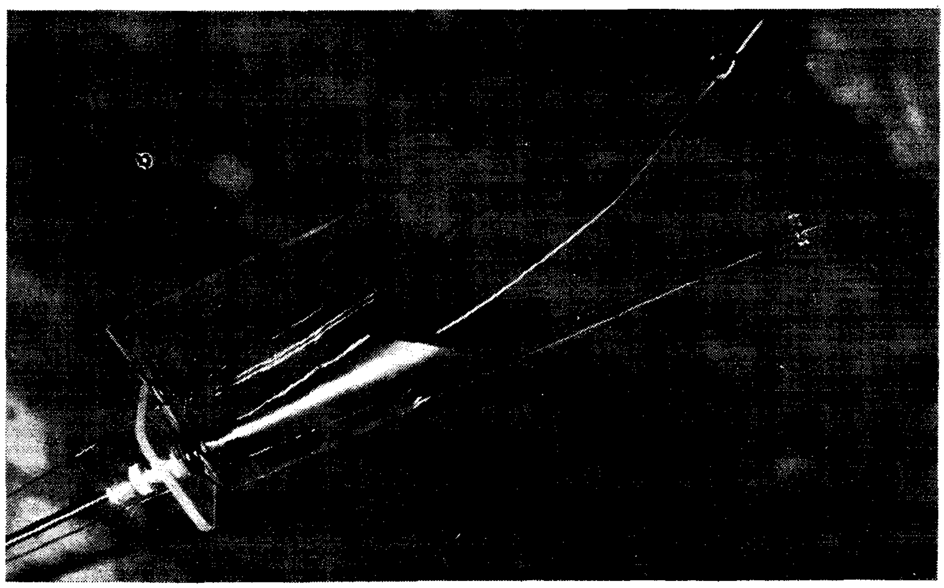


Fig. 6. Construction of the coaxial to open-wire flare shown in Fig. 5.

gressively increases. One can imagine an established current in L_1 charging C_1 at the expense of the magnetic energy in L_1. As the voltage builds up in C_1 current starts to flow in L_2 which in turn starts to fill C_2. This is the basic process of the running wave. Now since C_2 is less than C_1 and L_2 is greater than L_1 they will pass the same amount of power at higher voltage and less current. Likewise with C_3 and L_3, so that as the wave progresses it will acquire more voltage and less current. By the time it reaches the 600Ω spacing of the flare the impedance transformation will be complete and the wave may be launched in a 600Ω line. This, of course, is not the whole story because if the flare is short compared with a wavelength it does not work. Mathematicians, please note that I think the transition must at least be $\frac{1}{4}\lambda$ and preferably longer but I have made no attempt to prove it. Of course, this sort of transition must take place on the rhombic aerial itself as the wires spread out, but more of this later. The above is, of course, argued in terms of transmission but the reverse is true in reception.

Thinking in practical terms, then, what sort of flare is needed from the 70Ω coaxial cable? Without fussing about minimum size it appeared to me that the desirable arrangement would be first to arrange a transition from the semi-solid dielectric coaxial cable to a convenient diameter of airspaced coaxial, followed by some sort of graded transition to an open-wire line. This is because nature has decreed that enormous spacings are required to produce a coaxial of c.i. higher than 150Ω and negligible spacings are required for an open-wire line of the same impedance. The simplest way to do this was to taper the polythene inner insulation down to zero thickness and at the same time to flare the outer in some way to the diameter corresponding to about 150Ω c.i. From this point onwards the flare would be cut away to a tapered point where it would be joined to one wire of the rhombic. The inner would, of course, be extended to join the other wire.

I discussed this with a colleague and, jointly, we arrived at the design shown in Fig. 5. We then each built a rhombic and its transition into our respective lofts. I should add that my collaborator is in a locally notorious signal-strength "hole", where even diffracted signals are loth to reach.

The flare of the transition is made of pieces of copper foil cut to form a cone which has a diameter of 0.6in at about 4in from the start. Beyond this the copper cone is cut away in a gentle curve to a point about 10in from the start. (Provided that sharp discontinuities are avoided, the dimensions are not critical.) The polythene inner insulation of the coaxial cable is tapered down to zero thickness at about 2in from the start of the cone; thereafter, the bare wire emerges to a suitable anchoring point (see later). The wire should run through the middle of the cone, but it was found that this requirement is not ultra-critical (a 10% deviation either way made no significant difference) and the wire is sufficiently self-supporting to remain *in situ* without spacers. The complete device is mounted on a Perspex cradle which keeps the structure rigid and provides means of anchorage for the connections. As already stated, one end of the rhombic is connected to the end of the tapered copper cone, while the other end connects to the central bare wire. My colleague, being more finished-product-conscious than I am, decided to fit a connector at the coaxial end, whereas mine is simply joined directly to the down-lead to the receiver. Fig. 6 is a photograph of his version.

The next problem was how to check it and see if it would work. We had available to us a Rohde and Schwarz Polyskop which covered the frequency range up to 1000MHz and is a combined frequency sweep generator and cathode-ray display. Basically this instrument feeds the output terminal from a high impedance source, measures the voltage amplitude of the signal at this point and displays the result against a timebase synchronized with the frequency sweep. Thus it can measure the effective impedance of any device connected to its output.

We therefore decided to connect a short length of coaxial cable to our flare, terminating it with a 560Ω resistor, and in effect measure the input impedance of the coaxial cable. Over the range of frequencies where the termination is correct, the Polyskop trace should be level, and if not, the trace should show a series of undulations where the frequencies corresponded to those at which the cable is a multiple of quarter-wavelengths long. As would be expected at low frequencies the standing wave ratio, which is in effect what the test is showing, was bad, but over the range of about 550 to 680MHz it was only 3:2 which is quite satisfactory. We found this was little different from the cable terminated with a standard 70Ω load. However, the surprising thing was that it started to increase again above this frequency.

It then dawned on us that the fault lay not in the flare but in the terminating resistor which, together with its end wires, was too long. Standing waves were being built up on it, resulting in various values of effective terminating impedance.

On the entry to the rhombic aerial this, of course, is of no consequence as it is simply a continuation of the flare, but it suggests that the spacing at the far end should be reduced to about ½in which is the length of a resistor and is sufficiently small compared with a wavelength. The termination would then be about 400Ω, the nearest preferred value being 390.

However, by the time these conclusions were reached my own aerial was installed and it is unfortunate that I have left the end spacing at about 4in and terminated with 560Ω but this is clearly not critical.

Let me say at this juncture that so far I have made no attempt to explore the transition v.s.w.r. situation in greater depth, as the construction of the arrangement described was essentially a practical exercise and an unavoidable interruption to my other electronic interests! One day I hope to experiment, but in the meantime some interested reader might care to take the matter further.

One possible approach is shown in Fig. 7. This consists of a flare from 70Ω to 600Ω spacing, followed by a length of 600Ω line and then a reverse flare to the terminating resistance. I suggest that the terminating flare should be brought down to about 300Ω spacing and terminated with two 150Ω resistors as shown.

The whole could then be tried on a Polyskop or some other device which permits the checking of the v.s.w.rs. If any reader happens to live in an area where there are two transmitters on reciprocal bearings, a flare could be fitted to both ends of the rhombic and a coaxial lead brought down from each. In theory the lead which is out of use should be terminated in 50Ω or 70Ω as the case may be; however, the loss on an open-circuited coaxial may be enough to terminate the aerial adequately.

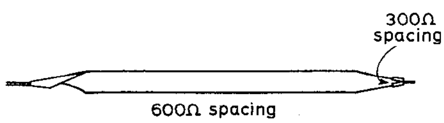


Fig. 7. Improved arrangement for checking flare matching.

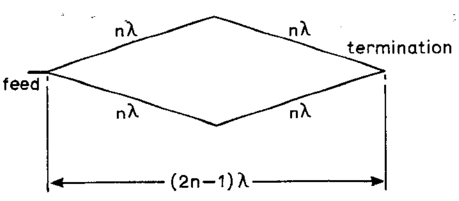


Fig. 8. Rhombic aerial dimensions. Note that n does not have to be an integer.

One further point that may occur to readers contemplating building this device is that here we have the classic situation of a balanced aerial being fed with an unbalanced feeder and is therefore one in which squint might be introduced.

The only contribution I can make at the moment is a practical comment. After installation I discovered that the local 600MHz transmitters were farther east than I had thought and that an additional error had put them just about on the edge of the expected beam. (So much for being in a hurry!) However, subsequent correction to the geographical line-of-sight made only a slight improvement in the original received signal. My knowledge of field theory is somewhat limited, but I would have thought that, because of the large voltage transformation to the point of maximum spread (12 or 14:1), squint is unlikely to be significant. The phase considerations are unaffected and my present belief is that the capacitance between the lines and nearby objects (wiring conduit, water pipes, etc.) would mask any basic effects. However, it would be interesting to explore the field with a directional probe and examine all the perturbations in orientation.

But enough of theory. The more practical will want to know something of received picture quality. In fact this was eminently satisfactory, all three local transmissions (two BBC and one IBA) coming in clearly with no noise either on sound or on vision. Here, perhaps, I should add that my own experience does not in itself settle whether it is a good aerial or not, firstly because I am probably in a fairly strong region of field strength and secondly because I had no previous u.h.f. aerial with which to compare it. My colleague, however, is in a field strength "hole" and has hitherto used a log periodic aerial previously described in *Wireless World*[2]. This, at his location, gave a very poor signal-to-noise ratio. The rhombic on the other hand, has given a startling improvement; an estimated gain of about 10dB signal-to-noise.

I have not dealt with the construction of the rhombic itself as there is plenty of literature concerning the design of such aerials. Those unfamiliar with such a device will see from Fig. 8 that the construction is extremely simple and eminently suitable for medium-sized lofts. Larger aerials still are obviously possible where space permits and may be desirable in extreme fringe areas. In regions where the signals are vertically polarized, the aerial should, of course, be turned over on its side.

In conclusion, I should like to thank my colleague Mr R. A. Tyler for his help and also the Editor of *W.W.* for his valuable suggestions concerning the presentation of this article.

References

1. Frederick E. Terman. Electronic and Radio Engineering. McGraw Hill.
2. M. F. Radford. "Logarithmic Aerials for Bands IV and V", *Wireless World*, Sept. and Oct., 1964.

Meetings

LONDON

2nd IEE—"Early development of the television camera" by Prof. J. D. McGee at 17.30 at Savoy Pl., WC2.
4th IEE—"High power radar studies of the ionosphere" by Dr. J. V. Evans (Tenth Appleton Lecture) at 17.30 at Savoy Pl., WC2.
5th RTS—"The Canadian domestic communication satellite system" by R. F. Chinnick (Shoenberg memorial lecture) at 19.00 at the Royal Institution, Albemarle St., W1.
9th IEETE/Inst. MI—"The applications of electronics to the design and testing of automobiles" by T. R. Aston at 18.30 at the IEE, Savoy Pl., WC2.
10th IEE—"Electroluminescence" by A. Vecht at 17.30 at Savoy Pl., WC2.
10th IEE—"High power stepping devices" by Prof. P. J. Lawrenson and Prof. R. J. A. Paul at 17.30 at Savoy Pl., WC2.
11th IERE—Colloquium on "The graduate electronic engineer in Britain and Europe" at 10.00 at 9 Bedford Sq., WC1.
11th IEE—"Some applications of digital techniques to television broadcasting" by F. H. Steele at 17.30 at Savoy Pl., WC2.
12th IEE/R.Ae.S.—Symposium on "The application of digital avionic systems in aircraft" at 9.45 at the Royal Aeronautical Society, 4 Hamilton Pl., W1.
13th IEE—Colloquium on "Techniques at high voltages" at 10.30 at Savoy Pl., WC2.
16th IEE—"Exposition of quadraphony" at 14.30 at Savoy Pl., WC2.
17th AES—"Audio oscillators" by P. J. Baxandall at 19.15 at the IEE, Savoy Pl., WC2.
18th IERE—Colloquium on "Electronics and the motor vehicle" at 10.00 at 9 Bedford Sq., WC1.
18th IEE—Colloquium on "Integrated circuits for analogue functions" at 14.30 at Savoy Pl., WC2.
18th IEE—"Transformer multiflow hottest-spot rating proposed standard specification" by E. T. Norris at 17.30 at Savoy Pl., WC2.

BRIGHTON

12th IEETE—"Simply and or not—a review of elementary logic gates" by E. Keeler at 19.30 at Royal Albion Hotel, Old Steine.

EXETER

5th IEETE—"Computers and programming" by L. M. Goddard at 19.30 at Exeter College, Hele Road.

GUILDFORD

4th IEE—"Nuclear power—its promise and problems" by H. H. Gott at 19.30 at the University of Surrey, Stag Hill.

HULL

11th SERT—"Trinitron tube" by speaker from Sony (UK) Ltd at 19.30 at Hull College of Technology.

LEEDS

12th IEETE—"New developments in integrated environmental design" by R. D. Parker at 19.00 at Kitson College, Cookridge St.

MAIDSTONE

2nd IEE—"Electronic aids to night vision" by Dr. P. Schagen at 19.00 at S.E.E.B. Maidstone Dist. Offices, Parkwood, Sutton Road.

READING

5th IERE/IEE—"The application of electronics in telephone exchange switching" by F. W. Croft at 19.30 at the J. J. Thomson Physical Laboratory, University of Reading, Whiteknights Park.

Tickets are required for some meetings: readers are advised therefore to communicate with the society concerned.

News of the Month

Low-light camera

The determined intruder is not easily defeated, but the use of invisible "light" with television cameras must pose a pretty problem to him. We were recently shown a system developed by ADT which uses radiation at a wavelength of 1.1 microns (effectively total darkness), or a slightly more visible 0.8 microns, to irradiate the scene, reflected radiation being picked up by a silicon diode array.

The use of the diode pick-up tube is claimed to offer advantages over the conventional method of a vidicon camera used with an image intensifier, the main one being that the signal-to-noise ratio is markedly improved. As the diodes have their peak sensitivity at the radiation wavelength used, a very small aperture can be used, with a consequent increase in the depth of field. Readers may remember that a similar pick-up tube used on a normal moon-shot suffered a dismal fate when it was accidentally aimed at the sun. ADT have fitted an automatic iris which varies the aperture from f1.2 to f360 sufficiently rapidly to protect the diodes against burn-out.

Apart from the obvious security value, the system is expected to find application in hospital surveillance, where the absence of visible lighting would be of great benefit to patients.

The low-light television surveillance system by Electronic Protection Services, Hillgate House, 26 Old Bailey, London EC4, a subsidiary of ADT of America (see accompanying news item).

Quis custodiet

The Design Centre in Haymarket, London will be reconsidering their security arrangements during the next few days, following the disappearance of one of their "high-technology" displays. An electronic transmitting key and control unit made by security experts Distloc, and used for remotely locking and unlocking strong doors, van doors, cash registers, petrol pumps etc, have been taken from their display case. Distloc promise enough flashing lights and clanging bells around any future exhibits to send any prospective purloiner on a hallucinatory trip.

Electric gas cookers

Electronic spark ignition units are not new, but the application of electronics to spark ignition for gas appliances is relatively recent. Ignition for fuel gases, unlike petrol vapour, demands a high degree of efficiency. This can be provided by the capacitor discharge principle. One of the major advantages of using these electronic spark ignition units is that ordinary pilot lights are rendered unnecessary. In California, legislation aimed at saving natural gas by the elimination of gas-fuelled pilot lights has recently become law. During the preparation of the bill, it was estimated that between 10 and 15% of natural gas used by domestic appliances throughout the state was consumed by pilot jets.

Plessey Windings has received a substantial order from the Caloric Corporation, Topton, Pennsylvania, USA for the supply of electronic spark ignition units. The Caloric Corporation, one of the major cooker manufacturers in the USA, is incorporating the units in its latest gas cookers.

Energy conversion alternatives

Methods of producing electrical power from coal will be assessed by a NASA industrial team in an 11-month study. Development and operating costs and the impact on the environment will be compared for a variety of systems using coal or coal-derived fuels. Conventional fossil-fuelled power plants operate at efficiencies of up to 40%, but greater efficiencies are possible. For example, a potassium Rankine system added as a "topping cycle" (additional heating stage) to a plant may increase efficiency to 50%. The study will compare a variety of energy systems. These include: advanced steam plants; open and closed cycle gas turbine systems; combined systems such as a gas turbine system used with a steam plant; supercritical carbon dioxide systems; liquid metal Rankine topping cycle magnetohydrodynamic systems and fuel cells.

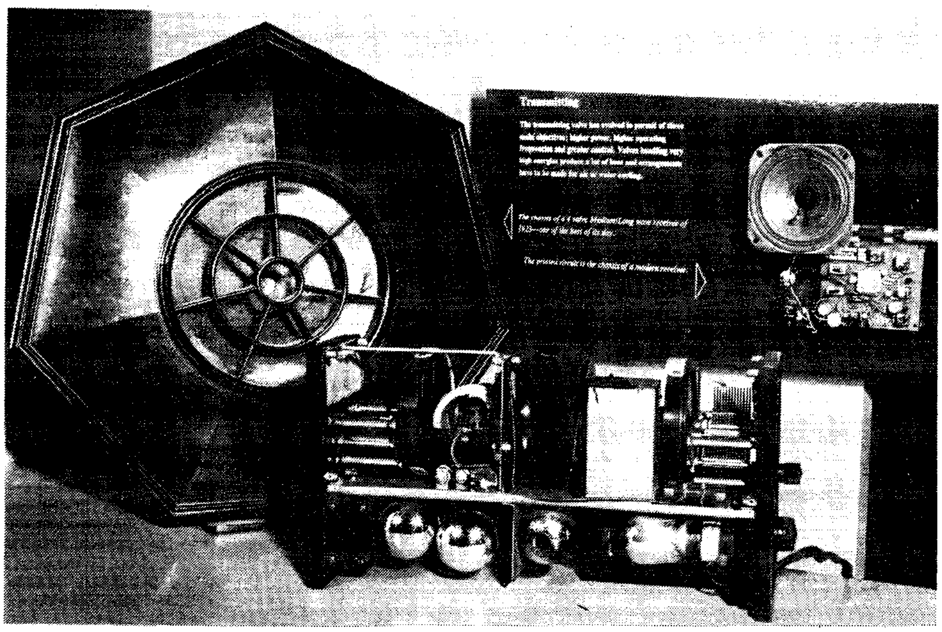
Scotland goes stereo

From the start of programmes on October 14, some of Radio Scotland's music and light entertainment programmes and certain Radio 4 items are now broadcast in stereo from the Kirk o'Shotts v.h.f. transmitter. Radio 2 and Radio 3 are already in stereo. The stereo signals will be re-broadcast by the relay stations at Ashkirk (serving much of the border country), Ayr, Campbeltown, Forfar, Millburn Mair (Vale of Leven), Rosneath (Gareloch) and Toward. Some of these stations are a long way from Kirk o'Shotts so the quality and the consistency of the re-broadcast stereo signals will not be known until some time after tests have been carried out. The programme link to Scotland uses p.c.m.

Business abroad for Britain

The UK is rapidly expanding its electronics operations in North America. In response to fast-developing market opportunities, notably in the areas of advanced technology, commercial and medical electronics, the EMI Group is now progressively establishing a network of manufacturing and marketing facilities throughout the USA. Their latest move is the acquisition of Electron Technology Inc. of Kewny, New Jersey, who manufacture specialised glass components for the electron tube industry.

Back home, the tape division of EMI has recently launched a new ferric oxide cassette tape which is 30% cheaper than high quality chromium dioxide cassettes but is claimed to produce results at least as satisfactory as chrome formulations. The new Emitape X1000 is the result of two years' research and development using a new ferric oxide micro-particle. The main technical improvements claimed compared to low noise tapes are: an increase of 3-4dB output in the 8–15kHz region; improved overload characteristics; wider dynamic range; improved h.f. response and lower intermodulation distortion.



On the left the chassis of a 1923 medium- and long-wave receiver and on the right its present-day equivalent. These are two Philips radio receivers on show in a display covering the story of radio at the newly opened extension of the IBA's Broadcasting Gallery, Brompton Road, London.

Channel link in service

Expansion of Britain's busiest single international route, the 38-mile radio "hop" across the English Channel, has taken a further step forward. Under the Post Office's plan to double the route's call-carrying capacity the first 60 telephone circuits of a new microwave link are now carrying calls to France. The new link, which will eventually be handling up to 1,800 calls simultaneously is the first of two to be provided in the Post Office's drive to expand telephone and telex services with Europe.

The route from the microwave station on Kent's Channel coast to its French counterpart can at present carry 2,160 telephone calls simultaneously. The new microwave links will boost this to 5,760. Under present plans, the Post Office expects to add 1,000 circuits of the extra capacity during the next five months. Further groups of circuits will be progressively introduced next year.

Broadcasting conference opened

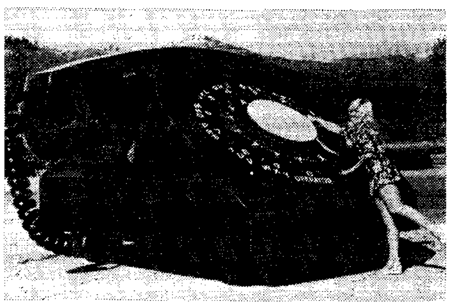
The first session of a Regional Administrative Conference for the re-planning of medium- and long-wave broadcasting in Regions 1 (Europe and Africa) and 3 (Asia and Australasia) opened at the beginning of October at the Geneva International Conference Centre. More than 400 delegates from 70 member countries of the International Telecommunications Union took part in the conference which lasted for three weeks (see August issue pp. 266–271, "The future of medium- and long-wave broadcasting", which described the problems facing the conference). This first session concentrated on formulating the technical and operational criteria and the planning methods which will serve as a basis for the preparation by the second session of frequency assignment plans covering the l.f./m.f. broadcasting bands in Regions 1 and 3. The second session is to be held from October 6 to November 22, 1975.

Technical and operational criteria took into account propagation data, modulation standards and channel spacings, protection ratios (including noise levels), transmitting antenna characteristics and transmitter powers and planning methods.

Giro errors detected

Holland's largest commercial bank is installing a new British electronic error detector and control unit to further safeguard the accuracy of its Giro payment transfers. The units are plugged in to the bank's electric typewriters which are used to prepare the optical character reading input for the payment transfers. Each unit can be added on to a standard office typewriter without requiring any electrical interconnection and can be operated directly from the typewriter keyboard to carry out computer compatible check digit verification and a variety of totalling or other functions according to a pre-determined programme.

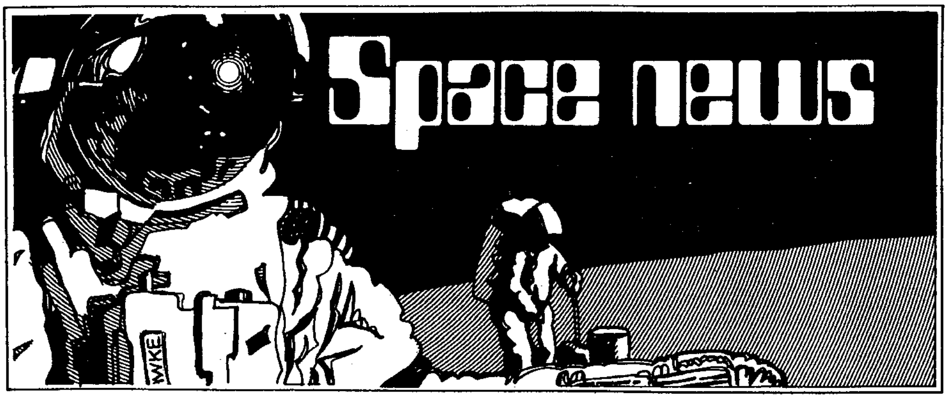
It is important to safeguard the accuracy of the two different bank account numbers which are being debited or credited with the money value involved in each transaction. Normally, any transposition or transcription errors are discovered as soon as the data reaches the central computer, but at that stage the problems involved in investigating and rectifying errors in account numbers are such that it becomes increasingly important for any errors to be detected at the original point of entry when the source documents are still at hand.



Not a telephonist's nightmare, but a giant mobile telephone built in the USA by General Telephone and Electronics Corporation to promote a new concept to conserve petrol, "dial before drive". Motorists are urged in a TV commercial to phone before setting out in their car to check that the trip is really necessary. The giant phone is mounted on a VW chassis and can be driven up to 35 mph

Stereo f.m. radio in Australia

The Federal Cabinet in Canberra has authorised the introduction of stereophonic frequency modulated radio in Australia and the establishment of new radio stations in both Sydney and Melbourne for the Australian Broadcasting Commission. The new f.m. stations will be operated by the musical broadcasting societies of New South Wales and Victoria and will aim to be self-supporting. A number of stations could be licensed over the next few years. The initial steps will enable the Government to assess the demand for public broadcasting.



Camera on Mars

The first tests of the camera that will photograph Mars from ground level when NASA's Viking spacecraft lands on the planet in 1976 have been successful. The camera has very small photo-diodes positioned in the focal plane where film would be in a conventional camera. An image is reflected from a mirror through lenses onto the diodes. The mirror rotation essentially scans the image and each time it moves through one cycle, a single vertical line is scanned in the field of view. The entire camera is then slightly rotated and the next vertical line is scanned. Several minutes are needed to obtain a complete photograph because the image information is sequentially acquired at about five lines per second. Colour photos are produced by combining data from three diodes (blue, green and red sensitive).

Each Viking spacecraft consists of an "orbiter" and a "lander". The lander's imaging system consists of two cameras providing colour, black-and-white, infrared and stereoscopic views of the Martian surface. The instruments are facsimile cameras designed for operation in unusual conditions. One of the most important jobs will be to characterize the area near the lander, so scientists on Earth can select spots from which samples should be obtained for chemical and biological analysis in the miniature laboratory on board each lander. The imaging system will also provide photometric information from near-by materials that will help deduce composition and particle sizes. It will monitor the Martian atmosphere opacity and record the position of the sun and brighter planets, to allow precise location of the lander on Mars.

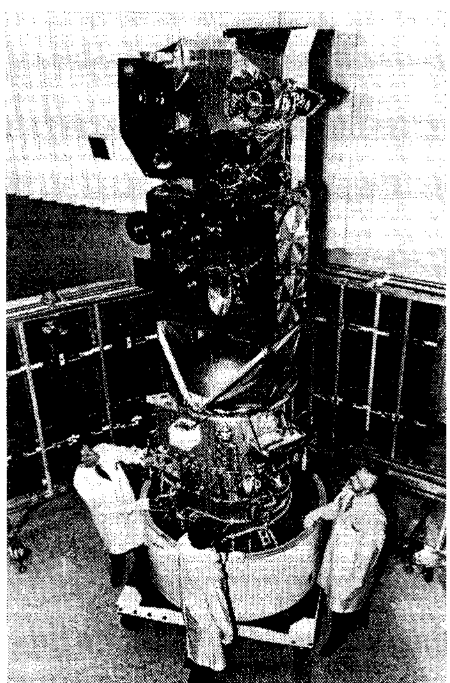
Domestic satellite launch

The United States second commercial domestic communications satellite was launched aboard a Delta rocket during October. Final positioning of the satellite is in a synchronous orbit over the equator south of Los Angeles.

Each of the satellite's 12 independent fixed-gain amplifiers has a bandwidth of 36MHz. A duplicate receiver is on board that can be switched on if necessary—the onboard wideband receiver is common to all transponders and is necessary for proper functioning.

Ion engine survives

An electric rocket engine which short-circuited on a NASA spacecraft nearly four years ago has been restarted in space, prompting scientists at the Lewis Research Centre, Cleveland, to resume the Space Electric Rocket Test (SERT II) mission on a part-time basis. Launched in 1970, the SERT II mission was intended to demonstrate the feasibility of electric propulsion for future space missions such as planetary probes or station-keeping in Earth orbit. The aim was to operate an ion engine for six months in space.



Engineers are dwarfed by the US Air Force's newest and most sophisticated weather watcher, a 17-ft-tall giant called the Defence Meteorological Satellite. The spacecraft uses a single on-board control system which steers both the launch vehicle and the satellite.

Presumably, the sliver of molybdenum which caused the October 1970 short-out of thruster 2 is now gone. Spinning the spacecraft to obtain a better Sun angle for the solar arrays created a small amount of artificial gravity which could have dislodged the chip. Since then thruster 2 has been operated successfully several times for short periods of up to 60% of maximum thrust, proving the long term reliability of this thruster system design.

In the ion thruster, used for orbital manoeuvre secondary engines, an electrical discharge in mercury vapour provides a dense "plasma" of electrons and positive ions. The ions are accelerated out of the thruster by a strong electric field to produce the desired thrust. Such a thruster has also been under development by the Space Department of the Royal Aircraft Establishment, Farnborough. The first use of this thruster will probably be for north-south station-keeping on a communications satellite. In this role, its thrust will be used to balance the gravitational effects of the sun and moon which would otherwise cause the satellite's position to oscillate daily in a north-south direction. With no oscillation, such a satellite could broadcast directly to individual households using fixed, inexpensive aerials.

Telemetry transmission

The telemetry links that will be used in Europe in the near future for satellites, missiles and launchers, will operate from 2.2 to 2.3GHz (in S-band). So states the introduction to a description of the new S-band telemetry transmitter specially developed for ESRO (ITT *Electrical Communication*, Vol. 49, No. 3, p.251). For satellites, phase modulation is used with a peak modulation index that can reach several radians. Missiles and launchers, however, use frequency modulation. Typically, the modulating signal can be a message of the p.c.m./phase shift keying type modulating the carrier directly or alternatively, a composite signal containing subcarriers modulated by various analogue or digital signals representing telemetry and distance measurement information. The spectral bandwidth of the modulating signal may well be several megahertz for large capacity satellites and this puts severe constraints on the phase modulator.

Output power for the transmitter depends on the information rate and on the link budget and this varies from one satellite to another. A telemetry transmitter on board a satellite can work alone or as part of a coherent transponder. In the first case it is fed with a signal delivered by the oscillator of the phase lock loop of the associated receiver which is thus in phase with the signal received by the transponder. This enables Doppler effect on the carrier to be measured so that the radial velocity of the satellite can be determined.

Surround-sound psychoacoustics

Criteria for the design of matrix and discrete surround-sound systems

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There are a number of different mechanisms by which the ears localize sounds, including several low-frequency, mid-frequency and high-frequency mechanisms, as well as information derived from the reverberation of sounds. With only a few transmission channels available, one cannot hope to satisfy them all, but most existing "discrete" and "matrix" systems do not satisfy more than one or two criteria. The approaches associated with the Nippon Columbia UMX system and the NRDC ambisonic system are the only ones so far to adequately allow for several criteria.

When stereo was introduced commercially in the 1950s, it had been subjected to experiments and theoretical studies for 25 years, by Fletcher[1] in the USA, Blumlein[2] in England, and de Boer[3] in the Netherlands. Despite a remarkable anticipation of modern "matrix" four-speaker systems by Blumlein[2] in 1931, virtually no work had been done on four-speaker surround sound before its recent commercial introduction. We are thus only beginning to understand how it works, and it is the object of this paper to describe the fruits of this new understanding. Not surprisingly, hastily introduced commercial systems have proved to be sub-optimal.

Because the mathematical description of surround-sound systems is far from elementary, this aspect is not dealt with here; references[4 to 10] contain such information. In this article the principles of surround-sound psychoacoustics are described, i.e. the relationship between the sound field presented to the listener and what he actually hears.

Lord Rayleigh discovered[11, 12] that the human hearing system appears to use different mechanisms to localize sounds at frequencies below and above 700Hz. Other evidence by Rayleigh[12, 13], Stevens & Newman[14] and Roffler & Butler[15] and others suggests that above about 5KHz, yet other localization mechanisms come into play, relying on the pinnae (the flaps on the ears) to modify sounds from different directions.

To make matters even more complicated, there is considerable disagreement both among theorists and experimenters as to the localization mechanism used within each band of frequencies, quite contrary results being obtained in different cases[16]. It seems that the ears must use a number of different methods of sound localization, possibly deciding on a "majority verdict" in the case when different mechanisms would, if used in isolation, give differing results.

In the presence of such contradictory information, the apparent localization of a sound also depends on the experience and expectations of the listener and on the type of attention he is paying to the sound. This can easily be demonstrated by reproducing via a stereo pair of good loudspeakers a sound positioned half-way towards the left speaker, but with the speakers connected out of phase. A suitably positioned listener can then hear the sound to be either between the speakers or beyond the left speaker (sometimes, both at once!).

Because most matrix four-speaker systems give highly ambiguous sound position information to the listener's ears, the results obtained will depend on the individual listener. Some listeners will learn to assign sounds to their "correct" positions with experience, and others will not. As a degree of subjectivism is a poor basis for any technology, the general principles behind various different sound localization mechanisms will be examined, with a view to extracting from these common features that can be used in designing surround-sound reproduction systems.

To design surround-sound systems we do not need to understand the full intricacies of the sound processing mechanisms in the ears and brain. As far as engineering is concerned, all we need know is what type of stimulus (i.e. sound field information) is needed to create a given subjective impression, and then we can design apparatus to produce a stimulus of the required type.

However, it is also necessary to have a description of the required stimulus that is simple enough mathematically to handle in detailed calculations. Otherwise we will only be able to design a system by guessing a circuit configuration and then "number crunching" the data in a computer to see whether it will work. As there are many millions of possible system configurations, it is extremely unlikely that such a design procedure would happen to hit upon the best possible result, or even something approximating to it. Such considerations rule out from our account such phenomena as the Haas effect, which says in essence that the earliest arrival of a sound at the ears determines its apparent direction. This is difficult to analyse mathematically, as well as being an unreliable guide to the subjective sound

Quadraphonic quandary

While this article was written before publication of B. J. Shelley's article *Quadraphonic Quandary* (*Wireless World*, July 1974 pp. 235–6), it does deal with many of the queries he raised on the aims and methods of quadraphonics. You may find it instructive to decide how far his particular criticisms are answered here. But note two points. Firstly, that two of the systems earlier proposed by the author on purely mathematical grounds (two-channel periphony and, via a tetrahedron of speakers, four-channel periphony) are here shown to be inadequate on the type of psychoacoustic grounds suggested by Shelley. And secondly that disagreements among experimenters about quadraphonic psychoacoustics are no new thing; Harwood[16] documented how little agreement there is on ordinary stereo localization. These disagreements may well be due to the conflicting directional cues at the ears inherent in all two-speaker stereo and in badly designed quadraphonic systems.

direction when sounds arrive from all round.

First, what is the aim of surround sound reproduction?

Recreating a sound field

Ideally, one would like a surround-sound system to recreate exactly over a reasonable listening area the original sound field of the concert hall, or in the case of popular or electronic music, a sound field envisaged by the record producer, with many different sounds in different directions at different distances. Unfortunately, arguments from information theory can be used to show that to recreate a sound field over a two-metre diameter listening area for frequencies up to 20KHz, one would need 400,000 channels and loudspeakers. These would occupy 8GHz of bandwidth, equivalent to the space used up by 1,000 625-line television channels!

The best that can be done with the two, three or four channels currently available is as follows. For each possible position of a sound in space, for each possible direction and for each possible distance away from the listener, assign a particular way of storing the sound on the available channels. Different sound positions correspond to the stored sound having different relative phases and amplitudes on the various channels. To reproduce the sound, first decide on a layout of loudspeakers around the listener, and then choose what combinations of the recorded information channels, with what phases and amplitudes, are to be fed to each speaker. The apparatus that converts the information channels to speaker feed signals is called a "decoder", and must be designed to ensure the best subjective approximation to the effect of the original sound field.

In commercial "discrete" practice, the process of assigning positions in the sound field to the available channels, known as "encoding", is done using four channels. Sounds not in the four corner positions are, in this procedure, assigned to just those two of the four channels representing corner directions adjacent to the desired direction. This only handles distant sounds in a horizontal direction, and it is by no means evident that this is the best way of assigning such a sound field to four channels. Similarly, it is not evident, and not in fact true, that feeding these channels directly to a square of speakers gives an optimum recreation of the original sound field.

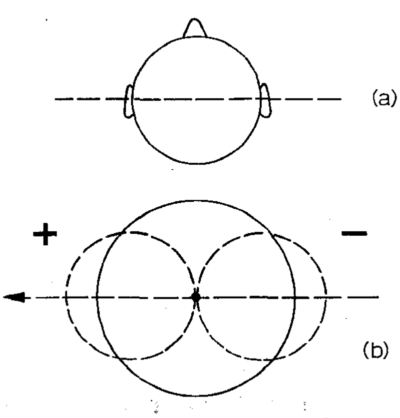

Fig. 1. Omnidirectional and velocity microphones (picture b) receiving the same low frequency information as the human hearing system (picture a).

Thus any surround-sound system gives rise to two distinct but related psychoacoustic questions:

- Is a given method of encoding the sound field *ever* capable of good subjective recreation of the sound field? That is, does the encoding method used permit the possibility of designing *some* decoder giving good results?
- Given a good method of encoding, what is the best design of decoder for use with a given layout of loudspeakers?

Low-frequency localization

The distance between the human ears is half a wavelength of a sound having a frequency of 700Hz. At frequencies appreciably below this, the head offers no obstacle to sound waves, and so the amplitude of sound reaching the two ears is virtually identical[11, 17–19]. The only information available at these low frequencies for sound localization is the phase difference between the two ears, and in 1907 Rayleigh[11] indeed showed that this was used to localize sounds below 700Hz.

There has, however, been disagreement as to how this low-frequency phase difference information is used to deduce sound position. One school of thought, represented by Clark, Dutton & Vanderlyn[20] and Bauer[21], derived a theory assuming that the listener does not move his head, whereas Makita[22], Leakey[23] and Tager[24] assume that the brain uses additional information from variations at the two ears caused by rotations of the head within the sound field.

It is possible to construct a "super-theory" including the above two classes of theories as special cases. Essentially, the sum of the waveforms reaching the two ears is the sound pressure that would be at the position of the centre of the listener's head were he absent. This information is the same as that picked up by an omnidirectional microphone (see Fig. 1). The remaining directional information at low frequencies reaching the listener is the difference of the waveforms at the two ears, which is the velocity of the sound field along the ear-axis (see Fig. 1). This is the information picked up by a sideways-pointing velocity or figure-of-eight microphone.

The fixed-head theories thus assume that the information picked up by an omnidirectional and by a sideways-facing velocity microphone is all that is available to the brain. The assumption that no use is made of amplitude differences at the two ears amounts to assuming that components of the velocity microphone information that are 90° out of phase with the omnidirectional information are not used in deducing the direction of sounds. The "moving head" theories assume that the velocity microphone information may point in any direction, but still assume that 90° out-of-phase velocity microphone information is not used.

It is not difficult to compute the "omnidirectional" and "velocity microphone" information produced by a quadraphonic reproduction system, and hence to calculate whether the useful information at low frequencies reaching the ears is the same as for live sounds (see Fig. 2).

Such calculations reveal that, for low frequencies, no existing two-channel matrix encode/decode system reproduces all the useful information as it occurs in live sounds, although the Cooper/Nippon Columbia BMX system[5] satisfies the hypotheses of Makita and Leakey. More remarkably, conventional discrete four-channel sound also does not satisfy low-frequency criteria other than those of Makita and Leakey. This is because phantom inter-speaker sound images with this system give too large an omnidirectional component of the sound field[25], which causes front-centre and side-centre sounds to be very poorly localized[26].

The poor positioning of phantom images suggests that discrete four-channel systems should not be used as a standard of excellence by which other systems are judged. There are better ways of representing the set of possible directions around the listener via four loudspeakers[8, 26]. The National Research and Development Corporation has recently been developing, with the author, a two-channel decoding apparatus for BMX or RM-encoded sounds, to feed four loudspeakers so as to satisfy the low frequency criteria shown in Fig. 2, and also the mid-high frequency criteria described later.

The three-channel system discovered

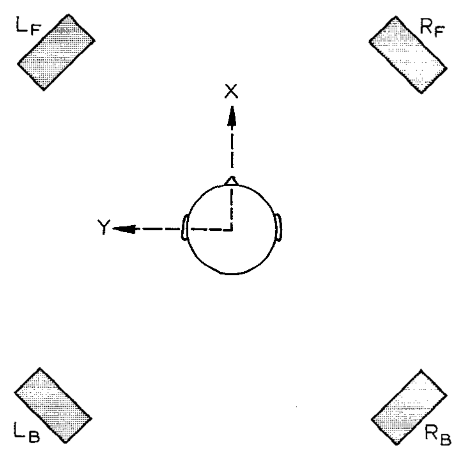

Fig. 2. Low-frequency quadraphonic localization information available to the ears.
Omnidirectional information:
$\Omega = L_B + L_F + R_F + R_B$
x-velocity information:
$X = \text{Real}(-L_B + L_F + R_F - R_B)$
y-velocity information:
$Y = \text{Real}(L_B + L_F - R_F - R_B)$
For "live" sounds we must have
$\Omega^2 = \frac{1}{2}(X^2 + Y^2)$.

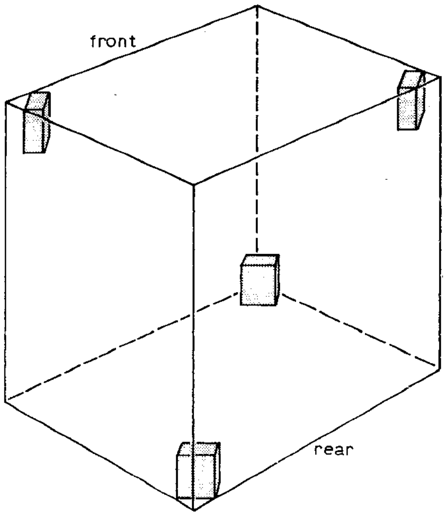

Fig. 3. Tetrahedral loudspeaker layout shown embedded in a cube.

independently by the author[10], Gibson et al[27], Eargle[28], Madsen (unpublished) and Cooper[5], is capable of correct low frequency results, as is the four-channel QMX system[5] and the tetrahedral with-height system of the author[6, 10, 29], which is reproduced via the speaker layout of Fig. 3. It is also possible to design a decoder for discrete recordings so as to satisfy all low-frequency requirements.

It is well known that velocity microphones give an exaggerated bass for very close sounds. Because the ears use velocity microphone information to localize sounds, close loudspeakers modify the directional effect at the ears. In particular, 90° out-of-phase velocity components caused by phase shifts are converted to phase differences between the ears. This causes the very low frequencies of phase-shifted sounds to be rotated around the listener. This effect has been observed by Bauer et al[30] via two speakers, but can be removed electronically. The degree of the effect is inversely proportional to loudspeaker distance.

Statistical methods may be used to apply the above theory to listeners not placed in the centre of the loudspeaker layout. The details are involved, but give results somewhat similar to the mid-high frequency theory of sound localization described next.

Mid-high frequency localization

Above 700Hz, the wavelength of sound is sufficiently small that the phase relationships between the loudspeakers are no longer of primary importance in sound localization. Under these conditions, what matters is the directional behaviour of the energy field around the listener. It is possible to show that, because of the positive nature of energy (in the mathematical sense), one can only exactly recreate the energy field of a live sound source through a small number of loudspeakers if the sound happens to be at the position of one of these. Thus at mid and high frequencies, not all of the ear's localization mechanisms can be satisfied in a practical reproduction system.

However, it is possible to analyse the directional energy field into omnidirectional and vector components analogous to those used for the sound amplitude field at low frequencies. If one assumes that the effect of head movement is used by the brain, these sound energy components can be used to estimate the probable subjective mid- and high-frequency sound direction. For a sound reproduced through several speakers, this direction may be calculated as the direction of the sum of vectors, one pointing at each speaker, each having as length the energy of the sound from that speaker. Calculations using this theory indicate that various four-speaker sound reproduction systems give the mid-high frequency sound localizations shown in Fig. 4, which agrees well with experimental data[26].

Note that if the number of channels equals the number of speakers (as for "discrete" and QMX via four speakers), then phantom inter-speaker sounds are drawn toward the nearest speaker. Cooper[31, 32] has called this the "detent" effect, but it is not significant for his BMX (two-channel) or TMX (three-channel) systems. A similar "pull" by the speakers is found for tetrahedral with-height reproduction (Fig. 3), but not when a cube of speakers is used.

The ratio of the length of the above-defined energy vector to the total reproduced energy should ideally be unity; in practice the larger it is the better defined the sound image—it is this that makes TMX better than two-channel BMX.

This mid-high frequency theory holds only so long as the ears do not have too great a directionality in their response to sounds. The data of Sivian & White[17] and Rolls[19] on the ear's directionality show that above about 5kHz a new theory is needed.

Localization above 5KHz

In 1907, Rayleigh[11] found that when the head was stationary the ability to distinguish front from rear relied entirely on high frequencies. This has been confirmed by Stevens & Newman[14] and Roffler & Butler[15], who showed that the ears could localize sounds in the plane of symmetry of the human head quite accurately despite the two ears receiving the same sound waveform! This ability disappeared when the pinnae were masked. Conversely, many workers have found that dummy head recordings (which incorporate the effect of the pinnae's acoustic obstruction) give good spatial localization when reproduced either via headphones or via loudspeakers with the pinnae masked[33]. Perhaps using the ultimate "purist" microphone technique, Edmund Rolls of Oxford University has made similar recordings using microphones inside the ears of real heads!

The pinnae localization mechanism is not well understood, but appears to rely on the fact that sounds from each direction arrive inside the listener's ear with a distinctive colouration. Thus, if we can reproduce that colouration in a

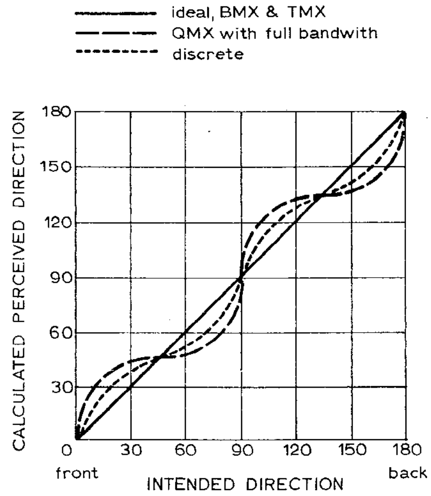

Fig. 4. Perceived localization vs intended direction of sounds in degrees, according to the mid-high frequency theory of this paper, for various systems via a square of speakers as in Fig. 2. Triangles indicate speaker positions. QMX data only applies for a full bandwidth system. Compare with Figs 19 and 20 of reference 26.

recording, we can reinforce the sense of direction created; to the author's knowledge, this has not yet been done in surround-sound recordings.

Reverberation to aid localization

It is possible to locate sounds more accurately in a moderately reverberant room than when there is no reverberation. Although the mechanism is not understood, it is found that correctly recorded reverberation also aids sound localization during reproduction[34], although poor artificial reverberation makes the sound image more indistinct. The author has computed the distribution of reverberation energy around the listener given by various recording techniques[34], and it is found that the most accurate sound localization is obtained when the energy is uniformly distributed, and not concentrated too much in any one direction.

Thus if a surround-sound system is to work optimally, it must be capable of capturing all nuances of reverberant sound and of reproducing these uniformly around the listener. Certain popular commercial matrix systems assign the original sound field to the two available channels in such a discontinuous manner[8, 9] that these criteria cannot be satisfied. "Variable matrix" or "logic" decoders, which work by pushing the whole sound field towards those directions in which the sound is momentarily strongest, clearly cannot reproduce those nuances of reverberation needed by the ears to localize sounds. The "detent" effect of discrete reproduction (Fig. 4) also prevents uniformly distributed reverberation.

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Integrated injection logic

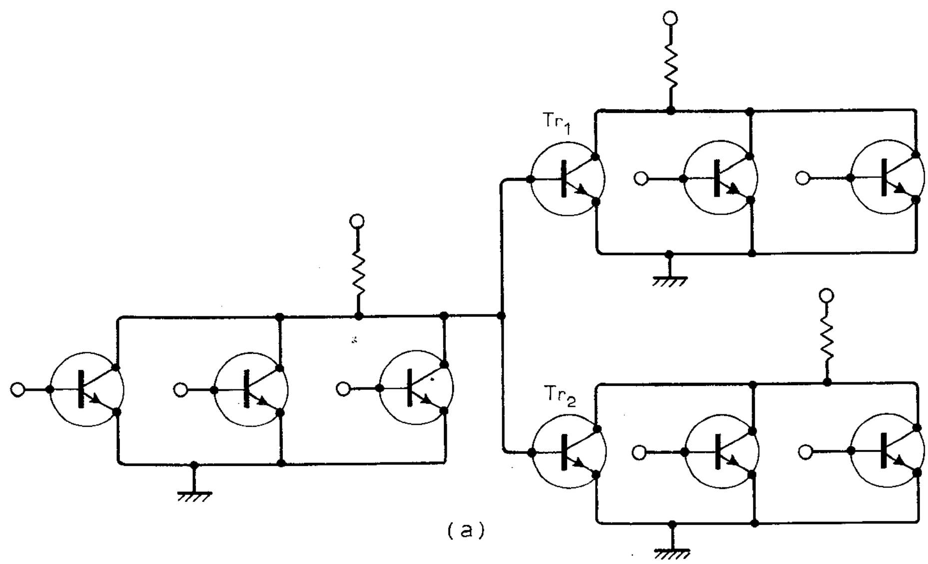
The development of new techniques in circuit integration has apparently been concentrated in the field of m.o.s. devices, and the amount of information appearing in the technical press about m.o.s. has tended to obscure the latest arrival on the bipolar logic field—integrated injection logic (i^2.l. for short). Its characteristics are impressive and it seems set to take over from conventional t.t.l. circuitry when packing density and low power dissipation are the essential requirements of a system.

As a result of the elimination of passive components in the basic gate and a reduction in the number of devices per gate, up to 3000 gates can be fabricated in one chip—an increase by a factor of ten over t.t.l. chips. The speed of i^2.l. is lower than that of t.t.l. (delay around 30ns instead of 10ns) but the speed-power product is only about 0.4pJ or less for i^2.l., compared with 100pJ. Cost is lower than in i.cs using the m.o.s. technology, particularly so as the same chip can contain both digital and analogue circuits.

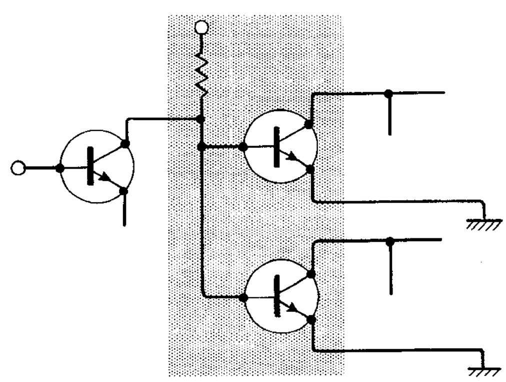
The circuit takes the form of a radically rationalized direct-coupled-transistor-logic (d.c.t.l.) element. In the diagram at (a), a typical d.c.t.l. gate (on the left) is shown driving one input of two other gates. Rearranging the interface gives (b) in the drawing, which can be further simplified by replacing the base resistor by an active current source and by substituting a multi-collector transistor for those with common bases. The result is (c), where the input emitter is termed the injector, the whole circuit being contained within the area of a t.t.l. multi-emitter input transistor. The combining of the two base emitter junctions of the interface gives protection against the effect, when junction voltages on different chips differ, of one gate monopolizing the current output from the previous gate, starving others connected in parallel.

The basic gate can operate at a current of around 1nA and a logic swing of 0.6V, which means interface circuits are needed between i^2.l. and other logic systems or linear devices. Variations of voltage and current can be obtained for different applications.

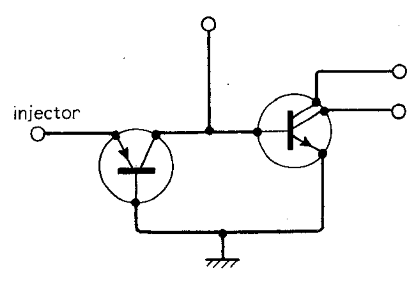
The new logic family can be used in a similar range of work as other l.s.i. systems. It was originated by Philips at Eindhoven, Netherlands, and at about the same time, but independently, by IBM at Boblingen.



(a)



(b)



(c)

Weather satellite ground station—2

Reception of cloud cover pictures; limiter and phase-locked loop system

by G. R. Kennedy

In an f.m. receiver, the signal limiter amplifies the signal so that any amplitude variations are minimized, in order that the detector may see a constant amplitude frequency modulated carrier. All f.m. detectors respond to some degree to a.m. as well as f.m. The principle of most limiters is amplification by a saturation amplifier. The process is sometimes referred to a clipping, although this implies a truncated sine output, with flat-topped sinewaves. Ideally, true f.m. receiver limiters should produce undistorted sinewaves. The amplitude variations in the i.f. signal may be due to relatively slow changes in the received carrier strength as well as due to faster impulse noise. The input signal, and i.f. signal strength may vary over a wide range, and hence the limiter must have a wide dynamic range. In order to limit amplitude changes at low signal input levels as well as at high levels, considerable gain must precede the limiter. A single-transistor limiting stage (Fig. 12) will not handle a wide range of limiting levels, and several cascaded stages must be employed.

Transistor Tr_{14} is biased so that with a small input of a few hundred millivolts the transistor saturates. The saturation knee-voltage may be varied by altering R_{48}, within the limits imposed by thermal runaway. Considerably more efficient limiting can be contrived using one of the commercially available integrated circuit limiters, made by such manufacturers as RCA and Motorola, or by employing an i.c. wide band amplifier and limiting the output above the knee voltage with diodes. Fig. 13 shows the simple connection of the RCA CA3076 limiter integrated circuit. The pin connections refer to the lead numbers of the eight-lead TO-5 package. The CA3076 will operate up to 20MHz, and at 10.7MHz provides 80dB voltage gain with a limiting knee above 50μV input. Fig. 14 shows two wide-band amplifiers connected for limiter service. The short circuits between 3 and 4, 6 and 7, and 8 and 9 of each i.c. connect diodes internally which limit the output voltage to about 25mV for any input voltage between 300μV and 3 volts r.m.s. up to 30MHz. The overall gain is about 100dB.

Phase-lock loop detector

For weather satellite applications the phase-lock loop detector is outstanding in performance[6]. The a.m. rejection and deviation linearity are far better than for conventional ratio detectors. Although limiters have been described, an integrated circuit phase-lock loop detector such as the Signetics NE565 does not need elaborate limiting preceding it[6], since the a.m. rejection is 40dB or so. However, phase-lock loops built from discrete components, such as a synchronized Wien bridge may not have such outstanding a.m. rejection. The basic block diagram of a phase-lock loop is shown in Fig. 15. The p.l.l. is a closed-loop servo where the input is a frequency signal, the error device is a phase-sensitive detector (p.s.d.), and the feedback path is a voltage-controlled oscillator (v.c.o.) fed through a low-pass filter which in turn is fed by the error output after amplification. The output is taken from the p.s.d. output either before or after filtering, depending on whether further filtering and buffering is required. The sense of the feedback path is such that a difference in phase (and hence, instantaneously, frequency) between the input or reference signal and the v.c.o. or control frequency, produces an output which alters the v.c.o. frequency to reduce the error. Since the phase detector is a sum-

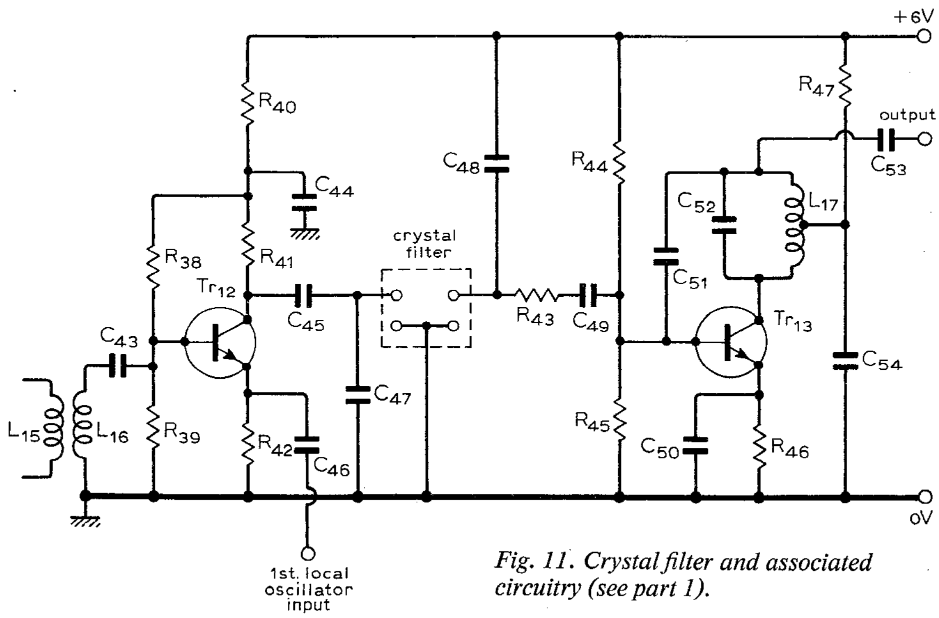


Fig. 11. Crystal filter and associated circuitry (see part 1).

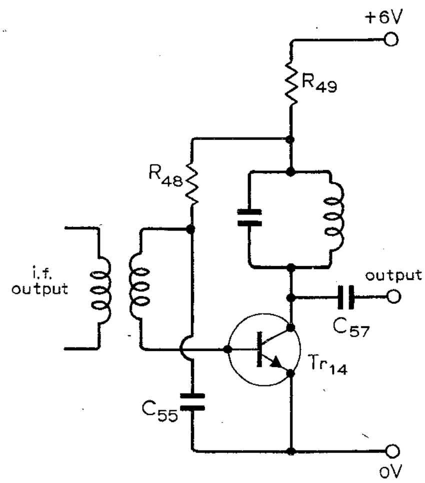


Fig. 12 (left). Single stage limiter.

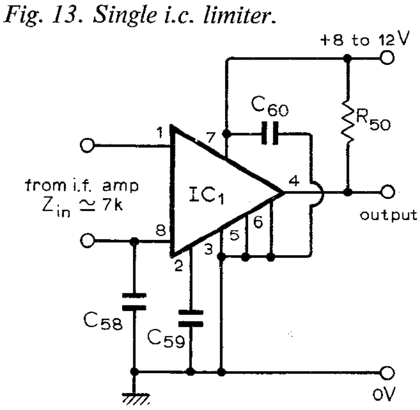
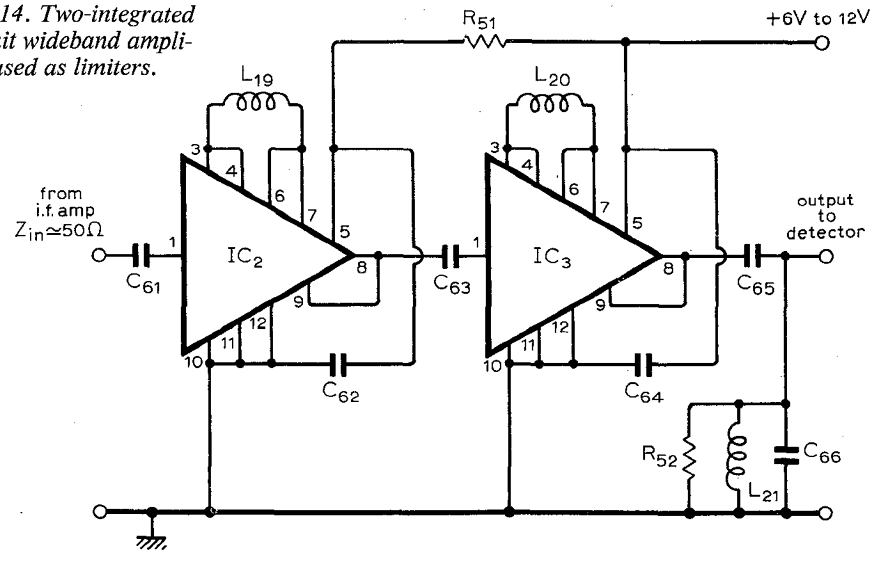


Fig. 13. Single i.c. limiter.

Fig. 14. Two-integrated circuit wideband amplifier used as limiters.



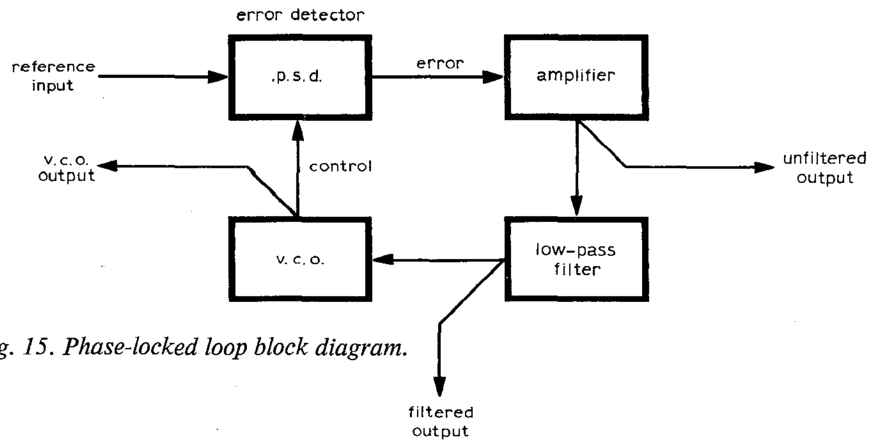


Fig. 15. Phase-locked loop block diagram.

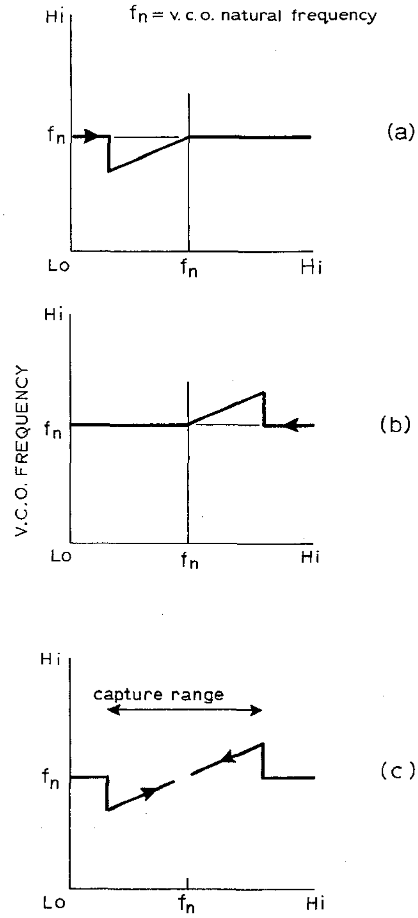


Fig. 16. Phase-locked loop capture range (a) reference frequency rising (b) reference frequency falling (c) resultant capture range. The v.c.o. natural frequency is f_n.

and-difference device much the same as the mixer in a superheterodyne receiver, there are sum-and-difference products produced at the p.s.d. output. The low-pass filter removes the higher frequency component, and allows an l.f. error voltage to drive the v.c.o. If the loop is in lock with a constant frequency reference, and the reference changes in frequency, the v.c.o. will change frequency in sympathy. If the reference input is frequency modulated, then, the p.s.d. output will vary with the reference frequency modulating frequency. The p.s.d. output can be made extremely linear with error and hence f.m. deviation, so that the p.s.d. output is an accurate f.m.-detected output signal. The phase-sensitive detector cannot have an infinite bandwidth. There comes a point where the frequency difference between the reference and v.c.o. frequencies is so large that the loop is not in lock, and the v.c.o. runs at its natural frequency f_n. As the reference frequency approaches the v.c.o. frequency at a given point the loop will lock up and the v.c.o. will run at the reference input frequency. This will happen at the same difference frequency, higher or lower, than the v.c.o. natural frequency. The difference between these frequencies is called the "capture range". This is shown diagrammatically in Fig. 16. There is frequency hysteresis in the p.l.l. operation so that if the reference frequency alters away from f_n, the loop will remain in lock beyond the capture point frequencies. The difference between the point where a locked loop will lose lock for an increasing or decreasing frequency from f_n is the "tracking" or "lock range". This is shown in Fig. 17. It then follows that as an input frequency sweeps high-to-low or low-to-high, the locking of the loop will not be symmetrical about f_n (Fig. 18). The apparent asymmetrical operation of the loop is important when the bandwidth of the receiver and the likely Doppler shift of the satellite received frequency are considered. If the receiver bandwidth is insufficient, the phase-lock loop may drop back at an extreme of carrier frequency deviation. This will cause the v.c.o to return to f_n, and lock will not be required until the deviation has returned through the appropriate capture point. There is therefore a longer period of dropped lock —and hence picture deterioration—than might be thought by simply regarding the tracking range. The capture range should be sufficient to lock on the expected satellite frequency deviation plus Doppler, but not too wide to allow transient lock on very strong out-of-channel signals which may break through even the narrow bandwidth i.f. amplifier stage. The use of the p.l.l. has an unexpected advantage when receiving grossly fading signals: if the loop does drop lock, the return of the v.c.o. to f_n causes the picture display to return to mid grey. This is the least conspicuous tone for picture interference.

A practical circuit, using a Signetics NE565 p.l.l. for an i.f. of 470kHz, is shown in Fig. 19. Here a single-rail supply is used, with appropriate biasing of the differential input, pins 2 and 3. The input is 470kHz deviated at a rate of 2.4kHz and may be to either of the input terminals for optimum a.m. rejection. The input for the NE565 should not exceed 400mV. Pins 8 and 9 set the v.c.o. frequency. Frequency f_n is given approximately by

$$f_n \sim \frac{1{\cdot}2}{4R_5C_2} \text{ where}$$

f is in Hz, R in ohms, C in farads. Resistor R_5 is usually set to be below 20kΩ, and ideally at 4kΩ. Capacitor C_3 decouples some of the input frequency from the output, which is taken from pin 7 and C_6 decouples the supply at the device pins, C_4 is the loop filter capacitor and sets the capture range of the loop.

Fig. 20 shows typical values of C_4 for an NE565 p.l.l. operating at 470kHz. For a 470kHz input at 300mV pk to pk deviated ± 10kHz the output at pin 7 is approximately 30mV pk to pk with a considerable amount of 470kHz output, which must be filtered out. Fig. 21 shows a two-stage 2.4kHz filter. The performance is as follows: input 30mV pk to pk; output at max. gain setting 7.5V pk to pk at 2.4kHz; overall gain 47dB; bandwidth 1.9kHz: 3dB points 1.2kHz, 3.1kHz.

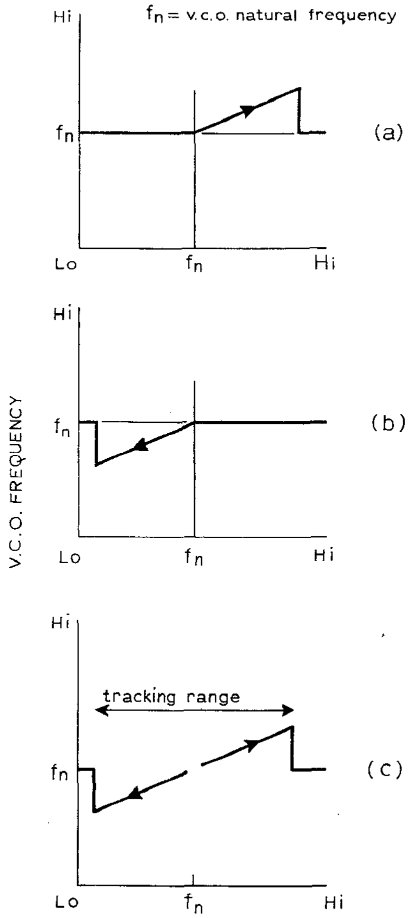


Fig. 17. Tracking range diagram for the p.l.l. (a) reference frequency rising (b) reference frequency falling (c) resultant tracking range.

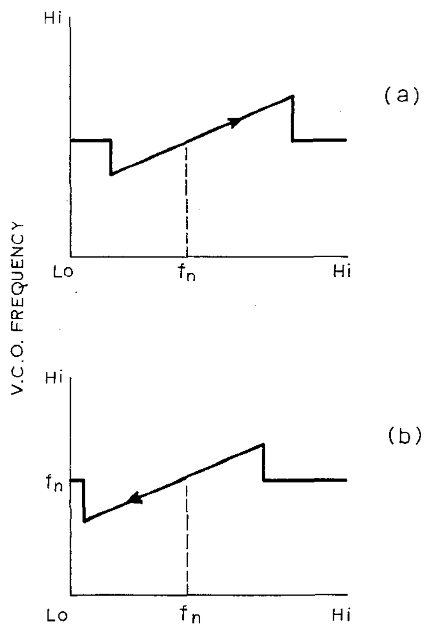
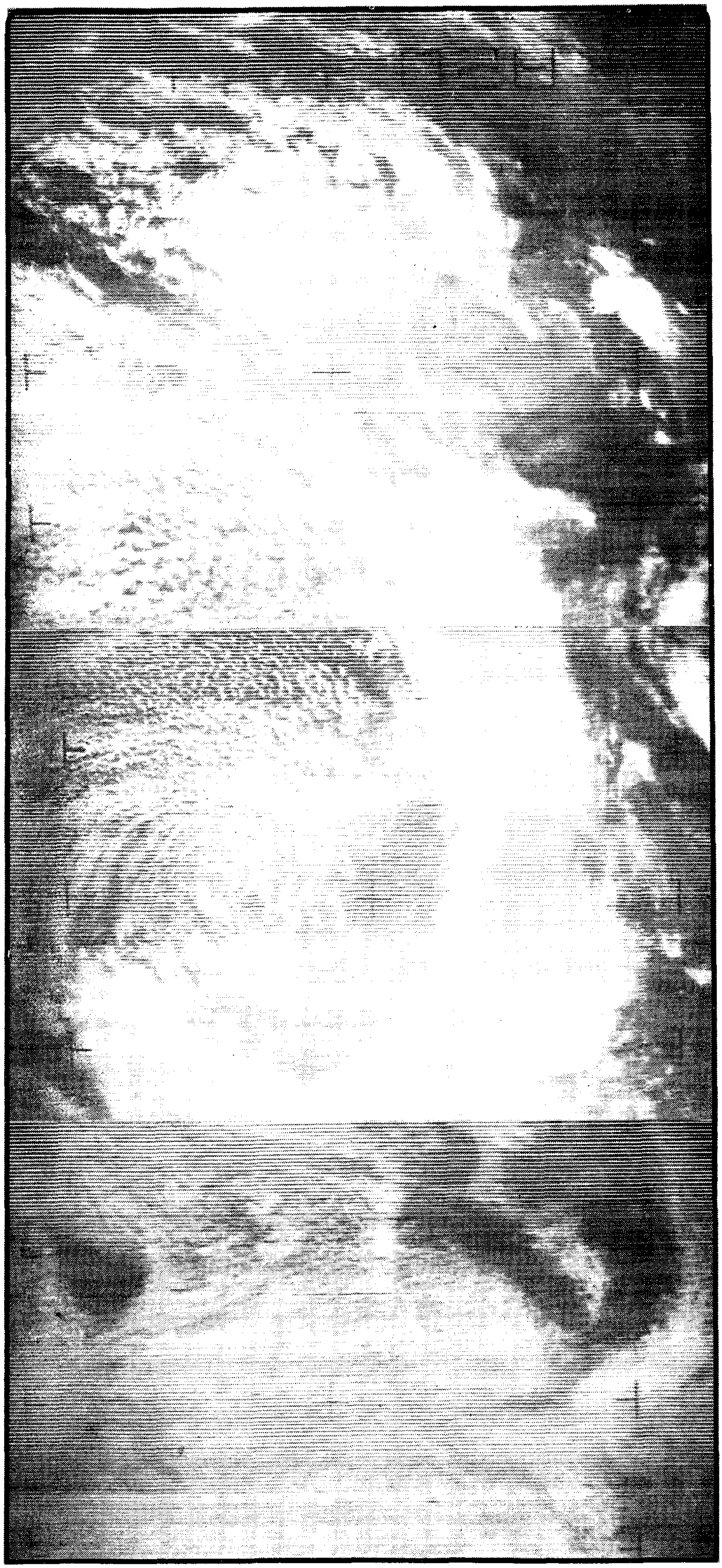


Fig. 18. Asymmetrical locking diagram of the phase-locked loop. (a) reference frequency rising (b) reference frequency falling.



Cyclonic depression in the North Atlantic between Greenland and the UK taken on Saturday, 21 Sept, 1974. The satellite was 68-114-A, ESSA-8.

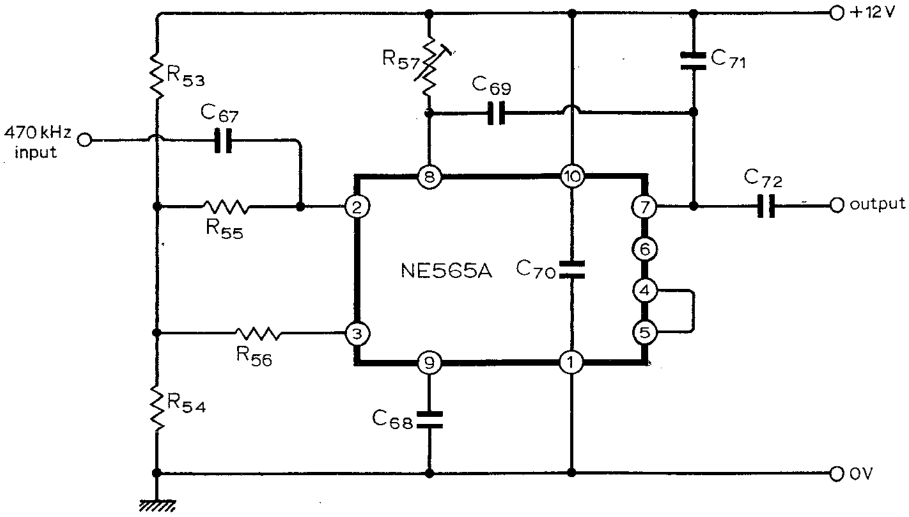


Fig. 19. Practical phase-locked loop circuitry.

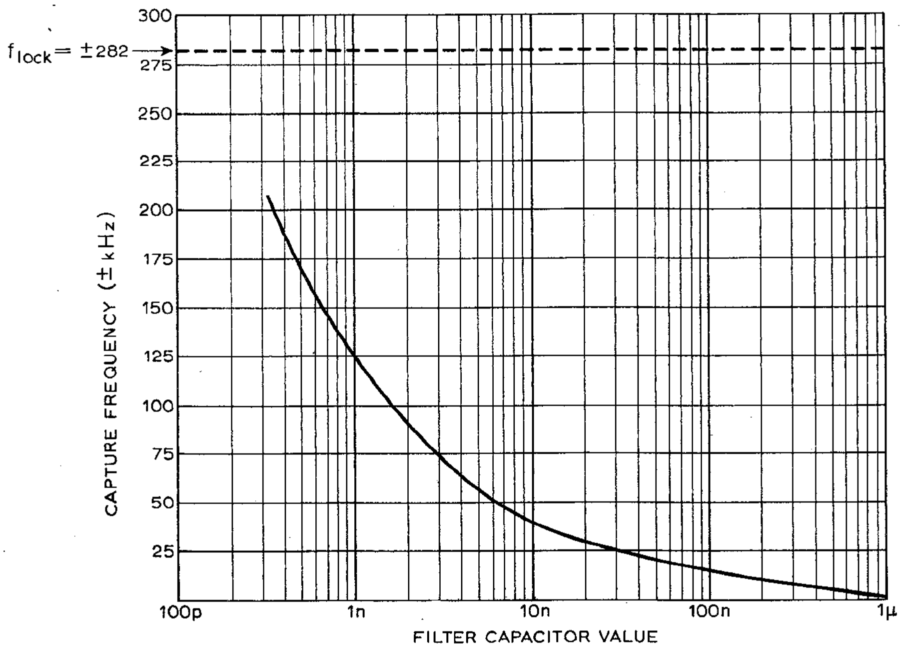
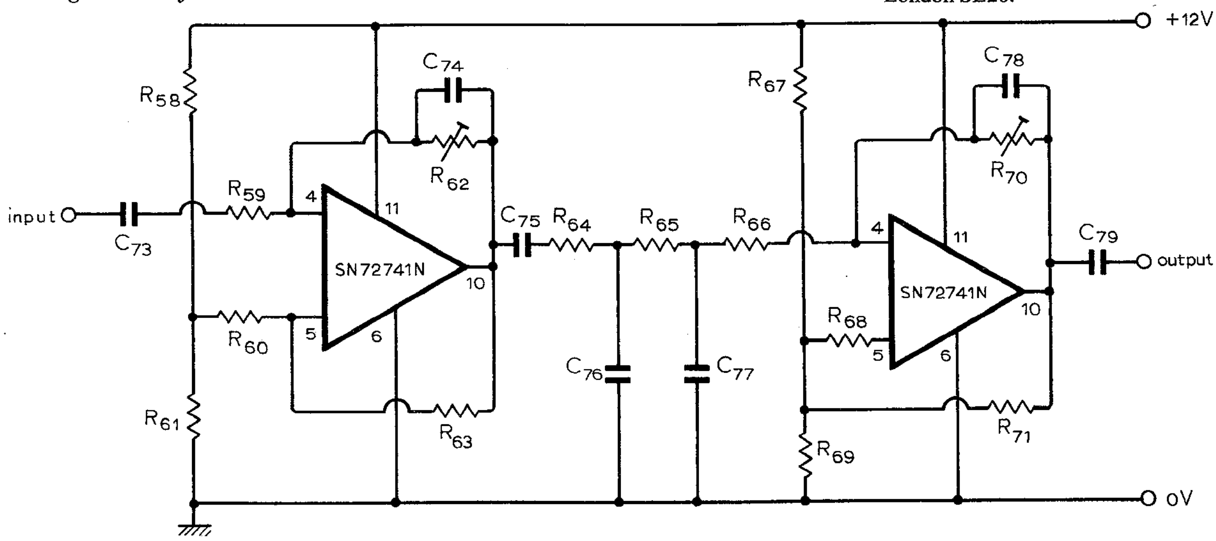


Fig. 20. Capture range versus filter capacitance for 475kHz p.l.l. circuit in Fig. 19. Discriminated output at pin 7 ≈ 100mV per 25kHz shift.

Fig. 21. Two stage 2.4kHz filter.



Components list

Resistors—*R*

Fig. 11.	38	18k
	39	3.3k
	40	330
	41	820
	42	2.2k
	43	680
	44	15k
	45	10k
	46	1k
	47	1.8k
Fig. 12.	48	82k
	49	1k
Fig. 13.	50	2.7k
Fig. 14.	51	100
	52	5.6k
Fig. 19.	53	10k
	54	4.7k
	55	1k
	56	1k
	57	5k
Fig. 21.	58	680
	59	10k
	60	10k
	61	680
	62	250k
	63	10k
	64	10k
	65	10k
	66	10k
	67	1k
	68	10k
	69	1k
	70	
	71	10k

Capacitors—*C*

Fig. 11.	43	1n
	44	1n
	45	1n
	46	1n
	47	18p
	48	18p
	49	1n
	50	5n
	51	5.6p
	52	20p*
	53	10n
	54	10n
Fig. 12.	55	10n
	57	10n
Fig. 13.	58	10n
	59	10n
	60	10n
Fig. 14.	61	10n
	62	10n
	63	10n
	64	10n
	65	10n
	66	20p*
Fig. 19.	67	1.5n
	68	150p
	69	1n
	70	10n
	71	
	72	10n
Fig. 21.	73	10n
	74	150p
	75	22n
	76	10n
	77	10n
	78	100p
	79	0.1μ

Inductors—*L*

Fig. 11.	15	0.05 *link coupling
	16	0.5 *
	17	10 total tapped one-third way up
Fig. 14.	19	Self-resonant at i.f. frequency
	20	Self-resonant at i.f. frequency
	21	10 *

*Value depends on circuit tuning

Transistors—*Tr*

Fig. 11. 12 BSX20
13 BSX20
Fig. 12. 14 BSX20

Crystal filter

Fig. 11. ITT 015AD or 901AM or similar for 10.7MHz

Integrated circuit

Fig. 13. 1 CA3076

(To be concluded)

Reference

6. Signetics Linear Phase Locked Loops Application Book, Signetics International Corporation, Yeoman House, 63 Croydon Road, London SE20.

PROJECT

A digital clock and calendar

Part 3. Concluding the clock calendar project with leap-year logic and a power supply design

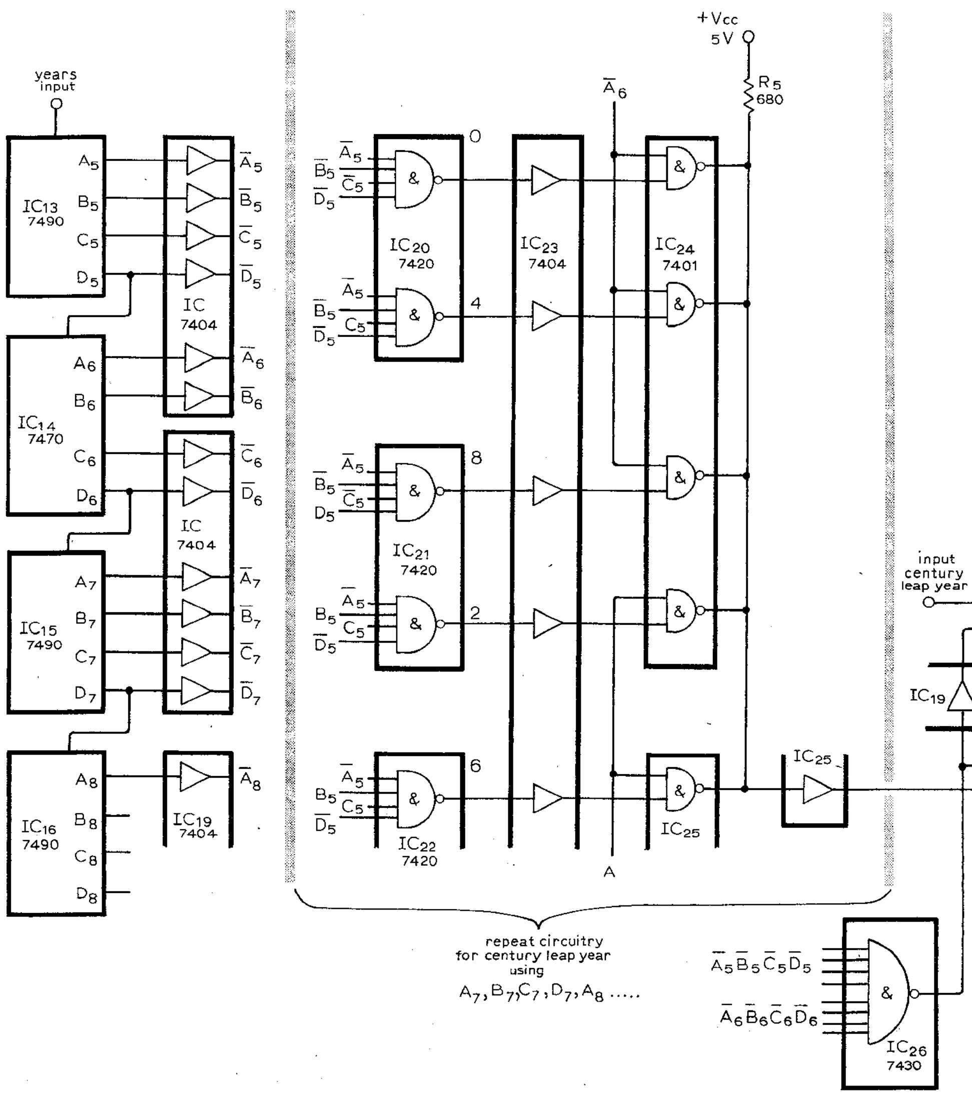
by J. K. F. Nosworthy and N. J. Roffe

Fig. 10 shows the circuitry for the years counter and the associated leap-year logic. The years counter itself is straightforward, consisting of four sequential decade counters IC_{13-16}. Drive is of course derived from the output of the months section. Reset is to 0000, presenting no problems, and this is actuated conventionally from the terminal output.

Leap-year detection follows the principles already set forth. Reviewing these, it will be seen that it is necessary to examine the last two digits of the year in order to decide whether or not the year is an ordinary leap-year, and all four digits in the event that the last two are 00 (century) in order to decide a century leap-year. For the first and third digits, to cover all contingencies, all possible digits from 0–9 need to be examined; for the second and fourth digits, only even numbers (including 0) need to be examined.

Examination of the year being displayed is by the array of NAND gates IC_{20-25} so far as the last two year digits are concerned (i.e. examination for ordinary leap-years) and by a duplication of these to deal with the first two digits for century leap-years. All these gates are fed either direct from the binary-coded outputs of the years counters, or via inverters IC_{17-19}, according to their particular logic requirements. Breaking the gates down into groups, IC_{20-22} deal with the fourth digit; an output being passed by IC_{20} (a) or (b) for a 0 or a 4 respectively; IC_{21} (a) or (b) for a 8 or a 2; IC_{22} (a) for a 6. The output in each case, if it occurs, is a low, and this is inverted by IC_{23} to a high before being passed to an input of IC_{24} or IC_{25}. IC_{24} and IC_{25} repeat the screening process on the third digit; if this is odd, it will enable, via the A6 output from IC_{14}, both IC_{24} (d) and IC_{25} (a); so that if a fourth-digit 2 or 6 has been screened through by IC_{21} (b) or IC_{22} (a) an output will be derived from $IC_{24/25}$. Similarly, if the third digit is even, the $\overline{A6}$ output from IC_{14} via IC_{17} will enable IC_{23} (a, b, c); so that if a fourth-digit 0, 4, 8 has been screened through by IC_{20} (a) or (b) again an output will be derived from IC_{24}. In each case the output from IC_{24} or IC_{25} will be a logic 0; and since these are open-collector i.cs with a common collector load R_5, wired-OR logic applies so that the input of invertor IC_{23} will be driven to logic 0.

A final piece of detection must be applied to the last two digits of the year; that is the detection of a specific 00. This must be detected if it occurs in order that the "repeat" circuitry for scanning the first two digits may be actuated in the case of a century leap-year. This is done by IC_{26}, an 8-input NAND gate fed with the appropriate outputs of counters IC_{15} and IC_{16}. If the output from IC_{26} is favourable, it enables (after suitable inversion) the top gate of IC_{25} to accept a signal from the first two digits screening circuitry, indicating the presence of a century leap-year. If IC_{26} output is unfavourable, it will leave the second gate of IC_{25} in operation so as to allow an output through from the last two



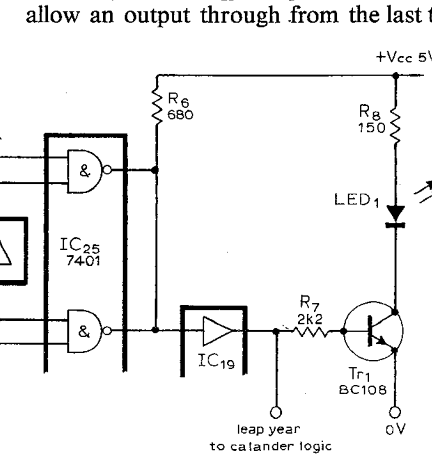


Fig. 10. "Years" counter and "leap-year" logic. Gates are identified from the top of the diagram, e.g. $IC_{20(a)}$ is associated with "0" and $IC_{21(b)}$ with "2". The input A to $IC_{24,25}$ is A6 from IC_{14}.

digits screening circuitry, for indication of ordinary leap-year. In either case, whichever gate a signal comes through, it will cause a resultant output of logic 0 since again IC_{25} is an open-collector type and the common collector resistor R_6 gives wired-OR logic.

Finally, the resultant leap-year signal is inverted by IC_{19} to give a high, and this is used both to drive the alternative February line on the ROM matrix (see Fig. 9) and to drive TR_1 for illumination of the l.e.d. which indicates a leap-year. (TR_1 is interposed between IC_{19} output and the l.e.d. because the direct output from IC_{19} would not give sufficient brightness owing to its current-sink limitations—an alternative, if any spare sections of i.cs were available, would be to parallel several of them up to increase the current availability.)

Main power supply

The circuit for this is given in Fig. 11. The principle adopted is that the function of the main power unit is to produce a minimal 24V supply, thoroughly smoothed as regards mains ripple and major supply transients but not necessarily precision-regulated. This supply is fed to the various units, and these each contain their own on-card i.c. regulators, providing for each unit a precisely regulated supply rail which is readily adjustable to individual unit requirements. This two-stage approach also ensures really efficient inter-unit decoupling which, as any user of digital i.cs has doubtless found out the hard way, is absolutely vital!

Two separate outputs are in fact provided; the reason being that, on considering the requirements for the stand-by battery facility, it is found that several portions of the clock do not have to be kept powered during a mains power cut. These are principally the nixie decoder/drivers, which consume quite a fair amount of current, also various ancillary portions such as the BBC accuracy comparator. The display itself can also be dispensed with during a power cut; and obviously these economies are desirable in order to lengthen stand-by battery life. The 24V output is therefore split into one line which must always be kept alive, i.e. backed up by the batteries, and one which is powered solely from the mains. The two outputs are respectively labelled (2) and (1).

For the stand-by battery supply, manganese dry-cells are used. Rechargeable batteries were considered, but lead-acid was thought to be too messy and labour-demanding and alkaline cells, which would have been ideal as they could have been left on permanent floating charge, were unfortunately ruled out by expense. Since, therefore, a floating-charge principle cannot be used, it was necessary to devise a changeover system which would operate in the event of main failure; and for this we have adopted the principle of steering diodes. The mains-fed supply is arranged to be of slightly higher voltage than that from the batteries, and the two are commoned via diodes (D_3, D_4). Under mains operation, therefore, the diode in the battery line will be reverse-biased, so that no current flows from the batteries, whilst the one in the mains-fed line will conduct. In the event of mains failure or serious mains under-voltage, the situation is reversed; the battery series diode supplying output current and the mains-fed diode preventing this from flowing back through the rectifier circuit. The principle is simple, foolproof and gives, of course, an instantaneous changeover. The only precaution which must be observed during design and initial set-up procedure is to ensure that the voltage limits are fairly carefully set so that, whilst the battery diode is held firmly off by the over-voltage of the mains-fed supply, this over-voltage is not so large as to give rise to an unmanageable falling transient as the batteries cut in. A point which is not perhaps immediately obvious in this connection is that the mains-fed supply must be substantially free from ripple, as otherwise its instantaneous voltage becomes a variable—hence the necessity for including a series regulator (TR_1) in the mains-fed supply line.

The standing drain from the batteries is very small, and their shelf life is long; but it was thought nevertheless desirable to provide a warning indication of when they were becoming exhausted. This is done by a 709 op-amp which continually compares the battery voltage with that set by a reference zener D_2 fed from the mains-operated supply. Preset R_4 adjusts this reference voltage to the level at which it is desired that warning shall be given (this can be decided on by reference to the battery manufacturer's data—we have actually decided on 20.5V). While the battery voltage is above this level, a positive output is derived from the op-amp which turns TR_2 on and illuminates LP_2. When, however, the battery voltage falls below that selected by R_4, the op-amp output swings to negative, TR_2 cuts off, turning on TR_3 which lights LP_3. We used the 709 op-amp in preference to the more obvious 710 voltage-comparator because we found the latter to be troublesome during the changeover period, which is of course very slow—the 710 tended to give parasitic oscillations during this time. The 709 is used on open-loop gain and the 100μF used as output frequency compensator gives the necessary slight hysteresis. The back-to-back zeners strapped across the op-amp inputs merely limit the maximum input voltage in either direction to a safe level. The op-amp and its circuitry are fed from the 24V line by a 15V regulator, since 24V is considerably higher than its maximum V_s rating. In this application, the provision of a negative op-amp supply rail is not necessary, and the $-V_s$ connection is simply grounded.

Switch S_3 is provided so that the operation of the comparator circuit may be checked from time to time. In its normal position (up) it supplies battery voltage to the op-amp, as described above. Depressed, it supplies instead an auxiliary reference voltage derived from D_2 by R_5. This is set to be slightly lower than the voltage from R_4, so that it simulates a low battery voltage and operates the warning indicator.

To save stand-by battery current during

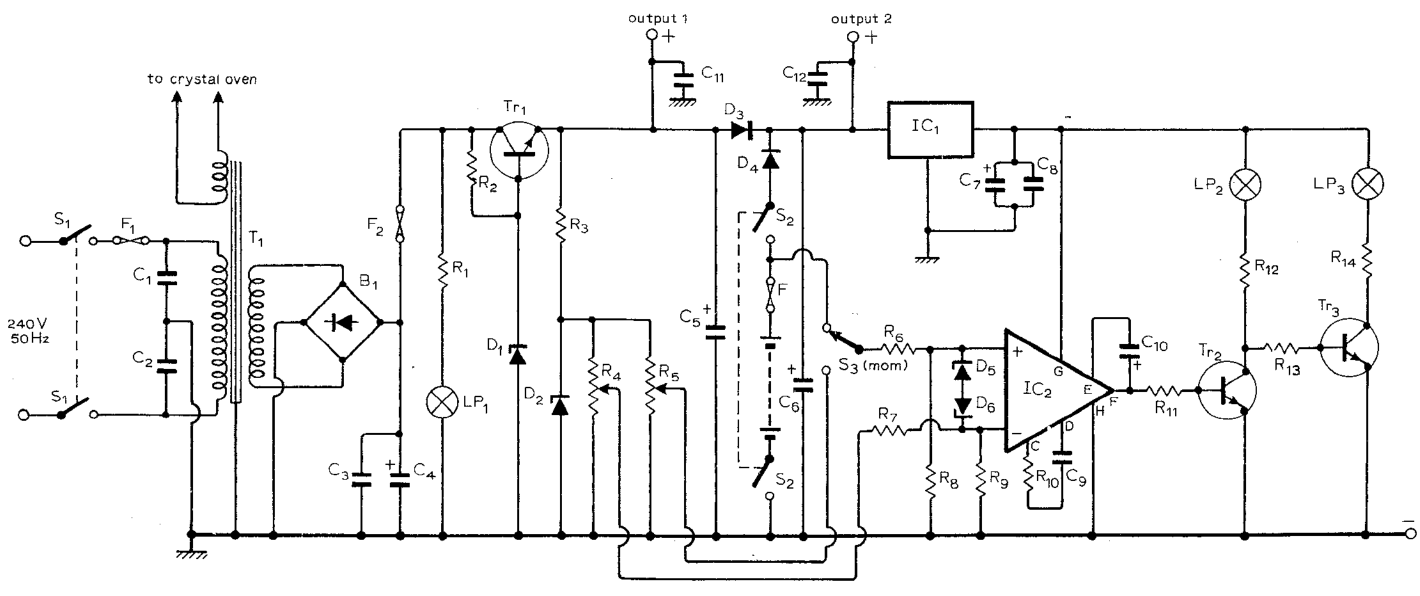


Fig. 11. Main power supply, with battery-condition indicator.

power cuts, the indicator circuitry could be fed from output (1) instead of from output (2). However, if this is done LP_2 will not be illuminated during a power cut, neither will any other indicator; and since the display will also be off, there will be no indication that the clock is functioning at all. We thought this to be undesirable.

The main power supply feeds all the units except the nixie display and the BBC accuracy monitor. For the former, the usual 180V is required, with no stand-by battery facility; we do not give the circuit here since it presents no difficulty. (It is, however, interesting to note in passing that our solution for the regulation requirement was the use of a good old-fashioned cathode follower—solid-state circuitry still has a

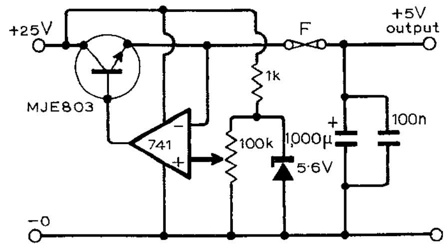
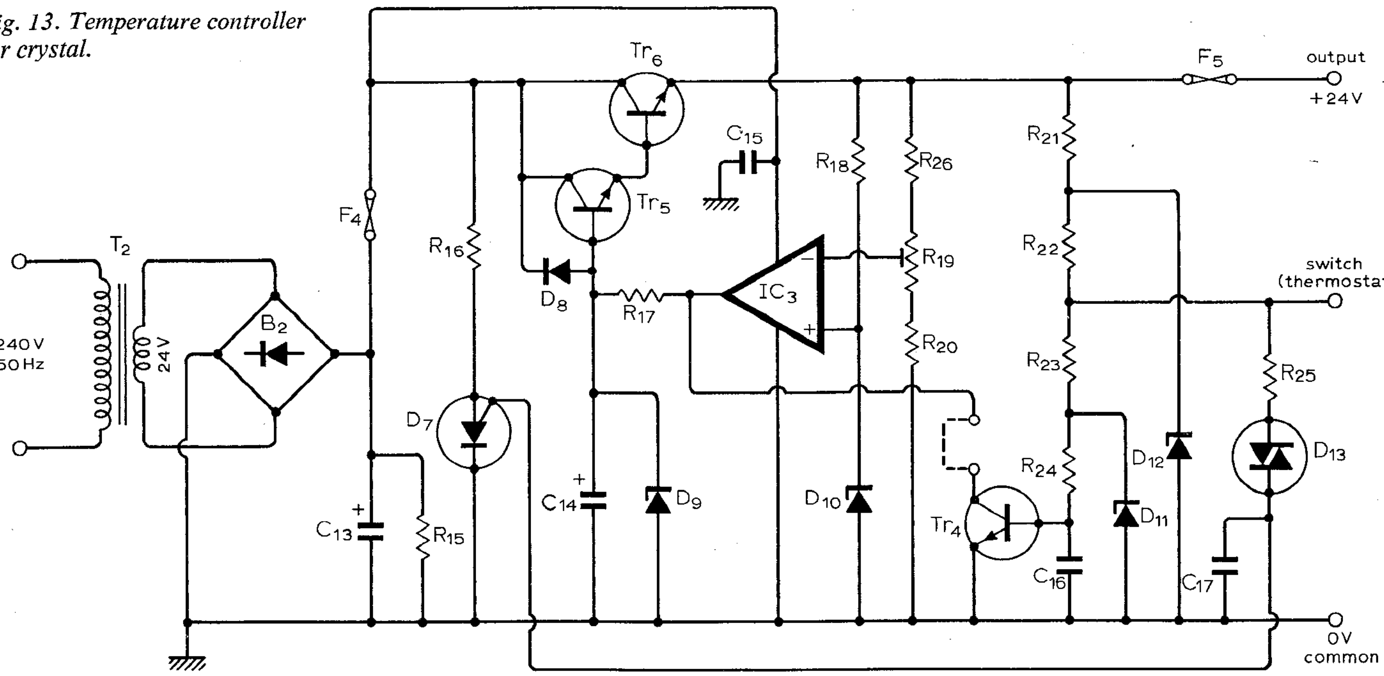


Fig. 12. Circuit of high-current 5V regulator for on-card use.

few outposts to conquer!) For the latter, again no stand-by facility is required; and since it requires a dual-rail supply for its op-amp, we found it simplest to power it via a small separate on-card supply, using a sub-miniature mains transformer and an MC1468 dual-tracking regulator.

For remaining on-card regulation of the 5V logic rails, either LM309K potted regulators have been used or, where higher output current is required, the circuit shown in Fig. 12. The theoretical maximum current available from this circuit is 2A, representing a dissipation in the series transistor of 40W, but practical limitations of heat-sink restrict this to about 1.5A. It should be noted that the output voltage control R_4 is used to tap down the zener reference source instead of, as is more usual, the output voltage—this not only gives better stability, since errors in output voltage are not attenuated before being fed back, but it also allows the use of a 5.6V

Fig. 13. Temperature controller for crystal.



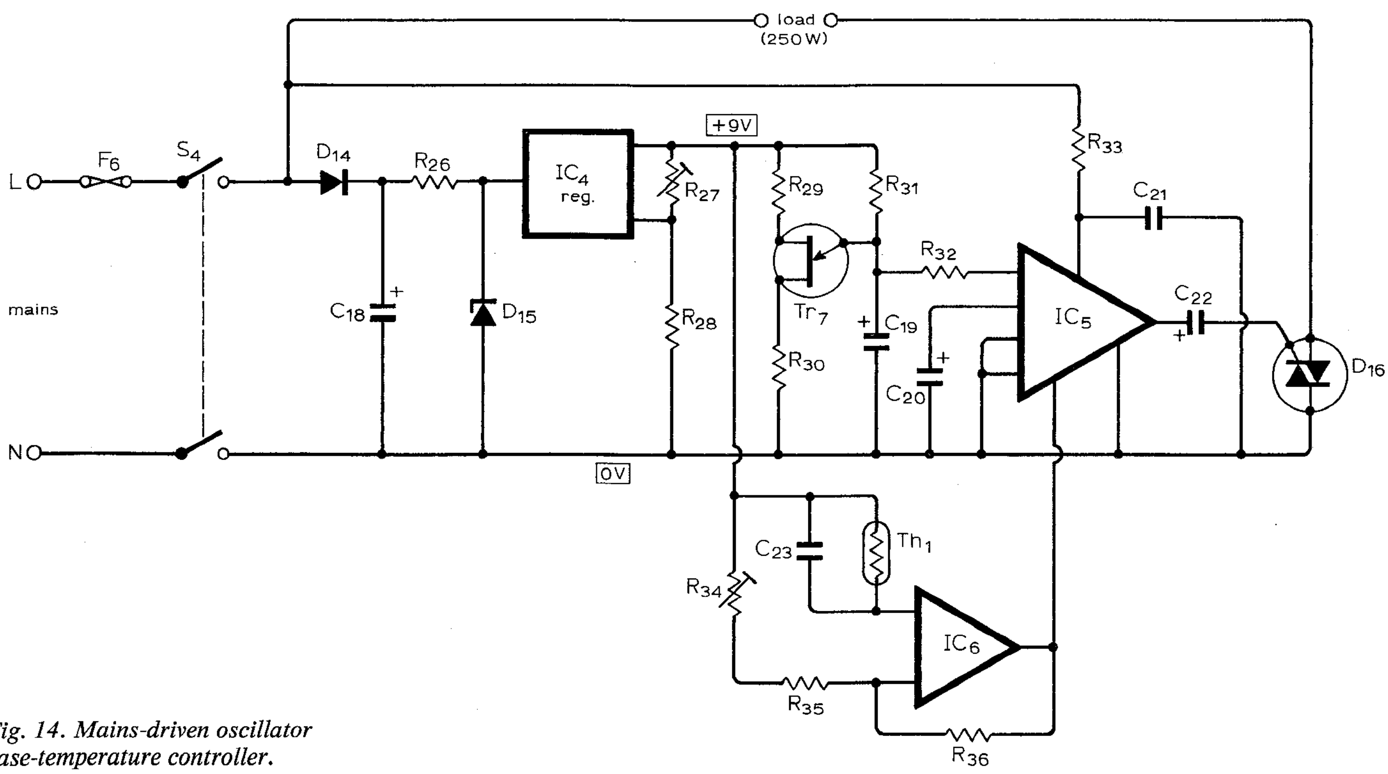


Fig. 14. Mains-driven oscillator case-temperature controller.

Parts list for oscillator chain (Fig. 2)

Resistors

R_1	1MΩ
R_2	2.2kΩ
R_3	1.5kΩ
R_4	22kΩ
R_5	47kΩ preset
R_6	22kΩ
R_7	470Ω
R_8	1kΩ (see corrections)
R_9	8.2kΩ
R_{10}	12kΩ
R_{11}	1kΩ
R_{12}	5.6kΩ
R_{13}	2.2kΩ
R_{14}	1.5kΩ
R_{15}	5.6kΩ
R_{16}	560Ω
R_{17}	470Ω
R_{18}	5kΩ multi-turn preset
R_{19}	4.7kΩ

Capacitors

C_1	0.1μF
C_2	0.1μF
C_3	39pF preset
C_4	200pF
C_5	30pF preset (see correction)
C_6	500pF preset (see correction)
C_7	300pF
C_8	0.1μF
C_9	0.01μF

Semiconductors

D_1	1N4004 (used as varicap)
D_2	6.8V zener diode
$Tr_{1,2}$	2N3819
$Tr_{3,4,5}$	BC108
Tr_6	BC477

Transformer

T_1	Denco IT

Parts list for BBC comparator (Fig. 4)

Resistors

R_{20}	10kΩ
R_{21}	47kΩ
R_{22}	10kΩ preset
R_{23}	470kΩ
R_{24}	2.2kΩ
R_{25}	39kΩ
R_{26}	1kΩ
R_{27}	220Ω
R_{28}	39kΩ
R_{29}	560Ω
R_{30}	390Ω
R_{31}	12kΩ
R_{32}	100kΩ
R_{33}	12kΩ
R_{34}	1MΩ
R_{35}	2.2kΩ
R_{36}	12kΩ
R_{37}	47kΩ
R_{38}	1.5kΩ
R_{39}	10kΩ preset
R_{40}	100kΩ preset

Semiconductors

Tr_7	2N3819
Tr_8	2N3819
Tr_9	BC109
Tr_{10}	BC479
Tr_{11}	2N3820
Tr_{12}	2N3819
IC_1	Signetics NE561B
IC_2	709 operational amplifier
D_3	1N4001
D_4	1N4001

Capacitors

C_{10}	1–6pF preset
C_{11}	33pF
C_{12}	1–6pF preset
C_{13}	2400pF
C_{14}	0.01μF
C_{15}	0.01μF
C_{16}	0.1μF
C_{17}	1000pF
C_{18}	0.1μF
C_{19}	0.1μF
C_{20}	10pF
C_{21}	0.1μF
C_{22}	0.1μF
C_{23}	5000pF
C_{24}	0.1μF
C_{25}	200pF
C_{26}	0.1μF
C_{27}	2μF

Transformer

T_2	Denco IT Blue
T_3	Denco IT Yellow

Meter

M_1	200—0—200A

Parts list for main power supply (Fig. 11)

Resistors

R_1	150Ω
R_2	150Ω
R_3	68Ω
R_4	2kΩ preset
R_5	2kΩ preset
R_6	100kΩ
R_7	100kΩ
R_8	68kΩ
R_9	68kΩ
R_{10}	1.5kΩ
R_{11}	4.7kΩ
R_{12}	33Ω
R_{13}	4.7kΩ
R_{14}	33Ω

Miscellaneous

LP_1	24V, 1W lamp
$LP_{2,3}$	12V, 0.1A lamp
F_1	2A antisurge
F_2	3A antisurge
F_3	3A antisurge

Capacitors

C_1	0.1μF
C_2	0.1μF
C_3	0.1μF
C_4	3,300μF electrolytic
C_5	10μF electrolytic
C_6	10,000μF electrolytic
C_7	5,000μF electrolytic
C_8	0.1μF
C_9	4.7nF
C_{10}	100μF electrolytic
C_{11}	0.1μF
C_{12}	0.1μF

Semiconductors

B_1	4 × Rec 31 (Radiospares)
D_1	26V zener diode
D_2	24V zener diode
$D_{3,4}$	1N5401
$D_{5,6}$	3.9V zener diodes
IC_1	Reg 15V (Radiospares)
IC_2	709
$Tr_{1,2,3}$	2N3055

Parts list for oven supply (Fig. 13)

Resistors

R_{15}	15kΩ
R_{16}	3.9Ω
R_{17}	1kΩ
R_{18}	470Ω
R_{19}	1kΩ preset
R_{20}	4.7kΩ
R_{21}	2.2kΩ
R_{22}	2.2kΩ
R_{23}	2.2kΩ
R_{24}	27kΩ
R_{25}	1MΩ

Miscellaneous

F_4	2A fuse
F_5	2A fuse

Capacitors

C_{13}	5,000μF electrolytic
C_{14}	2,200μF electrolytic
C_{15}	0.1μF
C_{16}	0.1μF
C_{17}	0.1μF

Semiconductors

B_1	4 × 1N5401
D_7	C106B1 (s.c.r.)
D_8	1N4001
D_9	27V zener diode
D_{10}	12V zener diode
D_{11}	3.3V zener diode
D_{12}	3.0V zener diode
D_{13}	ST4
Tr_4	MPS13
$Tr_{5,6}$	2N3054
IC_3	741

Transformers

T_2	240V Prim, 24V Secondary

Parts list for temperature controller (Fig. 14)

Resistors

R_{26}	1kΩ, 10W
R_{27}	4.7kΩ preset
R_{28}	2kΩ
R_{29}	2.2kΩ
R_{30}	47Ω
R_{31}	22kΩ
R_{32}	2.2kΩ
R_{33}	20kΩ, 5W
R_{34}	1MΩ preset
R_{35}	150kΩ
R_{36}	1.5MΩ

Miscellaneous

F_6	2A fuse

Capacitors

C_{18}	32μF, 450V electrolytic
C_{19}	100μF electrolytic
C_{20}	470μF electrolytic
C_{21}	0.1μF
C_{22}	47μF electrolytic
C_{23}	0.1μF

Semiconductors

D_{14}	1N4005
D_{15}	20V zener diode
D_{16}	2N6073
IC_4	MFC4060A
IC_5	JA424 (Jermyn)
IC_6	¼ MC3301P
Tr_7	2N2646
TH_1	THB11

zener, which is the best choice from the point of view of temperature coefficient.

Temperature control

This is necessary both in the case of the crystal, which is of prime importance, and in the case of the oscillator circuit as a whole. We found, in fact, that it was necessary to maintain the crystal itself within very fine limits of temperature (of the order of 0.01°C) and the oscillator circuit as a whole within ± 0.25°C in order to achieve our designed accuracy of frequency stability.

For control of the crystal temperature, we had the good fortune to be given a suitable oven by Marconi Ltd, to whom we are therefore greatly indebted. The temperature controlling element in this oven is stable within ± 0.0014°C. We did, however, encounter one difficulty with it—we originally fed its heater element, which consumes 36W when active, from a.c. (50Hz), but found that this induced hum modulation into the crystal. The obvious answer was to provide a d.c. source; but this in turn gave the problem of switching transients each time the thermostat switch cut in or out. The final solution was the power supply shown in Fig. 13, giving a stable heater supply with very slow switching action (approx. 3s rise and fall times). Switch-on is accomplished by the thermostat switch grounding the base of Tr_4, which therefore ceases to conduct; the short-circuit which it represents in the conducting state is removed from the output of op-amp IC_3; IC_3 output therefore swings positive because its input potentials are unbalanced, thus charging C_{14} through R_{17} which takes about 3s. The potential on C_{14} controls the series Darlington pair $Tr_{5,6}$, giving the required output of 24V at the emitter of Tr_6, the output stabilizing, of course, when the potential at the slider of R_{19} equals that of D_{10} reference zener. It is worth noting, incidentally, that D_{10} is fed from *within* the feedback loop—a concept which has been discussed previously in this journal[3]. Turn-off of the supply is achieved by the reverse action; thermostat switch opens, Tr_4 base is switched via R_{21-24}, Tr_4 conducts and discharges C_{14} via R_{18} (and a further discharge path is provided through the output circuitry of IC_3 as the output voltage dies). Zener diode D_{11} limits the voltage handled by the thermostat switch to approximately 1.5V; D_{11} limits the maximum voltage applied to the base of Tr_4; D_8 has the not very obvious function of preventing C_{14} discharging back through the base-collector circuit of Tr_5 should the incoming mains supply be switched off—we lost a couple of transistors before we woke up to this hazard! Zener diode D_9 limits the maximum output voltage to approximately 26V in case of any other accident. Resistor R_{21}, D_{11}, R_{23} and D_7 form a final safety circuit. The thermostat switch is arranged mechanically so that gross overheating of the oven forces its live contact by thermal expansion against the live terminal of the heater winding. This passes a trigger current to D_7, which latches in across the supply and blows F_3.

For control of oscillator temperature, we decided that the most practical course was to temperature-stabilize the entire clock case using proportional temperature control. A 250W mains-fed heating pad is used and control is by the circuit of Fig. 14.

Conclusion

As we said at the beginning of this article, construction of this project has taken almost three years. Looking back, it is sobering to realize how much this branch of technology has changed during even this comparatively short period. In fact we chose a fortunate moment to commence the project, being the period when bipolar digital i.cs had dropped to an acceptable price level but before their successors in technology (c.m.o.s.) had begun to be too demanding of attention. We have already given the reasons why we as a school undertook the project, and our aims in this respect have certainly been vindicated. Perhaps one proof of this lies in the fact that, of the two co-authors of this article, one is a master at the school and the other a former pupil.

References and acknowledgement

1. Osborne, J. M., "High standard low frequency source", *Wireless World*, Jan. 1973.
2. Clayton, G. B., "Op-amp used as phase sensitive detector", *Wireless World*, July 1973.
3. Letters, "Regulated power supplies", *Wireless World*, Nov. 1972; Anon, "Thermometer", *Practical Electronics*, Nov. 1973.
We also wish to acknowledge gratefully the gift by Marconi Ltd to the school of the high-quality crystal oven used in this project.

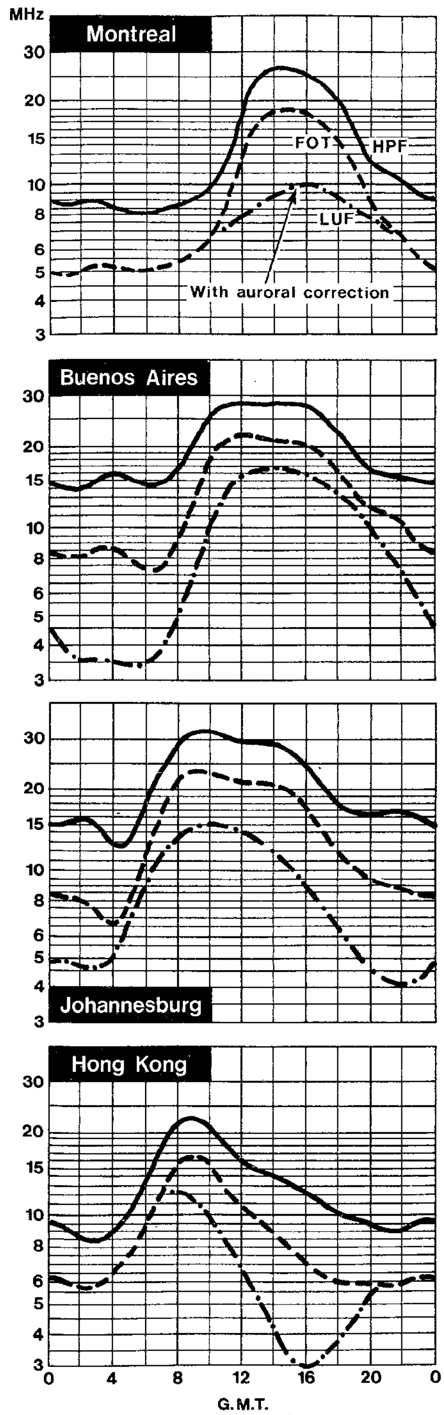
Corrections

Fig. 2. Resistor R_8 should be connected in the emitter lead of Tr_3, below the emitter connection with Tr_4. Two trimmer capacitors appear with the designation C_5. The correct C_5 is connected across L_1 and the second trimmer across the secondary of T_1 should be C_6. The control output of the varicap control unit should have a 100kΩ resistor connected in series.
Fig. 4. A connection should exist between the top end of R_{35} and the junction of R_{34} and C_{21}.
Fig. 9. Outputs to IC_3 should be labelled A_1, B_1 D_1 (not C_1) and A_2.

HF predictions

MUF (maximum usable frequency) at a given hour varies from day to day. HPF (highest probable frequency) and FOT (optimum working frequency) curves enclose the decile range of this MUF variation. The prediction is that on 24 days of a month (30 days) observed MUFs will lie between HPF and FOT, on three days MUFs will be greater than HPF and on the remaining three days MUFs will lie below FOT.

The above assumes a quiet ionosphere; on disturbed days MUFs will generally lie below predicted quiet FOT. Prediction of disturbed days in these notes, based on a 27-day recurrence pattern, has been about 70% correct over the last two years.



Letters to the Editor

THYRISTOR CONTROL OF D.C. MOTORS

We read with interest the article on thyristor control of d.c. motors by F. Butler in the September issue. The article itself was excellent but perhaps might be a little misleading, especially as on page 328 he states "Merely by up-rating the semiconductor devices the scheme appears to be applicable to large motors, certainly up to tens of horsepower". This is not strictly true for thyristor controllers using the "thyristor across the bridge technique" and unfortunately most users, power supply authorities and thyristor drive manufacturers would similarly disagree with that conclusion simply from the viewpoint of harmonic interference injected into a single phase supply.

However, the uninitiated reader might well fall into another trap as, again on the same page, Mr Butler refers to the requirement for "an overriding control which will limit the circuit current to a safe value". Alas, this could well be an understatement because many other would-be users have condemned thyristor motor speed controllers because "when they switched on the supply the fuses blew and kept on blowing". What they had forgotten of course was that the d.c. shunt wound machine, without some form of acceleration control and current limiting, presents almost a short circuit across the supply system with the inevitable result that the fuses blow.

To sum up, the article is indeed praiseworthy but should be regarded with a certain amount of caution, the maximum horsepower, from a reasonable design point of view anyway, being of the order of 2h.p.—certainly not tens as stated in the article.

P. A. Bennett,
Allen Bennett Ltd,
Sheffield,
Yorks.

Mr Butler replies:

Some of the points raised by Mr Bennett were discussed in my original article. However, they are worth stressing a little more forcibly, as he has done, and his letter gives me the opportunity of adding a few comments on matters which were omitted or glossed over in my paper.

As regards power limitations of thyristor drives, a glance through the advertisement pages of technical journals shows that systems up to 260kW (350h.p.) are readily available from companies such as Laurence, Scott and Electromotors, Maudsley and Hugh J. Scott. No doubt the larger installations operate from three-phase supplies, but in principle there is nothing against the use of single-phase sources, subject only to restrictions imposed by supply authorities.

A valid criticism of thyristor controllers is concerned with waveform distortion. To avoid this, variable phase-angle control must be abandoned and the "missing cycle" system used instead. In this system, thyristor firing either occurs at the start of a particular half-cycle or not at all. Though more acceptable to the supply authority, the scheme does not always appeal to the user because of the violent torque fluctuations at low speed and low power.

Starting problems with large d.c. motors are just as bad whether operation is from d.c. mains or from a.c. through a thyristor controller. In the first case, full field current is applied and a manual or automatic starter feeds armature current through a stepped resistor, sections of which are shorted out as the motor gathers speed. It is damaging if not dangerous to overspeed this operation.

With the thyristor controller, the motor must be started with fully retarded firing pulses; the control must then be advanced slowly or some overriding current-limit control must be fitted. The Mullard trigger modules MY 5001 and MY 5051 together give these facilities The simpler arrangement I described is perfectly satisfactory if used sensibly. Its only weakness is that the motor speed tends to drop as the load is increased. To counter this, a feedback loop, such as I mentioned in the article must be added. This, too, is available with the Mullard units.

The vital elements in my controller are the auxiliary power diodes and thyristor load resistor. These prevent the repeated fuse-blowing which is the bane of the simpler controllers. Another point, not previously mentioned, concerns the power factor of a thyristor drive. Delayed firing pulses obviously cause a lagging current to be drawn from the supply, though it is doubtful if matters are worse than when using under-loaded induction motors. Because of the distorted current waveform, precise correction by shunt capacitance across the supply line is impossible.

Since my article was written I have built a universal grinder, the wheel-head drive being from a variable-speed d.c. motor of $\frac{3}{4}$hp. Grinding wheels between 1 and 6in diameter can be run at the optimum speed, which can be measured by a non-contacting tachometer. A colleague, Mr B. Reid, developed a very useful instrument for this purpose. Unfortunately, variable speed grinders contravene the Factory Acts, so that they cannot be used industrially (overspeeding can result in burst wheels). The drive unit for this machine has given no trouble. Another colleague, Mr John Lennan, has built a 1kW controller to supply a 1h.p. motor used to drive a 6-in centre lathe. This, too, has given trouble-free service and I can see no reason why larger units cannot be built with every confidence. Fractional-h.p. motors pose no problems at all.

COMPONENT IDENTIFICATION

As an engineer, I welcome, as I am sure many of my fellows do, the now almost universal adoption of the BS 1825 resistance code. In this, and similar systems, the decimal point and multiplier are combined, so that a one-point-five ohm resistor is expressed as "1R5", and a point-one-five ohm component as "R15".

This is fine, but why, then, is a one hundred and fifty ohm device specified as "150R"? Surely, "K15" would be more logical, as it conserves the three-character format, and is no less informative. This system may of course be extended to capacitors and inductors, "n10" neatly replacing "100p".

Such a modification to accepted practice is only justifiable if widely publicised and understood. I would welcome readers' comments on my suggestion.

S. J. Pardoe,
Altrincham,
Cheshire.

HORN LOUDSPEAKER DESIGN

A number of readers have pointed out that in many cases the minimum space necessary to enclose the rear of the bass loudspeaker apparently exceeds the optimum cavity volume for giving the correct upper cut-off frequency, often by a factor of four or five times. Since the cut-off frequency is inversely proportional to the cavity volume, this will have the effect of giving a serious "trough" in the overall frequency response before the mid-frequency horn takes over. The answer is to reduce the cavity to the correct volume by means of a circular plaster or wood moulding leading from the rear of the loudspeaker diaphragm to the throat of the horn. This technique has been well described by John Crabbe (*Wireless World*, Feb. 1958, my ref. 19).

A further point raised by several readers is the lack of detailed constructional data for the practical horns described in part 3. This was a deliberate policy on my part, because earlier experience had shown that no design seemed to suit more than a very small number of constructors. Indeed, I have already received a number of letters proposing alternative designs and configurations, and asking for my advice regarding their performance—advice which in most cases is quite impossible to give.

Nevertheless, I am very sympathetic

towards those readers who require detailed constructional information, and I hope to make available early next year detailed drawings of a moderately-sized corner horn which gives a very satisfactory performance.
J. Dinsdale,
Olney,
Bucks.

As ref. 20 in the interesting series of articles on acoustic horn design by Mr Dinsdale (March, May, June issues), I would like to reinforce the warning on differential time delay given by Mr Hamill in the September issue. Experience with a 16-ft bass horn (described in "Acoustic Compensation", *Hi-Fi News*, November 1964) confirms that the reproduction of transients is most subjectively accurate when l.f. and h.f. path delays are similar, although if some differential must be endured results are less unnatural if h.f. energy is received first. Experiments suggest that, as a rough empirical guide, the time differential introduced should not exceed $1/f_c$, where f_c is the crossover frequency. Thus, for f_c at 400Hz, up to 2.5ms would be allowable, equivalent to a path difference of nearly 3ft.
R. N. Baldock,
Harrow,
Middlesex.

DIGITAL SPEEDOMETER

Having designed and partly constructed a digital speedometer before coming to Saudi Arabia this summer, I was interested to note the similarity of approach in the design offered by Messrs Bishop and Woodruff (September, October issues). Perhaps you would allow me to make the following comments.

Firstly, by expanding the display to three digits and altering the count period generator to include a switched resistor, the display could indicate either miles or kilometres per hour, together, perhaps, with a suitable indicator to show which is being displayed.

Secondly, in my design I used an optical pick-up from a modified speedometer, and by doing this was able to dispense with the frequency multiplier. This reduces the circuit complexity quite considerably, but requires knowledge of the individual speedometer gearing to calculate the correct number of slots in the rotating disc. I have also considered the use of storage and calculation logic to display acceleration. But this seems to be adding much cost and work for very little gain.

I have been thinking about the addition of variable retard or advance to a thyristor ignition circuit. Perhaps an automobile engineer could tell us whether such a control on the dashboard would be of advantage in the fields of performance or economy?

During the petrol crisis last winter I connected a reed relay and light bulb to indicate each stroke of the electric petrol pump. Although the pump frequency varies with engine speed, and thus the display cannot give a true indication of m.p.g., it is certainly a constant—and effective—reminder of the absolute rate of flow of fuel!
N. H. Jennings,
Dhahran,
Saudi Arabia.

CALCULATOR AS SIGNAL SOURCE

At the risk of appearing frivolous, may I suggest a possible secondary application for the now ubiquitous electronic pocket calculator?

Recently, while re-aligning a pre-war a.m. broadcast receiver, it became necessary to convert wavelength (in which the set's tuning scale was calibrated) into frequency and this simple calculation was carried out on a Sinclair "Cambridge", which I keep handy in the workshop. With the set switched on it was noticed that a high pitched buzzing emanated from the speaker whenever the calculator was operated and that this note could be altered in pitch as the various function keys were depressed.

Analysis of the "r.f. field" with an oscilloscope indicated a strong square wave radiation extending up to 3MHz. Subsequent experimenting suggested that the calculator acts as a very effective signal injector and my "Cambridge" has in fact been used as such (in addition to its normal intended use, of course!) in the repair of long- and medium-wave radio receivers for the past few months. It would be interesting to hear other readers' comments—other calculators currently available may yield quite different results and may possibly radiate at frequencies above 3MHz.
A. D. Thomas (GW8DXA),
Cardigan,
West Wales.

F.M. TUNING INDICATORS

I have followed with interest the correspondence on f.m. tuning indicators, and I think readers may be interested in my approach to the problem.

My circuit arrangement has the advantage of the two-lamp system, i.e. it indicates direction of mistuning and also has the additional advantages of maximum sensitivity at the tuning point and requires no judgement to be made by the operator.

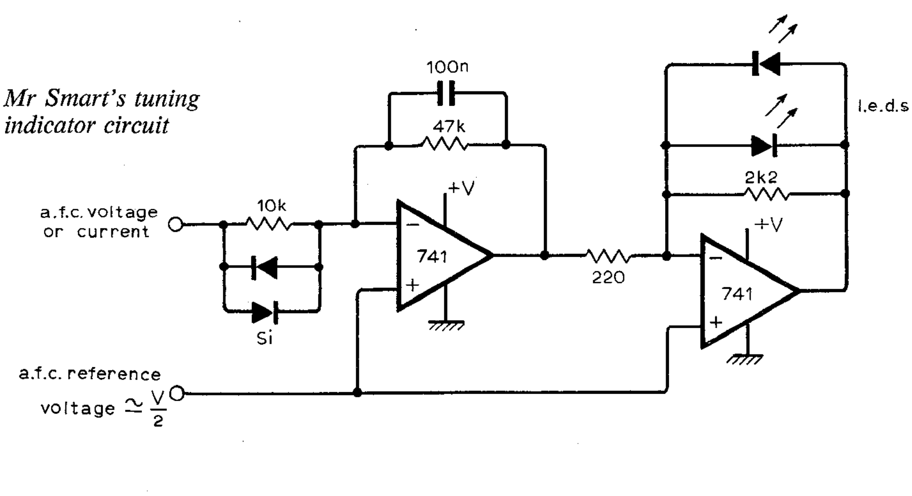
These features are obtained by putting the two lamps (l.e.ds) in the feedback loop of an op-amp (741). The high open-loop gain of the 741 and the forward voltage drops of the l.e.ds combine to produce a very sensitive null detector. The a.f.c. reference voltage is fed to the non-inverting input of the 741 and the a.f.c. voltage to the inverting input via a second 741 as an amplifier/buffer. When the set is on tune the output of the 741 will be at mid-rail voltage and neither l.e.d. lit, but only a small tuning error is required to swing the output to the "knee" of the l.e.d. characteristic, turning it on and so indicating mistuning in that direction. The l.e.d. current in the "off tune" state will be automatically limited by the built-in current limit of the 741. To reduce the sensitivity to usable levels a shunt resistor is connected across the l.e.ds, otherwise the output level will tend to sit so that one or other of the l.e.ds is conducting. The gain of the buffer and the value of the input resistor, which sets the l.e.d. current, are chosen to suit the a.f.c. voltage available. Typical values are given on the diagram. This circuit is used with an RCA CA3089 i.f. chip, which has the a.f.c. output in the form of a current. Silicon diodes across the a.f.c. resistor limit the range of the a.f.c. in a similar manner to the design by J. A. Skingley and N. C. Thomson (*W. W.* April, 1974).

The capacitor across the first 741 removes the modulation components from the a.f.c.
M. G. Smart,
Sunbury-on-Thames,
Middlesex.

DOPPLER IN LOUDSPEAKERS

Mr Edgar's novel approach (August Letters) made me think again about this matter, and I came to the conclusion that not only does Doppler effect physically exist when loudspeakers are playing (as James Moir confirms in your October issue) but that it exists in general whenever two or more sounds are in the air together.

Mr Smart's tuning indicator circuit



The fact that in most cases the effect is negligibly small does not affect the principle. Or can someone explain why (e.g.) a large-amplitude low-frequency waving of the air to and fro does *not* frequency-modulate a small-amplitude high-frequency wave (from another source) being carried by that sinusoidally moving air?
"Cathode Ray".

MAKING P.C. BOARDS

For some years now I have been using Letraset for making printed boards. Perhaps your readers would like to know of this method. As a start I can recommend sheets number 557, 556, 804. About three years ago I contacted Letraset in the U.K. and they showed interest. Perhaps if someone produced a greater variety of connections then the use of this method would become more popular.

I would like to put these points forward: 1, clean the copper board well, e.g. with steel wool and warm water, then dry completely and allow to reach room temperature, which should be at least 20°C. 2, use light pressure when rubbing; do not burnish, just press down with finger. 3, when making joints, "overlap". 4, to cut just use a sharp knife. 5, mistakes are easily removed by scraping with a plastic tool on tape, but beware of this as it could leave a trace of adhesive which will prevent etching.
H. Wedemeyer,
Vanse,
Norway.

LOUDSPEAKER DAMPING

Mr Marshall refers in a letter in the October issue to a contribution (Transients and Loudspeaker Damping) I made in May 1950 on the subject of the damping factor of amplifiers. Reference to the contribution indicates the degree of misunderstanding commonly involved in thinking that high damping factors are significant.

Briefly, motion of the loudspeaker voice coil is "damped" by the motionally induced current circulating in the voice coil-amplifier circuit. The amplitude of the current is controlled by the *total* impedance of the circuit, amplifier + voice coil + wiring. The amplifier output impedance obviously has no significant effect on the total current when it is only some 10% or less of the total circuit impedance. Thus extremely high damping factors, i.e. very low amplifier output impedances, are of no engineering significance in damping the oscillation of the voice coil; indeed they may impair the performance of a loudspeaker. The contribution includes some oscillograms showing the actual effect of amplifier output impedance on the transient oscillations of the voice coil of a typical loudspeaker.

It is also worth noting that while the amplifier output circuit impedance may have some effect on the transient oscillations at low frequency, the cone is so loosely coupled to the voice coil in the middle and high frequency bands that the cone or small areas of the cone can continue to oscillate although the voice coil is stationary.

As the contribution demonstrated, there appears to be no engineering advantage in achieving damping factors much greater than about ten. In many instances there are positive disadvantages in using amplifiers with high damping factors.
James Moir,
Chipperfield,
Herts.

TRIALS—AND TRIBULATIONS!

A photograph of a charming young lady holding one of the new push-button dialling telephones (STC Trimphone, I believe) appears on p. 374 of your October issue. The caption states that if the London trials "go as the Post Office expects" the new phones will be made available progressively in other parts of the country.

If one compares the telephone keyboard with that used on calculators it will be seen that only four figures—4, 5, 6 and 0—are in the same positions. (See, for example, the calculator advertised on p. a53 of the same issue.) It does not require much imagination to foresee the sort of confusion which could arise if the two instruments—calculator and push-button phone—are side by side on a desk.

The calculator keyboard has been standardized for some time. Whey then should a telephone manufacturer and/or the Post Office introduce a variant? It can, of course, be argued that the Trimphone keyboard with the zero after figure 9 is in keeping with the sequence of figures on the normal telephone dial. With the logic of this one would agree, but with the calculator becoming increasingly a tool of everyday life, would it not have been logical for the new phone keyboard to conform with what is established practice in another branch of electronics?
Harold Barnard,
Leigh-on-Sea,
Essex.

AUDIO VISUAL GROUP

May I inform you that the British Kinematograph, Sound and Television Society has, for some time past, been planning to improve services to existing members working in the audio visual field and to fill a suspected need of potential members for an organisation that will provide papers, presentations, technical articles and technical information on audio visuals.

Although the Society originated as a film orientated organisation it has widened its scope by entering the television and sound fields where appropriate to its aims and objects and now has considerable experience and some reputation in the proper integration of these three separate techniques. Where better then to find the resources and the skill in the efficient use of film, television, video, sound and vision techniques used in combination?

The very nature of the Society's undertaking requires the closest co-operation with all organisations catering to the separate needs of those techniques that go to make up audio visuals, and the BKSTS has every intention to provide its members not only with their brand of information but information on the activities of other organisations bearing on audio visuals.

In this connection I hope that we can be of mutual service to *Wireless World* and to its many readers, some of whom may be looking for an organization to serve their needs in the dissemination of technical information which, in these days, comes and goes in such prolific quantity and at such a rapid pace.

The BKSTS Audio Visual Working Party has, as its brief, the task of improving existing services and of creating a climate that will encourage an increase in our 2,000 strong membership.
Robert R. E. Pulman,
BKSTS Audio Visual Working Party,
London, WC1.

ELECTROSTATIC FORCES ON PICKUPS

Like Mr Hide I have also found when using an SME arm under a plastic cover that the arm would occasionally lift from the playing surface. I have found that a cure could be effected by damping the cover by means of a damp cloth or by using an anti-static cleaner to clean the cover (similar to the method of preventing dust accumulation on TV screens).

However, I also suffered from snap, crackle and pop, and, blaming this on central heating and a rather dry atmosphere, I now use a wet sponge in a tray on the baseboard of my plinth, inside the cover. This overcomes the spurious clicks and no longer is the pickup arm liable to lift from the record, presumably because the slight increase in humidity inside the plinth inhibits the development of electrostatic charges on record or cover.

Previously the pickup could be lifted off the record simply by rubbing on the outer surface of the cover (not to be recommended with an expensive stylus and one's favourite disc) when the pickup could be induced to lift and return to position to the outside of the record. With this primitive humidifier device *in situ* no amount of rubbing on the cover will induce the pickup to miss a note.
Alec West,
Milton Keynes,
Bucks.

WESCON 1974 convention

Electronics in medicine ● microprocessors ● speech recognition

by Aubrey Harris
University of California

The 1974 WESCON (Western Electronic Show and Convention), the big electronics event of the year in the Western United States, was held September 10 to 13 in Los Angeles. Many of the papers this year stressed practical applications and only a small number of new items were displayed in the show: the big semiconductor manufacturers were notably absent.

One of the areas in which electronics is becoming more and more needed, and accepted, is the field of medicine. Perhaps the earliest application of electronics was in the use of x-rays last century, but since then a whole host of uses have been developed: electro-cardiograph and electro-encephalograph apparatus, pacemakers, hearing aids, myo-electric control and many measuring and monitoring equipments. These latter are of particular importance for such uses as alerting medical personnel in the event of a change in vital body functions of critically ill patients.

A paper by J. R. Singer, T. Grover and A. Poggio, "Progress in blood flow measurements" described their work in this area using nuclear magnetic resonance (n.m.r.). This technique has advantages because blood flow can be determined without inserting probes or other devices into the subject to be tested. A large percentage of blood is water, and it is the magnetic properties of the hydrogen nuclei of the water molecules which are used in the measurements.

It is known that the hydrogen protons in the blood are magnetic and possess spin, and each proton is like a gyroscope or spinning magnetic top. When placed in an external magnetic field, the "magnetic tops" align themselves north-to-south with the external field. In fact, this alignment is not immediate but takes about three seconds in pure water and in venous blood (because of the paramagnetic nature of the haemoglobin molecules) the protons require only 0.5 sec to align (Fig. 1). When the alignment has taken place the protons as a group behave as a gyroscope and precess. That is, just as a spinning top will do, the axis tilts out of the vertical and describes a cone due to the force of gravity. In the case of a fluid in a magnetic field, the hydrogen protons precess in a similar way (Fig. 2).

The tilt may be increased to a greater extent by applying a radio frequency field in such a way that the magnetic action of the r.f. provides torque to tip the spinning protons. A coil carrying a few milliwatts of pulsed r.f. power produces a rotating magnetic field (during each pulse) and when the rotation is equivalent to the rate of the spinning protons they will tip. In these experiments the r.f. was at 10MHz.

Another coil is used to detect the tipping and is arranged to be perpendicular to the excitation coil, some 3cm away. The precessing protons, being magnetic, induce small signal voltages in the detector coil which, after amplification, can be measured. Protons tipped by the r.f. will produce a different output in the detector coil compared to untipped protons; this is because of the different angles which the axes of the tipped and untipped protons make with the axis of the detector coil.

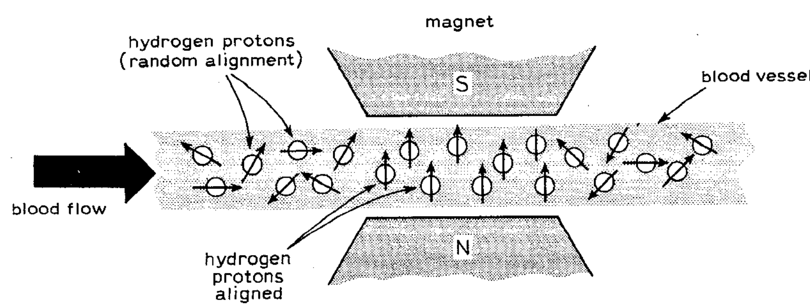


Fig. 1. Hydrogen protons in the blood being aligned during their passage through a magnetic field.

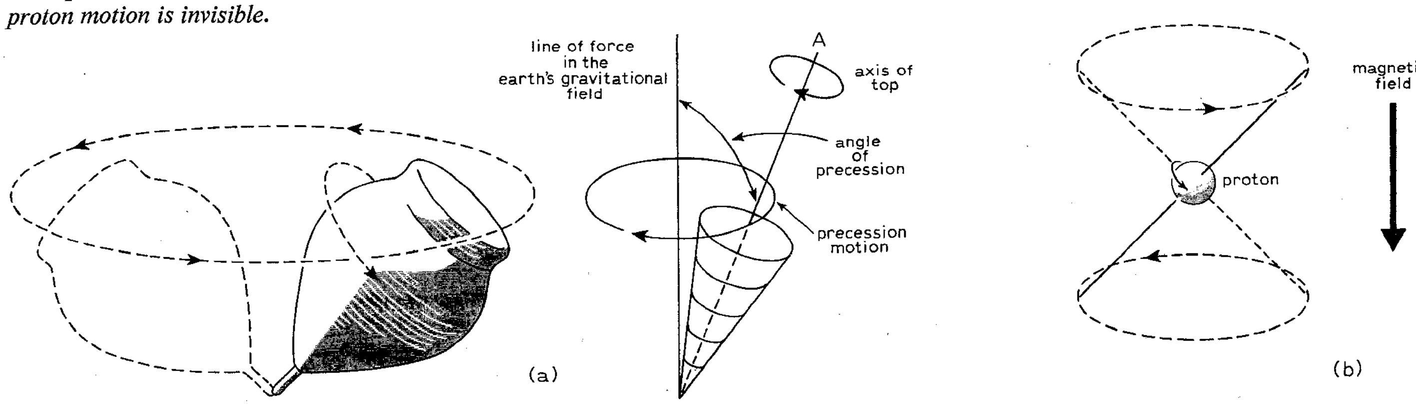
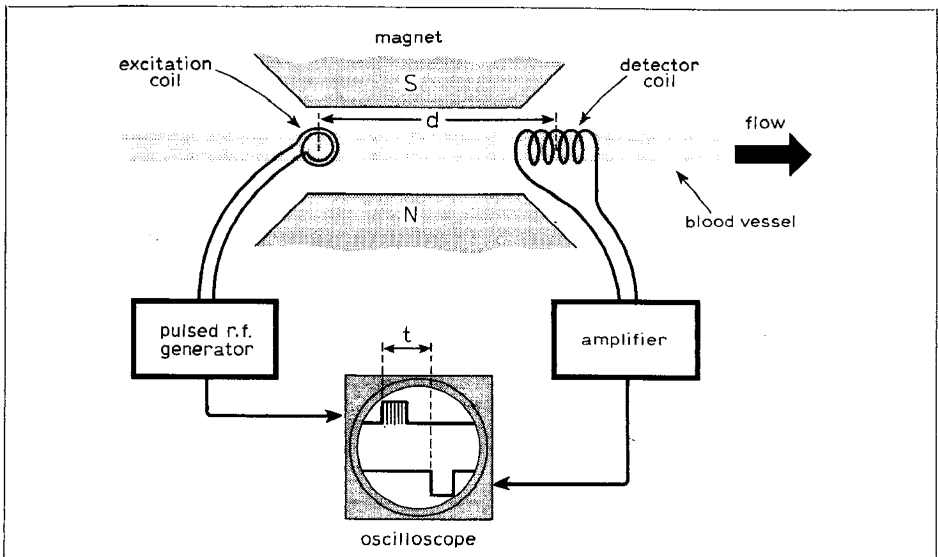
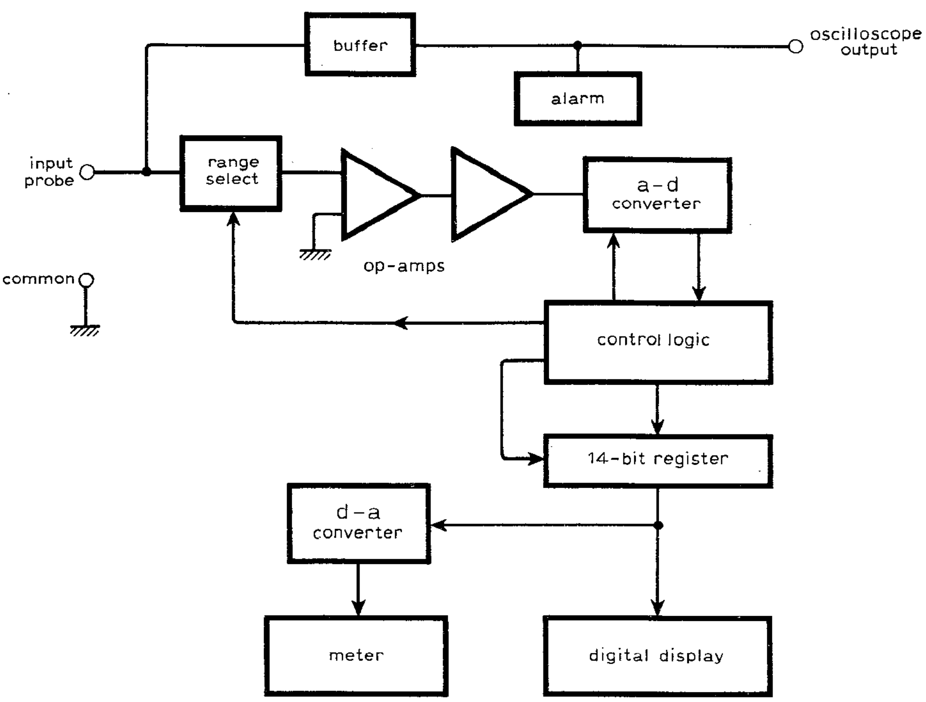


Fig. 2. Representation of the proton or group of protons as a spinning top which precesses about the direction of a magnetic pole. A top precesses about the gravitational field in a familiar way. (a) The proton has spin like a top and precesses about the magnetic field. (b) The description is very similar even though the proton motion is invisible.





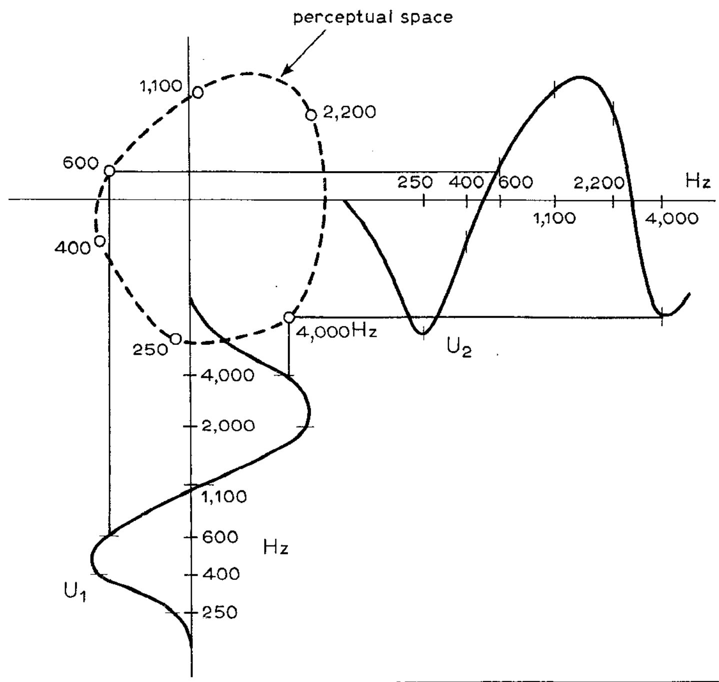


Fig. 3. Schematic arrangement for determining blood flow using nuclear magnetic resonance. The time taken (t) for protons "tipped" at the excitation point to reach the detector coil is used to calculate flow. Typical spacing (d) is 3cm.

Fig. 4. Block diagram of "acumonitor" for use in acupuncture.

Fig. 5. Voice entry encoder: the perceptual space and its relationship to the sine (U_1) and cosine (U_2) functions. Filter frequencies are also indicated.

Thus, it is possible to determine at the pick-up coil when protons in the blood which have been tipped by an r.f. pulse are passing the detector point. The flow rate may then be determined by noting the time taken for tipped protons to move between the excitation and detector coils, and, knowing the spacing between the two points, the average flow velocity may be determined (Fig. 3).

One problem in using this system under clinical conditions is the cost of the large magnet required, which has a magnetic flux density of about 2500 gauss. These may be produced in quantities economically but are expensive in small, experimental numbers. It is hoped that this restraint can be soon overcome.

A related series of papers under the collective title of "Psychotronics" was chaired by Dr Thelma Moss of the Neuropsychiatric Institute of the University of California, Los Angeles. Although not strictly directly related to electronic equipment, a tremendous interest was aroused amongst engineers at WESCON with about 1200 of them attending an evening meeting on the subject. This serves to emphasize the growing appreciation and realization by many professionals that there is a large number of events and "happenings" which cannot be explained by our present scientific knowledge.

My apologies to those of my readers who are disbelievers (or pre-believers) of such esoteric manifestations as are described hereunder; I, too, was among your erstwhile millions—now, no longer so.

The areas covered included a laboratory investigation of telepathy, some new work in Kirlian photography, a remarkable demonstration of changes in human physical states by Jack Gray using his own personal energies of an, as yet, unexplained nature, and some work on an "acumonitor" by B. E. Taff. He explained that there has been increasing interest in the past few years by the medical profession in the Western world in acupuncture, the ancient Chinese method of preventive medicine and pain reduction. Their theories state that there are 12 meridians in the body, acting as prime "energy circuits": for perfect health the energy in these circuits must be balanced properly between the meridians. Acupuncture is used as an aid in obtaining the correct balance. The meridians are thought to be a fourth (and distinct) body system in addition to our blood circulation, lymph and nerve systems. The actual nature of the "energy" in the meridians is not clear but has been shown to be real.

There are various methods of stimulation for correcting the energy imbalance in the circuits: (a) by chemical means, (b) by massage or pressure (acupressure), (c) by needles (acupuncture), (d) by electrical energy injection, and (e) by laser beams.

These latter two require a good deal of understanding and sophisticated equipment; however, it was demonstrated in the USSR that a mild intensity laser beam directed at the meridian above the lip caused immediate cessation of an epileptic seizure. Work has been directed at devices capable of determining the location of the meridians. The Russian scientist V. G. Adamenko wrote in 1972 about a device called the "tobiscope" enabling measurements of resistance points on the body to be made, which show a one-to-one correspondence with the known oriental acupuncture meridians. The device appears as a metal cylinder with a probe at the top, insulated from the metal body. In use, an operator holds the cylindrical part and applies the probe to the skin of the subject. The operator completes the electrical circuit by maintaining contact to the subject's body with his free hand.

Networks of low resistance can be traced which correspond within a millimetre or so to the acupuncture meridians. These networks are differentiated from skin probing of other areas of the body by a ten-to-one resistance ratio. Approximate measurements recorded are 0.5 to 1.5×10^5 ohms at the meridians and about 10^6 ohms on other areas. Due regard is taken of shunt low resistance paths due to moist skin. For this work low values of direct current were used (a few microamps at four volts) but some experiments have also been successfully made with a.c. at 1000Hz.

A more sophisticated device designed and developed by Taff is the "acumonitor" mentioned above, basically a single channel d.c. analogue/digital metering device. It has stainless steel electrodes, one a 2mm probe and the other a hand-held circuit return. A block diagram is shown in Fig. 4: the actual circuit is still proprietary. The probe signal is fed through several stages of i.c. f.e.t. operational amplification providing an input impedance of about 2×10^8 ohms. In searching for the acupuncture meridians an alarm is set to trigger whenever potential is indicated at over 37 millivolts and resistance under 2.5×10^5 ohms. However, parameters are also visually displayed with an l.e.d. digital display.

The "acumonitor" has been used on a subject under stimulation, to measure changes in readings at specific locations. In one test, voltage measurement increased by a factor of five and resistance decreased by 40% during two-minute stimulation of the subject by a 15-mW helium-neon laser.

Ever since the introduction in 1948 of the first solid-state active device, the transistor, there has been a significant impact every few years or so, with the development of more highly sophisticated devices—i.cs, m.s.i., l.s.i. The latest in this line of development is the microprocessor. The term microprocessor (often abbreviated to μP) is used to describe the central processor unit functions of a computing device implemented by one or a few m.o.s./l.s.i. chips. Significant differences between the μP and the minicomputer are the lower cost, reduced power requirements and often, lower speed. An important advantage of the μP over the other forms of l.s.i. is its capability of being programmed.

There were some 19 papers on μP presented in what was called the "microprocessors revolution". M. M. Saba and J. D. Grimes, in their contribution "Microprocessors: a component for all seasons", showed that the μP has really arrived and is now considered a single component characterized by such features as data word sizes of 2, 4, 8 or 16 bits, macro instruction cycle times between 300ns and 60μs, instruction sets between 50–100 items, memory address space ranges from 256 words to 65 kbytes, frequently requiring from ten to 40 s.s.i. or m.s.i. packages to interface them with other sub-systems. The μP presents itself as a powerful, inexpensive computing device, the implications of which upon the electronics and computing industries are not yet appreciated.

The uses to which the μP is now being applied are basically in the areas of calculation and control-type functions. It is often used as an alternative to hard-wired random logic and has been found an inexpensive alternative to the minicomputer, where speed is not of the essence. Such applications are, for example, point-of-sale and graphic terminals, and credit card verification systems. According to a report by Quantrum Science Corporation there were 100,000 units in the USA at the beginning of 1974; and the number is expected to increase to 800,000 units by the end of 1975. By 1976 the cost of a unit is predicted as either $10 or $130—depending on who you want to believe.

In reviewing the present and future trends of the market for microprocessors, Robert F. Wickham indicated that their role would be in "dedicated" systems such as computer peripheral controllers, office equipment, computer terminals, communications controllers, as well as test and measuring instruments offering programmability and "intelligence".

In the equipment show a remarkable piece of equipment was shown by Perception Technology Corporation. It was "voice entry", a device which provides a direct interface between the human voice and a computer system, making it possible for any person to address a machine in appropriate words chosen from one's own language.

This apparatus could be useful for controlling equipment or machine systems in situations where both hands and feet are already occupied or where there are restrictive physical limitations, such as in the cockpit of a test vehicle or where operations upon micro-components must be made while viewing the device through a microscope. Further uses are in directing materials, handling, sorting and in controlling physical access by personal (voice) identification. As the input is an audio signal, remote control of systems is possible by telephone.

The basic unit, designated the VE-100, is suitable for table top or rack mounting and costs $6,198. This provides an interface to a computer (such as a PDP/8E with 8k of memory) which is necessary for operation of the unit. The vocabulary is normally the digits "zero" to "nine" plus control words "enter", "cancel", "reset", and "function". The machine can be trained to recognize other words.

Machine recognition of speech regardless of the speaker's characteristics is a formidable problem and many systems so far have had a high rate of inaccuracy and speaker dependence. A novel solution is provided by the use of a set of transformations to map speech spectral parameters into a perceptual space.

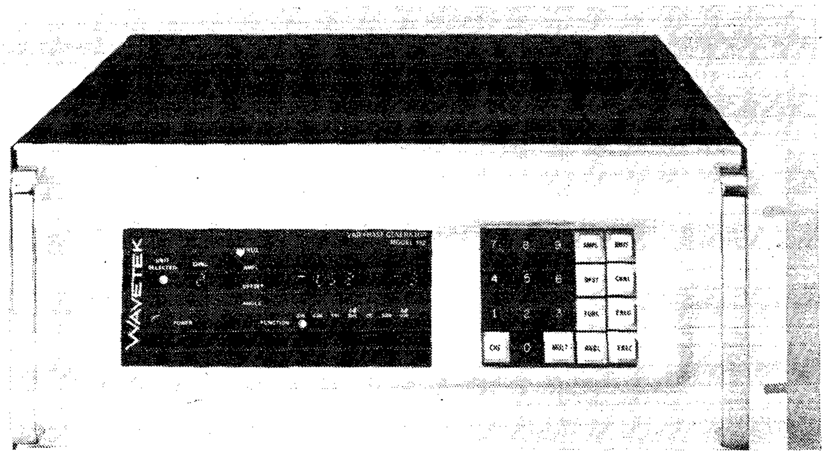
The problem of accuracy of recognition can be appreciated when it is observed that the variation, in spectral terms, of a given phoneme between different speakers is often greater than the difference between two distinct phonemes. The problem is compounded because, even with a single speaker, monitoring shows that spectral differences occur at different times, contexts and circumstances which are comparable to the differences between speakers.

Speech parameters can be described by spectral distribution and to a general degree may be represented by points in a two-dimensional perceptual space approximating a circle (Fig. 5). A combination of more than one frequency will be indicated by a point within the figure. (This is somewhat similar to the representation of coloured light in the CIE chromacity diagram. However, the speech spectral distribution curve is continuous.) The co-ordinates of the curve approximate to sine and cosine shapes, and are derived from Fourier transformations. In the equipment the functions U_1 and U_2 are reproduced by six active bandpass filters, one at each of the frequencies noted, each with a Q of 1.67 and two filters with slope at 24dB/octave at 300Hz and 500Hz to provide the required shaping.

Phonetic segments are determined by noting changes in energy levels and transitions between voiced and unvoiced states. Then segments are fed to an 8×8 matrix space in the computer and these are compared with stored speech information in matrix form. A number is assigned to each of the comparisons of a given segment with all the stored patterns. The number is related to the closeness of the dominant vowel in the input vs. the stored pattern; the closer the number is to zero, the better the match. In a given word up to four segments will be recognized and

Fig. 6. Wavetek model 152 programmable function generator.

Fig. 7. Tektronix 31/53 data acquisition system.



compared for the matching process.

The system consists of speech processing circuits, a mini-computer and an interface between them. In operation an input word is processed and its identity verified within 160ms of the end of the spoken word. During this interval the spectral distribution of the speech signal is determined by the filters, whose outputs are rectified, smoothed, sampled every 10ms and input to a memory. The computer tabulates them to form the data points of the perceptual space. A comparison is then made with the related, stored pattern and operates on a decision algorithm built upon a broad statistical base, thus gaining a large degree of speaker independence and accuracy.

Regarding this latter aspect, accuracy is claimed to be from 90% to 99%. The higher figure may be achieved by "training" the system, by repeating via the input microphone the desired vocabulary and voice.

A new approach in programmable function and waveform generation was demonstrated by Wavetek. The Model 152 equipment (Fig. 6) allows, either from a manual keyboard on the instrument or remotely by an ASCII code, control of frequency, amplitude, waveform, d.c. offset, and trigger mode, as well as continuous phase variations of functions from 1Hz up to 100kHz, with harmonic distortion of less than 0.1%. (The models 158/159 have frequency ranges from 1Hz to 3MHz and can be programmed for 180° phase changes only.) Sine, triangle, ramp and square waveforms may be generated with output voltages of from 10 millivolts to 10 volts p-p into 50 ohms load impedance.

The programmable function generator has many applications in automated testing, where its output parameters may be controlled remotely from a computer in response to previously set up programmes and to adapt to special conditions. Remote programming is accepted into the unit as 7-bit parallel ASCII coded characters; up to nine instruments may be connected to a common line, controlled from one source. The unit will respond to input up to 1 Mbyte per second; the selected output function becomes stable within 1ms in all cases. With the variable phase feature, this parameter may be controlled with 4-digit resolution referred either to its own sync output or an external sync source.

Tektronix were displaying the DM43, a precision digital multimeter for use with the 465 and 475 portable oscilloscopes. The meter has $3\frac{1}{2}$ digits, five 7-segment l.e.ds and will display voltages from 1V to 1200V, resistance values from 0.1Ω to 20MΩ, temperature from −55°C to +150°C and also differential time delay measurements, which are resolved at an increased factor of ten times compared to the precision delay time dial on the oscilloscope.

Time measurements are made by selecting the first of the two points by means of the oscilloscope's delay time position control. The meter is set to zero at this point. Next the delay time position control is used to select the second point and the delay is read out directly on the meter. This direct time readout capability has application in checking the critical timing of digital systems.

Temperature probing of semiconductor power components can be accomplished while signal waveforms for the device are monitored at the same time. Test leads used for voltage, resistance and temperature are independent of the oscilloscope into which the meter is incorporated. Front panel pushbuttons provide separate selection of function and range.

Tektronix displayed for the first time the 31/53 Calculator-based Instrumentation System, which is capable of data acquisition, transformation and analysis (Fig. 7). Its main feature is its ability to log, compare and analyze measurement data as it arrives. The user can also store the data. The unit has many of the capabilities of the minicomputer, but it is cheaper and easier to use, as there is no need to learn a computer language to operate it. In many existing systems information is gathered by reading meters, strip charts or printed lists. Then it is interpreted or compiled and entered by hand into a calculator or a computer for statistical analysis or for storing on cards or tape. In the 31/53, the process data gathering, data analysis, documentation and permanent storage can be handled by the single calculator system. It combines the concept of a stand-alone data recorder and data analysis computation.

The system includes the Tektronix 31 calculator, a mainframe power source, an interface plug-in, standard software for data acquisition and analysis, and standard options and accessories. The cost is $3,995.

Data acquisition is accomplished by selected instruments from Tektronix's TM 500 line of modular measurement instruments. The system mainframe allows these modules to be plugged-in in any desired configuration.

Circuit Ideas

Electronic changeover switching

The circuit shown in Fig. 1 effects a changeover function when only a single pair of contacts is available. When the switch is open, only input A is admitted to the output via R_4. When the switch is closed, input B is admitted to the output together with an inversion of the input A signal, which cancels the direct signal A and leaves only signal B present. A gain of two is given to input B by the op-amp circuit, to bring the system gain to unity for both inputs A and B by compensating for the attenuation of signal B through R_5

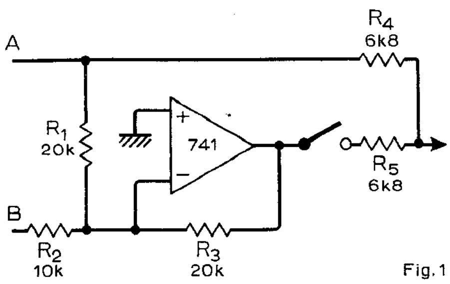


Fig. 1

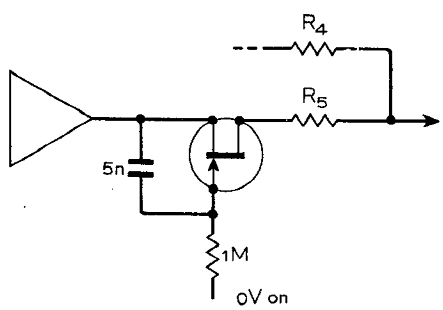


Fig. 2

and R_4 (assuming source impedance at input A≪6.8kΩ. The degree of attenuation of the unselected input depends on the tolerances of R_1, R_3, R_4 and R_5, and if more than about 30dB rejection is required, some trimming may be necessary.

Electronic switching can be accomplished by substituting an f.e.t. to replace the switch, as shown in Fig. 2. The 5nF capacitor prevents the f.e.t. from cutting off during the positive half-cycles above about 100Hz which exceed the f.e.t. pinch-off voltage when in the on state.

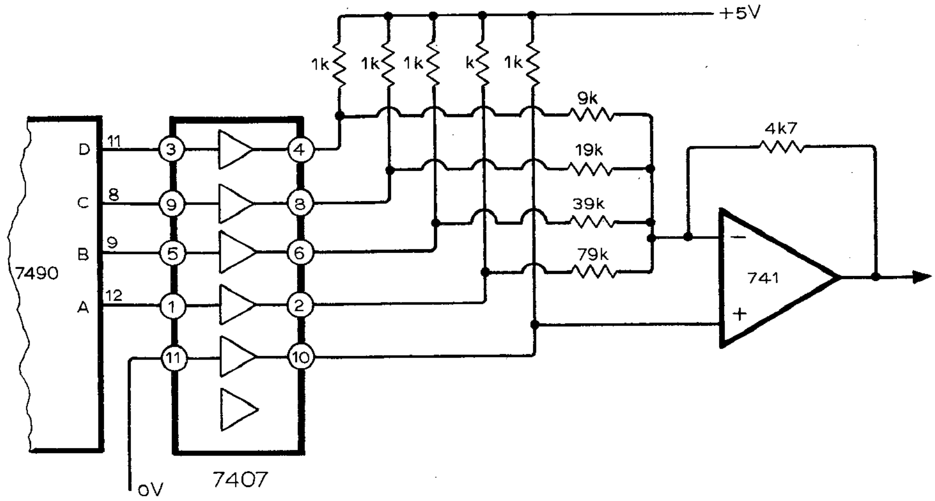
In certain multi-changeover switch functions the operational amplifier could be a section of a programmable op-amp.

M. J. Sells,
Reading.

Improved simple d. to a. converter

Readers may have difficulty in getting a satisfactory performance from D. James' digital to analogue converter (*W.W.* June, page 197) over a reasonable temperature range especially if the 7490 is driving other t.t.l. This is because of the necessity for equal logic 1 output voltages from the 7490 as well as matched v_{be} for the transistors. A better performance with similar economy can be achieved by using a 7407 hex buffer as shown in the accompanying diagram. The effect of changes in $v_{ce\,sat}$ with temperature can be minimized by connecting the non-inverting input of the op-amp to the output of an unused buffer at logic 0. The 7407 could be replaced by a 7405 if temperature compensation is not required or for the addition of a less significant digit.

R. J. Chance,
Birmingham.

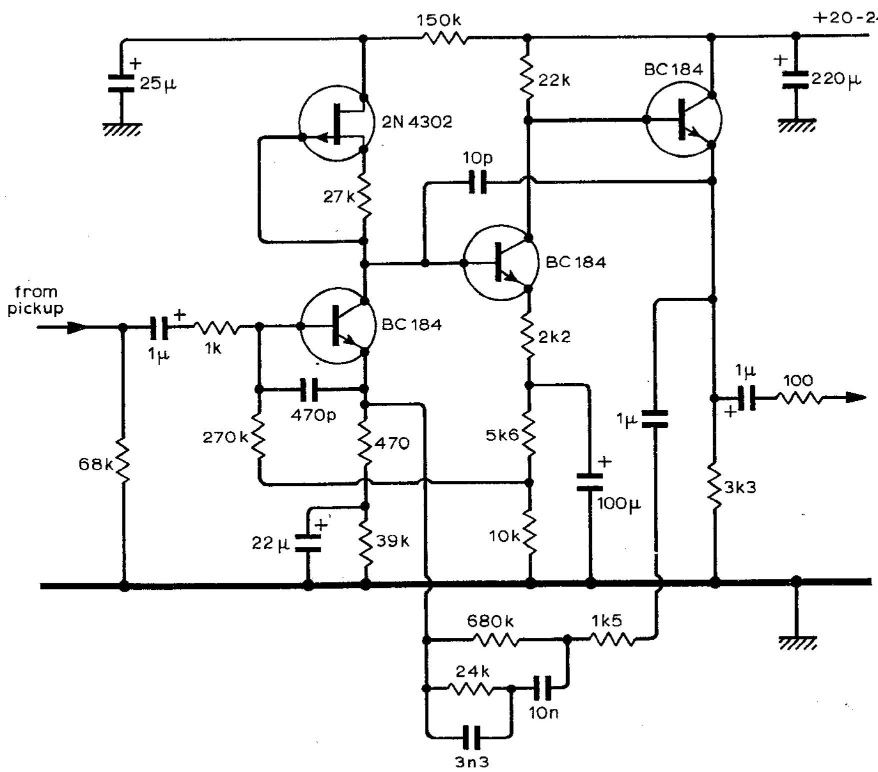


RIAA-equalized pre-amplifier

The amplifier shown in the diagram was designed to combine the advantages claimed by proponents of either side of a recent correspondence in this magazine. It has the low noise (less than −70dB ref. 5mV input) and high overload capability (almost 30dB above 3mV input) of a series feedback-pair design, and the low distortion (0.05% i.m. distortion at 2V r.m.s. output) of the Liniac.

The first stage is basically a Liniac-type circuit with emitter resistors, one of which reduces the d.c. gain, and thus the amount of d.c. feedback applied, improving transient response over the usual feedback pair arrangement. This feeds into a second, ×10 stage, which, contrary to normal practice, has part of its emitter resistance undecoupled, preventing shunting of the first stage high impedance dynamic load by this second stage input impedance.

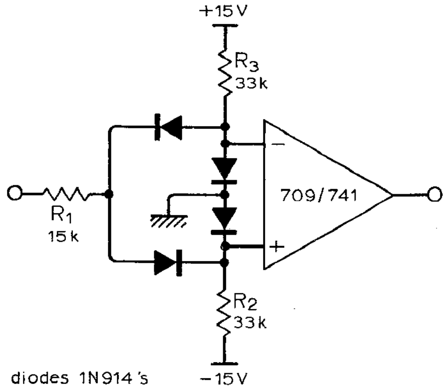
S. F. Bywaters,
University College,
London.



Dual limit comparator using single op-amp

This circuit was designed to give a positive output when the input voltage exceeded plus or minus 8.5 volts. Between these limits the output is negative. The positive limit point is determined by the ratio of R_1, R_2, and the negative point by R_1, R_3. The forward voltage drop across the diodes must be allowed for. The output may be inverted by reversing the inputs to the operational amplifier. The 709 is used without frequency compensation.

K. Pickard,
Otley, Yorks.



Novel power amplifier

This circuit obtains a differential output from a type 741 operational amplifier, by using its power supply pins. These outputs are used to drive power Darlingtons, which use high voltage supplies. This type of differential output is possible due to the op-amp power supply rejection ratio (typically 30μV/V) and its class B output stage. The output pin of the 741 is loaded with R_{11} to obtain maximum current swings at the 741's supply pins.

The ±15 volt supplies required by the 741 are obtained by resistor divider chains R_3, R_4 and R_5, R_6 and transistors Tr_1 & Tr_2 transfer their outputs to the 741's supply pins by their emitter follower action.

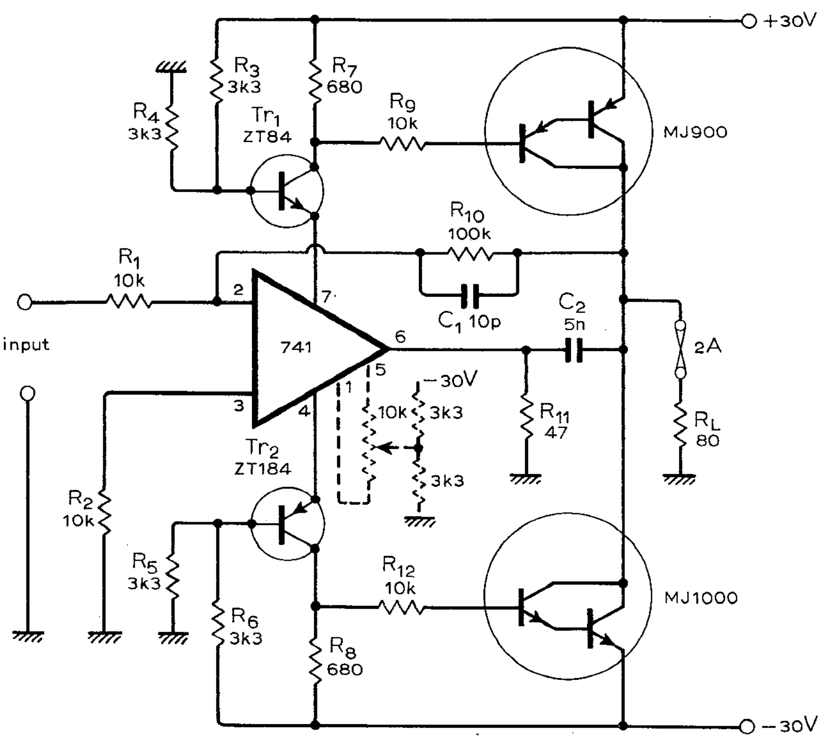
Quiescent current drawn from each high voltage rail by the 741 (typically 1.7mA) flows through the transistors producing a voltage across their collector loads that is fed to the base of the power Darlington output transistors to set their quiescent current. Darlington pairs are used to prevent loading of the voltages developed by the current variations through Tr_1 and Tr_2.

The capacitor connected between the 741's output and the power Darlington's output, supplies stabilizing negative feedback to the last-mentioned. The capacitor across R_{10} provides high frequency roll-off.

For other supply voltages, change the divider resistors but maintain the 5mA through the divider chain. Any general-purpose transistors for Tr_1 and Tr_2 may be used and the Darlington pairs may be made up from discrete types of transistors. Higher gains can also be used by changing R_1 and R_{10} and C_1 to maintain maximum frequency response with stability.

Components shown in broken lines are for optional zeroing of output offset, if the circuit is used in a servo system for example. With component values as shown, 30 watts can be delivered into eight ohms from d.c. to 100kHz (with ×10 gain) with less than 0.2% distortion.

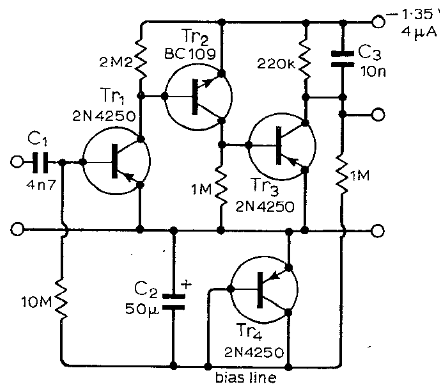
Kenneth Griffiths,
Yatton, Somerset.



all resistors 5% 1/4W

Micropower low-noise amplifier

This amplifier has ultra-low power requirements (1.35V, 4μA), low noise (about 10μV pk-pk equivalent input noise with 10MΩ source impedance), 10MΩ input impedance, and a high voltage gain of 2000. It was designed for use in implanted transmitters which detect brain and heart potentials.



High input impedance is attained by current-starving Tr_1, which operates in the 200nA region. The 2N4250 transistor was chosen because its gain remains high ($\beta \times 200$) at very low voltages and currents. It is, in addition, a low-noise transistor. The low current in Tr_1 limits the bandwidth of the amplifier to about 5kHz, but this is acceptable for biological work. The input impedance is determined primarily by the 10MΩ bias feed resistor. The transistors Tr_2 and Tr_3 provide additional gain.

The amplifier had gain constant to within 10% over a −10°C to +100°C temperature range. It is self-biased, with Tr_4 clamping the bias line, to prevent low-frequency instability. The low-frequency roll-off is determined primarily by C_1, but when changing this capacitor C_2 should also be altered in the same ratio. This will prevent another form of low-frequency instability which occurs when C_2 is too small. Capacitor C_3 adjusts the high-frequency cut-off point, and may be omitted if desired. As shown, the amplifier has 3-dB points at 3 and 80Hz, suitable for heart-beat monitoring.

C. Horwitz,
University of Sydney,
Australia.

WW Diary

The Wireless World Diary for 1975 is now available from booksellers price 62p or direct from the publishers, T. J. & J. Smith Ltd, Deer Park Road, London SW19 3UT, at 72p including postage and packing.

Liquid-cooled power amplifier

by I. L. Stefani and R. Perryman

The amplifier to be described in this article was developed as part of a research programme in which it was employed to excite magnetic specimens. The original model was designed to produce peak currents slightly in excess of 10 amperes at frequencies ranging from zero to 5kHz, but operating experience indicated that the equipment was capable of being uprated by a substantial amount, and it is thought that publication of the constructional details might be of use to workers in other fields.

The need to operate with d.c. and at very low frequencies indicated that some form of transistor bridge should be used, and after one or two simple air-cooled arrangements had been tried, it was decided to experiment with liquid cooling. The first tests used power transistors mounted in pairs in two water-filled copper tanks, and while this arrangement enabled the ratings to be raised by some 30%, the onset of thermal runaway was rather sudden and it was felt that the small increase in output was a poor return for the extra complications. The tests proved to be useful, however, as they pointed the way to a more satisfactory form of liquid cooling. The following points were noted:

Natural circulation was slow and hard to start.

Stagnant layers of fluid collected round the transistors.

Relatively large thermal gradients appeared to exist in the transistor cases.

As a result of these observations a new series of tests was undertaken with the output transistors mounted in such a way that each received a turbulent flow of liquid close to the active element. Forced circulation and a fan-assisted heat exchanger were also incorporated, although flow from a tap was found to be very effective.

The electrical circuit was initially designed round two complementary pairs of emitter-followers connected so that each pair formed one half of a bridge, but it was subsequently thought that performance could be improved if the output elements were used as current-boosters assisting emitter-followers of lower rating. A scheme of this type was employed by I. Hardcastle and B. Lane[1] and its success influenced the final decision to adopt this arrangement. Difficulties were encountered with output voltage stabilization and with the design of a gain control which did not cause a shift in the d.c. balance at the output. These points will be taken up later.

Various liquids were considered for the coolant, but the final choice was water with a little "Prestone" inhibitor added.

Output stage

The general layout of the liquid-cooled output stage is shown in Fig. 1. Cool liquid is pumped into a small tank to equalize the pressure applied to the branches and the coolant is then passed through four short lengths of polythene tubing to the transistor bank. After cooling the transistors the warm fluid is returned to another tank from which it flows to a fan-assisted heat exchanger of the type commonly used for car heating. The complete fluid circuit is outlined in Fig. 2. Fig. 3 shows the constructional details of the flow and return tanks which are identical except for the lengths of the inlet and outlet pipes. The transistor mountings are cut from $\frac{1}{4}$in brass plate to sizes given in Fig. 4, which also shows the manner of bending the pins and the construction of the cover plate. The skewing of the bent portions of the pins prevents contact between adjacent transistors when they are mounted in a bank. Before assembly, leads should be soldered to the pins, and the brass surfaces should be sealed with a little "Silcoset" sealing compound. Great care should be taken when sealing the transistors to the mounting blocks for if any seepage occurs in the regions of the base pins, the high current gains will make the booster stage virtually uncontrollable. Normal motor gasket sealing compounds have not been found to be satisfactory.

When the amplifier is operating, cool liquid is pumped into the lower tank where

1. High power amplifier. I. Hardcastle and B. Lane. *Wireless World*, Oct. 1970, p. 477.

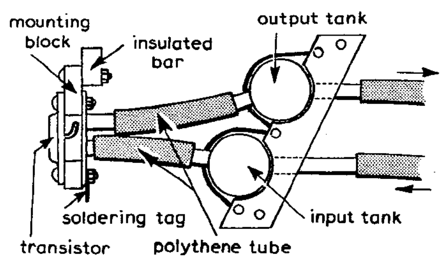


Fig. 1 Mechanical layout of liquid-cooled power output stage

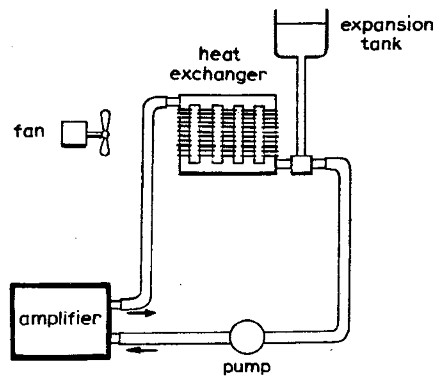


Fig. 2 Complete fluid cooling circuit

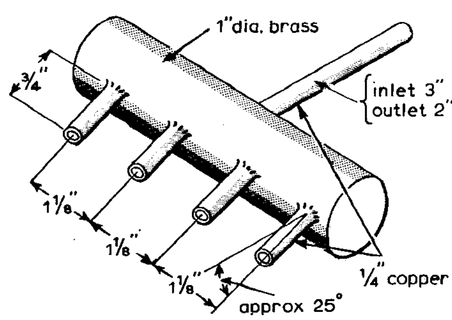


Fig. 3 Dimensions and constructional details of flow and return tanks.

it divides into four streams, each stream passing through a $\frac{5}{16}$in dia. hole in the mounting block to strike the transistor at a point immediately opposite its active element. The water subsequently passes up the $\frac{3}{32}$in wide slot to the $\frac{1}{4}$in diameter exit hole and back to the return tank.

The output circuit

The operation of the output stage may be readily understood by reference to Fig. 5, which shows emitter-followers Tr_2 and Tr_3 supplying a small current to a load. The resistors R_2 and R_3 have little effect on the performance of the transistors other than to cause a slight reduction in their maximum voltage swings, but the voltages developed across these resistors may be used to operate current boosters in the form of complementary power transistors Tr_4 and Tr_5. The collector of each booster acts as a current source and forces a large current into the load without substantially altering the voltage drop associated with the emitter-follower. Thus the load current is large and the effective source impedance

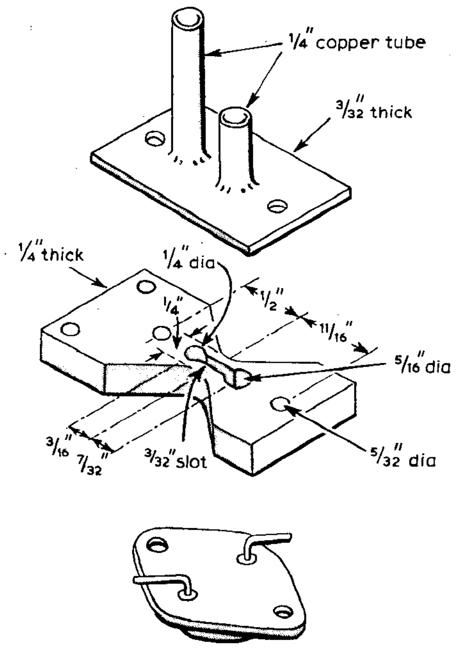


Fig. 4 Dimensions of transistor mountings.

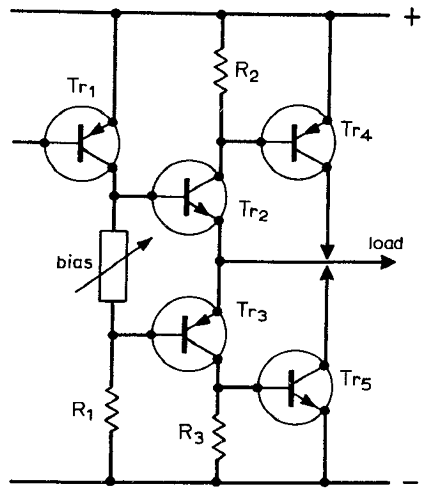


Fig. 5 Elements of the output circuit.

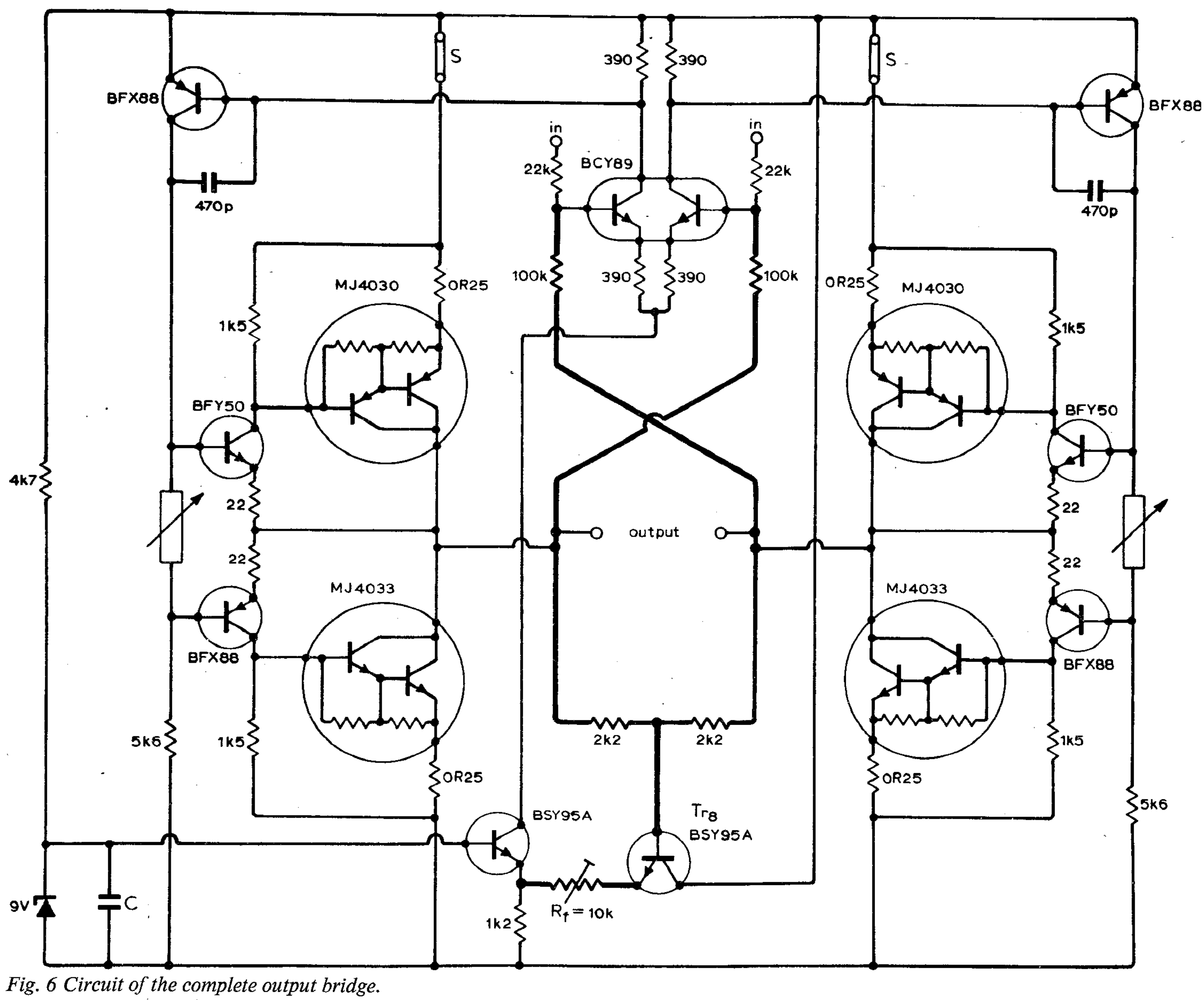


Fig. 6 Circuit of the complete output bridge.

is low. In the actual amplifier the transistors Tr_4 and Tr_5 are replaced by Darlington-pairs mounted in TO3 cases. This raises the sensitivity so that the booster operates directly from low power driver and output stages built into a printed circuit. When two output and booster stages are connected together to form a pair of bridge arms, the biasing of the emitter-follower bases requires the provision of a constant-voltage circuit capable of being preset to give an output between 1.2 and 1.5 volts. This biasing circuit is used to adjust the standing current passing through the power transistors which form the bridge arms. (See Fig. 5.) The complete output bridge is shown in Fig. 6.

The driving stages
The transistors driving the emitter-followers must be operated with their emitters joined to one of the supply busbars or it will not be possible to provide sufficient voltage swing to operate the bridge properly. (See Fig. 5.) This means that the driving stages are prone to drift and some means of correcting this tendency must be devised. The method used is the application of feedback in two separate forms: first, the mid point of the output is stabilized via (Fig. 6) Tr_8 and resistor R_f which regulate the standing current passing through the input stages, and second, conventional voltage or parallel feedback is used. The feedback circuits are drawn in heavy lines in Fig. 6, which shows the basic arrangement of the power stages. The 470pF capacitors connected to the driving stages prevent high frequency instability and emitter resistors in the booster stages produce a certain amount of thermal stabilization. The 0.25Ω resistors have to carry large currents and they are constructed from short lengths of Eureka wire wound into helical coils.

Finally, in order to facilitate setting up, it is advisable to insert manganin shunts or removable links in the bridge arms at S for monitoring the standing currents. The amplifier now in use has small ammeters permanently connected to manganin shunts.

The preamplifier
The duties of the preamplifier are threefold. First, it is required to provide a voltage gain, and second, it should enable this gain to be varied. Finally it must convert the single-ended input to a balanced output. The first and third functions present no difficulties, but the second is a possible source of trouble as the d.c. passing through the gain control produces a voltage drop which alters with the setting and is considerably magnified in passing through the amplifier. Matched f.e.ts were tried out in the controlled stages but the degree of balance did not prove sufficient to prevent severe drift with changes of temperature. The final arrangement used a rheostat to partially short-circuit the output of a carefully balanced double-transistor amplifier stage. The mean voltage drop using this scheme is independent of the control setting. The circuit, with component values, is shown in Fig. 7.

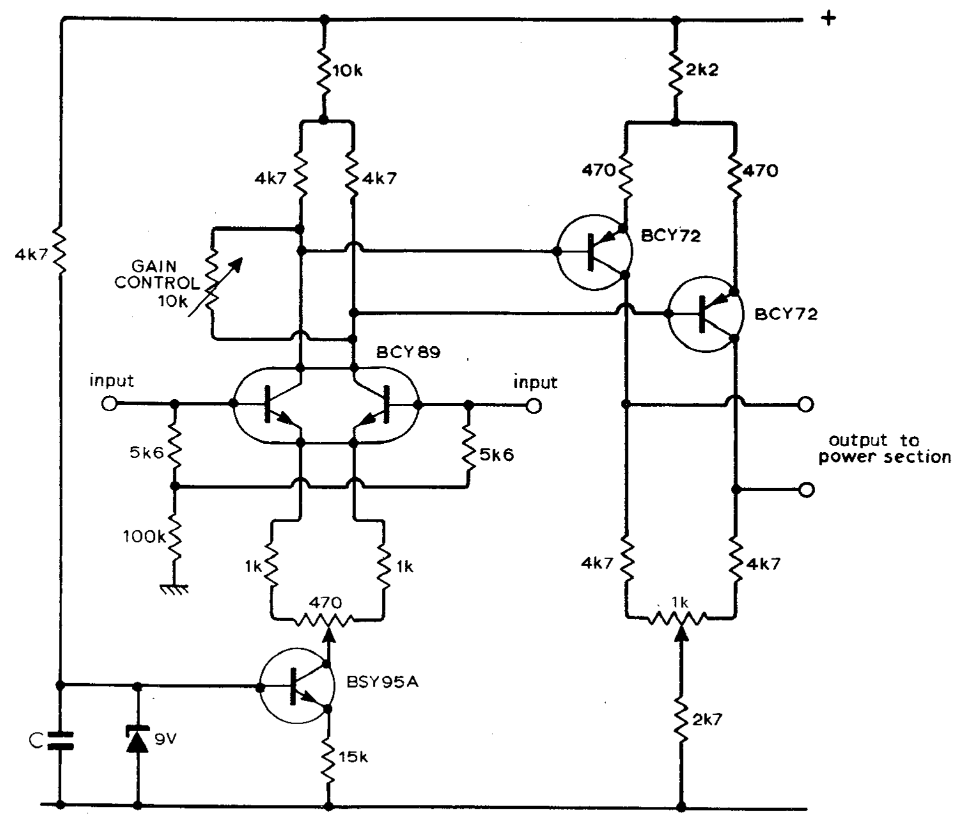


Fig. 7 Preamplifier circuit.

Setting up and testing: With water flowing through the output boosters and the 10kΩ bias trimmers turned right back, the supply voltage should be turned on and the feedback resistor R_f adjusted until the mean output voltage is about 15V for a 30-volt supply. The gain control should then be turned to the short-circuited position and the 1kΩ balance control on the preamplifier adjusted until the voltage between the output terminals shows zero on a d.c. voltmeter. When the gain is turned to a maximum this voltage will usually change and it should be returned to zero by means of the 470Ω balance control. The bias controls should then be carefully turned clockwise until currents of 1 to 2A flow in each of the pairs of bridge arms. After allowing the stage to warm up the trimmers should be rechecked. Exhaustive testing has not been carried out because the amplifier has been in continual use for well over a year, but a few test results are given as an indication of the performance.

Max. open circuit voltage swing when using a 32V d.c. supply: 58V (20.5V r.m.s.)

Max. output current swing (limited by the power unit): 34A (12A r.m.s.)

Max. power: greater than 230W

Output impedance: less than 0.5Ω

Frequency range: approximately 0–110kHz

For general use it is advisable to install some means of protection. Possibly a flow-operated switch and thermocouples on the transistor mounting blocks should be considered.

Finally, it should be recorded that the amplifier in its present form does not heat up very much. This suggests that it might be possible to uprate the design by a substantial margin; the simplest method would appear to be to raise the supply voltage and adjust some of the circuit component values accordingly.

Sixty Years Ago

It always seems a pity when legendary phenomena are explained in terms of modern scientific theories, and many people would ascribe this iconoclastic trend to the last 30 or 40 years. But it seems that we were at it long before that, as witness this extract from the December, 1914 issue of *The Wireless World*, in which W. B. Cole implies that Joshua was a bringer of "bad vibes".

". . . it seems quite clear to the writer that Moses, who was learned in all the wisdom of the Egyptians, imparted to his successor Joshua the knowledge of the principle of resonance, and that Joshua, discovering that the wall of Jericho responded to a certain note, made use of this principle.

"During the week he kept his men busy walking round the city in order to keep the inhabitants within (verse 1). The Israelites were strictly enjoined to maintain silence, so that the priests who blew with the trumpets might make the necessary acoustical experiments, and to tune all their trumpets to the same pitch. The seventh day all was ready. The people completely encircled the city and at a given signal the priests blew with their trumpets, the people shouted, the same note, and the effect of this choir of 40,000 men (Josh. iv, 13) caused the wall to collapse."

Measurement and detection with current differencing amplifiers

Introducing a set of tested circuits presented in cookery-card form

by J. Carruthers, J. H. Evans, J. Kinsler and P. Williams

Paisley College of Technology

Three sets of Circards deal with a new kind of i.c. building brick—the LM3900 current differencing amplifier. Sets 16 and 17 cover signal processing and generation circuits respectively, and set 18 on measurement and detection will be issued shortly.

Pattern recognition is one sign that a technology is reaching maturity. The early stages following new advances are a succession of bright ideas, half-worked-out theories and unrelated developments. This is inevitable as workers in many areas take from the original material that which meets their needs—or appeals to their prejudices.

In circuit design the same configurations appear under many guises and names, developed quite independently and for different applications. If we can recognize these similarities and construct the appropriate family tree this is worthwhile in itself.

But we can do more. If two circuits are similar in form because related in function, then by finding any other circuit designed for one of the functions there is a good chance that it can be modified to provide the other. A good designer is one who picks the best brains.*

The present topic is a particularly good illustration of this thesis. The problem is to measure some property of the amplitude of an a.c. waveform. Four circuits have their properties listed in the table and circuit diagrams representing a basic feedback form of each are shown in Figs 1 to 4. The configurations are identical, the differences lying only in whether conduction is through a diode or a switch, and whether the load is resistive or capacitive. This identity of form is far from apparent in practical versions since there are so many additional components and sub-circuits to optimize the response or effect coupling between other circuits/transducers.

The half-wave rectifier uses a diode as does the peak rectifier. It begins conduction through the diode as soon as the input goes positive remaining in conduction for the phase angle range 0 to π for sine-wave input. The mean value of the output is normally required, and a moving-coil meter is suitable as the deflection is proportional to the mean current.

*To quote Tom Lehrer:
Plagiarise Plagiarise
Remember why the good Lord made your eyes
So don't shade your eyes
But Plagiarise Plagiarise Plagiarise
—only please to call it Research

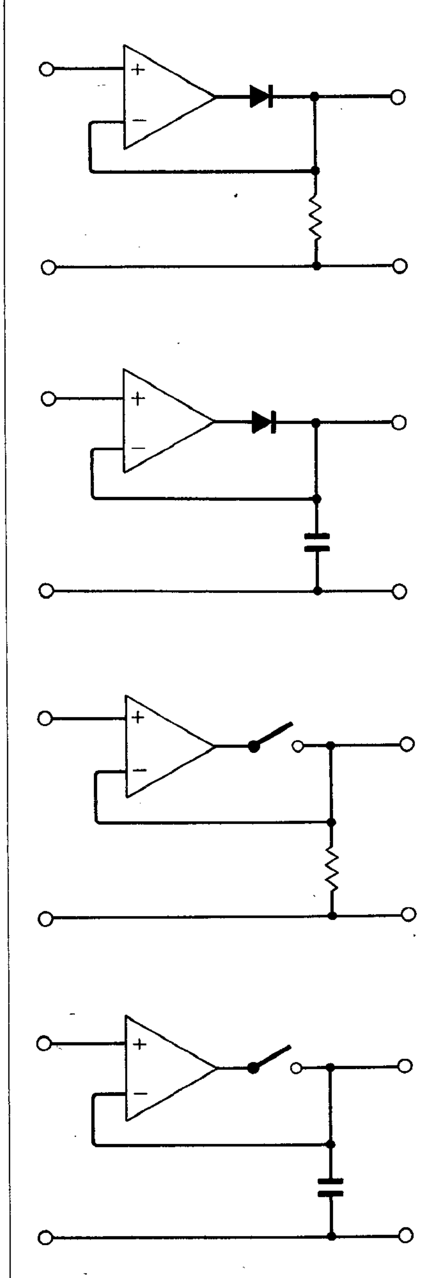
When the resistive load is replaced by a capacitor, conduction of the diode only takes place for those instants when the input voltage exceeds the voltage stored on the capacitor. For a steady-state a.c. signal this corresponds to the positive peak of the input, and assuming no discharge of the capacitor in the intervening period the conduction angle is vanishingly small and is centred on $\pi/_2$. The resulting constant voltage across the capacitor is measurable with any d.c. voltmeter whose input current requirements are so small as to avoid significant capacitor discharge.

To accommodate varying signal amplitudes some discharge must be permitted since a small amplitude would otherwise never be sensed if following a larger input. The resistive path leads to a compromise time constant between maximum holding time of the peak voltage and minimum recovery time after large peaks. Conversely, the half-wave rectifier suffers from capacitive effects at high frequency with stray capacitance leading to partial peak rectification. The resulting output/frequency characteristic often shows a rise of 1 to 3dB prior to the cut-off frequency limits of the amplifier.

The sampling circuit replaces the diode of the half-wave rectifier by a switch which closes for a brief interval at some phase angle determined by external circuits. The output is zero for all instants except the sampling instant. With capacitive loading, provided the switch closure is for a period of time greater than the time constant of the capacitance together with the amplifier output resistance, then the capacitor volt-

Four types of circuit, listed here, to measure the amplitude of an a.c. waveform—see Figs. 1 to 4.

Circuit	Load	Conduction angles, ϕ_1, ϕ_2	Conduction device	Voltmeter
Sample	R	arbitrary $\Delta\phi \to 0$	switch	instantaneous
Half-wave rectifier	R	$0, \pi$	diode	mean/d.c. moving coil
Sample and hold	C	arbitrary $\Delta\phi \to 0$	switch	d.c.
Peak rectifier	C	$\frac{\pi}{2}, \frac{\pi}{2}$	diode	d.c.



Figs. 1–4. Types of circuit used to measure amplitude of a.c. waveforms (see Table). Complete circuits are given in cards 7 and 8 in set 18.

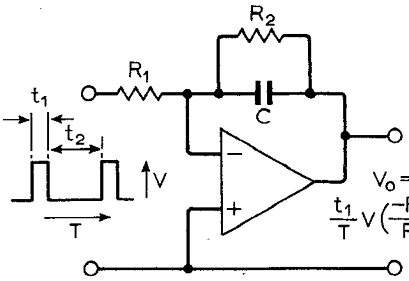


Fig. 5. LM3900 c.d.a. is well-suited to measurement of time period and frequency. An input capacitor can alternatively be charged through a diode to form a "pump" circuit (see card 10).

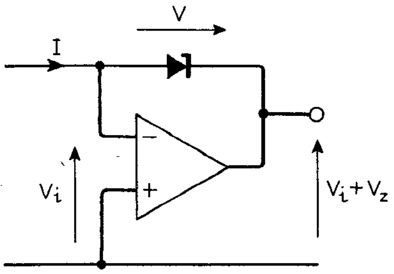


Fig. 6. Defining operating conditions for testing a zener diode with a c.d.a. (see card 5).

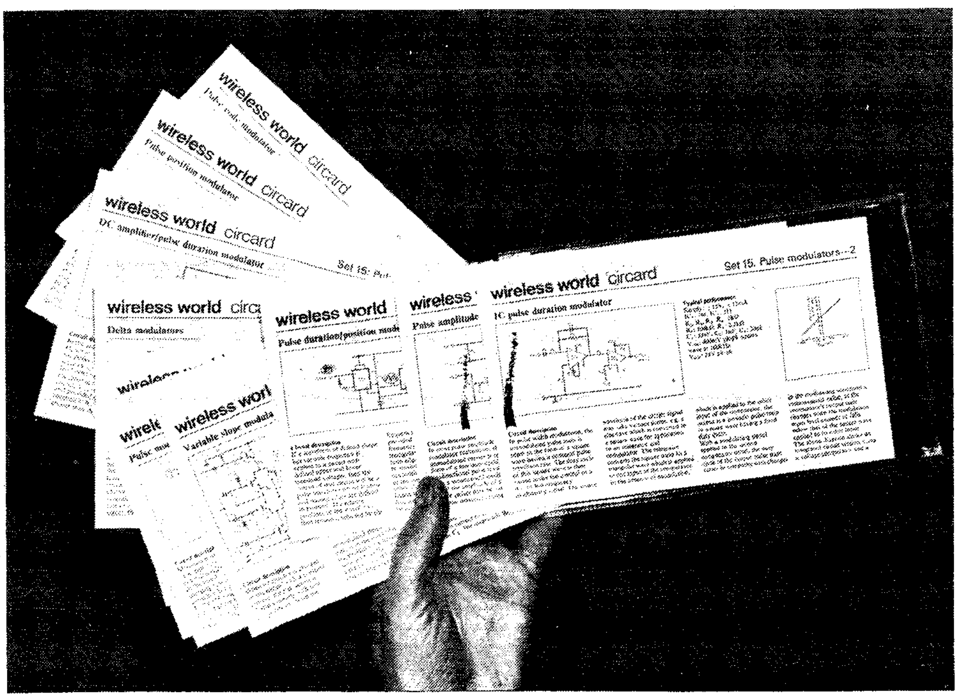
age becomes equal to the input voltage (again a compromise since the sampling period should not be so long as to allow a significant change in the input). If the switch is closed periodically at the same instant in successive cycles then the sampling time may be reduced, with the capacitor voltage increasing to the required level over a number of periods. With the switch open, as it is for most of the time, the capacitor stores or holds the sampled voltage, provided the measuring instrument is suitably buffered.

The sampling circuits are readily constructed with current-differencing amplifiers, and long hold times are possible. With careful adjustment the output drift can be < 5%/hour under controlled conditions which is a good performance from such a general-purpose circuit. The accuracy is less impressive since the current-mirror match is involved, and it cannot compete with standard op-amp circuits in this respect.

Measuring period and frequency

The measurement of time period and frequency is another field to which the circuit is well-suited. A pulse waveform of constant width and height but variable frequency is fed as in Fig. 5 to the amplifier with parallel RC feedback. The mean voltage across the capacitor is then directly proportional to the input frequency. Alternatively frequency and pulse height may be kept constant when the output becomes a measure of pulse width. The availability of two inputs extends this capability to the measurement of frequency difference or sum. Alternatively an input capacitor may be charged and discharged through a diode network to give the equivalent of a diode pump/transistor pump type of frequency meter (tachometer).

The d.c. characteristics of the amplifier can be used to simultaneously define the operating conditions of diodes, zeners etc, while providing a low output impedance point for ease of measurement (Fig. 6). Finally, the circuit may be used in conjunction with an external network of resistors and diodes to perform quite complex logic functions such as exclusive-OR. Though offering no competition for the usual logic families for large-scale applications, they are very convenient for providing a small number of logic functions in an existing system. The wide range of supply voltages particularly commend them for such applications.



Examples of the redesigned circards, taken from a recent set.

Titles of cards in set 18 of Circards are

1 Measurement and detection
2 Logic circuits
3 Phase-locked loop
4 Transducer driving
5 Semiconductor device testing
6 Negative resistance circuits
7 Peak/mean rectifiers
8 Sample and hold circuits
9 High-frequency circuits
10 Tachometers

What are Circards?

Circards are a new method of collating and presenting data about circuits in a compact and easily retrievable way. The sets of 203 × 127mm (8 × 5in) double-sided cards are designed for easy filing in standard boxes and for easy access at the desk or at the bench, where transparent plastics wallets keep the cards in good condition.

Each card normally describes operation of a selected circuit, gives *measured* performance data and graphs, component values and ranges, circuit limitations and modifications to alter performance. Suggestions for further reading are included together with cross references to related circuits. The Circard concept was outlined more fully in the October 1972 issue of *Wireless World*, pp. 469/70.

How to get Circards

Order a subscription by sending £13.50 for a series of ten sets to

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IPC Electrical-Electronic Press Ltd
General Sales Department, Room 11
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9 optoelectronics: devices and uses
10 micropower circuits
11 basic logic gates
12 wideband amplifiers
13 alarm circuits
14 digital circuits
15 pulse modulators
16 current-differencing amplifiers—signal processing
17 c.d.as—signal generation
18 c.d.as—measurement and detection

Future sets will cover monostable circuits, two-transistor circuits, multipliers and dividers, code converters, d.c. amplifiers and choppers, amplitude modulation and detection, transistor arrays, a.f. oscillators and voltage-to-frequency converters.

Capacitors

A survey of present day capacitor technology and applications

by R. A. Fairs

Rank Radio International

This is a survey of the properties and parameters involved in the construction and use of capacitors and dielectrics. Simple equivalent circuit analysis is also explained. The second half of the survey deals with different types of capacitors: electrolytics, paper, plastic film, mica and ceramic. The construction of each type is described together with particular properties of each type and their circuit application. Finally an applications chart relates the different properties and parameters.

Progress in semiconductor technology has led to an increasing dependence on the role of commercially available capacitors in a circuit. A glance at any electrical network reveals that about 30% of the components used are capacitors; and that about 40% of all failures encountered are due to misuse in circuit application of these capacitors.

The impedance of a capacitor, Z, largely controls its behaviour in any circuit application. The manner in which this impedance deviates from that of a true capacitor requires the construction of an equivalent circuit for practical capacitors. This can be done quite simply and Fig. 1 shows the familiar parallel plate capacitor together with its equivalent circuit.

We can reduce this circuit to a simple resonant circuit (Fig. 2) whose impedance curve (impedance vs frequency) when plotted on log-log. graph paper is a hyperbola whose shape and orientation depends on the values of L_s, R_s, and C (Fig. 3).

We can make the following observations:

- f small $Z \approx 1/2\pi fC \approx X_c$
- f resonant $Z \approx R_s$ (20kHz→1MHz)
- f large $Z \approx 2\pi fL_s \approx X_{Ls}$

The resonant frequency of capacitors varies considerably from about 20kHz for electrolytic capacitors to around 1MHz for plastic film types and is even higher for ceramics. Fig. 4 shows the impedance curve of a tantalum electrolytic capacitor. The prime cause of the curve deviating from a hyperbola is temperature differences which affect the parameters of a capacitor in a non-linear fashion, so in some applications manufacturer's data must be consulted.

The inductance of the capacitor is largely controlled by the dimensions of the external leads and the method of connection to the capacitor section. In tubular capacitors the ratio of the length of the capacitor section to its diameter is also significant. To minimize the effect of inductance, most electrolytic capacitors have low inductance windings. Fig. 5 shows a reduction in inductance by a factor of 26 by this method.

As a rule of thumb the inductance of a normal capacitor, length 1cm, is of the same order as a piece of 22 swg wire of length 1cm.

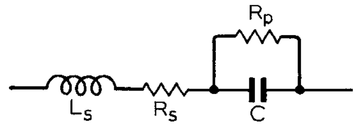


Fig. 1. Equivalent circuit of a typical capacitor: L_s—equivalent series inductance, R_s—equivalent series resistance, R_p—leakage resistance (or parallel loss resistance), C—apparent capacitance.

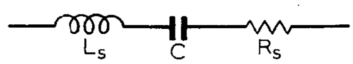


Fig. 2. Simple series resonant circuit where $Z=\sqrt{R_s^2+(X_{Ls}-X_c)^2}$

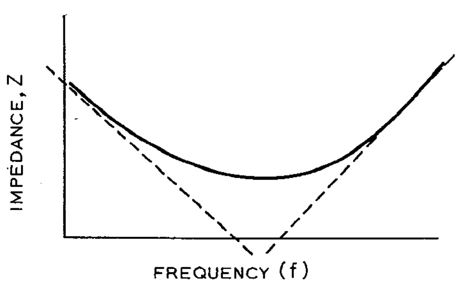


Fig. 3. Impedance versus frequency curve of the simple resonant circuit shown in Fig. 2.

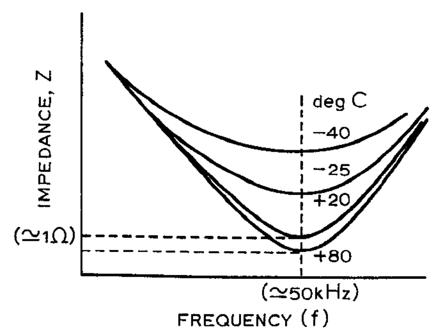


Fig. 4. Impedance curve for a tantalum electrolytic capacitor.

For capacitance value a temperature coefficient (t.c.) is defined by:

$$\text{t.c.} = \frac{\Delta C \times 10^6}{C.\Delta t}$$

$$= \frac{\text{change in capacitance} \times 10^6}{\text{orig. capacitance} \times \text{change in temp.}}$$

$$= \alpha \text{ppm}/^\circ\text{C}$$

where ppm = parts per million.

By defining the temperature coefficient in this manner it is independent of the units of capacitance.

It is usual to operate capacitors well below their resonant frequency, and thus neglect the effects of inductance. Fig. 2 simplifies to an equivalent circuit which is universally used, that of a "lossy" capacitor in Fig. 6.

By considering this circuit one can develop terms which are extensively used throughout the capacitor industry. From

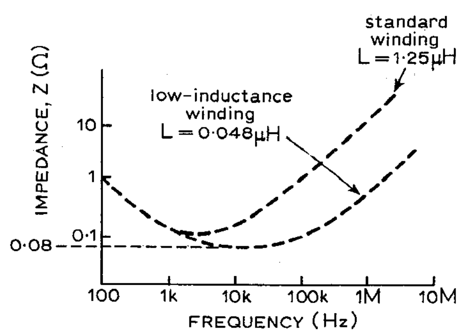


Fig. 5. Impedance reduction obtained by low inductance winding.

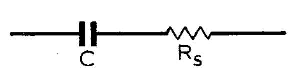


Fig. 6. Equivalent circuit of a "lossy" capacitor operated well below the resonant frequency.

the phasor diagram, Fig. 7, we make the basic definitions:

Loss angle, δ

Phase angle, ϕ

Impedance, $Z=\sqrt{X_c^2+R_s^2}$

$$\text{Power factor (p.f.)}=\frac{\text{true power}}{\text{apparent power}}$$

$$=\frac{P_s}{Z}=\cos\phi=\sin\delta$$

$$\text{Dissipation factor (d.f.)}=\frac{\text{resistance}}{\text{reactance}}$$

$$=\frac{R_s}{X_c}=\tan\delta$$

For small R_s, d.f.$\approx$p.f. (since $\sin\delta\approx\tan\delta$ for $\delta<0{\cdot}15$)

This relation holds for almost all commercially available capacitors.

It is easily seen that for a good capacitor, δ must be small, but exactly what variations occur with frequency and capacitance value will be important in capacitor application and requires some dielectric theory explained in the appendix.

Leakage current

This quantity is dependent on the parallel loss resistivity (R_p) of the capacitor, which has a negligible effect on the equivalent series resistance, R_s, except for low frequencies. It can be shown that

$$R_p=\frac{1}{\omega CR_s}+R_s$$

The relationship can be understood by considering a perfect capacitor discharging through a resistor as shown in Fig. 10. The behaviour of the circuit is described by:

$$\frac{Q}{C}+\frac{dQ}{dt}R_D=0$$

$$\text{i.e., }\frac{dQ}{Q}=\frac{-dt}{RC}$$

$$(\log_e Q)_0^t=(-t/RC)_0^t$$

$$\text{or: }Q=Q_o\,e^{-t/RC} \qquad (1)$$

$$I=\frac{dQ}{dt}=\frac{I_o}{RC}e^{-t/RC} \qquad (2)$$

Eqn. (1) shows that the leakage current varies with time, and thus a fixed value of the current, I, is only realized after a fixed time. For electrolytic capacitors this time is usually 15 minutes.

The quantity RC is known as the time constant of the capacitor and is of the order of days for polystyrene capacitors, and several seconds for electrolytics.

Dielectric absorption

The rate at which a capacitor charges is important. A perfect capacitor when connected to a d.c. supply of E volts would charge according to

$$I=(E/R)e^{-t/RC} \qquad (3)$$

In practice, deviation from (3) occurs because if a fully charged capacitor is discharged and allowed to remain open circuit for some time a new charge accumulates within the capacitor showing that a fraction of the original charge has been "absorbed" by the dielectric. A time log therefore exists between the rate of charging and of discharging the capacitor.

Dielectric strength

The voltage at which the dielectric breaks down is a measure of the dielectric strength of the medium. This depends on the test conditions and the thickness of the material. It thus imposes a stress on the medium and is usually measured in volts/metre. Of associated importance is the insulation resistance which will follow approximately eqn (4)

$$R_T=\frac{R_t}{eK(T-t)} \qquad (4)$$

where R_T=insulation resistance at temperature T and R_t=insulation resistance at temperature t. K is a constant (0·1 for paper capacitors and 0·05 for mica and ceramic capacitors).

Energy losses

For a perfect capacitor, C, operating at V volts, the energy stored is given by eqns (5) and (6).

$$E=\int_0^V v\,dQ \qquad (5)$$

$$=\int_0^V v\,d(C.v)=C\int_0^V v\,dv=1/2CV^2 \qquad (6)$$

However, the phase difference between the vectors E and D defined in the appendix causes a hysteresis loop (similar to the B, H curves observed for ferromagnetic materials), between the charge Q, and applied voltage V. The energy dissipated per cycle of the loop will be given by eqn (5) and will vary with the frequency of the applied field, so that the total energy stored in the capacitor will be less than the result predicted by eqn (6).

General considerations

For a parallel plate capacitor working in vacuo, the capacitance, C, between the plates, ignoring edge effects, is given by

$$C=\epsilon_o A/d \qquad (7)$$

where ϵ_o is the permittivity of free space, A is the area of plates, d is the distance between plates.

When a dielectric is placed between the plates the capacitance of the system changes to C^1 where C^1 is related to C by

$$\epsilon=\frac{C^1}{C}=\text{permittivity of dielectric or dielectric constant.} \qquad (8)$$

From these equations we see that to obtain the highest capacitance in the smallest volume, ϵ must be high, and d must be small. Translated into manufacturing techniques this requires a thin foil of high permittivity capable of withstanding the stresses imposed by the working conditions of the capacitor.

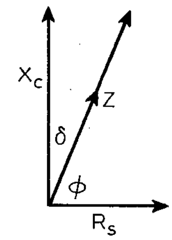


Fig. 7. Phasor diagram related to the equivalent circuit of a "lossy" capacitor.

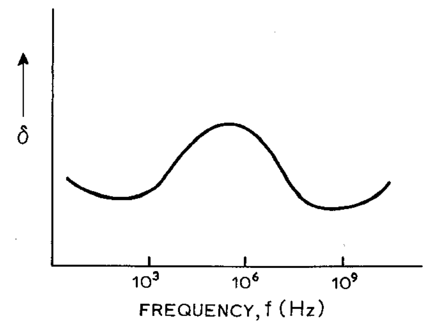


Fig. 8. Loss angle versus frequency for a polar dielectric material.

One has already seen that the cost of obtaining a high permittivity, illustrated by Fig. 8, is its frequency dependence.

The most important considerations in choosing a capacitor for particular applications are: capacity/physical size, and shape; working voltage; frequency characteristics (effect of frequency in impedance and dissipation factor); insulation resistance; environmental conditions (temperature and humidity considerations) and cost.

A brief survey of the types of capacitors available now follows.

Electrolytic capacitors

Capacitors of this type are physically the largest available; their CV product (capacitance value × working voltage) is also large. Typical application of these capacitors is to be seen in power supply circuits and coupling between audio amplifier stages.

The large capacitance evolves from the use of a very thin dielectric film (about 1nm thick). Such a film is realized practically by oxidizing a suitable metal (usually aluminium or tantalum). The method employed is that of anodic oxidation, i.e. by making the metal the anode when immersed in an electrolytic bath.

The resulting dielectric film is extremely strong possessing a dielectric strength of the order of $10^5\,Vm^{-1}$, although imperfections in this film lead to leakage being a typical characteristic.

For aluminium electrolytic capacitors, the oxide is produced on a 99.99% pure aluminium foil at an oxide thickness proportional to the working voltage of the capacitor. This voltage is often called the polarising voltage and its function is maintain the oxide film at a specified thickness, thus giving consistent capacitance value.

The foil, now known as the anode foil, is then concentrically wound with another aluminium foil (about 98% pure) which acts as a cathode. The two foils are separated by a layer of highly porous paper and the whole assembly immersed in an electrolyte (usually ethylene glycol) which promotes the forming of oxide film when the capacitor is in operation.

The capacitance section is then placed in an aluminium can which is hermetically sealed. A typical arrangement is shown in Fig. 11.

To give an increased capacitance value in the same physical size the aluminium oxide may be etched. This process effectively increases the area of the dielectric and increases its permittivity from about 7 to about 10. However, electrolytics made in this manner are unable to withstand high currents, compared with the plain foil type.

Tantalum capacitors. These capacitors employ tantalum oxide as a dielectric which has a higher permittivity than aluminium oxide (typically up to 25), and as a result give a high capacitance in a relatively small size.

There are three distinct types of tantalum capacitors available: solid tantalum, wet sintered tantalum and tantalum foil (the construction of this is similar to that of an aluminium foil and will not be discussed).

The electrolyte used is solid manganese dioxide used in solid tantalum types or aqueous phosphoric or sulphuric acid used in the latter two types.

Solid tantalum capacitors. Capacitors of this variety are constructed by sintering tantalum powder particles around a tantalum anode, the resulting assembly is rigid after manufacture and is known as a "slug" (Fig. 12).

By controlling the temperature and time of the sintering process one may control the size of the slug, its density and its oxide content. The purity of the tantalum used is also important since it largely controls parameters such as leakage current and power factor.

The cathode of the solid tantalum capacitor is formed by dipping the slug in a solution of manganese nitrate which when passed through ovens at 300°C decomposes to a semiconductor layer of manganese dioxide, this is then coated with graphite and silver.

A schematic diagram of a complete solid tantalum capacitor is shown in Fig. 13.

The final encapsulation of the solid tantalum capacitor can be in several forms, the most common ones being: polyester sleeve with epoxy end seals, dipped epoxy coated, metal case with resin seal or epoxy resin moulding.

Wet sintered tantalum. The slug used is similar to that employed in the solid tantalum variety; the distinct difference between the two types being in the cathode system. Fig. 14 shows these differences.

Table 1. Comparison of tantalum capacitor types

Parameter	Solid	Wet	Foil
Maximum d.c. voltage rating	100V	125V	450V
CV product	inflexible	inflexible	flexible
Closest capacitor tolerance	±5%	±5%	±10%
Volume efficiency*	2	1	3
D.C. leakage current per *CV* ($AF^{-1}V^{-1}$)	0·02	0·0005	0·01
Temperature stability**	1	2	3
Frequency characteristics**	1	2	2
Reverse voltage	≯1V	0	≯3V
Cost*	3	2	1

* ** 1 indicates highest* or best**
2 indicates intermediate stage between 1 & 3
3 indicates lowest* or worst**

Table 1 provides a general comparison for the three types of tantalum capacitors discussed, however for more precise information it is necessary to consult manufacturer's data.

Reliability. (a) solid tantalum: very reliable, working failures generally due to misuse; intrinsic failure due to oxide crystallisation, (b) wet sintered tantalum: failure due to vapour transmission of the electrolyte through the capacitor seal, causing a fall in capacitance and degradation in the dissipation factor; hence hermetic seals are desirable. Aluminium and tantalum foil types also suffer from the same defect.

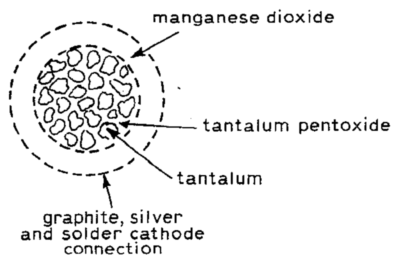


Fig. 12. Solid tantalum capacitor slug formed by sintering tantalum powder particles around a tantalum anode.

Paper capacitors

In this type of capacitor a thin sheet of

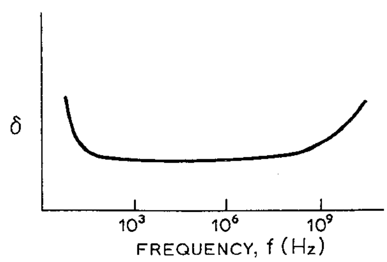


Fig. 9. Loss angle versus frequency for a non-polar dielectric material.

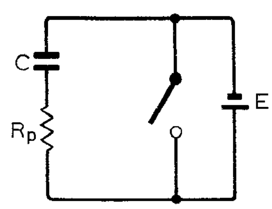


Fig. 10. Perfect capacitor before discharge through a resistor.

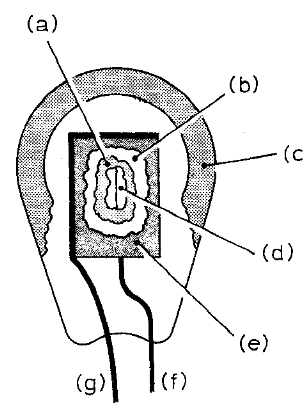


Fig. 13. Schematic of a complete solid tantalum capacitor (a) tantalum impregnated with manganese dioxide (b) graphite layer (c) resin outer coating (d) tantalum shown cut away to indicate anode terminal and tantalum pentoxide layer (e) solder layer completely surrounding cylinder (f) welded anode connection (g) cathode connection.

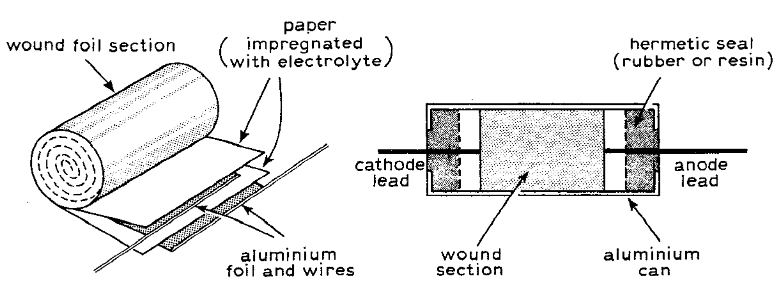


Fig. 11. Construction of an aluminium electrolytic capacitor.

paper is impregnated with another suitable dielectric to prevent moisture absorption (see Table 2 for details of typical dielectrics used). The electrode of the capacitors is usually aluminium and two basic types of capacitor exist, one being the metal foil variety which functions at high voltages and currents, the other being the metallized variety where the dielectric is coated with a thin layer of aluminium or zinc; this method of construction leads to a size reduction due to the thinness of the metallized film but has a disadvantage in that pulse handling is bad.

Encapsulation of paper capacitors is usually by moulding the capacitor element in resin or encasing it in metal cans, the latter being hermetically sealed to prevent evaporation of the dielectric.

Reliability. The power factor of paper capacitors is dependent on the type of impregnant used. In some cases it may be large and will always increase rapidly with frequencies above 10kHz.

A defect in the dielectric of a capacitor will cause an electric arc between the electrodes which will destroy more of the surrounding dielectric and result in catastrophic failure.

The disadvantage is not seen in metallized film types because the heat generated by the arcing process will rapidly vaporize the electrode section, this clearing the short. Metallized film construction is thus not confined to paper capacitors but is used extensively in plastic film types. A schematic diagram of the process is shown in Fig. 15.

Plastic film capacitor

Plastic films are used extensively in capacitor manufacture due to their high reliability and low cost. A number of leaves of plastic film are interleaved with aluminium electrodes rolled into a coil and encapsulated by a metal case or plastic encapsulation. A typical plastic film capacitor is shown in Fig. 16.

Historically, the first plastic film capacitor consisted of polystyrene film, which produced a realiable capacitor, although expensive. Nowadays, numerous plastic films are used and Table 3 gives a synopsis of the relative advantage of the four most common types.

It should be noted that it is not possible to vacuum deposit a metallized film on polystyrene film due to its low melting point.

Mica capacitors

Mica is a naturally occurring silicate which due to its platelike crystal structure, can be laminated into thin sheets suitable for capacitor construction. Being chemically inert and possessing a high permittivity (6·5 to 8·7) mica is capable of a precise electrical performance.

The construction of a mica capacitor is shown in Fig. 17, and consists of a number of small parallel capacitors to form the main capacitor.

Metallized film techniques in mica capacitors have led to the silver mica capacitor becoming extensively available in the capacitor market. In this capacitor, silver electrodes are fired directly onto the sheets of mica giving better stability due to the defined distance of the electrodes and the lack of air pockets in the capacitor (and hence their associated instability).

Encapsulation of the capacitor is commonly by means of a moulded epoxy resin although this does produce a fatigue condition on the capacitor due to the heat of the moulding which affects the reliability of the capacitor. In contrast the dipped mica capacitor, being encapsulated by dipping in resinous material below atmospheric pressures gives better electrical characteristics than the moulded types and high reliability.

Ceramic capacitors

Ceramic capacitors may be divided into two classes; the high permittivity type (high K, $\epsilon \approx 1000$) and low permittivity type (low K, $\epsilon \approx 10$).

Characteristics of the two types are widely different. The low K types possess low power factor, small linear temperature coefficients, and operating frequency capabilities of up to 1000MHz. The high K types have high power factors (dependent on the applied a.c. and d.c. fields due to electrical hysteresis) and non-linear temperature coefficients. By a suitable choice of materials a dielectric can be useful in circuit applications where an otherwise detrimental temperature drift would occur, e.g. tuned circuits and

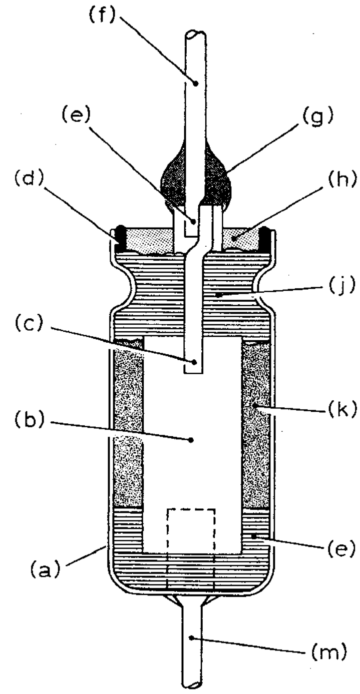


Fig. 14. Schematic of a wet-sintered tantalum capacitor (a) fine silver (b) anodized sintered tantalum anode (c) tantalum wire (d) solder seal (e) tantalum to nickel weld within header (f) nickel wire (g) solder seal between header and external anode lead (h) glass-to-metal seal (j) internal seal (k) electrolyte (l) anode boot (m) cathode.

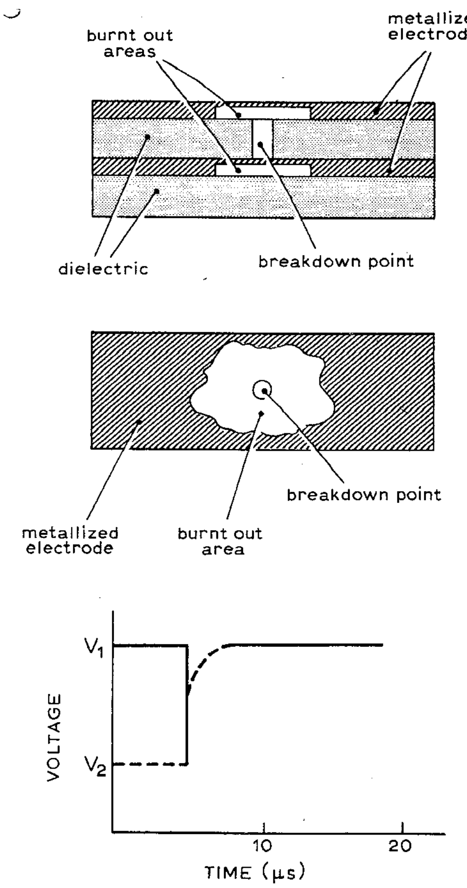


Fig. 15. Process of self healing of a metallized dielectric capacitor. The voltage trace is typical during the process.

Table 2. Dielectrics for paper capacitors

Dielectric	Permittivity (P1)	Permittivity with paper (P2)	Comment
Natural products (oils, waxes, etc)	2·2 to 6·0	≈4	Low dielectric stress due to difference of $P1$ and $P2$
Synthetic halogenated products	5·0	≈5	More even dielectric stress due to equality of $P1$ and $P2$
Plastic polymers	2·5	≈3·5	Possible voids form in polymerisation; low cost

Table 3. Plastic film dielectrics

Characteristic	Polystyrene	Polyethylene terephlalate	Polycarbonate	Polypropylene
Structure	non polar	polar	polar	non polar
*Permittivity	2·4	3·3	2·8	2·25
Production of film	extrusion	melt casting	extrusion or solvent casting	extrusion
Film-thickness (μm)	8	3·5	1·5	8

*decreases with frequency for polar material

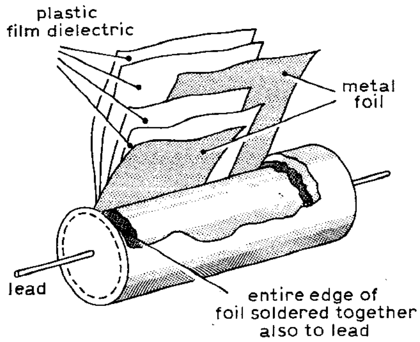


Fig. 16. Constructional features of a plastic film capacitor.

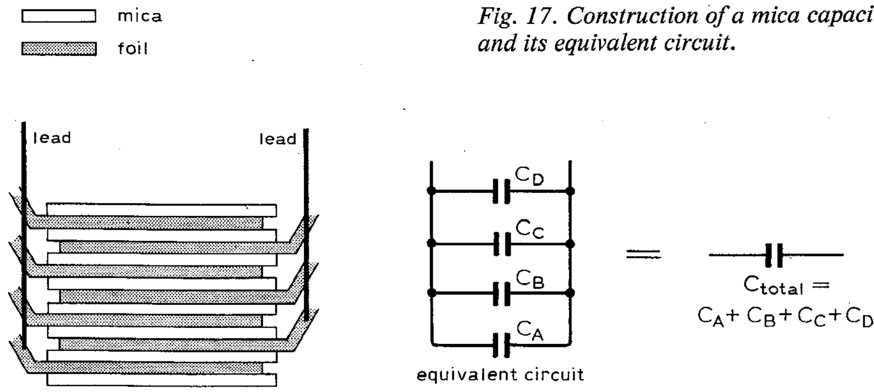


Fig. 17. Construction of a mica capacitor and its equivalent circuit.

filters.

The high K ceramic capacitors are able to give a large capacitance in a small space and find application in decoupling and by-pass capacitors.

Manufacture

The ceramic materials used in capacitor manufacture are made from natural minerals such as steatite, titanium dioxide, and alkaline earths. The ingredients, after being finely ground are compressed, heated to 900° C to remove any impurities; then reground and finally recast in a carefully controlled atmosphere of about 1300° C.

Ceramic capacitors are found in either disc or tubular form. The electrodes are a film of silver fired on to both surfaces of the ceramic. Encapsulation is usually by means of a wax impregnated phenolic dip.

Of particular interest is the barrier layer ceramic capacitor. In this type the high K thin film ceramic plates are fired in a deoxidising oven so as to convert the plates into a conducting metal. The capacitor assembly is then fired in a reoxidizing oven so as to restore the external surfaces in the assembly to a dielectric. Normal silvering is now applied resulting in two high capacity capacitors connected in parallel.

This technique enables high capacitance to be obtained in a relatively small space.

Further reading and acknowledgement

Most manufacturers provide excellent information on capacitors, among those of particular interest are technical literature by: Waycom, Philips, Plessey, Lemco and Erie.

Of deeper and of a more theoretical nature are "Fixed Capacitors" by Dummer (Pitman) and "Dielectrics" by P. J. Harrop (Butterworths).

The author wishes to thank the staff of the Components Laboratory, Rank Radio International for their consistent help and enthusiasm.

Appendix

It is known that when a dielectric is polarized the electric field (E) within the dielectric is vectorially displaced according to eqn.1.

$$\epsilon_o E = D - P \qquad \text{(A1)}$$

where: ϵ_o = permittivity of free space
D = dielectric displacement of the medium
P = polarization of the medium

This equation can be physically interpreted by considering a dielectric as a collection of atoms, positively or negatively charged, each separated by a small distance, and arranged in some regular pattern to form what is known as a lattice. The dielectric may be fundamentally classified as polar or non-polar according to whether or not it possesses a permanent dipole moment (a dipole consists of two charges equal in magnitude, q, but of opposite sign, separated by a small distance, a. The dipole moment is the quantity qa). Under the action of an electric field, E, the lattice of the dielectric is distorted (or displaced) and its dipole moment is altered in magnitude and direction. The dielectric is said to be polarised.

It is also useful to define the "polarizability" of the medium, X, from

$$P = X\epsilon_o E \qquad \text{(A2)}$$

hence from (A1) and (A2), $D = (1+X)E$.

This defines the permittivity of the dielectric, ϵ (see general considerations for the physical importance of this parameter) by $\epsilon = (1+X)$.

The loss angle, δ, is defined as the phase angle between E and D, but is complicated by the fact that X is not dependent on a single variable but on four physically distinct mechanisms viz: electronic polarizability (e), atomic polarizability (a), dipole polarizability (d), space charge (s)

$$X = \alpha e + \beta a + \gamma d + \delta s$$

where ($\alpha, \beta, \gamma, \delta$ are constants dependent on the dielectric).

Capacitor comparison chart

	Polypropylene		Polyester		Polycarbonate		Mica	Paper		Polystyrene	Ceramic		Electrolytic		
	metallized	film/foil	metallized	film/foil	metallized	film/foil		metallized	film/foil		disc/tube	monolithic	aluminium foil	foil	tantalum solid & wet
Insulation resistance Ω	10^5M	5.10^4M	5.10^4M	10^5M	5.10^4M	10^5M	10^5M	3.10^3M	2.10^4M	10^6M	10^2M	10^4M	practical measurement by leakage current		
Dissipation factor	0.0003	0.0003	0.01	0.005	0.005	0.001	0.02 to 0.0005	0.01	0.005	0.0003	0.002 to	0.02	very poor 0.08	poor 0.01	poor 0.0005 to 0.02
Tolerance (%)	5	2	5	5	5	2	0.5	10	5	0.625	10	20	10	10	5
Temperature range (°C)	–40 to 85	–40 to 100	–55 to 125	–55 to 125	–55 to 125	–55 to 125	–55 to 125	–30 to 100	–30 to 100	–40 to 70	–55 to 125	–55 to 125	–20 to 80	–40 to 125	–40 to 150
Size per CV	small	small	small	small	small	small	small	small	large	large	small	small	very small	small	
Stability	fair	excellent	fair	fair	fair	fair	excellent	fair	fair	excellent	fair	fair	fair	very good	excellent
Cost per CV	low	low	low	fair	fair	fair	fair	fair	fair	high	low	low	fair	high	high
Capacitance range (µF unless indicated)	0.001 to 100	100pF to 0.47µF	0.001 to 10	100pF to 0.01µF	0.001 to 100	5pF to 0.01µF	5pF to 0.01µF	0.01 to 100	0.001 to 100	100pF to 0.6µF	5pF to 1µF	0.001 to 10	typically 1 to 22,000	1 to 1000	*CV* product inflexible (3500 max normally)
Voltage (a.c.) (V)	250 to 440	63 to 500	63 to 400	90 to 160	40 to 250	63 to 160		250 to 630	250 to 630	—	63 to 250	—	—	—	—
(d.c.)	750 to 1000	100 to 1500	100 to 1500	160 to 400	63 to 1000	100 to 400	63 to 630	500 to 5000	—	63 to 1000	63 to 10000	63 to 450	6.3 to 500	6.3 to 300	1 to 50
Temperature coefficient PPM/°C	–170	–120	400	400 (non linear)	150	– 50 to – 100	100	300	300	–150	non linear positive to 1000 neg		1500	1000 (non linear)	200 to 1000
Appx. resonance MHz	0.1	1	0.1	1	0.1	1	1.0	0.1	0.1	1	10	100	0.05	0.1	0.1

World of Amateur Radio

The Moscow way of licensing

At a time when the h.f. bands are less frequently open to DX I find that a high percentage of all my contacts seem to be with amateurs in the USSR where activity and standards of operating are high and where many amateurs seem to be using home-built transceivers. Considerable official encouragement is given to amateur radio in the USSR including access to surplus equipment and technical information. But at the same time by British standards the licensing is very much on an "incentive" basis and demands considerable effort on the part of those wanting licences.

A recent survey of Russian licence conditions in *Electronics Australia* shows that the Muscovite's path to a first-class licence is long and arduous. In essence the procedure is: complete a basic electronics course; join a radio club and take a test (including a 10 w.p.m. Morse test) which licenses you to *listen* on the amateur bands and log stations; after six months you can take a "third-class" test (more difficult examination on simple transmitter theory and practice and 12 w.p.m. Morse test). If you pass this you are permitted to operate a 10-watt transmitter on sections of the 3.5 and 7MHz bands c.w. and 28MHz phone. These licences can be renewed only by the operator moving to a higher class. To do this requires another ("second-class") examination and a pass allows operation of a 40-watt transmitter on 3.5 to 420MHz c.w. (phone restricted to 28MHz). Finally to obtain a "first-class" licence requires the applicant to send and receive Morse at 18 w.p.m., be able to design transmitter and receiver circuits, and build and service advanced transmitters and receivers. If he or she (for some 10% of Russian amateurs are "YLs") passes, then permission is given to operate 200 watts on 3.5 to 420MHz c.w. or phone (there are no 1.8, 50 or 70MHz bands available in Russia – I am not certain about microwave bands).

V.h.f. going factory-built

Not so long ago it was common practice for v.h.f. enthusiasts to claim that their bands had become the last refuge of those who liked to build their own equipment (although in practice reception usually depended on a home-built converter in front of a commercially-built h.f. communications receiver). But there is plenty of evidence to show that factory-built equipments are today becoming almost as widely used on 144MHz as on 14MHz. In the last two or three years there has been an influx of v.h.f. transceivers such as the Yaesu FT-2 series, Trio TR7200 and TR2200 and kit units such as the Heathkit HW202, 144MHz transverters, Inoeu and Icom units such as the IC22 and IC210 with its phase-locked v.f.o., the Liner 2 transceiver that has enormously increased the amount of s.s.b. on 144MHz, and a growing number of 144MHz hand-held units for working direct or through repeaters.

One wonders whether, in the face of this invasion, the home-builders will tend to retreat to the u.h.f. bands or subscribe to the growing interest in microwaves.

Ionospheric storms in a quiet year

Recent months have been marked by pronounced 27-day repeats of pretty severe magnetic storms. They start off with a steep rise in maximum usable frequencies, leading on to auroral effects and then followed by several days of disturbed conditions and low m.u.f., particularly on the North Atlantic paths. It has of course long been recognised that the 27-day repetition period of these storms allows them to be predicted with good accuracy during the decreasing phase of the sunspot cycle. But one certainly has the feeling that the storms have been more severe this year than one would expect in what many regard as "a year of the quiet sun".

For example, October 12 saw a high m.u.f. with the 28MHz band opening well to Australia and Japan; this was soon followed by Aurora openings on v.h.f. and then a lengthy period of subdued h.f. conditions.

Clamping down on Citizen's Band violations

The American FCC appears to be taking seriously a series of measures aimed at better regulation and supervision of 27MHz CB operation where in the past the Class D regulations have been honoured mostly in the breach. For example the Commission has recently set up four specially equipped and trained enforcement teams; obtained a well-publicised series of criminal convictions for gross violations; established temporarily some 40 special inspection stations to check the use of CB equipment by lorry drivers (of 36,000 vehicles checked about 7,000 were carrying 27MHz CB equipment, more than half unlicensed and many others exceeding the power regulations). There are current proposals in the United States to prohibit the sale or importation of linear amplifiers in the 20 to 40MHz range as these are being widely used to run high-power CB stations.

However, there are also proposals to increase the number of 27MHz channels (adding 27·23 to 27·54MHz), to permit the use of omnidirectional aerials at heights up to 60ft (20ft will still be the limit for beams) and to relax some of the restrictions on hobby use of Citizen's Band.

Type approval of amateur gear?

One aspect of so much amateur equipment now coming from factories rather than being built on the kitchen table is the question of whether this is likely to lead to the introduction of some form of type approval, type acceptance or recognised "performance standards". Probably the main question is that of the levels of spurious emission outside of amateur bands, a factor that has been emphasised by the more general use of mixing processes rather than straight frequency multiplication in transmitter practice. It is by no means unusual, even in reputable designs, for there to be spuriae of the order of –40dB or so with reference to wanted output. This may or may not result, for example, in interference to television reception or to other communication services; much depends on what additional suppression is provided by the operator in the form of filters or resonant aerials. But there is an argument that if equipment is sold for amateur operation should it not be expected to be suitable, without additional suppression, for use at all normal locations?

One answer might be for the licensing authorities to insist that all equipment conformed to a published performance specification, but where would this leave the amateur who wishes to modify equipment and lacks measuring equipment to ensure that the performance is still within spec?

The ARRL Board of Directors recently decided that if any form of type approval is instituted in the United States the League would urge continuation of the amateur's right to build, to modify and to adapt surplus equipment to his own use.

In brief

The installation of the RSGB president for 1975 (C. H. Parsons, GW8NP) will take place at Cardiff on January 17 . . . Nobel prize winner Sir Martin Ryle holds the amateur callsign G3CY . . . The final RSGB 144MHz contest for 1974 takes place on December 8 . . . Microwave operating awards are issued by the RSGB for the first contact an amateur makes over the following distances: 13-cm band 500km; 9-cm 400km; 6-cm 300km; 3-cm 150km; and 15-mm 150km . . . "I would like to voice my personal firm support of the Amateur Radio Service," from a recent address by Richard E. Wiley, chairman of FCC . . . Over 1,000 repeater stations have been licensed in the United States, making this the fastest growing segment of amateur radio, and it seems likely that restrictions on the linking of repeater stations may be lifted, together with those relating to cross-band operations.

PAT HAWKER, G3VA

New Products

Sweep/function generator

Line, square, triangle and swept waveforms, as well as fixed-amplitude pulses are available from the model 195 generator. A frequency range from 2Hz to 200KHz in three ranges, with a linear/logarithmic frequency control is offered by the instrument which will span three decades on any frequency range. Slow, medium and fast sweep rates are provided, with high- and low-level sine outputs, and a voltage-controlled frequency input permitting remote control of the frequency. The three sweep rates give sweep times of 25s, 250ms and 2.5ms, and the frequency accuracy is claimed to be ±2% of full scale. The instrument measures 18.7 × 21.6 × 7.3cm and costs £79. Dana Electronics Ltd, Collingdon Street, Luton, Beds.
WW300 for further details.

Direct current calibrator

The 609S is a d.c. source for calibration from nanoamp levels up to 100mA in five ranges. An accuracy of ±0.05% of setting ±0.005% of range ±0.2nA is quoted for the instrument, which has a regulation for the load and supply of 5ppm/V. Output noise for the 100, 10, and 1mA ranges is less than 5ppm of full scale, and 10ppm of full scale ±0.1nA for the 100 and 10μA ranges. The unit, which measures 22 × 16 × 19cm, is powered by ten U2-type batteries, but an interchangeable mains power unit is available. Time Electronics Ltd, Botany Industrial Estate, Tonbridge, Kent.
WW302 for further details

Pulse transformer

The 1060 series of miniature pulse transformers manufactured by Nano Pulse Industries has been designed for use with triac and s.c.r. circuits. Standard types in the range have either two or three windings and ratios of 1:1, 1:1:1 or 2:1:1 respectively. Minimum inductances can be either 1.5 or 5mH with maximum leakage inductances between 0.5 and 2.3μH. Tekdata Ltd, Westport Lake, Canal Lane, Tunstall, Stoke-on-Trent, Staffs ST6 4PA.
WW306 for further details

Cable identification system

A system comprising the model H8030-30TC pulse transmitter, and the model TCD-2 pulse detector is capable of identifying each phase anywhere along cable runs. A series of coded pulses are transmitted by the H8030-30TC on "A" and "B" phases, these pulses combine and return on "C" phase. In three-conductor cables, each phase can be identified by moving a pick-up coil around the cable, and by observing the meter on the TCD-2 detector. Hipotronics Inc, Brewster, NY 10509, USA.
WW311 for further details

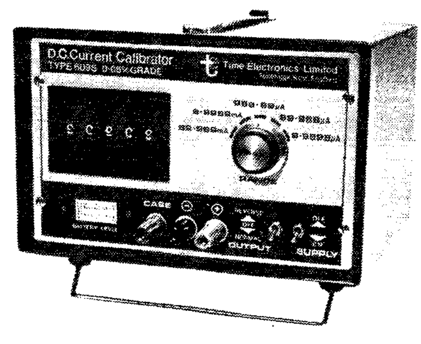
Multichannel VU meter

A new instrument called the VUE-SCAN replaces conventional VU meters and accepts up to 28 channels of audio information which are displayed simultaneously as illuminated vertical bars on a television monitor screen. The bars are always present as a background reference. The lower two-thirds of the screen has a blue filter and the remaining upper third has a red filter. As the level of a channel increases the bar representing that channel increases in height and intensity. Any channel which moves into the red position is identified as over-modulated. Audio Designs & Manufacturing Inc, 16005 Sturgeon, Roseville, Mich 48066, USA.
WW304 for further details

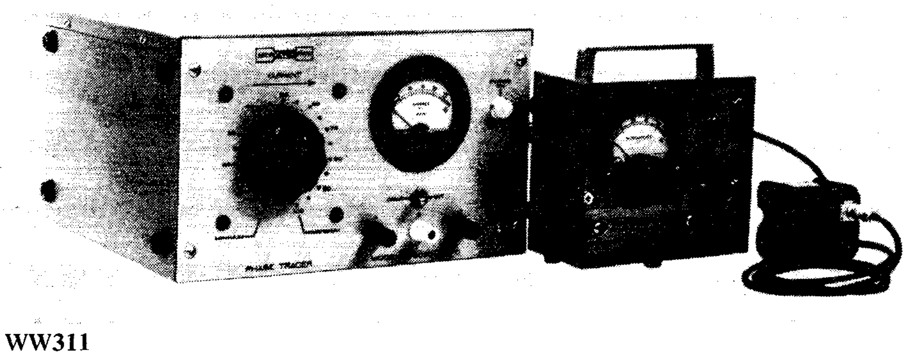
Digital clock

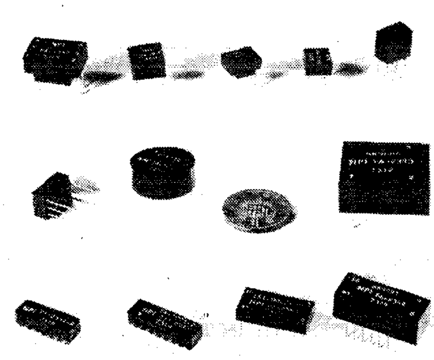
Emihus Microcomponents have designed a universal digital circuit specifically for use in mains driven electronic digital clocks, timers and time-base circuits. The circuit, which uses p.m.o.s. technology, has two designations—EDC6051 and EDC6052. Common features to both are: 50Hz, 60Hz or 100kHz control frequency options; three inputs for setting minutes, tens-of-minutes and hours; stop control feature,

WW300



WW302


WW311


WW306

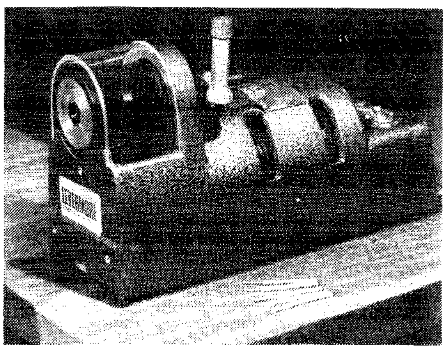
reset facility, 12- or 24-hour display, a.m./p.m. indication, and eight-decade counting in 1, 2, 4, 8, b.c.d. option. The EDC6051, however, includes a 24-hour alarm setting and a "snooze alarm" feature. The circuit is contained in a 28-pin d.i.l. package. Emihus Microcomponents Ltd, Clive House, 12 Queens Road, Weybridge, Surrey.
WW303 for further details

Rotary wire stripper

The model 70 wire stripper has been designed as a production line machine and is capable of handling most types of wire up to 0.201in outside diameter. A solid carbide swing blade is adjusted to suit the wire thickness. The machine is mains-powered, measures 5¾ × 3¾ × 10in and weighs 7¼lb. A. Levermore & Co Ltd, 40 The Broadway, London SW19 1SQ.
WW309 for further details

Milliohmeter

The Toneohm 400A is a mains-operated milliohmeter offering five ranges from 30 milliohm to 3 ohm. The readout is indicated on a panel meter, and in the form of a resistance dependent audio tone. Accuracy is quoted as 5% of f.s.d. and the maximum probe voltage is 0.7V. Calibration is by means of a preset control on the front panel of the meter which measures 15.5 × 10 × 10cm and weighs 1.1kg. Polar Electronics, P.O. Box 97, Les Villets Forest, Guernsey, Channel Islands.
WW301 for further details



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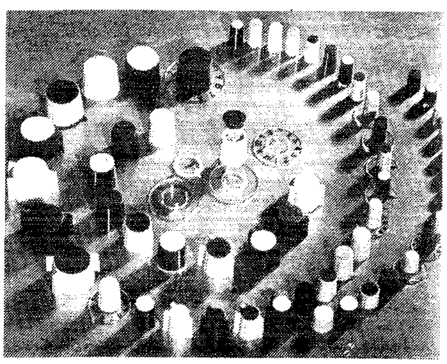


WW308

Radio power meter

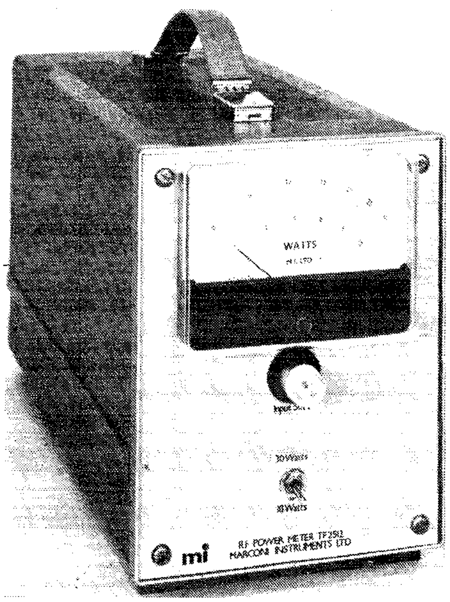
A mobile r.f. power meter, TF2512, from Marconi is a 50 ohm direct reading absorption power meter having a 10W and 30W full-scale range. Frequency range is from d.c. to 500MHz, with an accuracy of ±5% up to 250MHz and ±7% up to 500MHz. A thermocouple sensing element provides true-mean-power measurements from any applied waveform. Changing the power range is achieved by altering the meter sensitivity, therefore it is impossible to damage the thermocouple by inadvertently switching to the wrong range. Marconi Instruments Ltd, St Albans, Herts.
WW310 for further details

Knobs

Sifam have introduced a range of knobs and accessories which are available in 11, 15, 21 and 29mm base-diameter sizes with or without indicating line. All the accessories are made from nylon except for transparent dials which are made from a polycarbonate. Black and grey shades are standard with green, blue or yellow caps and pointers. Sifam Ltd, Woodland Road, Torquay, Devon TQ2 7AY.
WW308 for further details

Pattern generator

A pocket-sized u.h.f./v.h.f. 625 line pattern generator has been announced by Labgear. The unit produces a blank raster, 12 horizontal/13 vertical lines, and an eight-bar grey scale. Both u.h.f. and v.h.f. outputs are available from the generator which has a mains/battery facility. The instrument measures 4.5 × 10 × 17.5cm and is available from Labgear Ltd, Abbey Walk, Cambridge CB1 2RQ.
WW315 for further details



WW310

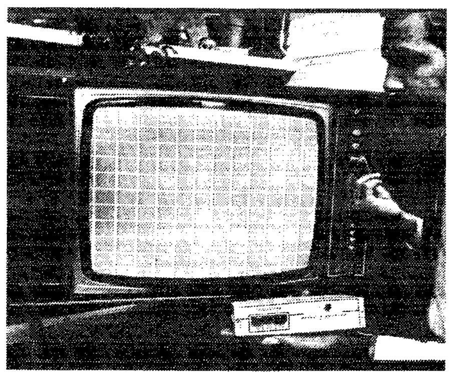
C-band amplifier

A solid-state amplifier for use in line-of-sight communication systems has been introduced by Raytheon. The model VCM-5004 delivers one watt minimum between 7725 and 8275MHz. The design incorporates a power output monitor, self-contained input-output circulators and current regulators. Noise figure rating for the device is 33dB, gain 27dB minimum, phase linearity ±2°/40MHz, and amplitude linearity ±0.2dB/40MHz. The amplifier operates in a temperature range from 0 to +55°C and measures 5.75 × 4.75 × 1.25in. Raytheon Company, 130 Second Avenue, Waltham, Mass 02154, USA.
WW307 for further details

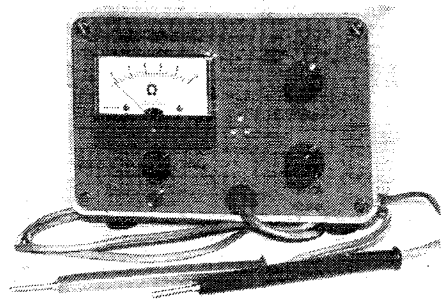
Electronic teleprinter

The ITT-Creed model 2300 is the first teleprinter to feature l.s.i. circuits and first to feature a clutchless print mechanism. It offers a cost reduction of about 20% on the previous ITT machine, at the same time featuring an interchangeable keyboard and a link option board to cater for the different Telex systems. The machine is lighter, smaller and more reliable than its predecessors, as well as being cheaper.

Ability to work into any Telex system is achieved by a plug-in board system that includes a diode matrix board from which



WW315



WW301

selected diodes are clipped out for individual systems (as well as for identification codes). "On the fly" printing is used where a rotating wheel in front of the paper is struck from behind the paper—a technique previously applied to data printers. An impregnated porous wheel (Porlon) resting on the character wheel provides inking and is claimed to have a life six times that of a normal ribbon.

Operating speed can be 50, 75 or 100 bauds and the 5-unit (Telex code) electronics have the potential for conversion to an 8-unit code for data terminals. ITT Creed Ltd, Hollingbury, Brighton BN1 8AL.
WW312 for further details

Graphic equalizer

A graphic equalizer called the Dual 11s comprises two identical 11 band equalizers in one case. Each unit uses overlapping *LCR* filters arranged for boosting and cutting each channel by up to 12dB. The instrument features a noise figure of better than −90dBm and total harmonic distortion of less than 0.01%. The equalizer is available as either a rack-mount unit or fitted in a portable case from Klark-Teknik Ltd, Summerfield, Kidderminster, Worcs DY11 7RE.
WW313 for further details

High voltage capacitors

Perdix Components are now offering a range of high-voltage capacitors for applications where a military grade is not required. Standard types are available from 2kV d.c. working to 150kV d.c. working and capacitances from 500pF to 0.5μF with a tolerance of ±20%, ±10% or ±5% in the operating temperature range −40 to +80°C. Perdix Components Ltd, Perdix House, 31 Green Lane, Chislehurst, Kent BR7 6AG.
WW314 for further details

Capacitance meter

The ESP direct-reading capacitance meter provides measurement in the range 1pF to 10μF. No balancing is required and the value is indicated on a linear scale. The instrument is powered by a 9V battery whose condition is continuously monitored by a l.e.d. which will not light if the battery voltage drops to a level which will affect the performance. The meter is priced at £25 plus v.a.t. and is available from Electronic Services & Products Ltd, 2a Badby Road, Daventry, Northants.
WW319 for further details

TV camera tubes

The latest Mullard television camera tubes for use in surveillance systems are claimed to operate in light levels of 10^{-2} lux, which is equivalent to half moonlight conditions. They consist of Vidicon tubes coupled to image intensifiers by means of fibre-optic plates. Each device contains its own high voltage power supply, a target signal amplifier and an automatic brightness level control. The brightness level control produces a signal that operates the camera iris enabling the tube to operate in varying light conditions. Mullard Ltd, Mullard House, Torrington Place, London WC1.
WW316 for further details

Decade resistance box

The D61/A is a six-decade resistance box offering a nominal accuracy of 1% from 1ohm to 1,111,110ohm in steps of 1ohm. The junction between each decade is brought out to a socket, allowing the box to be used as a potential divider. Metal film 1% resistors are used except for the 1ohm decade which uses a ±0.05milliohm type. Maximum permissible current varies from 700μA at 1Mohm to 2.2A at 1ohm. D. H. Davies, 4 Middleton Drive, Guisborough, Cleveland.
WW317 for further details

Fusible resistor

A new and patented thick-film fusible resistor from Erie is claimed to supersede the conventional wire-wound types in which solder has to melt. The resistor has a "flip top" mechanism which ejects an inert top to provide the fusing action. Two speeds of "flip tops" are available; red types fracture in five seconds at 15W and ten seconds at 9W while blue types fracture in 20 and 30 seconds respectively. Both types are flame retardant and designed to withstand 100% overload for one minute. Erie Electronics Ltd, South Denes, Great Yarmouth, Norfolk.
WW318 for further details

Solid State Devices

Names of suppliers of devices in this section are given in abbreviation after each entry and in full at the end of the section.

Power transistors

International Rectifier have announced a range of discrete and Darlington, high voltage, power transistors. A feature of the new range is the use of glass passivation which allows "on-the-junction" hermetic sealing which in turn prevents the ingress of impurities.
WW350 for further details **International Rectifier**

U.h.f. transistor

The MRF621 has been designed for 12.5V operation between 406 and 512MHz. The transistors will provide 45W at 470MHz from a 12.5V collector supply. Minimum power gain is 4.8dB with a collector efficiency of 55%.
WW351 for further details **Motorola**

Diode bridges

The SCBHO5F-4F series are fast recovery bridges in an "Alpac-T" aluminium package. P.i.v. ratings are from 50 to 400V with an average output current of 10A and a quoted recovery time of 250ns.
WW352 for further details **Bourns**

Regulator

A hybrid i.c. regulator, in a TO-3 package, called the MIVR 42050-055 will deliver up to 5A at 5V ±0.1V without the need for external components. The device incorporates short-circuit protection, voltage shutdown and current foldback. Power rating is 120W at 25°C.
WW353 for further details **GDS**

1GHz decade counters

A new range of decade counters comprises the SP8665B 1GHz, the SP8666B 1.1GHz, and the SP8667B 1.2GHz counters, with guaranteed operation over the temperature range 0 to 70°C. The counters feature a self-biasing clock input, and a clock inhibit input for direct gating capability. The devices have a typical power dissipation of 550mW with a 6.8V supply.
WW354 for further details **Plessey**

Linear i.cs

Recent additions to the RCA range of linear i.cs are the TA6480 tv sound i.f. and audio output system, the CA1352 tv video amplifier, the CA3131 5W audio amplifier, and the CA810 7W audio power amplifier with thermal shutdown.
WW355 for further details **RCA**

1024-bit r.a.m.

Sample quantities are now available of the 2102 1024-bit static r.a.m. which has an access time of 650, 450 or 350ns in the temperature range 0 to 70°C. The devices are constructed using the Fairchild n-channel isoplanar process and are produced in a 16-pin d.i.l. package.
WW356 for further details **Fairchild**

Suppliers

International Rectifier, Hurst Green, Oxted, Surrey.
Motorola Inc., Semiconductor Products Division, European Headquarters, P.O. Box 8, 16 Chemin de la Voie-Creuse, 1211 Geneva 20, Switzerland.
Bourns (Trimpot) Ltd, Hodford House, 17 High Street, Hounslow, Middx TW3 1TE.
GDS (Marketing) Ltd, Michaelmas House, Salt Hill, Bath Road, Slough, Bucks.
Plessey Semiconductors, Sales Office, Cheney Manor, Swindon, Wilts SN2 2QW.
RCA Ltd, Solid State-Europe, Sunbury-on-Thames, Middlesex.
Fairchild Semiconductor Ltd, Kingmaker House, Station Road, New Barnet, Herts.

Real and Imaginary

by "Vector"

How quo was my status?

In the October issue the Editor sprang to the stirrup to bring us the good news that active steps are being taken to improve our professional status. As one whose status only departs from the zero line to swing negative I fervently applaud this noble project.

In his communiqué the Editor emphasized the importance of status and, as ever, Sir is so right. I remember one instance at a Farnborough Air Show. I'd been invited to a wining and dining session by a couple of high-powered aviation executives who were under the impression (rightly) that our Chairman was in the market for a private heavier-than-air machine. They were also under the impression (terribly wrongly) that I had some pull with the Old Man. (Actually they'd confused me with another chap of the same name who was a big wheel in our company.) The rendezvous they'd chosen resembled a morgue with waiters, but the food was cordon bleu stuff so I let them stay confused. Not until the coffee-and-liqueurs stage had been reached was the conversation ever-so-delicately steered around to executive aircraft, whereupon the truth was revealed and it wasn't long before I was cast forth into outer darkness.

Upon reflection, this last bit isn't quite true, for the hotel forecourt, like its customers, was well lit. I was halfway across it when my way was barred by a drunken Irishman who was built roughly to the scale of the Giant's Causeway. Without ado he seized my lapel in one massive paw and swept his other arm around in a magnificent arc which encompassed the assembled battalion of Mercs, Jags and Rolls-Royces.

"If yez ask me," he said, thrusting his seven o'clock shadow to within three inches of mine, "if yez ask me, dese are nudding but a bunch of ****** status symbols!" And releasing his grip he lurched off into the night. So did I, but in the opposite direction; I didn't want to be in the immediate vicinity if a Rolls suddenly went off bang. But I couldn't help agreeing with the expressed philosophy. An engineer with a five-year-old Mini doesn't stand a dog's chance with the dollies on the Air Show stands when these counter-jumpers with their hired status symbols are around. So vive le status!

The brisk, ambitious lad who is contemplating entering electronics should have no great difficulty in acquiring a status which is instantly recognizable throughout the profession, but there are short cuts to the top of the tree. As a first step he should hang on at university for as long as the state and his parents can be coerced into subsidizing him. During this foetal phase he should collect as many degrees as possible, including, naturally, a Ph.D. This won't necessarily give him the engineering capability of replacing a busted fuse but it looks very fetching on an application for a job. A word of warning, however. I believe that in the USA Ph.Ds are so thick on the ground (I use the term "thick" to mean a high population level and not in its "thick as two planks" connotation) that only the medical profession uses the word "doctor". So if you do get one, don't emigrate to the States.

If you must go into the electronics industry, join a big firm. Having got a Ph.D. on the payroll they won't know what to do with you, so you can easily get yourself lost in the organization. Join as many learned societies as you can and spend your time in the sanctuary of the firm's library, writing papers for their Proceedings. Provided that you make them completely unintelligible the learned societies will publish them and you'll soon establish an enviable reputation for appearances in the literature. You are now well on your way to becoming a world authority on the sex life of the electron (or whatever your chosen subject is) and invitations to speak at conferences and symposia will flow in. Choose your acceptances with care, selecting those which coincide in venue and timing with the Motor Show, the Boat Show or whatever function forms your particular interest. Many symposia are held abroad, usually in some warm, exotic locality; with care, you can spend nine months of the year overseas, living on your expense account. Your firm will be so bucked at all this they they'll create you a Plenipotentiary Scientific Consultant which merely means that what you've formerly been doing under cover can now be done in the open.

Other forms of status in industry are often more apparent than real. Long ago, firms tumbled to the fact that the tea-boy works better if he's called a Stimulant Provision Officer and that the arrangement operates to some extent in lieu of more pay. It works up to a point, but when everybody in the organization is an admiral you're back to square one, for status is relative, not absolute. There are other, more reliable, guidelines. In any given Product Division there may be a dozen managers; at tea break, eleven will send their secretaries for a cuppa from the automatic dispenser while one will get a pot of tea on a tray brought by a waitress. Guess who's the big wheel?

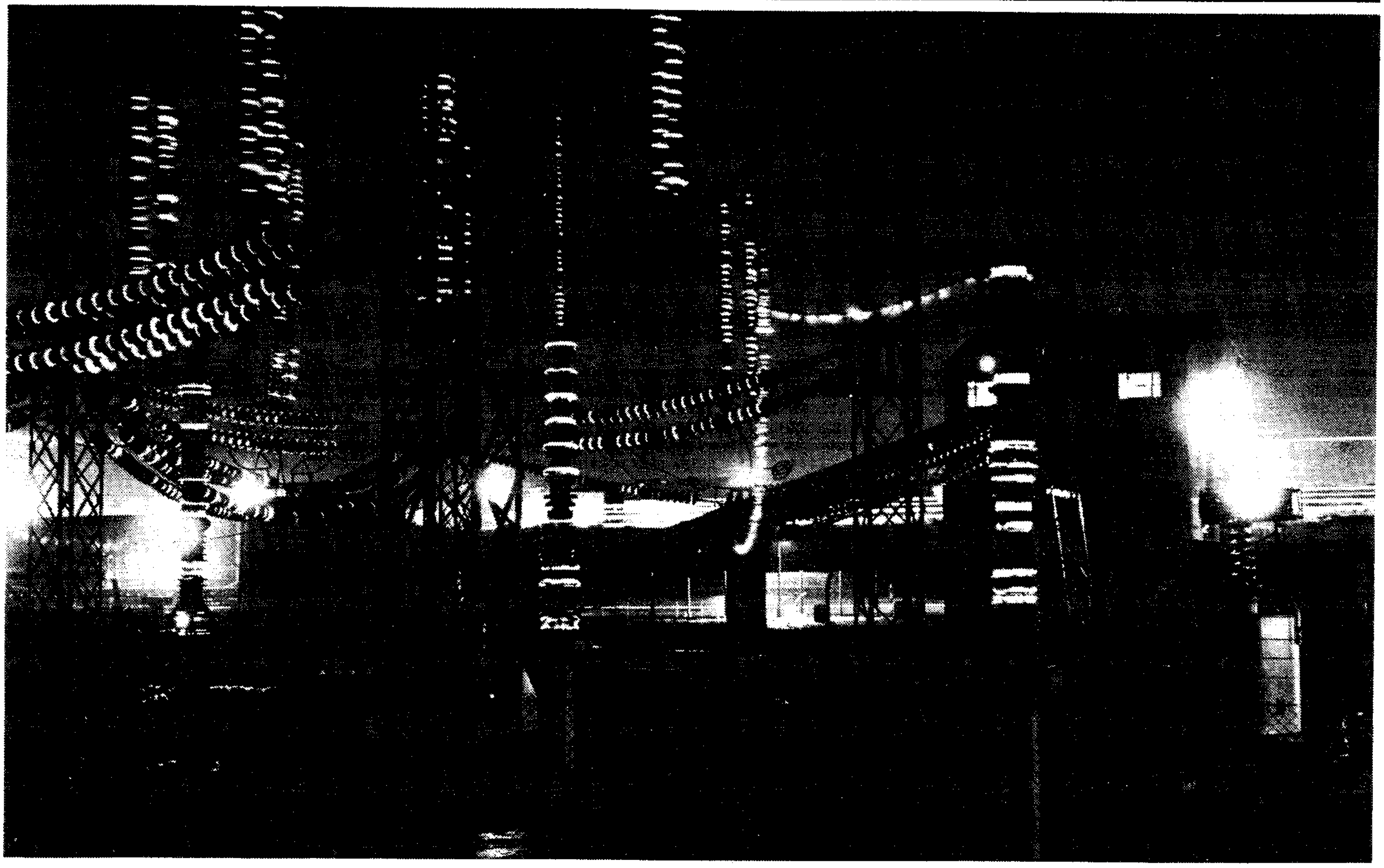
Offices are another status symbol. Titles who share an office with half a dozen other titles don't rate in the hierarchy, but conversely, the news that you're to be given an office on your own does not necessarily mean that you've arrived. It could merely be that Works and Bricks have discovered a disused store cupboard and you're being bunged in there to get you out of everybody else's hair. Only when you move into a room big enough to house six, with carpet on the floor and a shapely blonde secretary installed in an outside office, can you feel that you're in the big league. From then on, promotion will take you to more and more opulent structures; from the Chairman's doorway, for instance, you can just glimpse his desk on a clear day while, for all you know, a couple of tigers may be lurking in the pile of the carpet.

But as the Editor points out, status-recognition within the profession is relatively straightforward; it's recognition by the public that's the problem. They brush shoulders with us in the street in total unawareness that we're the chaps who've brought fulfilment to their lives. Without us they'd never have known those tender moments with Ena Sharples, neither could they ever go on safari to Mummerset to help the Archers with the carrot harvest. Little do these lesser mortals know that supermen are standing alongside them in the queue. That, if we chose to turn from electronics to some honest form of toil, we would divorce them for ever from sight and sound of Messrs Wilson, Heath, Thorpe, Savile, Blackburn, Waring *et al.* If they did know this, I'm sure they would make due obeisance.

The tragedy is that, away back in the Stone Age of radio, we—at least our forebears—had the adulation of the general public and lost it. If you have access to the early volumes of *W.W.*, take a look at the photographs and you'll see what I mean. There he sits, this superman of old, stonefaced in front of a pile of ironmongery and curly wires; twin-banded earphones are clamped on his head; one hand is adjusting a stud-switch while the other is poised over a morse key. Clearly matters were at crisis point when the picture was taken; a message from Mars, perhaps? Or an SOS from mid-Atlantic? The general public never saw these wizards in the flesh but gazed in awe at their pictures, knowing that they conversed not in mortal tongues but in an alien dot-dash language of their own. Then along came the loudspeaker and the microphone and killed the mystery stone dead. I think the headphones were the key feature; shorn of those we became indistinguishable from the common herd.

So the problem resolves itself into one of instant recognition; here, I think we might learn from the Armed Services, with their insignia. Couldn't we, for instance, borrow the hand grasping a bunch of straws that the RAF use to distinguish their electronics personnel? On second thoughts, no; it isn't showy enough. Personally, I think something along the lines of Batman's uniform is called for. That really should do something for our public image.

When flashover is the danger. Use EEV spark gaps.



Photograph courtesy of C.E.G.B.

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For data and any help you need, write or 'phone EEV at the address below.

Right, GXQ400, a crowbar protection device and GXU40, for protection circuits in ground/air communications equipment.

LAP 93

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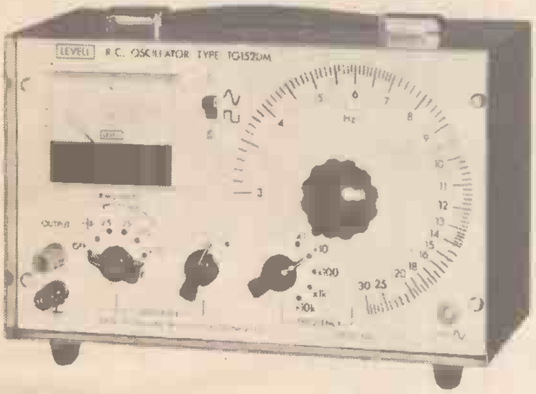

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DISTORTION	< 0.2% from 50Hz to 50kHz.
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METER SCALES	0/2.5V & –10/+10dB on TG152DM.
SIZE & WEIGHT	7″ high x 10¼″ wide x 5½″ deep. 8 lbs.

TG152D Without meter. **£46**

TG152DM With meter. **£56**

FREQUENCY	1Hz to 1MHz in 12 ranges. Acc. ± 2% ±0.03Hz.
SINE OUTPUT	7V r.m.s. down to <200µV with Rs = 600 Ω.
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SQUARE OUTPUT	7V peak down to <200µV. Rise time <150nS.
SYNC. OUTPUT	> 1V r.m.s. sine in phase with output.
SYNC. INPUT	±1% freq. lock range per volt r.m.s.
METER SCALES	0/2V, 0/7V & —14/+6dBm. on TG200M & DM only.
SIZE & WEIGHT	7″ high x 10¼″ x 5½″ deep. 10 lbs.

TG200	TG200D	TG200M	TG200DM
Sine O/P	Sine & Sq. O/P.	Sine O/P +meter.	Sine & Sq.O/P + meter.
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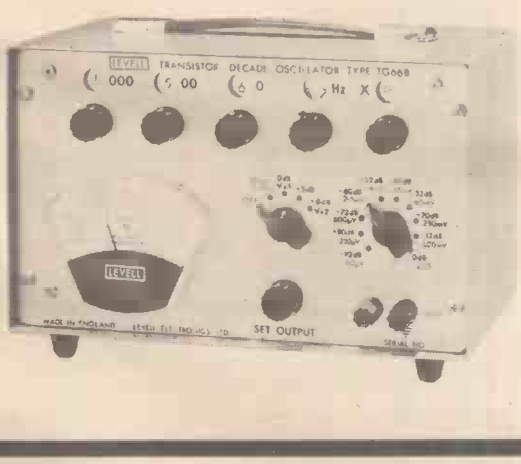

FREQUENCY	0.2Hz to 1.22MHz on four decade controls.
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METER SCALES	2 Expanded voltage & —2/+4dBm.
SIZE & WEIGHT	7″ high x 10¼″ wide x 7″ deep. 12 lbs.

TG66B Battery model. **£150**

TG66A Mains & battery model. **£170**

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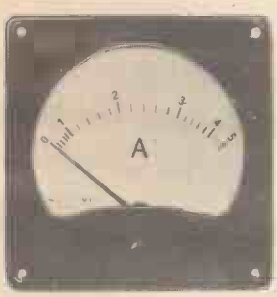
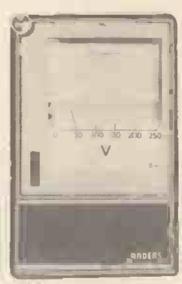
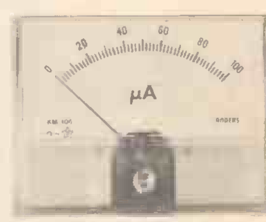
Popular models and ranges are stocked in depth while a specially equipped instrument department enables swift production of non-standard ranges and scales, to suit individual customer requirements, in large or small quantities.



Vulcan Moving Iron. 4 models, 1·5″, 1·8″, 2·7″, 3·7″ scales. Voltmeters, ammeters and motor starting meters.



Recorders 60 or 120 mm. charts. Non-ink marking. DC moving coil and AC rectified.



Kestrel Clear Front. 7 models, 1·3″ – 5·25″ scales. DC moving coil, AC moving coil rectified, AC moving iron.

Regal Range 100° flattened arc. 2 models 2.5″ and 3.2″ scales. Taut band. DC moving coil and AC moving coil rectified.

Profile 350 edgewise 4·3″ scale. DC moving coil and AC moving coil rectified. Horizontal or vertical mounting.

Stafford Long Scale 240°. 6 models, 3·5″—11·5″ scales. DC moving coil, AC moving coil rectified, AC moving iron. Also 98° scale.

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standards go on getting higher.
helps keep up the good work...

million component hours.

Unreliable products mean more servicing, more replacements, more guarantee claims . . . dissatisfied customers . . . so you won't save any money by leaving component quality to chance. Unknown components mean that your goods inward testing has to be much more stringent too.

Remember that quality can't be 'tested into' a component after it's been made. It's a function of every step from initial design and raw material specification right through each production process to the finished product.

We have developed a series of quality assurance criteria which are applied throughout the Mullard organisation wherever actions or decisions can affect quality, however indirectly.

- Quality targets are clearly defined for all components.
- Test specifications cover all approved applications.
- Procurement specifications define essential quality requirements for outside suppliers.
- Manufacturing specifications are precise on all factors affecting quality.
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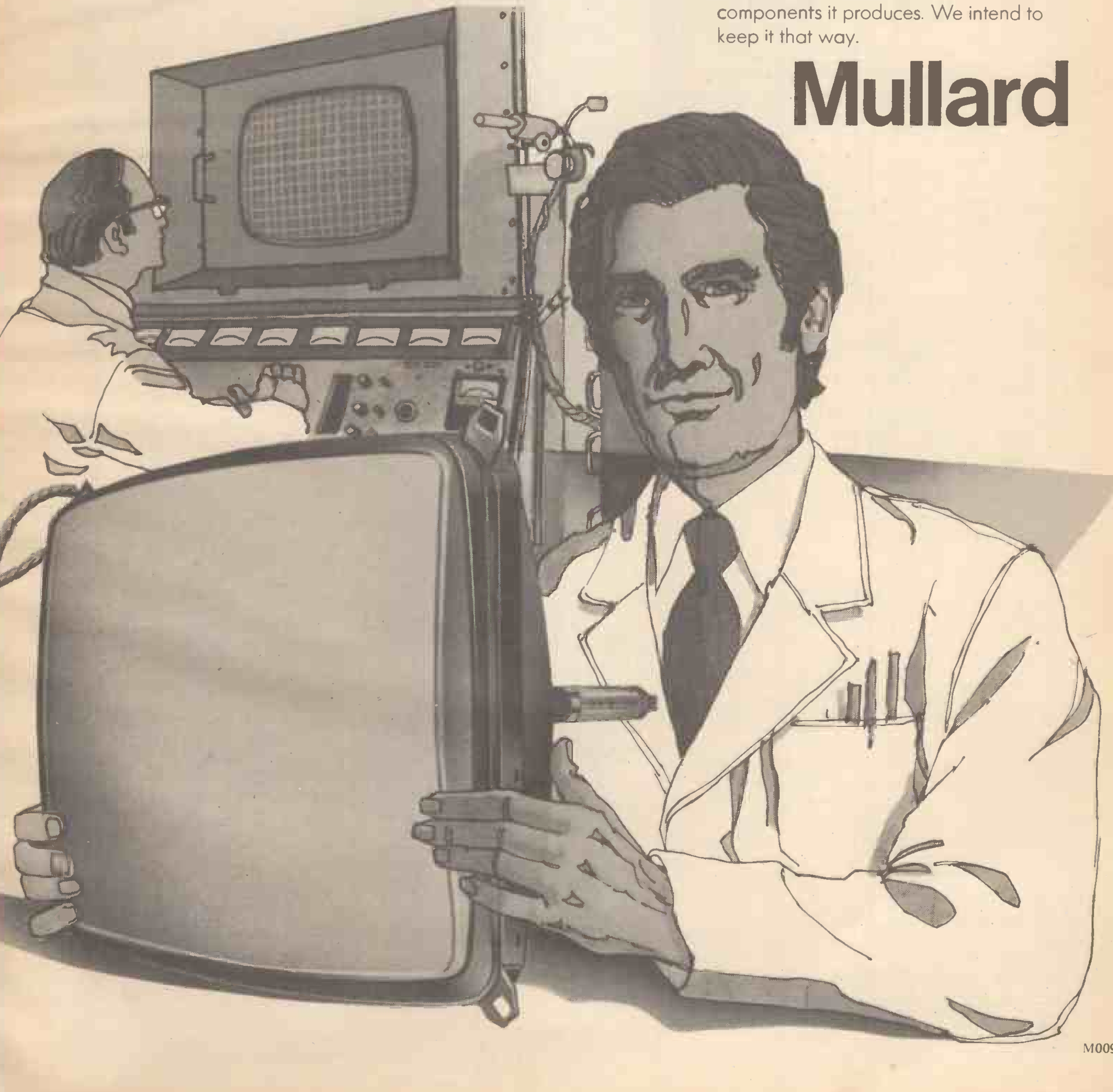

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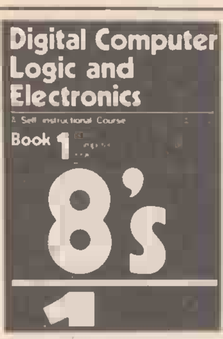

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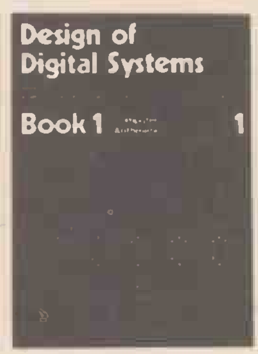

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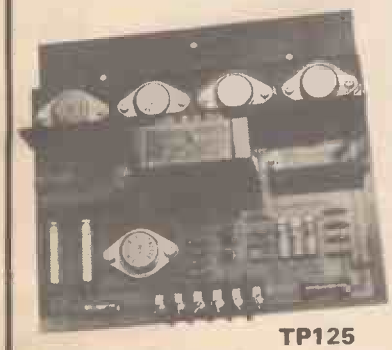

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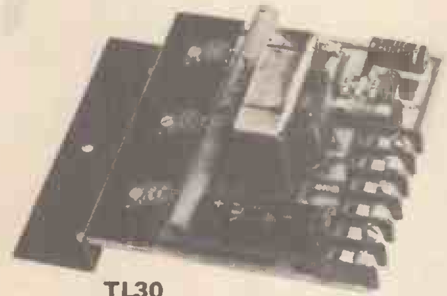

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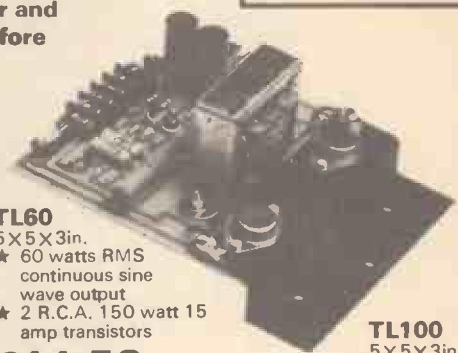

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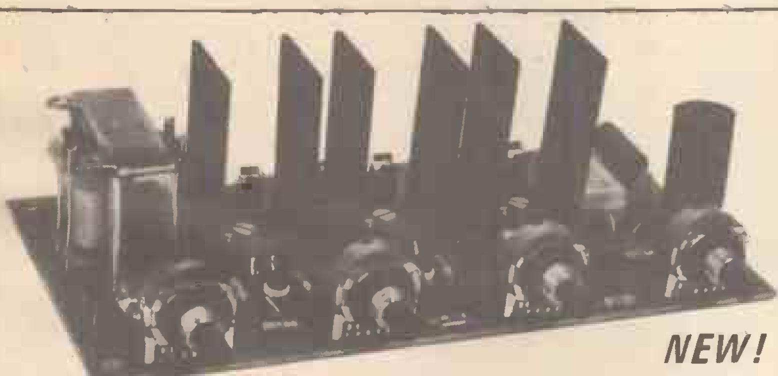

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This model employs three active drive units, the total range of which extends beyond the nine audible octaves.

By giving attention to all components and design detail the colouration and distortion is negligible and the energy distribution is as constant as possible.

Five year warranty
Because of the precision required in manufacturing loudspeakers to a consistent specified performance, we can confidently predict that the Achromat 400 will have a long and trouble-free life when correctly operated.

We can therefore offer a five-year warranty on this loudspeaker system.

Stand
The Achromat 400 will give its most accurate reproduction in normal conditions when spaced at a distance of 10–20 cms above the floor.

The Goodmans Loudspeaker Stand CS3 is recommended and gives the option of vertical or 5° tilt positioning.

Specification
Drive units
Bass unit 26cm dia long-throw
Mid-range unit 44mm dia viscous damped dome radiator. Flush mounted
HF unit 25mm dia viscous damped dome radiator. Flush mounted
Frequency range 40–22,000 Hz ± 5dB
Nominal impedance 8 ohms.
The loudspeaker is suitable for use with amplifiers rated at 4 or 8 ohms.
Recommended amplifier music power rating 25 to 75 Watts
Sensitivity 12 Watts for 96dB at 1 metre
Effective enclosure volume 39.5 litres
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Weight 16.5 kg (36 lbs) net
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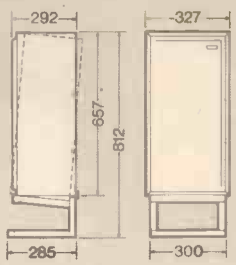

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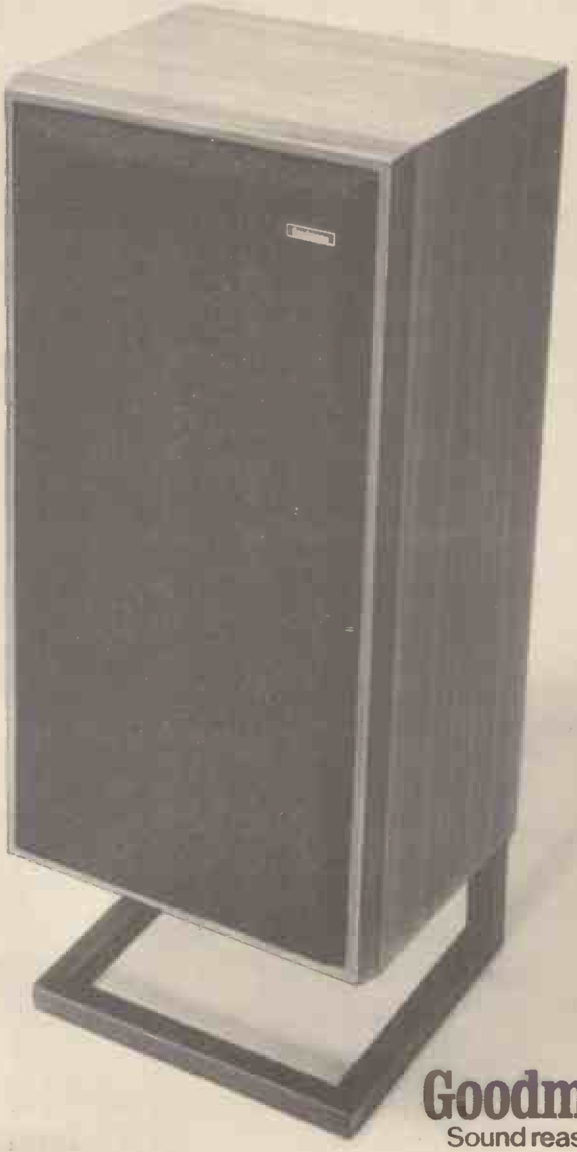

*from *Shorter Oxford Dictionary*
Achromatic 1. Optics–free from colour, not showing colour
2. Biol.–of tissue, uncoloured (1882) ie after staining
Achromatization–the action or process of removing colour

Goodmans
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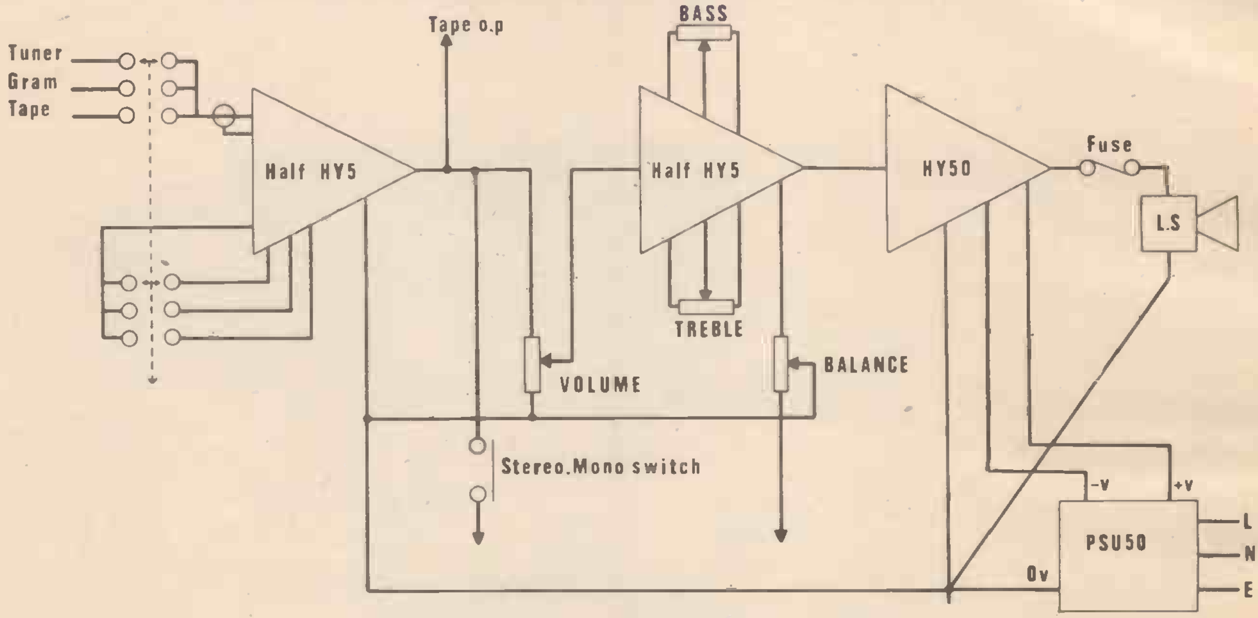
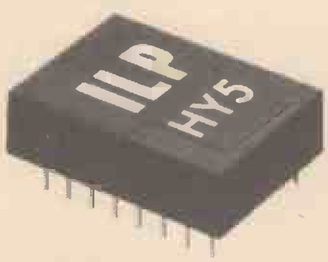


Mono electrical circuit diagram with interconnections for stereo shown



The HY5 is a complete mono hybrid preamplifier, ideally suited for both mono and stereo applications. Internally the device consists of two high quality amplifiers—the first contains frequency equalisation and gain correction, while the second caters for tone control and balance.

TECHNICAL SPECIFICATION

Inputs

Magnetic Pick-up	3mV. RIAA
Ceramic Pick-up	30mV
Microphone	10mV
Tuner	100mV
Auxiliary	3-100mV
Input impedance	47kΩ at 1kHz.

Outputs

Tape	100mV
Main output	Odb (0.775 volts RMS)

Active Tone Controls

Treble	±12db at 10kHz
Bass	±12db at 100Hz

Distortion	0.05% at 1kHz
Signal/Noise Ratio	68db
Overload Capability	40db on most sensitive input
Supply Voltage	±16—25 volts.

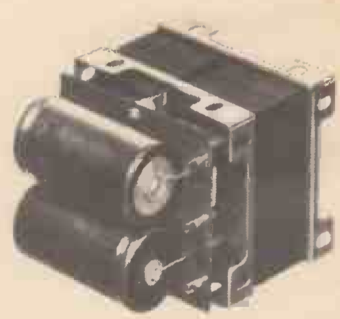
PRICE £4.50 + 0.36 V.A.T. P & P free.

The HY50 is a complete solid state hybrid Hi-Fi amplifier incorporating its own high conductivity heatsink hermetically sealed in black epoxy resin. Only five connections are provided: Input, output, power lines and earth.

TECHNICAL SPECIFICATION

Output Power 25 watts RMS into 8Ω
Load Impedance 4—16Ω
Input Sensitivity Odb (0.775 volts RMS)
Input Impedance 47kΩ
Distortion Less than 0.1% at 25 watts typically 0.05%
Signal/Noise Ratio Better than 75db
Frequency Response 10Hz—50kHz ± 3db
Supply Voltage ± 25 volts
Size 105 x 50 x 25 mm.

PRICE £5.98 + 0.48 V.A.T. P & P free.



The PSU50 can be used for either mono or stereo systems.

TECHNICAL SPECIFICATIONS

Output voltage	25 volts
Input voltage	210—240 volts
Size	L. 70, D. 90, H. 60 mm.

PRICE £5.00 + 0.40 V.A.T. P & P free.

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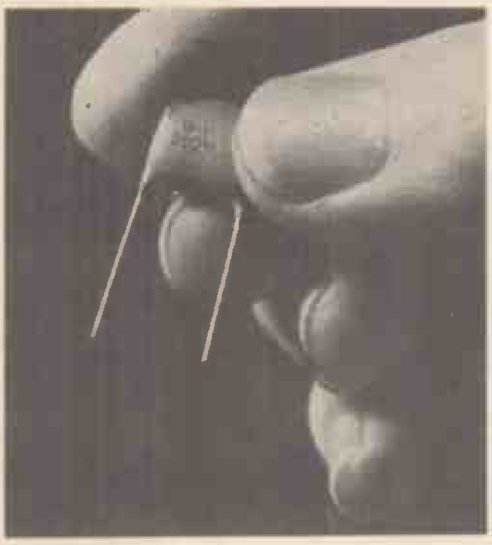
ERIE NEWSFLASH!

New! Straight–lead metallised Polyester Film Capacitors

* small package
* prompt delivery
* low inductance

These latest additions to the Series 51016 range come in four working voltages (160 Vdc-630 Vdc), have a capacitance range of 0.01 μF to 10 μF and have a flame-retardent and solvent-resistant coating. Kinked lead versions for p.c. board stand-off also available.

Axial lead requirements can also be met from Series 61013 and 51012 ranges.



Improved Ratings on Aluminium Electrolytic Capacitors

* **early delivery**
* **high ripple current capability**
* **high temperature ratings**
* **high capacitance-to-size ratio**

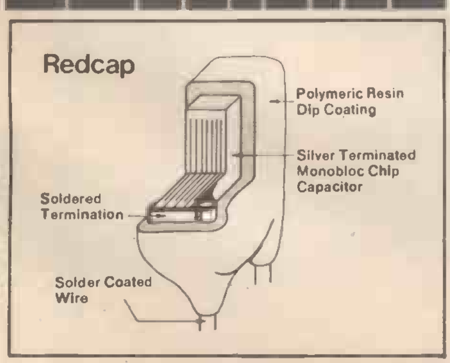
Tubular Polarised (types 201 and 211) manufactured to BS 9078-NOO1 and to DIN 41332 Ripple rating standards with temperature ratings up to 85°C.

General Purpose Polarised (types 311, 312 Dual Section and 321), first introduced in 1973 as a concise yet wider range to conventional sizes. Now being stocked in much larger quantities to meet growing demand. Eight working voltages (6.3 Vdc-160 Vdc) at 85°C with improved ripple current capability.

Transcap Miniature Ceramic Disc Capacitors

* **high capacitance-to-size ratio** * **low cost**
* **early delivery** * **10,000 pF-0.22 μF.**

Primarily for decoupling applications, these Transcaps, together with the standard temperature-compensating, Hi-K and High Voltage devices offer complete disc ceramic capability.



'Monobloc' Monolithic Ceramic Capacitors

* **high capacitance**
* **good delivery** * **premium quality**

Designed for professional applications where size and stability of performance are paramount.

Available in BS 9000 approved moulded finish as well as dipped ('Redcap') and chip configurations. Ideally suited for coupling and decoupling of integrated circuits.

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For quantities of up to 1000 Transcaps, Monoblocs and Aluminium Electrolytic Capacitors ex stock and, in due course, for the new Straight Lead Polyester Film Capacitors contact our Supplies Division.

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COMMUNICATIONS CONTACT!

4 PAGES of news from **Mullard**

Wide range of TTL to Post Office Spec

The Mullard range of TTL integrated circuits approved and provisionally approved to the stringent Post Office Specification D3000 now comprises 22 types. They are being supplied to Post Office contractors and are to be offered to other equipment manufacturers who are concerned with very high standards of reliability.

All types in the D3000 range are functionally equivalent to types in the well-known GFB7400D series. Encapsulation is ceramic 14- and 16-lead dual-in-line.

The specification includes important overstress and endurance tests with exacting internal inspection requirements. It assures an extremely high standard of reliability and long life performance, and users can expect a component life of forty years with cumulative failures not greater than 2 per cent. For a leaflet summarising the range use reader enquiry service no. WW069.

NEW MODULES FOR MOBILES

The highly successful u.h.f. amplifier modules manufactured by Mullard are to be followed up by two v.h.f. types. These are type numbers 437BGY and 438BGY covering the frequency ranges 148–174MHz and 68–88MHz respectively.

Apart from their frequency range, both the v.h.f. modules provide the same performance: minimum output power 18W for an input of 150mW with a typical efficiency of 45%. Input and output impedances are 50Ω, and the nominal supply voltage is 12·5V.

Among the operational features are the ability to withstand severe load mismatch and the provision for control of the output power by variation of the supply voltage. The operating temperature range is from –40° to +90°C.

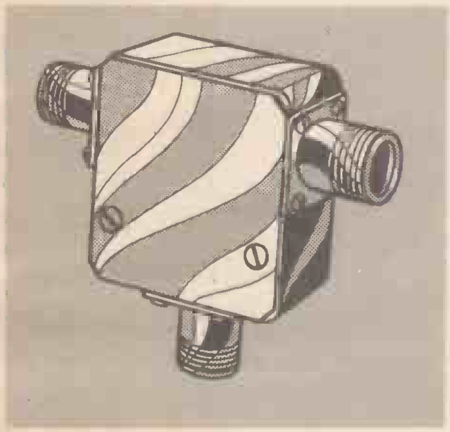
By basing equipment on the modules, manufacturers can cut design time and also reduce the number of assembly operations. Furthermore, as the modules are untuned, no adjustment is needed in the test room. For provisional data please use reader enquiry service no. WW070.

Photograph by kind permission of New Scotland Yard.

Mullard Communications Contact

Space-saving circulators

Significant savings in space and weight can be made in communications and radar equipment by using Mullard miniature circulators. Despite their small size, they feature the same low-loss characteristics and wide bandwiths as their full-size counterparts.



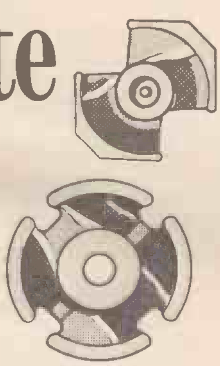
There are eight ferrite 3-port types capable of handling up to 300W in the u.h.f. region, and four microwave types rated at 50W.

The u.h.f. types are divided into 100W and 300W families. Bandwidths fall within the spectrum 470 to 1000MHz, and isolation is typically 25dB. Connectors are N-type with the option of HF 7/16 DIN 47223 connectors for the high power circulators.

The four microwave circulators are broadband types providing coverage through the S, C and X bands, and isolator versions are available of each type. Isolation depends on the band and is typically between 23 and 27dB. Connectors are SMA coaxial.

For further information please use reader enquiry service no. WW072.

Which Ferrite Core?

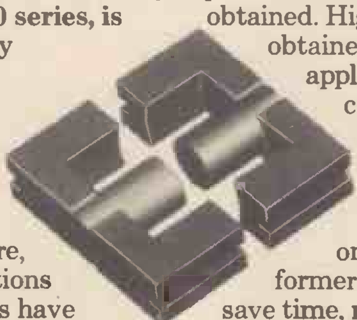


A useful aid to finding the right type of ferrite inductor or transformer core for any particular application is provided by a new wallchart from Mullard. All preferred design types in their various shapes, sizes and materials are clearly summarised. For a copy please use reader enquiry service no. WW071.

NEW CORES SPECIFICALLY FOR SWITCHED MODE POWER

Designers of switched mode power supplies no longer have to use transformer cores of a material and shape which are meant for quite different applications. A new range of ferrite cores being introduced by Mullard, the FX3700 series, is intended specifically for the job.

Insulation and safety, the special stresses of switched mode operation, winding economics, modes of circuit failure, mechanical specifications and BSI requirements have all been carefully considered in the design.



The cores may be used in units where the input is derived from rectified mains or from batteries, and are suitable for designs covering a wide range of outputs. When used in 25kHz push-pull circuits at the unfavourable end of the application spectrum (supplying low voltage, 5V, output) d.c. output powers from 50W to 500W can be obtained. Higher outputs can be obtained in more favourable applications, and the cores can, of course, also be used in single-ended circuits.

An application note is available which not only simplifies transformer design but helps to save time, money and trouble elsewhere in the circuit. For a free copy and data on the cores please write to Dept. C.I.H., Ref: CPS/C23, Mullard Ltd., New Road, Mitcham, Surrey CR4 4XY.

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JUST THE WAY YOU WANT THEM

You can get Mullard 400mW and 1W Zeners selected for voltage and other parameters to meet your own exact specifications. Voltages can be within 1% if you want them that way.

Quantities of up to 2,000 can be supplied with fast delivery through the Mullard SOSWIFT Service. Bulk selections of over 2,000 pieces can be made to negotiated delivery times through the SELECT 61, 79 and 88 Services.

400-MILLIWATT TYPES

BZY88: DO-7 glass encapsulation
2·7 to 36V
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BZX79: DO-35 miniature glass encapsulation
4·7 to 75V
SELECT 79 Bulk Selection Service

1-WATT TYPES

BZX61: DO-15 plastic encapsulation
7·5 to 75V
SOSWIFT Service and SELECT 61 Bulk Selection Service

Mullard

Please use reader enquiry service no. WW073 for data on all of the above types.

Linear power for S.S.B.

Three highly linear r.f. power transistors for single-sideband applications from manpacks to ship-to-shore transmitters are available from Mullard.

In all three the intermodulation products are typically more than 30dB down on full rated output. Under some conditions this figure is even better than 40dB. Furthermore, all three are electrically rugged and can withstand severe load mismatch.

The most powerful member of the family is the BLX15. Operating from supplies of up to 50V in the range 1·6 to 28MHz, it can supply 150W p.e.p. singly or 300W p.e.p. in push-pull. Also, the full power rating is maintained up to 108MHz in the c.w. mode.

The two companion types, the BLX13 and BLX14, operating from 24/28V supplies over the range 1·6 to 28MHz can supply p.e.p. outputs of 25W and 50W respectively.

All three transistors are in plastic 'capstan' packages. For full data please use reader enquiry service no. WW074.

Key to colour camera tv reliability

Millions of burning hours are being registered by Plumbicon* colour camera tubes in television broadcasting in the U.K. Some programme companies are reporting lives of over 7,000 hours. In telecine equipment, lives of over 10,000 hours are not uncommon.

If you are 'tubing up for colour', Plumbicon tubes from Mullard are a wise choice. There are 36 types to choose from. Use reader enquiry service no. WW075 for a wallchart.

**Registered trademark for television camera tubes.*

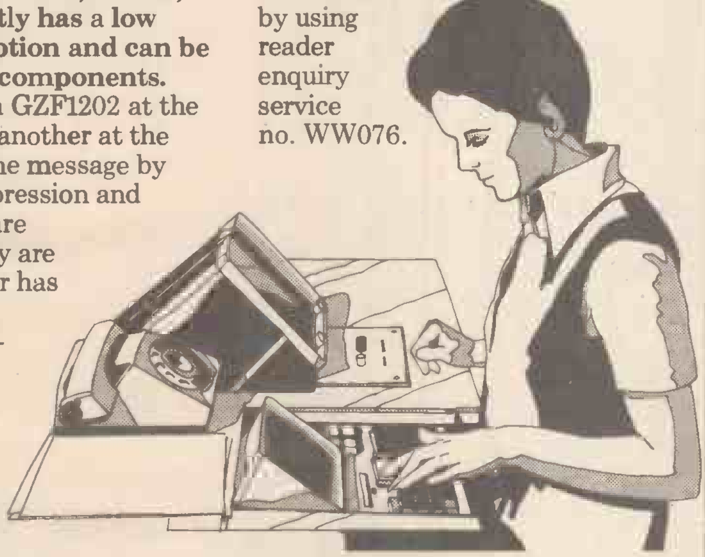
Mullard Communications Contact

SINGLE-CHIP ERROR DETECTOR

What is virtually a complete sophisticated error detection system is contained in one 18-lead DIL integrated circuit recently announced by Mullard. Designated type GZF1202, it is a LOCMOS (local oxidised silicon complementary MOS) device, and consequently has a low power consumption and can be used with TTL components.

In operation, a GZF1202 at the transmitter and another at the receiver divide the message by a polynomial expression and the remainders are compared. If they are different, an error has occurred. The message is transmitted in its original form with the remainder added to the end.

The GZF1202 provides for the use of six standard polynomials, and is thus suited for use in a variety of applications from modem interfaces to peripheral equipment such as disc stores. Samples of the IC are available for evaluation and data can be obtained by using reader enquiry service no. WW076.



A HUNDRED-THOUSAND TIMES BRIGHTER

Image intensifiers which enable you to see on an overcast moonless night, by amplifying light by as much as 100,000 times, are fully-engineered items in regular production at Mullard.

The intensifiers manufactured include single- and multi-stage electrostatically focused types and electrostatically focused microchannel inverter types. For information on the range and its special features use reader enquiry service no. WW077.

Contact Column

SECOND GENERATION BROADBAND TRANSISTORS

The Mullard company is no newcomer to the supply of components for TV distribution systems and similar applications. For nearly a decade it has made available broadband transistors, and types such as the BFY90, BFW30 and BFW16A are now well established.

With demands for lower and lower cross-modulation distortion and more and more channel capacity, a second generation of Mullard broadband transistors has appeared. Prominent among them is the BFR94. This has an f_T of 3GHz which is maintained at currents up to the unusually high region of 125mA. In this transistor, low cross-modulation, inter-modulation and second-order distortion are combined with excellent broadband and low-noise performance.

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Another second-generation broadband device, the BFR96, can be used to drive the BFR94. It covers the range 40 to 860MHz, power gain is typically 8dB and typical output voltage is 600mV. Other types of transistor of similar interest are the BFR90 to BFR93. Data on all types mentioned can be obtained through the reader enquiry service no. WW078. *by 'Electron'*

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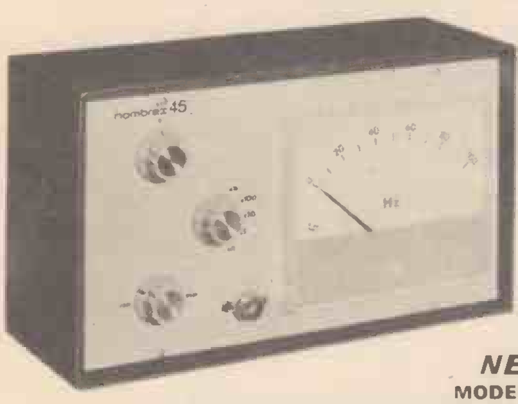

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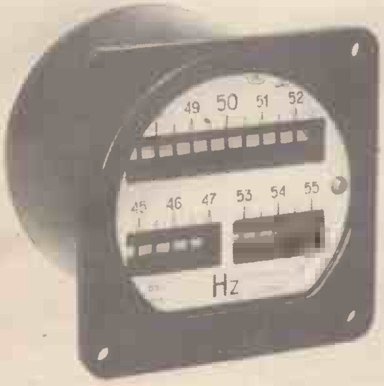

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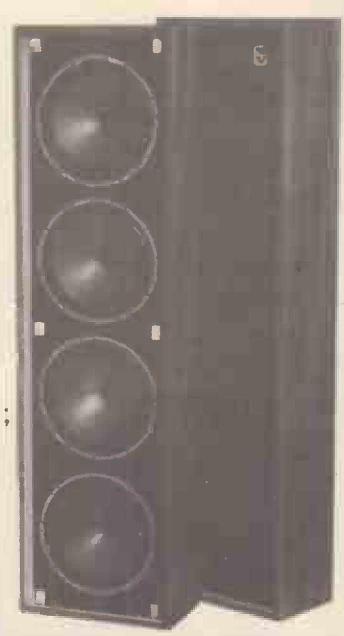

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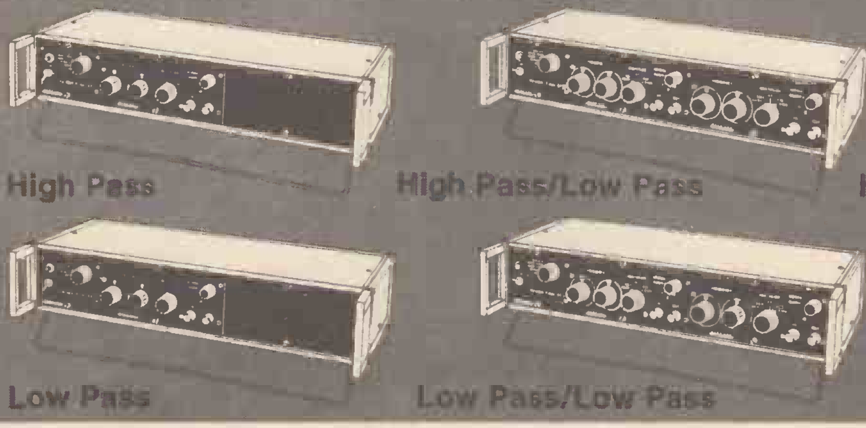

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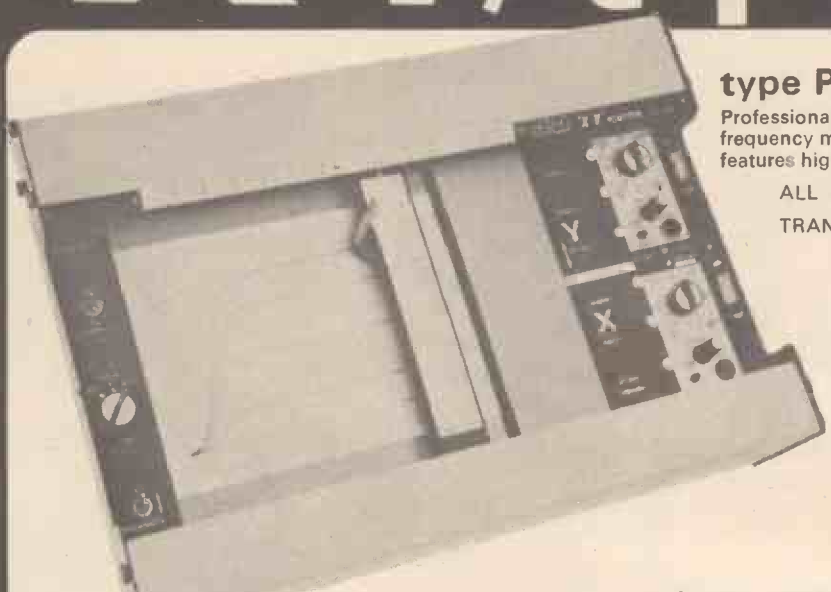

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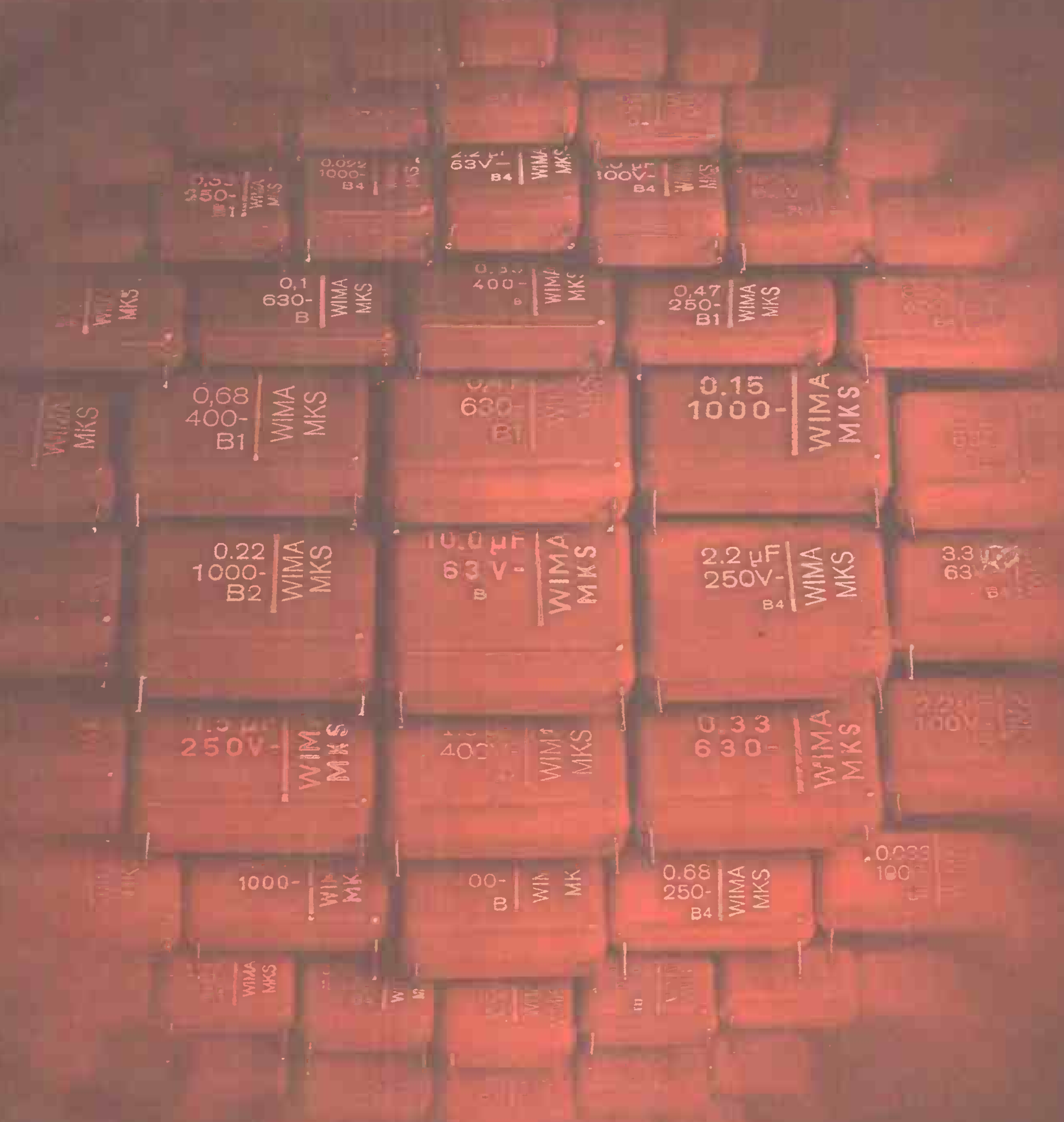

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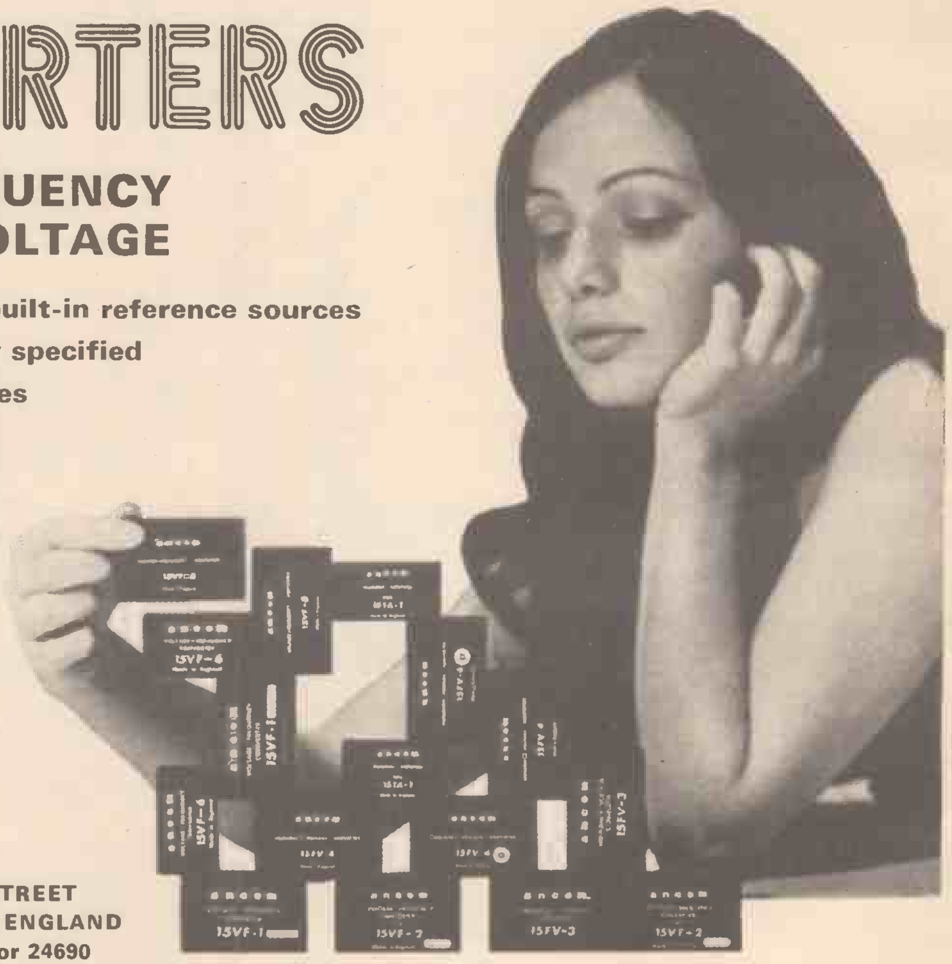

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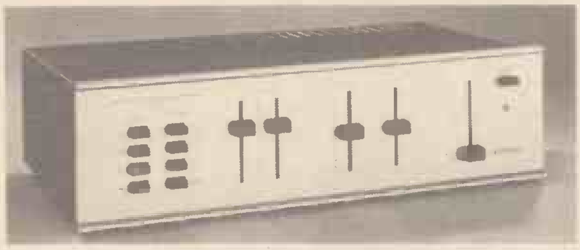

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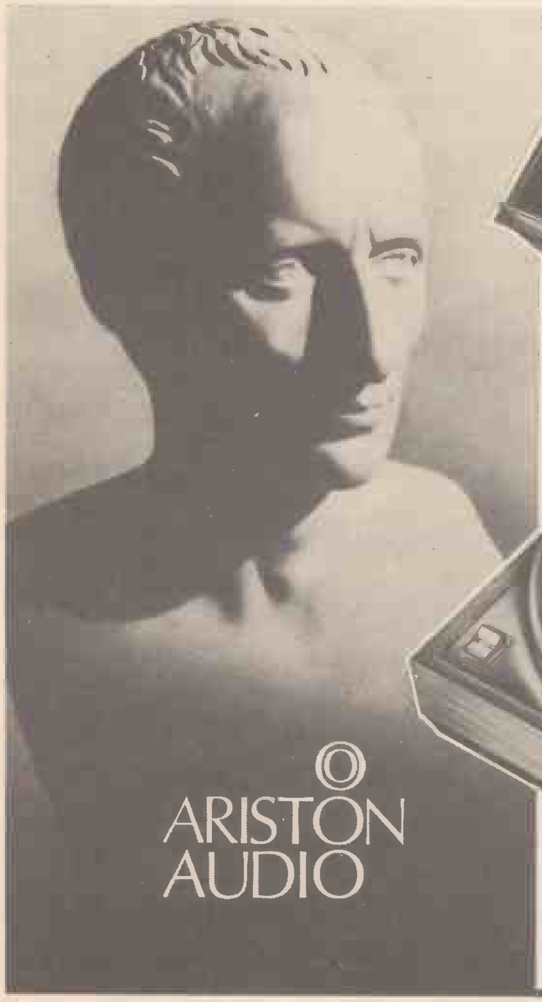

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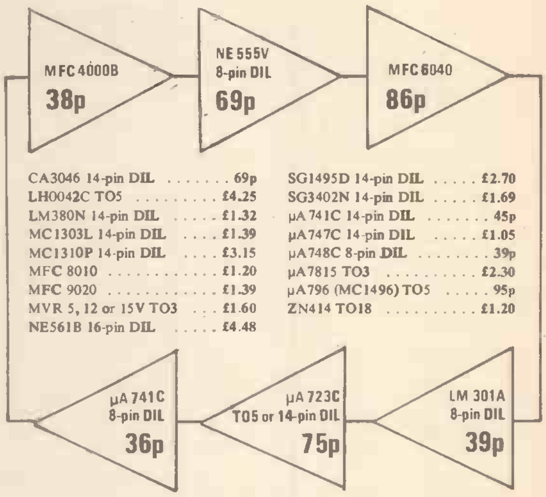

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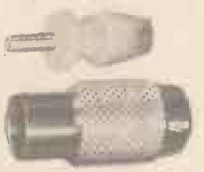

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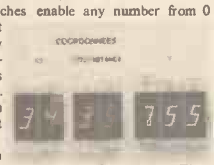

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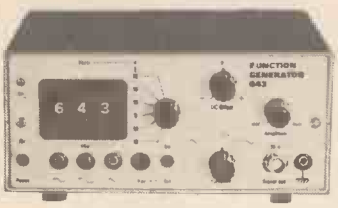

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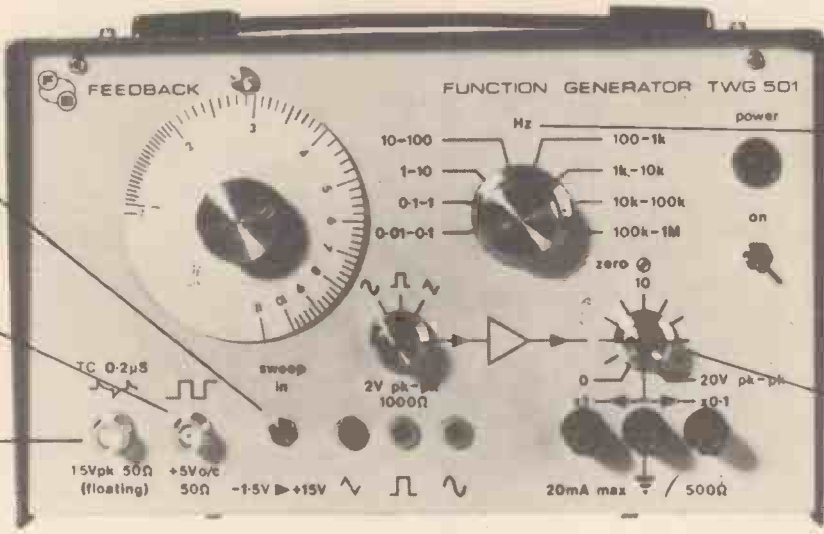

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or 0 to 30V @ 2A
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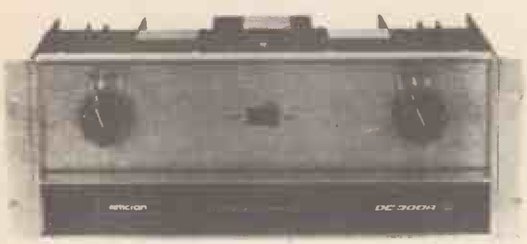
Coutant take the initiative in new technology

WW—102 FOR FURTHER DETAILS

HIGH POWER DC-COUPLED AMPLIFIER



- ★ UP TO 500 WATTS RMS FROM ONE CHANNEL
- ★ DC-COUPLED THROUGHOUT
- ★ OPERATES INTO LOADS AS LOW AS 1 OHM
- ★ FULLY PROTECTED AGAINST SHORT CCT, MISMATCH, ETC.
- ★ 3 YEAR WARRANTY ON PARTS AND LABOUR

The DC300A Power Amplifier is the successor to the world famous DC300 which is so widely used in Industrial, and Research applications in this country. It is DC-coupled throughout so providing a power bandwidth from DC to over 20,000Hz.The ability of the DC300A to operate without fuss into totally reactive loads while delivering its full power, and maintaining its faithful reproduction of Pulse or complex waveforms has established the DC300A as the world's leading power amplifier. Each of the two channels will operate into loads as low as 1 ohm, and the amplifier can be rapidly connected as a single ended amplifier providing over 650 watts RMS into a 4 ohms load, and still providing a bandwidth down to DC. Below is a brief specification of the DC300A, but if you require a data sheet, or a demonstration of this fine equipment please let us know.

Power Bandwidth	DC-20kHz @ 150 watts + 1db, − 0db.	Slewing Rate	8 volts per microsecond
Power at clip point (1 chan)	500 watts rms into 2.5 ohms	Load impedance	1 ohm to infinity
Phase Response	+0, −15′ DC to 20kHz, 1 watt 8Ω	Input sensitivity	1.75 V for 150 watts into 8Ω
Harmonic Distortion	Below 0.05% DC to 20kHz	Input Impedance	10K ohms to 100K ohms
Intermod. Distortion	Below 0.05% 0.01 watt to 150 watts	Protection	Short, mismatch & open cct. protection
Damping Factor	Greater than 200 DC to 1kHz at 8Ω	Power supply	120-256V, 50-400Hz
Hum & Noise (20-20kHz)	At least 110db below 150 watts	Dimensions	19" Rackmount, 7" High, 9¾" Deep

Other models in the range: D60 — 60 watts per channel D150 — 150 watts per channel

MACINNES LABORATORIES LTD
MACINNES HOUSE, CARLTON PARK INDUSTRIAL ESTATE, SAXMUNDHAM, SUFFOLK IP17 2NL
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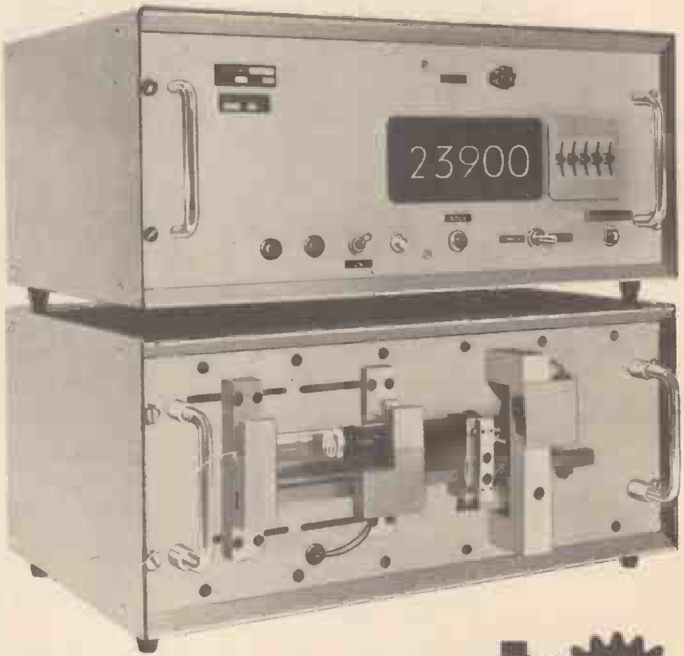

DIGITAL SYRINGE TYPE DS110

Fluid pulse 1·0 or 10 micro litres
Number of pulses presettable from 1–50,000
Pulse rate 400Hz–1 Hz or ·01 Hz in the case of frequency divider model
Digital 'fluid delivered' display monitors output at all times
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OTHER ITEMS MANUFACTURED BY McLENNAN ENGINEERING INCLUDE:

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Peristatic pumps
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COLOUR TELEVISION SERVICING

GORDON J. KING,

RTechEng, MIPRE, FSRE, MRTS, FISTC

This comprehensive book deals straightforwardly with the servicing of PAL receivers, using a minimum of mathematics.

It is divided into three sections: the first surveys the colour TV system as a whole, the second studies the elements involved (e.g. picture tubes, conveyance systems, chroma channels) and the third is devoted exclusively to servicing.

0 408 00044 9 328 pages illustrated 1971
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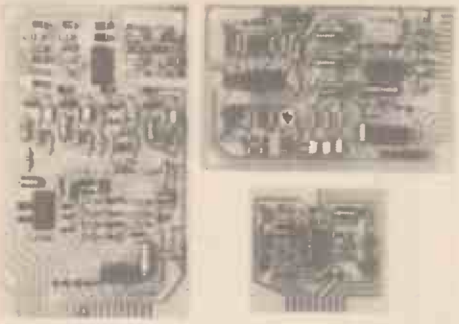
SQ IS A TRADEMARK OF CBS INC.



SQ QUADRAPHONIC DECODERS

SQ the leading quadraphonic system, designed by CBS engineers, offers not only 4 channel ambiophony from the fast expanding range of SQ encoded discs but also immensely increased depth and fullness of sound from standard stereo recordings too.

Feed 2 channels (200–1000mV as obtainable from most pre-amplifiers) into your choice of any 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, LB–RB and Dimension controls can all be implemented by simple single gang potentiometers—no need for exotic 4-gang units!

These state-of-the-art circuits, used under licence from CBS, are offered in kit form comprising first grade components only—fibre glass circuit boards of professional quality designed for edge connector insertion, all resistors 2% metal oxide, all polystyrene and polycarbonate capacitors 5% or better and in decoder L2 ultra low noise (MPS A18–0.5dB typ.) transistors used in each amplifying stage.

M1 Basic matrix decoder with fixed '10–40' blend. 10 Resistors, 14 Capacitors, 1 Integrated Circuit, Printed Circuit Board. **£6·54.**

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All kits include IC sockets and construction notes. Prices include CBS licence fee.

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United Kingdom: Post Free. Please add 8% VAT. Overseas: No VAT. Please add (per kit) £1·50 p & p AIR MAIL or 80p p & p SURFACE MAIL.

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Send 5p stamp for illustrative brochure and price sheet.

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Tel. 01-898 1569

WW—203 FOR FURTHER DETAILS

STEREO IC DECODER

HIGH PERFORMANCE PHASE LOCKED LOOP
(as in 'W.W.' July '72)

MOTOROLA MC1310P EX STOCK DELIVERY

SPECIFICATION

Separation: 40dB 50Hz-15kHz. Distortion: 0·3%
I/P level: 560mV rms O/P level: 485mV rms per channel.
Input impedance: 50kΩ. Power requirements: 8-16V at 16mA
Will drive up to 75mA stereo 'on' lamp or LED.

KIT COMPRISES FIBREGLASS PCB (Roller tinned), Resistors, I.C., Capacitors, Preset Potm. & Comprehensive Instructions — ONLY **£3·98** — WHY PAY MORE? post free.

LIGHT EMITTING DIODE Suitable as stereo 'on' indicator for above — RED 29p, GREEN 59p

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NOTE
As the supplier of the first MC1310P decoder kit, of which we have sold literally thousands, our customers can benefit from our wide experience.

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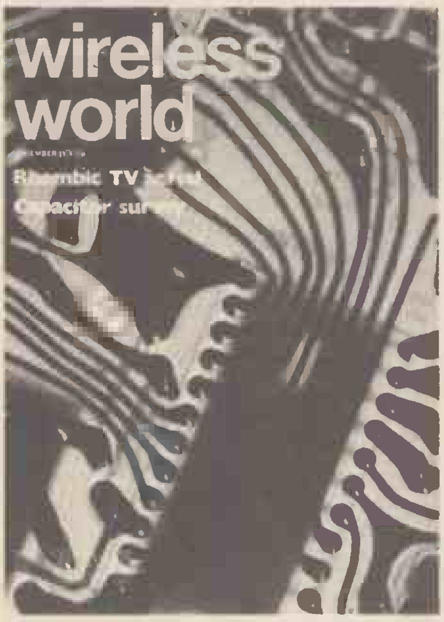
DM63

wireless world

Electronics, Television, Radio, Audio

DECEMBER 1974 Vol 80 No 1468

SIXTY-FOURTH YEAR OF PUBLICATION



This month's front cover shows part of a printed circuit of Sphericall, a Pye TMC l.s.i. device for push-button telephone dialling.
(Photographer Paul Brierley)

Contents

IN OUR NEXT ISSUE
(published December 18)

Electronics and oil. An inside view of the communications, telemetry and navigational aids used in drilling for North Sea oil

Silent switch for stereo-pair comparisons. Construction of an f.e.t. electronic switch that meets stringent requirements

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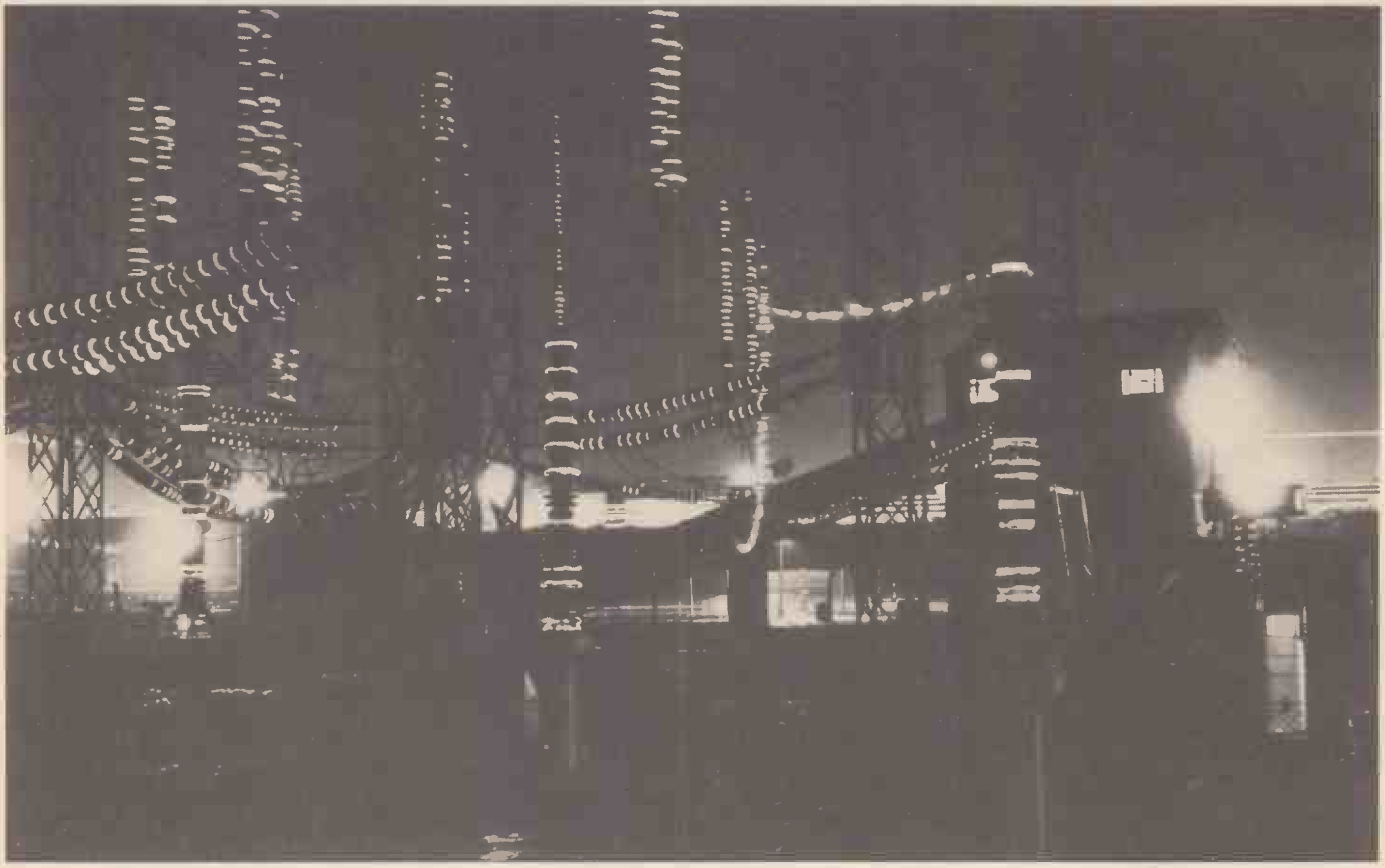
When flashover is the danger. Use EEV spark gaps.



Photograph courtesy of C.E.G.B.

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Our range covers any voltage from 400-40,000V and handles powers up to 15 kilo joules. Types are available in glass or ceramic envelopes.

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For data and any help you need, write or 'phone EEV at the address below.

Right, GXQ400, a crowbar protection device and GXU40, for protection circuits in ground/air communications equipment.

LAP 93

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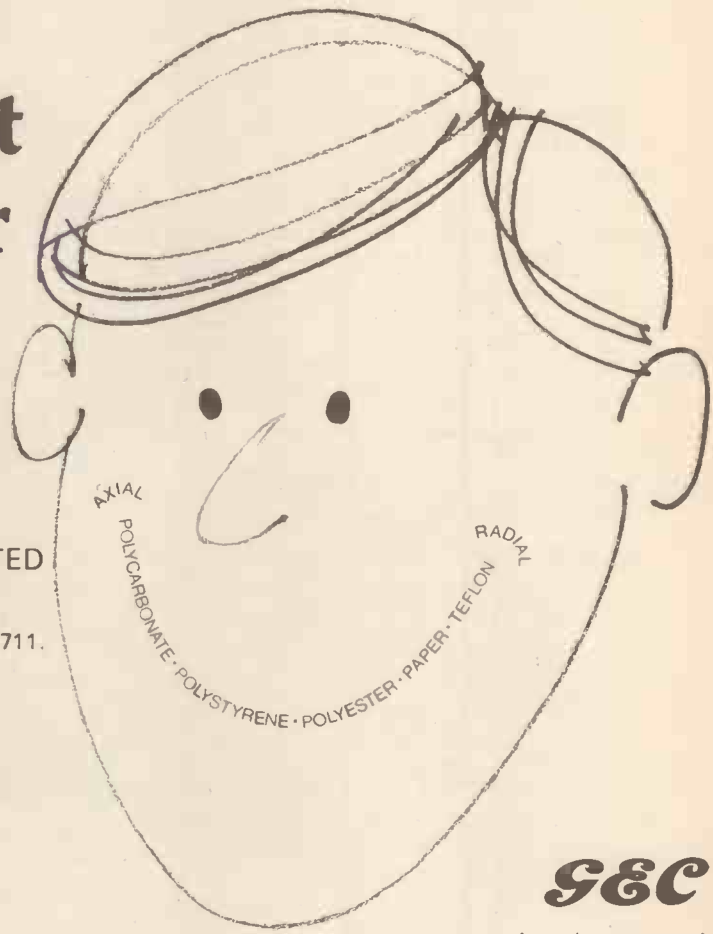

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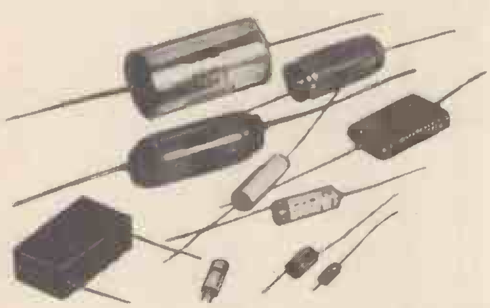

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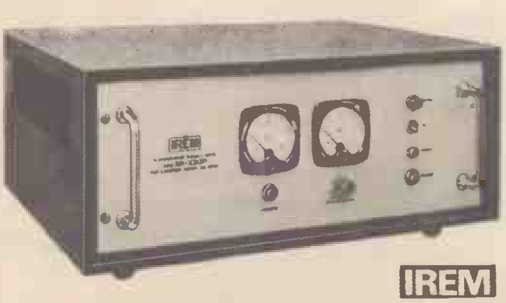

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Now–two fascinating ways to enjoy saving money!

NEW! Sinclair Scientific kit £19.95 (INC. VAT)

Britain's most original calculator now in kit form
The Sinclair Scientific is an altogether remarkable calculator.

It offers logs, trig, and true scientific notation over a 200-decade range – features normally found only on calculators costing around £100 or more.

Yet even ready-built, the Sinclair Scientific costs a mere £32.35 (including VAT).

And as a kit it costs under £20!

Forget slide rules and four-figure tables!
With the functions available on the Scientific keyboard, you can handle *directly*

- sin and arcsin,
- cos and arccos,
- tan and arctan,
- automatic squaring and doubling,
- $\log_{10}$, antilog_{10}, giving quick access to x^y (including square and other roots),
- plus, of course, addition, subtraction, multiplication, division, and any calculations based on them.

In fact, virtually all complex scientific or mathematical calculations can be handled with ease.

So is the Scientific difficult to assemble?
No. Powerful though it is, the Sinclair Scientific is a model of tidy engineering.

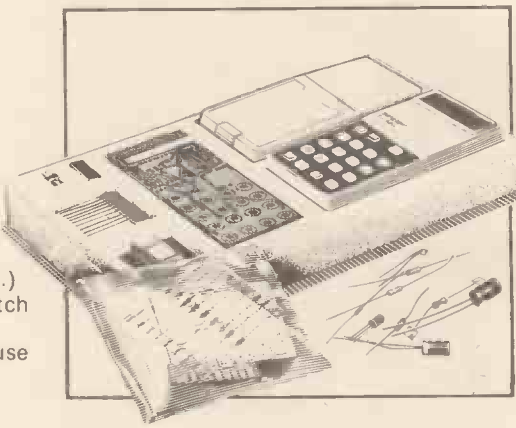
All parts are supplied – all you need provide is a soldering iron and a pair of cutters. Complete step-by-step instructions are provided, and our Service Department will back you throughout if you've any queries or problems.

Of course, we'll happily supply the Scientific or the Cambridge already built, if you prefer – they're still exceptional value. Use the order form.

Components for Scientific kit (illustrated)

1. Coil
2. LSI chip
3. Interface chips
4. Case mouldings, with buttons, windows and light-up display in position
5. Printed circuit board
6. Keyboard panel
7. Electronic components pack (diodes, resistors, capacitors, etc.)
8. Battery assembly and on/off switch
9. Soft carrying wallet
10. Comprehensive instructions for use

Assembly time is about 3 hours.



Features of the Sinclair Scientific

- **12 functions on simple keyboard**
Basic logs and trig functions (and their inverses), all from a keyboard as simple as a normal arithmetic calculator's. 'Upper and lower case' operation means basic arithmetic keys each have two extra functions.

- **Scientific notation**
Display shows 5-digit mantissa, 2-digit exponent, both signable.

- **200-decade range**
10^{-99} to 10^{+99}

- **Reverse Polish logic**
Post-fixed operators allow chain calculations of unlimited length – eliminate need for an = button.

- **25-hour battery life**
4 AAA manganese alkaline batteries (e.g. MN 2400) give 25 hours continuous use. Complete independence from external power.

- **Genuinely pocketable**
4 1/3" x 2" x 11/16". Weight 4 oz. Attractively styled in grey, blue and white.

Sinclair Cambridge kit

Now only £14.95 (INC. VAT)

At its new low price, the original Sinclair Cambridge kit remains unbeatable value

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It's not surprising. Check the features below – then ask yourself what other pocket calculator offers such a powerful package at such a reasonable price.

Components for Cambridge kit

1. Coil
2. LSI chip
3. Interface chip
4. Thick film resistor pack
5. Case mouldings, with buttons, window and light-up display in position
6. Printed circuit board
7. Keyboard panel
8. Electronic components pack (diodes, resistors, capacitors, transistor)
9. Battery clips and on/off switch
10. Soft wallet

Assembly time is about 3 hours.

Take advantage of this money-back, no-risk offer today

The Sinclair Cambridge and Scientific kits are fully guaranteed. Return either kit within 10 days, and we'll refund your money without question.

All parts are tested and checked before despatch – and we guarantee any correctly-assembled calculator for one year. (This guarantee also applies to calculators supplied in built form.)

Simply fill in the preferential order form below and slip it in the post today.

Scientific
Price in kit form £19.95 inc. VAT.
Price built £32.35 inc. VAT.
Cambridge
Price in kit form £14.95 inc. VAT.
Price built £21.55 inc. VAT.

Features of the Sinclair Cambridge

- Uniquely handy package. 4 1/3" x 2" x 11/16", weight 3 1/2 oz.
- Standard keyboard. All you need for complex calculations.
- Clear-last-entry feature.
- Fully-floating decimal point.
- Algebraic logic.
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- Constant and algebraic logic combine to act as a limited memory, allowing complex calculations on a calculator costing less than £15.
- Calculates to 8 significant digits
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- Operates for weeks on four AAA batteries.

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Please send me
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☐ Sinclair Scientific built at £32.35
☐ Sinclair Cambridge kit at £14.95
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All prices include 8% VAT.

*I enclose a cheque for £ ....
made out to Sinclair Radionics Ltd, and crossed.

*Please debit my *Barclaycard/ Access account. Account number
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WW/12/74

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Sinclair Radionics Ltd, FREEPOST, St Ives, Huntingdon, Cambs. PE17 4BR.

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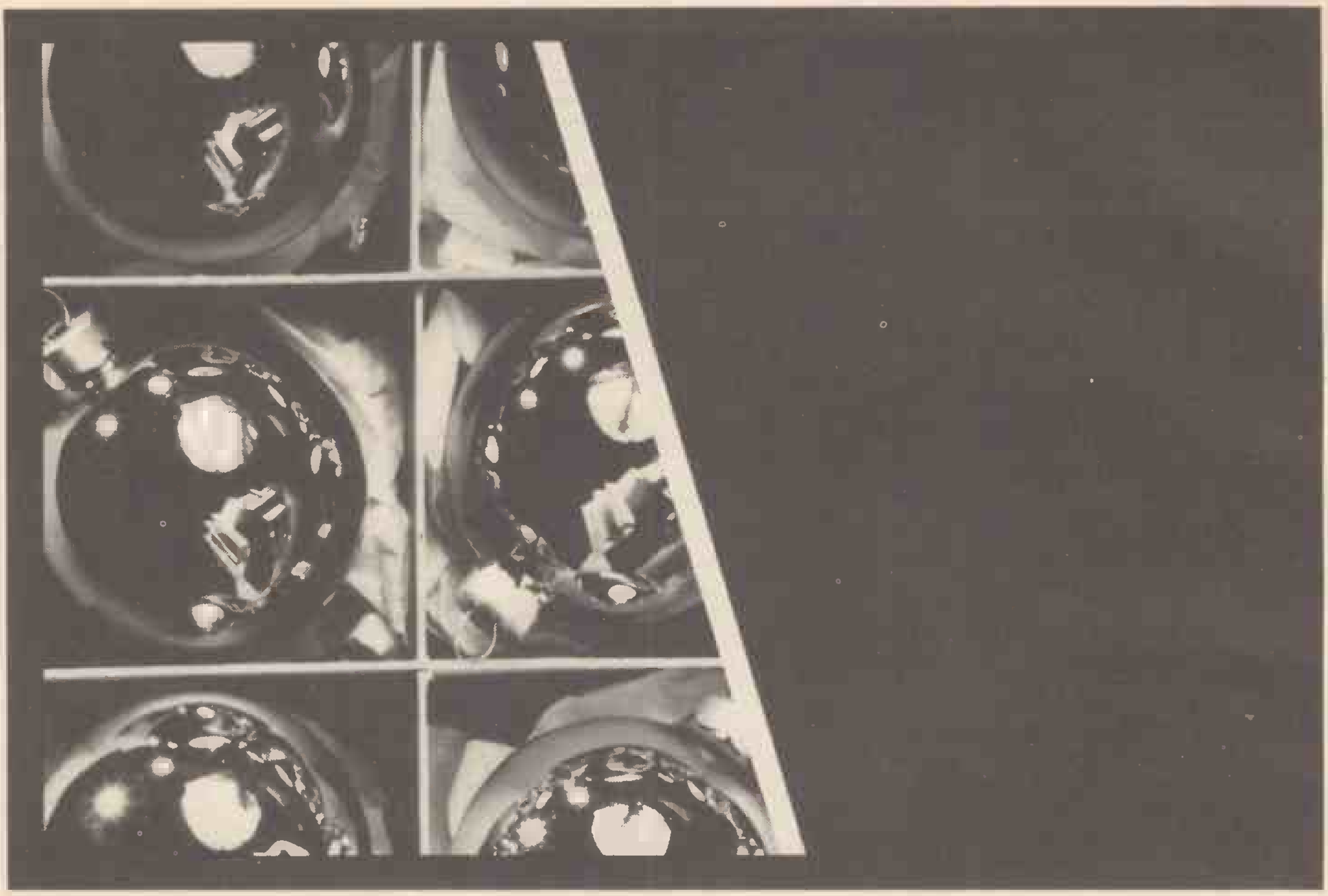

A cartridge in a pear tree.

What a superb Christmas Gift a Shure V-15 Type III would be! With it you could hear the true sound of pipers piping, drummers drumming, rings ringing. As the giver, you would make a Hi-Fi enthusiast supremely happy not only at Christmas time but throughout the years to come. As a last resort, if nobody else takes the hint, why not give one to yourself!

Shure Electronics Limited
Eccleston Road, Maidstone ME15 6AU
Telephone: Maidstone (0622) 59881

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BI-PRE-PAK

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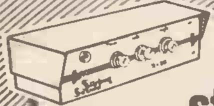


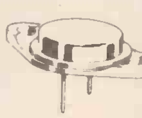
12 Watt stereo amp

Only **£10** 45p p & p SPECIAL OFFER LIMITED QUANTITY

6 watt music power each channel

This excellent little amplifier is of the latest integrated circuit design, and will work into 4, 8 or 16 ohm speakers. The reproduction is excellent for an amplifier of this size, only 8" × 3½" × 2". The case is made of chromed metal.

Tested and Guaranteed Paks



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The 'TACHO BLOCK'. This encapsulated block will turn any 0-1mA meter into a linear and accurate rev. counter for any car with nomal coil ignition system.

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Electronic Transistor Ignition £6.00

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Our new, vastly improved Mark Two Cross-Hatch Generator is now available. Essential for alignment of colour guns on all TV receivers. Featuring plug-in ICs and a more sensitive sync. pick-up circuit. The case is virtually unbreakable—ideal for the engineer's toolbox—and only measures 3" × 5¼" × 3".

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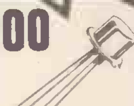

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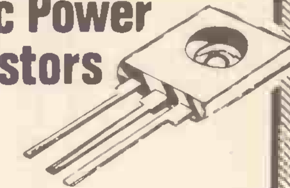

40 WATT SILICON

Type No.	Gain	VCE	Polarity	Price
40N1	15	15	NPN	20p
40N2	40	40	NPN	30p
40P1	15	15	PNP	20p
40P2	40	40	PNP	30p

90 WATT SILICON

Type No.	Gain	VCE	Polarity	Price
90N1	15	15	NPN	25p
90N2	40	40	NPN	35p
90P1	15	15	PNP	25p
90P2	40	40	PNP	35p

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7404	£0·18	£0·15	£0·12
7405	£0·18	£0·15	£0·12
7406	£0·375	£0·3125	£0·25
7407	£0·375	£0·3125	£0·25
7408	10·15	£0·125	£0·10
7409	£0·15	£0·125	£0·10
7410	£·015	£0·125	£0·10
7412	£0·195	£0·1625	£0·13
7413	£0·345	£0·2875	£0·23
7416	£0·345	£0·2875	£0·23
7417	£0·345	£0·2875	£0·23
7420	£0·15	£0·125	£0·10
7423	£0·27	£0·225	£0·18
7425	£0·27	£0·225	£0·18
7426	£0·27	£0·225	£0·18
7427	£0·27	£0·225	£0·18
7430	£0·15	£0·125	£0·10
7432	£0·25	£0·225	£0·18
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7446A	£1·05	£0·875	£0·70
7447	£1·05	£0·875	£0·70
7447A	£1·05	£0·875	£0·70
7448	£0·855	£0·7125	£0·57
7450	£0·15	£0·125	£0·10
7451	£0·15	£0·125	£0·10
7453	£0·15	£0·125	£0·10
7454	£0·15	£0·125	£0·10
7460	£0·15	£0·125	£0·10
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7474	£0·315	£0·2625	£0·21
7475	£0·465	£0·3875	£0·31
7476	£0·315	£0·2625	£0·21
7480	£0·435	£0·3625	£0·29
7482	£0·75	£0·625	£0·50
7483	£0·825	£0·6875	£0·55
7485	£1·275	£1·0625	£0·85
7486	£0·315	£0·2625	£0·21
7490	£0·465	£0·3875	£0·31
7492	£0·465	£0·3875	£0·31
7493	£0·465	£0·3875	£0·31

	1/99	100/499	500/1000
7494	£0·495	£0·4125	£0·33
7495	£0·63	£0·525	£0·42
7496	£0·72	£0·60	£0·48
74104	£0·315	£0·2625	£0·21
74105	£0·315	£0·2625	£0·21
74107	£0·315	£0·2625	£0·21
74121	£0·315	£0·2625	£0·21
74122	£0·45	£0·375	£0·30
74123	£0·63	£0·525	£0·42
74141	£0·75	£0·625	£0·50
74151	£0·69	£0·575	£0·46
74153	£0·69	£0·575	£0·46
74155	£0·69	£0·575	£0·46
74156	£0·69	£0·575	£0·46
74160	£1·005	£0·8375	£0·67
74161	£1·005	£0·8375	£0·67
74162	£1·005	£0·8375	£0·67
74163	£1·005	£0·8375	£0·67
74166	£1·425	£1·1875	£0·95
74174	£1·20	£1·00	£0·80
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KODAK RESIST COATED PRINTED CIRCUIT BOARD

BOARD SIZE	FIBRE GLASS												PAPER	
	1/32"—1 oz				1/32"—2 oz				1/16"—1 oz				1/16"—1 oz	
	Single Sided		Double Sided		Single Sided		Double Sided		Single Sided		Double Sided		Single Sided	
	Positive	Negative	Positive	Negative	Positive	Negative	Positive	Negative	Positive	Negative	Positive	Negative	Positive	Negative
75mm×100mm	14p	12p	15p	13p	8p	8p	8p	8p	16p	15p	14p	13p	8p	8p
100mm×150mm	27p	24p	29p	26p	15p	14p	19p	15p	33p	30p	29p	26p	15p	14p
150mm×200mm	53p	48p	56p	51p	30p	27p	37p	30p	66p	60p	60p	54p	30p	27p
200mm×250mm	88p	80p	92p	84p	51p	45p	63p	51p	£1·10	£1·00	£1.02	92p	51p	45p
250mm×250mm	£1·10	£1·00	£1·15	£1·05	65p	55p	80p	65p	£1·38	£1·25	£1·30	£1·15	65p	55p
12" × 6"	80p	70p	85p	75p	55p	45p	65p	55p	£1·00	90p	£1·10	£1·00	55p	45p
12" × 12"	£1·60	£1·40	£1·65	£1·45	£1·05	85p	£1·25	£1·05	£1·95	£1·75	£2·10	£1·90	£1·05	85p

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TEST SET FREQUENCY RESPONSE CT381
Consisting of: sweep generator, indicator response curve, flat-faced tube long persistance. Power supply. Calibrator frequency CT432. Frequency range: 10kc/s–33Mc/s in nine directly calibrated ranges. Accuracy ±3% of the indicated centre frequency. F.M. deviation: (nominal). 0–500kc/s above—4Mc/s. 0–400kc/s at 1.5Mc/s—4Mc/s. 0–165kc/s at 600kc/s— 1.5Mc/s. falling to 3kc/s at 10kc/s. Output impedance: 75 ohms resistive. Power supplies: Mains 100–120V and 180–250V. Frequency 50–500c/s. Consumption 340W (nominal). Price **£195**. **Belling Lee** radio frequency interference filter type Y2005S. 100 Amps. 400W. 440V. Single wave **£15**.

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1858. 1GHz SAMPLING OSCILLOSCOPE.
Horizontal Sweep speeds: 10 ranges. 10 nsec/cm to 10 sec/cm, accuracy within ±5%. Magnification: 7 calibrated ranges X1. X2. X5. X10. X20. X50 and X100. Increases maximum calibrated sweep speed to 0.1 nsec/sm: with vernier maximum sweep speed is further extended to 0.04 nsec/cm. Intensity and sampling intensity are not affected by magnification. High frequency: Input frequency: 50 to 1000 mc for sweep speeds 200mv and 1000mv: ±3%. Time: Approximately 5 sec burst of 50 mc sinewave. Frequency accuracy ±2%. In addition the Model 1858 provides output signals for X-Y recorders and provides means for controlling the display either manually or externally. Full specification on request.
Price **£295**.

430C Microwave power meter.	**£60**
H01-8401A Leveller amplifier.	**£39**
8709A Synchronizer.	**£120**
8734B Pin modulator 7.0–12.4GC.	**£95**
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8436A Bandpass filter 8–12.4GC.	**£95**
185A 800MHz Sampling oscilloscope.	
185B Sampling oscilloscope.	

L30047 CAMBRIDGE UNIVERSAL BRIDGE.
Measures DC resistance, self-inductance, mutual inductance, capacity and frequency. Full specification on request. **£95**.

Voltmeter Valve CT54 (Micovac). with mains power supply (power supply not available separately). In strong metal case with full operating instructions. 2.4V–480V AC or DC in 6 ranges. 1 ohm to 10 Megohm in 5 ranges. Indicated on 4 in. scale meter. Complete with probe. **£12.50** including p. and p. (Leads extra.)

TEKTRONIX

NON-PLUG-IN UNIT OSCILLOSCOPE.
515A. DC–15MHz. **£150.**
524AD. DC–10MHz. **£100.**
MAIN FRAME OSCILLOSCOPES:
543. DC–30MHz. 547. DC–50MHz.
545. DC–30MHz. 545A. DC–30MHz.
545B. DC–33MHz. 551. DC–27MHz.
PLUG-IN UNITS.
Type 1A 1.50mV/cm to 20V/cm5mV/cm. } Not available
Type 1A 2.50mV/cm to 20V/cm. } separately.
Type B. 0.005V/cm to 20V/cm. 0.05V/cm to 20V/cm.
Type CA. 0.05V/cm to 20V/cm.
Type D. 1mV/cm to 50V/cm. Type G. 0.05V/cm to 20V/cm.
Type L. 5mV/cm to 2V/cm. 0.05V/cm to 20V/cm.
Type M. 0.02V/cm to 10V/cm.
230 DIGITAL UNIT.
Digital readout parameters. Pulse amplitude, pulse risetime and falltime, pulse width, time interval.
R116. 10-NS PROGRAMMABLE PULSE GENERATOR
with Delay.
PASSIVE PROBE P6006 with 10X attenuation, designed for oscilloscopes having an input resistance of 1 megohm and input capacitance of up to 55pf. Price **£10.**
PROBE P6065 10X. 10 megohm. 12.5pf. 500V D.C. max. Length 6ft. Price **£15.**

MUIRHEAD FREQUENCY ANALYSER TYPE D-669-B.
Frequency range 30c/s–30kc/s. Accuracy better than 1.5%. Input voltage 300μV–100V for full scale deflexion. Smallest indication 15μV. Maximum input voltage 300V r.m.s. Price **£95**. Full spec. on request.

MUIRHEAD 2-PH. L.F. DECADE OSCILLATOR Type D880.
Frequency range 0.01c/s–11.2kc/s (continuously variable above 0.1c/s).
V.L.F. 0.01c/s–0.1c/s in steps of 0.01c/s. Hourly frequency stability.
Ranges X1. X10. X100 ±0.05% } After
Ranges X0. 1. V.L.F. ±0.1 } 3 hours.

T.F.801D/1/S A.M. SIGNAL GENERATOR.
Freq. range: 10 MHz to 485 MHz. Built-in crystal calibrator. Internal and external sine a.m. External pulse modulation. Calibration Accuracy: Using crystal calibrator, within ±0.2% over entire frequency range. R.F. output level 0.1μV to 1V source e.m.f. **£249.**

OA.1094A/3 H.F. SPECTRUM ANALYSER with L.F. extension unit type TM6448. Freq. range: 100 Hz to 30 MHz. Measures relative amplitudes up to 60 dB. Spectrum width 0-30 KHz. Sweep duration: 0·1. 0·3. 1. 3. 10. 30 sec. and manual. Full spec on request. **£695.**

OA.1094A/S H.F. SPECTRUM ANALYSER. Freq. range: 3 MHz to 30 MHz in nine steps. spectrum width 0 to 30 KHz. Sweep distortion: 0·1. 0·3. 1. 3. 10. 30 secs. and manual. Full spec. on request. **£445.**

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Employing plug-in pre-amplifiers for single or dual trace displays.
Wide-band pre-amplifier CX 1251. Bandwidth: OC –40Mc/s (–3dB ± 1dB); 2.5c/s–40Mc/s AC coupled (–3dB ± 1dB). Rise time 8 nanosec approx. Sensitivity: 50mV/cm–50V/cm in nine calibrated ranges with fine gain control.
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T.F.801B/3/S A.M. SIGNAL GENERATOR.
Freq. range: 12 MHz to 485 MHz in five bands. Built-in crystal calibrator. Full spec. on request. **£220.**

CT. 373 TEST SET. Oscillator: 17c/s–170kc/s ±1%. ±1c/s at ambient temp. 0°C–45°C. Distortion Meter: Freq. range: 20c/s to 20kc/s, distortion range: 10%, 30%, 100% f.s.d. 0.5% readable. Signal input: approx. 500mV to 130V basic range. 250mV to 1300V extreme limits. Full spec. on request. **£98.**

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AVO CT 160 VALVE TESTER. As above but in portable valise form. **£65.**
Viewing by appointment only.

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PYE Precision vernier potentiometer 7568. 1μV to 1.90100V in two ranges. Accuracy 0.002%.

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8 digit In-line read-out. Facilities include: direct frequency measurement up to 100 MHz; pulse, period, ratio, time interval and totalising measurements. Input sensitivity variable from 300MV to 9V, three independent inputs, self-check etc. Full spec. on request. **£145.**

CONTIL SAMOS miniature cases

in easy-to-work blue and white PVC/steel. Assemble in the lower half: complete before springing cover into place—four Pozidrives, two to hinge it, two to fasten it. Carries four P.C. boards horizontally, or two vertically; four required for each case (for one vertical board, two each case) Prices correct Nov. 74

		1 off
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S3	100×150×50mm	**£1.23**
S4	125× 50×75mm	**£1.37**
S5	125×100×75mm	**£1.56**
S6	125×150×75mm	**£1.84**
S7	125×200×75mm	**£2.05**

much less for quantity. Prices include P. & P.. 8% VAT. four feet and four plated screws. Special feet to carry Printed Circuit Boards sold separately. Price, incl. 8% VAT. 25p for four PC feet.

'Safecase' CARRYING CASE

is an engineer's carrying case with a unique "do-it-yourself" foam suspension system to carry delicate equipment safely. Very smart in moulded ABS "Royalite" and with a strong aluminium frame. The four types cover most presentation, display and service applications.

Type 1. Pre-cut ¾" sq. foam in base and pocket for manuals, etc., in lid. 5" × 12" × 16" **£10.96.**
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BRADRAD DRILLING & DEBURRING TOOL equals eleven drills. One cut drills and deburrs the normal run of steels, aluminium, brass, copper and all types of plastics, perspex, fibreglass, **etc.**, and hardboard. Should the need arise, it is designed to overcome all the problems associated with drilling thin materials—it drills interlocking holes for instance.
¼"–2½" in ⅛" steps or 6–36mm in 3mm steps. Both with ⅜" shanks **£10.56.** Also 1½"–2½" and 36–60mm **£27.37.**
All prices include P. & P. and 8% VAT.

Q·MAX METAL PUNCH

Q. MAX PUNCHES

⅜" **£1.16**
½" or ⅝" **£1.36**
¾" or ⅞" **£1.44**
1", 1⅛", 1¼" **£1.84**
1½" **£2.16**

Prices correct Nov. 74

ADEL NIBBLING TOOL

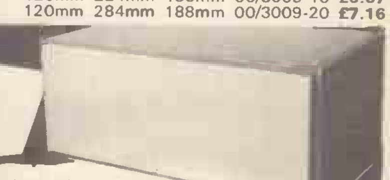
ADEL
The Adel cuts holes of virtually any shape and size starting from a 7/16" hole, cutting clean like a punch and die. Ideal for notching clearances on flanges of cabinets or chassis. **£6.64.**

AMTRON VENTILATED METAL CASES

AMTRON VENTILATED METAL CASES
A lightweight case with perforated sides and top. The front panel is of heavy-gauge anodised ali. The top, bottom, sides and back interlock, secured by screws. The front frame is a moulding. Prices include feet, tilt, 8% VAT and P. & P. Less for quantity. Prices correct Nov. 74.

Height	Length	Depth		1 off
120mm	284mm	138mm	00/3009-00	**£6.44**
120mm	224mm	138mm	00/3009-10	**£5.67**
120mm	284mm	188mm	00/3009-20	**£7.16**

CONTIL MOD·2



The design of these cases permits the instrument to be built or serviced within their external panels. 48 shapes.
Low cost. Blue PVC/steel with white PVC-coated aluminium panels.

	Width	Height	Depth	1 off		Width	Height	Depth	1 off
A	4.5"	3"	6.5"	**£3.88**	M	4.5"	3"	13"	**£4.77**
B	4.5"	7"	6.5"	**£4.77**	N	4.5"	7"	13"	**£5.84**
C	4.5"	10"	6.5"	**£5.28**	O	4.5"	10"	13"	**£7.41**
D	9"	3"	6.5"	**£5.28**	P	9"	3"	13"	**£5.84**
E	9"	7"	6.5"	**£5.84**	Q	9"	7"	13"	**£7.41**
F	9"	10"	6.5"	**£6.73**	R	9"	10"	13"	**£9.06**
G	13"	3"	6.5"	**£5.84**	S	13"	3"	13"	**£7.41**
H	13"	7	6.5"	**£6.73**	T	13"	7"	13"	**£9.06**
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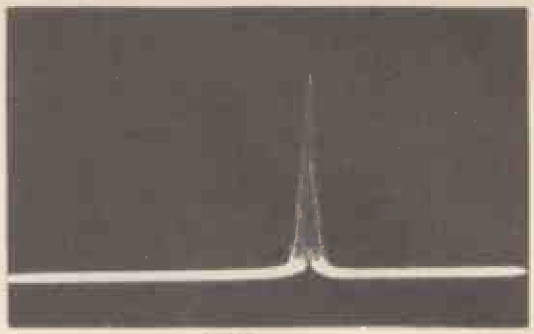

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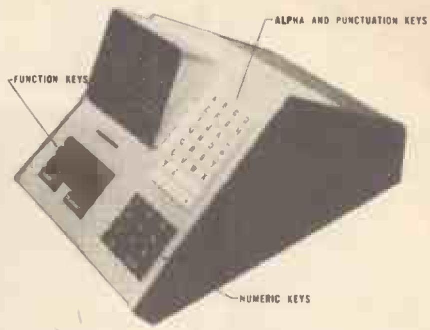

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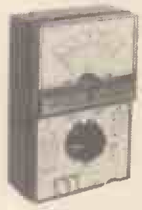

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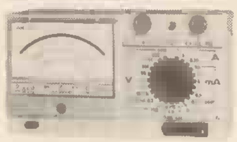

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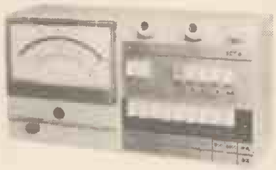

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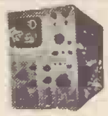

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C	1/2	4·7–10M	1·3	1·1	0·9 nett
C	3/4	4·7–10M	1·5	1·2	0·97 nett
C	1	4·7–10M	3·2	2·5	1·92 nett
MO	1/2	10–1M	4	3·3	2·3 nett
WW	1	0·22–3·9Ω	11	10	8
WW	3	1–10K	9	8	6
WW	7	1–10K	11	10	8

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C = carbon film, high stability, low noise.
MO = metal oxide, Electrosil TR5, ultra low noise.
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Values: All E12 except C ⅓W, C ¾W, and MO ½W.
E12: 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82 and their decades.
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1·0	—	—	—	—	—	11p	—	8p
2·2	—	—	—	—	11p	—	8p	9p
4·7	—	—	—	11p	—	8p	9p	8p
10	—	—	—	—	8p	9p	8p	8p
22	—	—	8p	—	9p	8p	8p	10p
47	8p	—	9p	8p	8p	8p	10p	13p
100	9p	8p	8p	8p	9p	10p	12p	19p
220	8p	8p	9p	10p	10p	11p	17p	28p
470	9p	10p	10p	11p	13p	17p	24p	45p
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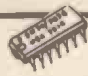
Semi-conductors. Any one type or mixed SN 74 Series 'IC'
12+ EXTRA 10% 25+ EXTRA 15% 100+ EXTRA 20%



INTEGRATED CIRCUITS

	£ p
SN7400N	0.16
SN7401N	0.16
SN7402N	0.16
SN7403N	0.16
SN7404N	0.26
SN7405N	0.22
SN7406N	0.42
SN7407N	0.42
SN7408N	0.28
SN7409N	0.28
SN7410N	0.16
SN7411N	0.25
SN7412N	0.30
SN7413N	0.36
SN7414N	0.72
SN7416N	0.36
SN7417N	0.36
SN7420N	0.16
SN7421N	0.33
SN7422N	0.25
SN7423N	0.37
SN7425N	0.37
SN7426N	0.32
SN7427N	0.37
SN7428N	0.40
SN7430N	0.16
SN7432N	0.37
SN7433N	0.37
SN7437N	0.37
SN7438N	0.37
SN7440N	0.22
SN7441AN	0.92
SN7442N	0.79
SN7443N	1.27
SN7444N	1.27
SN7445N	1.60
SN7446N	1.89
SN7447AN	1.60
SN7448N	1.27
SN7450N	0.16
SN7451N	0.16
SN7453N	0.16
SN7454N	0.16
SN7460N	0.16
SN7470N	0.36
SN7472N	0.38
SN7473N	0.41
SN7474N	0.42
SN7475N	0.59
SN7476N	0.45
SN7480N	0.60
SN7481N	1.10
SN7482N	0.87
SN7483N	1.10
SN7484N	1.00
SN7485N	1.63
SN7486N	0.47
SN7489N	3.87
SN7490N	0.55
SN7491AN	1.00

	£ p
SN7492N	0.70
SN7493N	0.70
SN7494N	0.80
SN7495N	0.80
SN7496N	0.95
SN7497N	3.87
SN74100N	1.89
SN74104N	0.58
SN74105N	0.53
SN74107N	0.45
SN74110N	0.58
SN74111N	0.86
SN74116N	1.89
SN74118N	0.90
SN74119N	1.68
SN74120N	0.95
SN74121N	0.50
SN74122N	0.70
SN74123N	1.00
SN74125N	0.65
SN74132N	0.72
SN74141N	0.90
SN74145N	1.26
SN74150N	1.75
SN74151N	1.00
SN74153N	0.95
SN74154N	2.00
SN74155N	1.00
SN74156N	1.00
SN74157N	0.95
SN74160N	1.38
SN74161N	1.38
SN74162N	1.38
SN74163N	1.38
SN74164N	1.76
SN74165N	1.76
SN74166N	1.60
SN74167N	3.00
SN74170N	2.52
SN74173N	1.66
SN74174N	1.57
SN74175N	1.10
SN74176N	1.26
SN74177N	1.26
SN74180N	1.26
SN74181N	3.95
SN74182N	1.26
SN74184N	1.80
SN74185N	1.80
SN74190N	2.00
SN74191N	2.00
SN74192N	2.00
SN74193N	2.00
SN74194N	1.30
SN74195N	1.10
SN74196N	1.20
SN74197N	1.20
SN74198N	2.77
SN74199N	2.52

RCA	£ p
CA3012	1.32
CA3014	1.80
CA3018	1.02
CA3019	1.12
CA3020	1.80
CA3022	1.93
CA3028A	1.03
CA3036	1.08
CA3046	1.03
CA3048	2.76
CA3075	1.75
CA3081	1.80
CA3089E	2.94
CA3090Q	5.40
Signetics	
NE555	0.85
NE560B	5.00
NE561B	5.00
NE562B	5.00
NE567B	3.50
Motorola	
MC1303L	1.42
MC1304P	1.79
MC1310P	2.91
MC1458CPI	0.77
MC1710CG	0.60
MFC4000P	0.45
MFC4010P	0.55
MFC6040P	1.00
Others	
TBA800	1.50
SN76003N	1.50
SN72741P	0.60
SN72748P	0.61
702C	0.75
709C	0.39
723C	0.90
728C	0.45
741C	0.60
747C	1.00
ZN414	1.20
748C	0.61
LM309K	2.00
TAA960	1.75

SINCLAIR IC12 6W AMP £2.20p

SILICON CONTROLLED RECTIFIERS

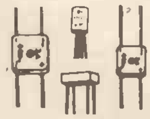
See above for small quantity discounts. Large quantities and OEM phone 01-723 3646

	£ p
TO5 1 Amp	
CRS1/05AF	0.42
CRS1/10AF	0.48
CRS1/20AF	0.52
CRS1/40AF	0.60
CRS1/60AF	0.78
TO48 3 Amp	
CRS3/025AF	0.36
CRS3/10AF	0.48
CRS3/20AF	0.54
CRS3/40AF	0.65
CRS3/60AF	0.80
TO48 7 Amp	
CRS7/400	0.84
CRS7/600	1.14
TO48 16 Amp	
CRS16/100	0.78
CRS16/200	0.85
CRS16/400	0.96

TRIACS

Triacs	£ p
3 Amp	
SC35A	0.85
SC35B	0.91
SC35D	0.99
SC35E	1.30
6 Amp	
SC40A	0.88
SC40B	0.97
SC40D	1.20
SC40E	1.50
10 Amp	
SC45A	1.09
SC45B	1.12
SC45D	1.50
SC45E	1.65
15 Amp	
SC50A	1.46
SC50B	1.57
SC50D	1.80
SC50E	2.00
Also	
40430	0.85
40669	0.90
40486	0.85

BRIDGE SILICON RECTIFIERS



	£ p
½ Amp	
B025/025	0.14
B025/05	0.16
1 Amp	
B1/05	0.20
B1/10	0.21
B1/20	0.24
B1/60	0.25
B1/100	0.30
2 Amp	
B2/05	0.30
B2/10	0.35
B2/20	0.40
B2/40	0.44
B2/60	0.45
B2/100	0.55
4 Amp	
B4/05	0.45
B4/10	0.48
B4/20	0.54
B4/40	0.60
B4/60	0.70
B4/80	0.90
6 Amp	
B6/05	0.50
B6/10	0.58
B6/20	0.68
B6/40	0.75
B6/60	0.87
1 Amp Tubular	
W005	0.27
W01	0.29
W02	0.30
W06	0.33

STC & ITT MINIATURE RELMS

1250Ω	12/18v	2p.c.o.	BRAND NEW 60p pp 15p
4000Ω	24v	2p.c.o.	
2500Ω	18/24v	2p.c.o.	
1700Ω	18/24v	2p.c.o.	
1800Ω	24v	4p.c.o.	
185Ω	6v	2p.c.o.	
150Ω	6v	2p.c.o.	
180Ω	6/12v	2p.c.o.	

TAPE HEADS

	£ p
Marriot XRSP/17 ¼-trace high	2.50
Marriot XPSP/18 ¼-trace med	3.50
Marriot XRSP/36 ½-trace med	5.00
Marriot XRSP/63 ½-trace high	1.75
Marriot XRSP/63 erase	0.75
Marriot erase heads for XRSP 17/18/36	0.75
R/RPI record/play ½-track	0.45
H/RP single-track rec/play	0.35
Bogen type UL290 erase	1.50
Miniature stereo-cassette rec/play	2.00

pp 15p

IN-LINE MAINS SUPPRESSOR

Type S.D.1/A50 1Amp Suppressor as featured in High-Fi Press
£2.75 pp 15p

PORTABLE RADIO

activity counter complete with power-pack
£9.97 pp £1

DOSIEMETERS

0–5R **62p**
0–50R **62p**
0–150R **62p**
45p each per dozen
pp 15p

GRAVINER INFRA RED DETECTOR

designed for heat or light detector containing 931A photo multiplier + GK45 & network.
£3.50 pp 25p

AMTRON KITS

AVAILABLE EX STOCK
SEND FOR FREE LISTS

JOSTY KITS

AVAILABLE EX STOCK
SEND FOR FREE LISTS

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15 watt **£5.20** pp 30p
40 watt **£6.80** pp 40p

PP9 BATTERY ELIMINATOR

complete kits of parts including P/C boards
£1.95 complete kit
pp 15p

5 WATT AMPLIFIER KIT

TBA 800 with printed circuit & all components.
£2.70 pp 15p

3 WATT AMPLIFIER KIT

complete with separate volume/tone controls for each channel with escutcheon **£5.50**
pp 15p

CRYSTALS

1 MEG. HC/6U TYPE
£2.25
100 Kcs & 1000 Kcs
10X TYPE **£1.50**

SL 414A PLESSEY

5 Watt i.c.
£1.65

CERAMIC FILTERS

miniature 10.7 maz. filters **40p** pair pp 15p

COSMOS INTEGRATED CIRCUITS FULL RANGE IN STOCK

	£ p
AAZ13	0.12
AC107	0.51
AC128	0.15
AC187	0.21
ACY17	0.40
ACY39	0.78
AD149	0.50
AD161	0.44
AD162	0.44
AF117	0.24
AF118	0.57
AF139	0.41
AF186	0.48
AF239	0.44
ASY27	0.33
BA115	0.10
BAX13	0.05
BC107	0.14
BC108	0.13
BC109	0.14
BC109C	0.16
BC113	0.15
BC147	0.10
BC148	0.08
BC149	0.10
BC169C	0.15
BC182	0.12
BCY32	0.85
BCT39	1.50
BCY56	2.64
BCY70	0.18
BCY71	0.22
BCY72	0.12
BD124	0.65
BD131	0.42
BF115	0.20
BF180	0.36
BF194	0.10
BFX13	0.26
BFX34	0.70
BFX88	0.24
BFY50	0.21
BFY51	0.20
BFY64	0.36
BFY90	0.81

	£ p
BLY36	6.00
BSX20	0.13
BU105	2.20
BY100	0.27
BY127	0.12
BYZ13	0.42
C106D	0.54
GET111	0.72
GET115	0.90
GET880	0.60
LM309K	2.00
MAT121	0.25
MJE340	0.47
MJE520	0.63
MJE3055	0.77
MJE2955	1.27
MPF105	0.36
NKT404	0.66
OA5	0.72
OA81	0.18
OA200	0.08
OA202	0.06
OC28	0.66
OC35	0.55
OC36	0.60
OC44	0.20
OC45	0.20
OC71	0.18
OC72	0.28
OC77	0.54
OC81	0.29
OC83	0.27
OC140	1.14
OC170	0.30
OC200	0.54
OC202	0.90
OCP71	1.20
ORP12	0.60
ORP60	0.55
P346A	0.18
TIL209	0.20
TIP29A	0.49
TIP30A	0.57
TIP31A	0.61
TIP41A	0.74

	£ p
TIP42A	0.90
TIS43	0.26
V405A	0.22
ZTX108	0.08
ZTX300	0.13
ZTX302	0.18
ZTX500	0.13
2N697	0.16
2N706	0.12
2N930	0.18
2N987	0.42
2N1132	0.24
2N1304	0.28
2N1613	0.21
2N1671	1.20
2N2147	0.78
2N2160	0.78
2N2926	0.12
2N3053	0.18
2N3054	0.48
2N3055	0.45
2N3440	0.58
2N3442	1.39
2N3525	0.91
2N3614	0.85
2N3702	0.11
2N3714	1.41
2N3771	1.77
2N3773	2.40
2N3790	2.10
2N3819	0.38
2N3886	0.72
2N3903	0.15
2N4002	0.14
2N4126	0.15
2N4871	0.34
2N5457	0.30
2S303	0.60
40550	0.54
40361	0.45
40362	0.40
40408	0.50
40486	0.85
40636	1.00
40430	0.85

JACKSON BROS TYPE 713 BUTTERFLY TUNING CONDENSERS

2 × 1 7pF
2 × 2 5pF
2 × 3 8pF
0.75p each pp 15p

MW/LW TUNER KIT ML3 MkIV

£5.25

ULTRASONIC TRANSDUCERS

with data/circuits
£5.90 pair
TAA960 **£1.75**

HITACHI CATHODE RAY TUBE TYPE 310DGB4

Brand New
£7.50
pp 50p

Henry's RADIO

EDGWARE ROAD, W2

CONTACT HENRY'S FIRST
see facing page for addresses

ELECTRONIC COMPONENTS AND EQUIPMENT
Retail · Trade · Educational · Export · Industrial Supplied
Let us quote for your requirements

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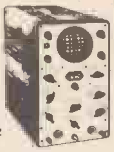
Also see following pages

CI5 PULSE OSCILLOSCOPE



For display of pulsed and periodic waveforms in electronic circuits. VERT. AMP. Bandwidth: 10MHz. Sensitivity at 100kHz VRMS/mm: 0.1–25; HOR. AMP. Bandwidth: 500kHz. Sensitivity ay 100kHz VRMS/mm: 0.3–25 Preset triggered sweep 1–3000usec. Free running 20–200 kHz in nine ranges. Calibrator pips. 220 x 360 x 430mm. 115–230V AC.

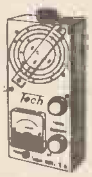
OUR PRICE £43.00 Carr. paid

RUSSIAN C116 Double Beam OSCILLOSCOPE

5 MHz pass band. Separate Y1 and Y2 amplifiers. Rectangular 5" x 4" CRT. Calibrated triggered sweep from 0.2usec. to 100 milli-sec/cm. Free running time base, 50Hz–1MHz. Built-in time base Calibrator and amplitude Calibrator. Supplied complete with all accessories and instruction manual.

OUR PRICE £87.00 Carr. paid

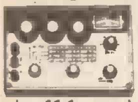
MODEL TE15 GRID DIP METER



Transistorised. Operates as Grid Dip, Oscillator, Absorbtion Wave Meter and Oscillating Detector. Frequency range 440kHz–280MHz in six coils. 500uA meter. 9V battery operation. Size: 180 x 80 x 40mm.

OUR PRICE £19.95 P&P 30p

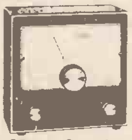
TRANSISTORISED L.C.R. A.C. BR/8 MEASURING BRIDGE



A new portable bridge offering excellent range and accuracy at low cost. Resistance: 6 ranges: 0.1 ohm-11.1 megohm ± 1% Inductance: 6 ranges: 1 microhenry-111 henries ± 2% Capacity: 6 ranges: 10pf-1110 mfd ± 2% Turns Ratio: 6 ranges: 1:1/1000-1:11100 ± 1% Bridge Voltage at 1,000cps. Operated from 9-volt battery. 100 micro-amp meter indication. Size 7⅞" x 5" x 2"

OUR PRICE £25.00 P&P 30p

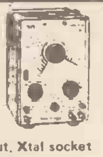
TE16A TRANSISTORISED SIGNAL GENERATOR



5 ranges, 400kHz to 30 MHz. An inexpensive instrument for the handy-man. Operates on 9V battery. Wide easy to read scale. 800kHz modulation. Size: 149 x 149 x 92mm. Complete with instructions and leads.

OUR PRICE £8.97 P&P 30p

TE-200 RF SIGNAL GENERATOR



Accurate wide range signal generator covering 120 kHz-500 MHz on 6 bands. Directly calibrated. Variable R.F. attenuator audio output. Xtal socket for calibration. 220/240V a.c. Brand new with instructions. Size 140mm x 215mm x 170mm.

OUR PRICE £17.50 P&P 50p

TE22 SINE SQUARE WAVE AUDIO GENERATOR

Sine 20cps to 200kHz on 4 bands. Square 20 cps to 30 kHz. Output impedence 5000 Ohms. 200/250V AC operation. Supplied brand new guaranteed, with instruction manual and leads.

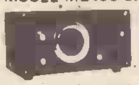
OUR PRICE £24.95 P&P 50p

ARF 300 AF/RF SIGNAL GENERATOR

All transistorised compact fully portable. AF sine-wave 18Hz to 220 kHz. AF square wave 18Hz to 100k Hz. Output Square/ Sine wave 10V. P-P RF 100kHz to 200MHz. Output 1V maximum. 220/240V AC operation. Complete with instructions and leads.

OUR PRICE £37.50 P&P 50p

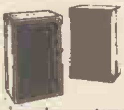
MODEL MG100 SINE SQUARE WAVE AUDIO GENERATOR



Range 19-220,000Hz Sine Wave 19–100,000 Hz Square Wave. Output Sine or Square wave 10v. P. to P. Size 180 x 90 x 90mm. Operation 220/240v. A.C.

OUR PRICE £19.95 P&P 50p

SPECIAL BARGAIN! FERGUSON 3406 HI-FI SPEAKERS



High quality 2 way speaker systems. 25 Watts. 4–8 ohms. 40Hz–18kHz. Size: 560 x 340 x 255mm. approx. Wood grain finish with black fronts.

OUR PRICE £22.50 PR. P&P £1

POWER RHEOSTATS

High quality ceramic construction. Windings embedded in vitreous enamel. Heavy duty brush wiper. Continuous rating.

Single hole fixing. ¼" diameter shafts. Bulk quantities available.

25 WATT 10/25/50/100/500/1000/2500 ohms. £1.15 P&P 10p

50 WATT 10/50/100/250/500/1500/5000 ohms. £1.62 P&P 10p

100 WATT 1/5/10/25/50/250/500/2500 ohms. 500 Ohms £2.34 P&P 15p

EMI LOUDSPEAKERS

Model 350 13 x 8" with single tweeter/crossover. 20–20,000Hz. 15 watts RMS. Available 8 or 15 ohms.

OUR PRICE £7.50 each P&P 37p

Model 450 13 x 8" with twin tweeter/crossover. 55–13,000Hz. 8 watts RMS. Available 8 or 15 ohms

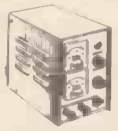
OUR PRICE £3.62 each P&P 35p

SPECIAL PURCHASE LIMITED QUANTITY! Tannoy 12" DR/8 Bass Speakers

8 ohms. 30 watt. Heavy duty, ideal for Hi-Fi P.A. Group.

OUR PRICE £12.50. P&P 50p.

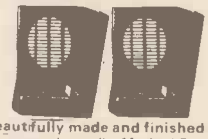
PS200 Regulated POWER SUPPLY UNIT



Solid state. Variable output 5–20V DC up to 2 Amp. Independent meters to monitor voltage and current. Output 220/240V AC. Size: 190 x 136 x 98mm.

OUR PRICE £19.95 P&P 50p

AUDIOTRONIC LE-102A INTERCOM



Beautifully made and finished in two-tone ivory/buff, the LE-102A is useful in the home, office or shop and is suitable for use as baby alarm. Wall or desk mounting 57mm speaker/mic gives clear 2-way communication with on/off and volume control on master unit. Operates on 9V batt. Approx. 60ft lead.

OUR PRICE £3.95 P & P 30p

TRITON 4318 PORTABLE 8 TRACK CARTRIDGE PLAYER WITH MW/LW RADIO

Will play 8 track stereo cartridge monaurally. Channel selector switch. Covers medium and long wave bands. Volume and tone controls. Earphone socket. Battery/Mains operation.

OUR PRICE £11.95 P & P 50p

EA41 REVERBERATION AMPLIFIER

Self contained, transistorised, battery operated. Simply plug in microphone, guitar etc. and output to your amplifier. Volume control and depth of reverberation control. Beau-walnut cabinet. 184 x 77 x 108mm.

OUR PRICE £7.50 P&P 30p

SPECIAL PURCHASES! RECORD DECK PACKAGE by Famous Manufacturer

GARRARD SP25 Mark 111 with G800 cartridge in luxurious plinth with cover.

OUR PRICE £13.95 P & P 75p

GARRARD SP25 Mark 111 Record deck fitted KS 40A cartridge.

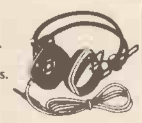
OUR PRICE £9.95 P & P 50p

LH02S STEREO HEADPHONES

Light weight headphones with padded ear pieces. 4/16 ohms 20–20,000Hz. Complete with 6' lead and plug.

OUR PRICE £1.97 P&P 30p

DH02S STEREO HEADPHONES



Wonderful value and excellent performance combined. Adjustable head band. Impedence 8 ohms. 20–12,000Hz. Complete with lead and plug.

OUR PRICE £2.25 P&P 30p

TE1035 Stereo HEADPHONES

Low cost with excellent response. Foam rubber earcups. Adjustable headband. 8 ohms impedence. Frequency response 25Hz–18kHz. Complete with cable and stereo jack plug.

OUR PRICE £2.60 P&P 30p

SDH8V MONO/STEREO HEADPHONES

Volume control for each channel. 4/16 ohms impedence. Frequency response 20Hz–18kHz. Complete with 10ft. coiled lead and jack plug.

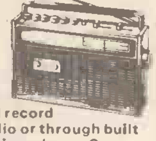
OUR PRICE £4.97 P&P 30p

BH001 HEADSET and Boom Microphone

Moving coil. Ideal for language teaching, communications etc. Headphone impedence 16 ohms. Microphone impedence 200 ohms.

OUR PRICE £5.95 P&P 30p

HANIMEX HRC 3075 CASSETTE RADIO



Covers Medium and FM wavebands. Slider volume and tone controls. Battery/Mains operation. Will record direct from radio or through built in condenser microphone. Complete with batteries, earphone, and cassette.

OUR PRICE £24·30 P & P 50p

SPECIAL BARGAIN !! STEREOSOUND SPEAKERS

Matched pair of stereo bookshelf speakers. Deluxe teak veneered finish. Size: 368 x 229 x 190mm. 8 ohms. 8 watts RMS, 16 watts peak. Complete with Din lead.

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FM TUNER CHASSIS

6 transistor high quality tuner. Size only 153 x 101 x 63mm 3 IF stages. Double tuned discriminator. Ample output to feed most amplifiers. Operates on 9V battery. Covers 88–108MHz. Ready built, ready for use. Fantastic value for money.

OUR PRICE £8.95 P&P 20p

Stereo Multiplex Adaptor £5.95 extra

SPECIAL OFFER! SAVE OVER 50%

AMSTRAD 8000/2 Stereo amplifier 7 watts per channel rms. Inputs for tuner tape, phono. Headphone socket. List price £29.95.

OUR PRICE £12.95 P & P 60p

SPECIAL OFFER! CONVERT YOUR STEREO SYSTEM TO 4D SOUND FOR UNDER £16.

Exclusive offer of GOODWIN 4-CHANNEL CONVERTER and a pair of AD15 10 watt 8 ohm bookshelf speakers enables you to add 4D sound to your existing system. Complete with simple connection details. Normal retail value £26.50.

OUR PRICE £15.80 P & P £1.

GOODWIN CONVERTER available separately £3.95 P & P 50p.

Model A1018 FM TUNER

6 transistor high quality unit–3 IF stages and double tuned discriminator. For use with most amplifiers. Covers 88–108MHz. Powered by 9V battery.

OUR PRICE £13.50 P&P 30p

Stereo multiplex adapter £5.95 extra.

ELECTRONIC CALCULATORS

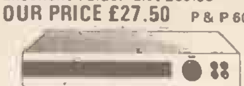
We carry a tremendous range of both pocket and desk calculators from as little as £9. Owing to the demand it is not possible to include them in this advertisement, so send for our latest price list or call into any branch.

SINCLAIR SYSTEM 2000 STEREO AMPLIFIER AND TUNER

2000 AMPLIFIER

Amplifier output 8 watts per channel RMS. Distortion less than 0·06%. Silicon transistors. Two pick-up plus radio and tape inputs, tape output and scratch filter. Excellent Value. List £39.95

OUR PRICE £27.50 P & P 60p.



2000 FM TUNER

Excellent selectivity and sensitivity. Twin dual-varicap tuning. 4 pole ceramic filter. 19 transistor stereo demodulator giving 40 dB separation. Distortion 0·2% output. Fantastic Value. List £39.95

OUR PRICE £27.50 P & P 60p.

SINCLAIR IC12 INTEGRATED CIRCUIT AMPLIFIER

complete with printed circuit mounting board.

OUR PRICE £1.50 P & P 15p.

SINCLAIR Project 80 Modules

240 Power Amp.	£5.95	P & P 15p
260 Power Amp.	£7.45	P & P 15p
Stereo 80 Pre-Amp.	£13.95	P & P 15p
Active Filter Unit	£7.45	P & P 15p
FM Tuner	£13.95	P & P 15p
Stereo Decoder	£8.95	P & P 15p
PZ5 Power Supply	£5.95	P & P 30p
PZ6 Power Supply	£8.95	P & P 30p
PZ8 Power Supply	£8.45	P & P 30p
Transformer for PZ8	£4.05	P & P 50p
IC 20 Stereo Amp. kit	£7.95	P & P 15p
PZ20 Power Supply kit	£5.45	P & P 15p

SINCLAIR Project 80 Packages

2xZ40/Stereo 80/PZ5	£28.60	P & P 35p each
2xZ40/Stereo 80/PZ6	£31.30	
2xZ60/Stereo 80/PZ8	£33.55	

TE1021 Stereo Listening Station

For balancing and gain selection of loudspeakers with additional facility for stereo headphone switching. Two gain controls, speakers on–off slide switch, stereo headphone socket.

OUR PRICE £2.25 P&P 15p

AUDIOTRONIC LOW NOISE CASSETTES

TYPE	5	10	25
C60	£1.57	£3.00	£7.08
C90	£2.24	£4.25	£10.00
C120	£2.73	£5.17	£12.24

AUDIOTRONIC 8 TRACK CARTRIDGES

TYPE	Each	5	10
40M	85p	£4.00	£7.50
80M	£1.15	£5.40	£10.25

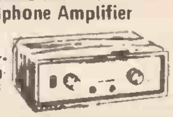
P&P Cassettes 3p, Cartridges 5p each OVER 10 of either POST FREE!

MP7 MIXER-PREAMPLIFIER

5 Microphone inputs each with individual gain controls enabling complete mixing facilities. Battery operated. Size: 235 x 127 x 76mm. Inputs: Mics. 3 x 3mV 50k; 2 x 3mV 600 ohms. Phono. Mag. 4mV 50k; Phono Ceramic 100mV 1 Meg. Output 250mV 100k.

OUR PRICE £8.97 P&P 20p

AUDIOTRONIC AHA101 Stereo Headphone Amplifier



All silicon, transistor amplifier operates from magnetic, ceramic or tuner inputs with twin stereo headphone outputs and separate volume controls for each channel. Operates from 9V battery. INPUTS: 5mV and 100mV. OUTPUT: 50mV per channel.

OUR PRICE £8.50 P&P 30p

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WE ARE APPOINTED STOCKISTS AT ALL BRANCHES

All kits are complete with comprehensive easy to follow instructions and covered by full guarantee.

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M1302 Transistor tester	£8.33
M191 VU Meter	£5.37
M192 Stereo balance meter	£5.93
LF380 Quadraphonic device	£ 8.42
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AT50 400W triac light dimmer/speed control	£5.18
AT56 2,200W triac light dimmer/speed control	£6.75
AT60 1 channel light control	£10.82
AT65 3 channel light control	£16.52
GU330 Tremolo unit	£8.10
HF61 Diode detector	£3.87
HF65 FM transmitter	£3.21
HF75 FM receiver	£3.66
HF310 FM tuner	£16.32
HF325 Deluxe FM tuner	£26.33
HF330 Decoder (HF310/325)	£10.55
GP310 Stereo pre-amplifier for use with 2 x AF310	£22.98
GP312 Circuit board	£10.02
GP304 Circuit board	£5.33
HF380 (w/vhf aerial amplifier	£6.02
HF395 broadband aerial amp.	£2.10
NT10 Stabilised power supply 100mA, 9V	£6.27
NT300 Stabilised p. supply	£13.16
NT310 Power Supply 240 V AC or 2 x 18 V D.C. at 2 amps	£5.64
NT305 Voltage converter	£5.64
NT315 Power supply 240V AC to 4.5/15V DC, 500mA	£12.06

Amateur Electronics by Josty-Kit, the professional book for the amateur –covers the subject from basic principals to advanced electronic techniques. Complete with circuit board for AE1 to AE10 listed below.

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AE4 Flasher	£1.26
AE5 Astable multi-vibrator	£1.14
AE6 Monostable multi-vibrator	£1.11
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AE10 CCIR filter	£1.05

Also see previous page

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Component packs for a choice of three outstanding amplifiers are stocked together with packs for a regulated power supply suitable for use with a pair of any of them. Also stocked are packs for a very well-established pre-amplifier—the Bailey-Burrows design which features six inputs, a scratch and rumble filter and wide range tone controls which may be either rotary or slider operating.

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Pk. 1 F/Glass PCB	£0.80
Pk. 2 Resistors, capacitors, pots	£1.75
Pk. 3 Semiconductor set	£4.70

30W BLOMLEY

Pk. 1 F/Glass PCB	£0.85
Pk. 2 Resistors, capacitors, pots	£2.15
Pk. 3 Semiconductor set	£5.60

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Pk. 1 F/Glass PCB	£0.85
Pk. 2 Resistors, capacitors, pots	£2.40
Pk. 3 Semiconductor set	£3.35

60V REGULATED POWER SUPPLY

Pk. 1 F/Glass PCB	£0.75
Pk. 2 Resistors, capacitors, pots	£1.40
Pk. 3 Semiconductor set	£3.10

BAILEY-BURROWS PRE-AMP

Pk. 1 F/Glass PCB	£2.05
Pk. 2 Resistors, capacitors, pre-sets, transistors	£4.95
Pk. 3R Rotary potentiometer set	£1.60
Pk. 35 Slider potentiometer set (with knobs).	£2.70

STUART TAPE RECORDER

A set of three printed-circuit boards has been prepared for the stereo integrated circuit version of this high-performance Wireless World published design.

TRRP Pk. 1	Reply amplifier F/Glass PCB	£0.90
TRRC Pk. 1	Record amp./meter drive cct. F/Glass PCB	£1.40
TROS Pk. 1	Bias/erase/stabilizer cct. F/Glass PCB	£1.00

For details of component packs for this design please write for free list.

TOROIDAL T20 + 20

Developed from the famous Practical Wireless Texan

20 WATTS/CHANNEL

Designed by Texas engineers and published in a series of articles in **Practical Wireless**. The TEXAN was a remarkable breakthrough in delivering true Hi-Fi performance at exceptionally low cost. Now further developed to include a true Toroidal transformer, this slimline integrated circuit design, based upon a single F/Glass PCB, features all the normal facilities found on quality amplifiers, including scratch and rumble filters, adaptable input selector and headphones socket.

FREE TEAK CASE and HANDBOOK with full kits

KIT PRICE only **£28.25** post free (U.K.)

Pack		Price
1	Set of all low noise resistors	£0.80
2	Set of all small capacitors	£1.50
3	Set of 4 power supply capacitors	£1.40
4	Set of miscellaneous parts including DIN sockets, fuses, fuse holders, control knobs, etc.	£1.90
5	Set of slide and push-button switches	£0.90
6	Set of potentiometers and selector switch	£1.45
7	Set of all semiconductors	£8.25
8	Special Toroidal Transformer	£4.95
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10	Complete chassis work, hardware and brackets	£4.20
11	Preformed cable/leads	£0.40
12	Handbook	£0.25
13	Teak Cabinet	£2.75

ACTIVE FILTER CROSSOVER

An essential and critical component in a high-quality speaker system is the crossover unit conventionally comprising of a series of passive networks which unfortunately, though introducing reactive impedances between the amplifier and the speakers, result in the loss of the advantage of high amplifier damping factor and renders the speakers prone to overshoots and resonances. An elegant solution to this problem, described by D. C. Read in **Wireless World**, involves the use of a series of active filters splitting the output of the pre-amplifier into three channels, of closely defined bandwidth, each of which is fed to the appropriate speaker by its own power amplifier. A design for a suitable 20-watt amplifier, based on a proven Texas circuit, was also described by Mr Read. The printed-circuit board for this has been designed such that three amplifiers may be stacked and mounted together on a common heat sink to achieve a conveniently compact module.

ACTIVE FILTER

Pack		
1	Fibreglass PCB (accommodates all filters for one channel)	£1.05
2	Set of pre-sets, solid tantalum capacitors, 2% metal oxide resistors, 2% polystyrene capacitors	£4.20
3	Set of semiconductors	£2.65

2 off each pack required for stereo system

SUITABLE ALSO FOR FEEDING ANY OF OUR HIGH-POWER DESIGNS

READ/TEXAS 20w amp.

Pack		
1	Fibreglass PCB	£0.70
2	Set of resistors, capacitors pre-sets (not including O/P coupling capacitors)	£1.10
3	Sets of semiconductors	£2.40

6 off each pack required for stereo system

4	Special heat sink assembly for set of 3 amplifiers	£0.85
5	Set of 3 O/P coupling capacitors	£1.00

2 off packs 4, 5 required for stereo system

POWER SUPPLY

FOR 20W/CHANNEL STEREO SYSTEM

Pack		
1	Fibreglass PCB	£0.50
2	Set of rectifiers, zener diode, capacitors, fuses, fuse holders	£2.60
3	Toroidal transformer	£4.95

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For quality sets of speakers

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2N699	£0.25	2N4302	£0.60	BC182L	£0.10	MJ481	£1.20	TIP29C	£0.71
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2N1711	£0.25	2N5210	£0.54	BC212L	£0.12	MJE521	£0.60	TIP31A	£0.60
2N2926G	£0.10	2N5457	£0.45	BC214L	£0.14	MPSA05	£0.30	TIP32A	£0.70
2N3053	£0.15	2N5459	£0.45	BCY72	£0.13	MPSA12	£0.55	TIP33A	£1.00
2N3055	£0.45	2N5830	£0.30	BD529	£0.85	MPSA14	£0.35	TIP34A	£1.50
2N3442	£1.20	40361	£0.40	BD530	£0.85	MPSA55	£0.35	TIP41A	£0.74
2N3704	£0.10	40362	£0.45	BDY56	£1.60	MPSA65	£0.35	TIP42A	£0.90
2N3707	£0.10	BC107	£0.10	BF257	£0.40	MPSA66	£0.40	IN914	£0.07
2N3711	£0.09	BC108	£0.10	BF259	£0.47	MPSU05	£0.60	IN916	£0.07
2N3819	£0.23	BC109	£0.10	BFR39	£0.25	MPSU55	£0.70	IS920	£0.10
2N3904	£0.17	BC125	£0.15	BFR79	£0.25	SN72721P	£0.58	5B05	£1.20
2N3906	£0.20	BC126	£0.15	BFY50	£0.20	SN72748P	£0.58		
2N4058	£0.12	BC182K	£0.10	BFY51	£0.20	TIP29A	£0.50		
2N4062	£0.11	BC212K	£0.12	BFY52	£0.20	TIP30A	£0.60		

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AC125	0·19
AC126	0·19
AC127	0·20
AC128	0·20
AC132	0·16
AC134	0·16
AC137	0·16
AC141	0·20
AC141K	0·32
AC142	0·20
AC142K	0·28
AC151	0·17
AC154	0·22
AC155	0·22
AC156	0·22
AC157	0·27
AC165	0·22
AC166	0·22
AC167	0·22
AC168	0·27
AC169	0·16
AC176	0·22
AC177	0·27
AC178	0·31
AC179	0·31
AC180	0·22
AC180K	0·32
AC181	0 22
AC181K	0·32
AC187	0·24
AC187K	0·25
AC188	0·24
AC188K	0·25
ACY17	0·28
ACY18	0·22
ACY19	0·22
ACY20	0·22
ACY21	0·22
ACY22	0·18
ACY27	0·20
ACY28	0·21
ACY29	0·39
ACY30	0·31
ACY31	0·31
ACY34	0·23
ACY35	0·23
ACY36	0·31
ACY40	0·19
ACY41	0·20
ACY44	0·39
AD130	0·42
AD140	0·53
AD142	0·53
AD143	0·42
AD149	0·55
AD161	0·39
AD162	0·39

Type	£
AD161 & AD162 (MP)	0·75
ADT140	0·55
AF114	0·27
AF115	0·27
AF116	0·27
AF117	0·27
AF118	0·39
AF124	0·33
AF125	0·33
AF126	0·31
AF127	0·31
AF139	0·33
AF178	0·55
AF179	0·55
AF180	0·55
AF181	0·55
AF186	0·55
AF239	0·41
AL102	0·72
AL103	0·72
ASY26	0·28
ASY27	0·33
ASY28	0·28
ASY29	0·28
ASY50	0·28
ASY51	0·28
ASY52	0·28
ASY54	0·28
ASY55	0·28
ASY56	0·28
ASY57	0·28
ASY58	0·28
ASY73	0·28
ASZ21	0·44
BC107	0·14
BC108	0·14
BC109	0·15
BC113	0·11
BC114	0·17
BC115	0·17
BC116	0·17
BC117	0·20
BC118	0·11
BC119	0·33
BC120	0·88
BC125	0·13
BC126	0·20
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BC140	0·33
BC141	0·33
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BC145	0·50
BC147	0·11
BC148	0·11
BC149	0·13

Type	£
BC150	0·20
BC151	0·22
BC152	0·19
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BC157	0·20
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BC181	0·27
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BC208	0·12
BC209	0·13
BC212L	0·14
BC213L	0·14
BC214L	0·18
BC225	0·28
BC226	0·39
BC301	0·30
BC302	0·27
BC303	0·35
BC304	0·40
BC440	0·34
BC460	0·40
BCY30	0·27
BCY30	0·27
BCY31	0·29
BCY32	0·33
BCY33	0·24
BCY34	0·28
BCY70	0·16
BCY71	0·22
BCY72	0·16
BCZ10	0·22
BCZ11	0·28
BCZ12	0·28
BD115	0·68
BD116	0·88
BD121	0·66
BD123	0·72
BD124	0·76

Type	£
BD131	0·55
BD132	0·66
BD133	0·72
BD135	0·44
BD136	0·44
BD137	0·50
BD138	0·55
BD139	0·61
BD140	0·66
BD155	0·88
BD175	0·66
BD176	0·66
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BD195	0·94
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BD197	0·99
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BD199	1·05
BD200	1·05
BD205	0·88
BD206	0·88
BD207	1·05
BD208	1·05
BDY20	1·10
BF115	0·27
BF117	0·50
BF118	0·77
BF119	0·77
BF121	0·50
BF123	0·55
BF125	0·50
BF127	0·55
BF152	0·61
BF153	0·50
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BF160	0·44
BF162	0·44
BF163	0·44
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BF165	0·44
BF167	0·24
BF173	0·24
BF176	0·39
BF177	0·39
BF178	0·33
BF179	0·33
BF180	0·33
BF181	0·33
BF182	0·44

Type	£
BF183	0·44
BF184	0·28
BF185	0·33
BF187	0·30
BF188	0·44
BF194	0·13
BF195	0·13
BF196	0·16
BF197	0·16
BF200	0·50
BF222	1·05
BF257	0·50
BF258	0·66
BF259	0·94
BF262	0·61
BF263	0·61
BF270	0·39
BF271	0·33
BF272	0·88
BF273	0·39
BF274	0·39
BFW10	0·66
BFX29	0·30
BFX84	0·24
BFX85	0·33
BFX86	0·24
BFX87	0·27
BFX88	0·24
BFY50	0·22
BFY51	0·22
BFY52	0·22
BFY53	0·19
BSX19	0·17
BSX20	0·17
BSY25	0·17
BSY26	0·17
BSY27	0·17
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BSY29	0·17
BSY38	0·20
BSY39	0·20
BSY40	0·31
BSY41	0·31
BSY95	0·14
BSY95A	0·14
Bu105	2·20
C111E	0·55
C400	0·33
C407	0·28
C424	0·28
C425	0·55
C426	0·39
C428	0·22
C441	0·33
C442	0·33
C444	0·39
C450	0·24
MAT100	0·21
MAT101	0·22
MAT120	0·21
MAT121	0·22
MJE2955	0·95
MJE3055	0·62

Type	£
MJE3440	0·55
MPF102	0·46
MPF104	0·41
MPF105	0·41
OC19	0·39
OC20	0·70
OC22	0·52
OC23	0·54
OC24	0·62
OC25	0·42
OC26	0·32
OC28	0·55
OC29	0·55
OC35	0·46
OC36	0·55
OC41	0·22
OC42	0·27
OC44	0·17
OC45	0·14
OC70	0·11
OC71	0·11
OC72	0·16
OC74	0·16
OC75	0·17
OC76	0·17
OC77	0·28
OC81	0·17
OC81D	0·17
OC82	0·17
OC82D	0·17
OC83	0·22
OC139	0·22
OC140	0·22
OC169	0·28
OC170	0·28
OC171	0·28
OC200	0·28
OC201	0·31
OC202	0·31
OC203	0·28
OC204	0·28
OC205	0·39
OC309	0·44
OCP71	0·48
ORP12	0·48
ORP60	0·44
ORP61	0·44
P20	0·55
P346A	0·22
P397	0·46
ST140	0·14
ST141	0·19
TI843	0·33
UT46	0·30
ZN414	1·20
2G301	0·21
2G302	0·21
2G303	0·21
2G304	0·27
2G306	0·44
2G308	0·39

Type	£
2G309	0·39
2G339	0·22
2G339A	0·18
2G344	0·20
2G345	0·18
2G371	0·18
2G371B	0·13
2G373	0·19
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2N388	0·39
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2N404A	0·31
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2N699	0·39
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2N706A	0·10
2N708	0·13
2N711	0·33
2N717	0·39
2N718	0·27
2N718A	0·55
2N726	0·31
2N727	0·31
2N743	0·22
2N744	0·22
2N914	0·16
2N918	0·33
2N929	0·23
2N930	0·23
2N1131	0·22
2N1132	0·24
2N1302	0·16
2N1303	0·16
2N1304	0·19
2N1305	0·19
2N1306	0·23
2N1307	0·23
2N1308	0·26
2N1309	0·26
2N1613	0·22
2N1711	0·22
2N1889	0·35
2N1890	0·50
2N1893	0·41
2N2147	0·79
2N2148	0·63
2N2160	0·66
2N2192	0·39
2N2193	0·39

Type	£
2N2194	0·39
2N2217	0·24
2N2218	0·22
2N2219	0·22
2N2220	0·24
2N2221	0·22
2N2222	0·22
2N2368	0·19
2N2369	0·16
2N2369A	0·16
2N2411	0·27
2N2412	0·27
2N2646	0·52
2N2711	0·23
2N2712	0·23
2N2714	0·23
2N2904	0·19
2N2904A	0·23
2N2905	0·23
2N2905A	0·23
2N2906	0·17
2N2906A	0·20
2N2907	0·22
2N2907A	0·24
2N2923	0·16
2N2924	0·16
2N2925	0·16
2N2926(G)	0·14
2N2926(Y)	0·12
2N2926(O)	0·11
2N2926(R)	0·11
2N2926(B)	0·11
2N3010	0·77
2N3011	0·16

Type	£
2N3053	0·19
2N3054	0·51
2N3055	0·55
2N3391	0·16
2N3391A	0·18
2N3392	0·16
2N3393	0·16
2N3394	0·16
2N3395	0·19
2N3402	0·23
2N3403	0·23
2N3404	0·31
2N3405	0·46
2N3414	0·17
2N3415	0·17
2N3416	0·31
2N3417	0·31
2N3525	0·83
2N3614	0·74
2N3615	0·82
2N3616	0·82
2N3646	0·10
2N3702	0·13
2N3703	0·13
2N3704	0·14
2N3705	0·13
2N3706	0·13
2N3707	0·14
2N3708	0·09
2N3709	0·10
2N3710	0·10
2N3711	0·10
2N3819	0·31
2N3820	0·55
2N3821	0·39
2N3823	0·31
2N3903	0·31
2N3904	0·33
2N3905	0·31
2N3906	0·30

Type	£
2N4058	0·13
2N4059	0·11
2N4060	0·13
2N4061	0·13
2N4062	0·13
2N4284	0·19
2N4285	0·19
2N4286	0·19
2N4287	0·19
2N4288	0·19
2N4289	0·19
2N4290	0·19
2N4291	0·19
2N4292	0·19
2N4293	0·19
2N5172	0·13
2N5294	0·60
2N5457	0·35
2N5458	0·35
2N5459	0·44
2N6121	0·75
2S301	0·55
2S302A	0·46
2S302	0·46
2S303	0·61
2S304	0·77
2S305	0·86
2S306	0·86
2S307	0·86
2S321	0·62
2S322	0·46
2S322A	0·46
2S323	0·62
2S324	0·77
2S325	0·77
2S326	0·77
2S327	0·77
2S701	0·46
40361	0·44
40362	0·50

DIODES

Type	£
AA119	0·09
AA120	0·09
AA129	0·09
AAY30	0·10
AAZ13	0·11
BA100	0·11
BA116	0·23
BA126	0·24
BA148	0·16
BA154	0·13
BA155	0·16
BA156	0·15
BA173	0·16
BY100	0·17
BY101	0·13
BY105	0·19
BY114	0·13
BY124	0·13
BY126	0·16
BY127	0·17
BY128	0·17

Type	£
BY130	0·18
BY133	0·23
BY164	0·55
BYX38/30	0·46
BYZ10	0·39
BYZ11	0·33
BYZ12	0·33
BYZ13	0·28
BYZ16	0·44
BYZ17	0·39
BYZ18	0·39
BYZ19	0·31
CG62 (OA91 Eq.)	0·06
CG651 (OA70-OA79)	0·07
OA5	0·39
OA5SL	0·23

Type	£
OA10	0·15
OA47	0·08
OA70	0·08
OA79	0·08
OA81	0·08
OA85	0·10
OA90	0·07
OA91	0·07
OA95	0·08
OA200	0·07
OA202	0·08
SD10	0·06
SD19	0·06
1N34	0·08
1N34A	0·08
1N914	0·06
1N916	0·06
1N4148	0·06
1S021	0·11
1S951	0·07

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Hat) 18p ea. 10W
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T3	8	D1216
T4	8	2G381T
T5	8	2G382T
T6	8	2G344B
T7	8	2G345B
T8	8	2G378
T9	8	2G399A
T10	8	2G417

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Code No's. mentioned above are given as a guide to the type of device in the pak. The devices themselves are normally unmarked.

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Q13	3	AF 117 type transistors	0·55
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Q19	3	MADT'S 2 × MAT 101 & 1 × MAT 121	0·55
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Q21	4	AC 127 NPN Germanium transistors	0·55
Q22	20	NKT transistors A.F. R.F. coded	0·55
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Q24	8	OA 81 diodes	0·55
Q25	15	1N914 Silicon diodes 75 PIV 75mA	0·55
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Q28	2	Silicon power rectifiers BYZ 13	0·55
Q29	4	Silicon transistors 2 × 2N696, 1 × 2N697, 1 × 2N698	0·55
Q30	7	Silicon switch transistors 2N706 NPN	0·55
Q31	6	Silicon switch transistors 2N708 NPN	0·55
Q32	3	PNP Silicon transistors 2 × 2N1131, 1 × 2N 1132	0·55
Q33	3	Silicon NPN transistors 2N1711	0·55
Q34	7	Silicon NPN transistors 2N2369, 500MHz (code P397)	0·55
Q35	3	Silicon PNP TO-5, 2 × 2N2904 & 1 × 2N2905	0·55
Q36	7	2N3646 TO-18 plastic 300 MHz NPN	0·55
Q37	3	2N3053 NPN Silicon transistors	0·55
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Q39	5	NPN transistors 3 × 2N3704, 2 × 2N3705	0·55
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Q46	3	BC 115 NPN TO-5 transistors	0·55
Q47	4	NPN high gain transistors 2 × BC167, 2 × BC168	0·55
Q48	3	BCY 70 PNP transistors TO-18	0·55
Q49	3	NPN transistors 2 × BFY51, 1 × BFY52	0·55
Q50	7	BSY 28 NPN switch transistors TO-18	0·55
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200	0·27	0·32	0·54	0·54	0·62	0·67	0·67	1·76
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100	0·05	0·07	1N4002	0·06	0·10	0·17	0·23	0·
200	0·06	0·10	1N4003	0·07	0·12	0·22	0·25	£1·
400	0·08	0·15	1N4004	0·08	0·15	0·30	0·38	£1·
600	0·09	0·17	1N4005	0·10	0·18	0·36	0·45	£1·
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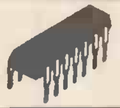

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SN7442	0·74	0·71	0·64	SN74118	£1·10	£1·05	£1·00				
SN7443	£1·20	£1·15	£1·10	SN74119	£1·50	£1·40	£1·30				
SN7444	£1·20	£1·15	£1·10	SN74121	0·50	0·48	0·45				
SN7445	£1·98	£1·95	£1·90	SN74122	0·88	0·86	0·84				
SN7446	£1·20	£1·15	£1·10	SN74123	£1·58	£1·54	£1·50				
SN7447	£1·10	£1·07	£1·05	SN74141	0·85	0·82	0·79				
SN7448	£1·10	£1·07	£1·05	SN74145	£1·58	£1·54	£1·50				
SN7450	0·18	0·17	0·16	SN74150	£2·50	£2·40	£2·30				
SN7451	0·18	0·17	0·16	SN74151	£1·10	£1·05	£1·00				

Devices may be mixed to qualify for quantity price. (TTL 74 Series only) data is available for the above series of I.C.'s in booklet form. Price 35p.

INTEGRATED CIRCUIT PAKS

Manufacturers "Fall Outs" which include Functional and Part-Functional Units. These are classed as 'out-of-spec' from the maker's very rigid specifications. but are ideal for learning about I.C's and experimental work.

Pak No. Contents	Price	Pak No. Contents	Price	Pak No. Contents	Price
UIC00=12±7400	0·55	UIC46=5×7446	0·55	UIC90=5×7490	0·55
UIC01=12×7401	0·55	UIC48=5×7448	0·55	UIC91=5×7491	0·55
UIC02=12×7402	0·55	UIC50=12×7450	0·55	UIC92=5×7492	0·55
UIC03=12×7403	0·55	UI351=12×7451	0·55	UIC93=5×7493	0·55
UIC04=12×7404	0·55	UIC53=12×7453	0·55	UIC94=5×7494	0·55
UIC05=12×7405	0·55	UIC54=12×7454	0·55	UIC95=5×7495	0·55
UIC06=8×7406	0·55	UIC60=12×7460	0·55	UIC96=5×7496	0·55
UIC07=8×7407	0·55	UIC70=8×7470	0·55	UIC100=5×74100	0·55
UIC10=12×7410	0·55	UIC72=8×7472	0·55	UIC121=5×74121	0·55
UIC20=12×7420	0·55	UIC73=8×7473	0·55	UIC141=5×74141	0·55
UIC30=12×7430	0·55	UIC74=8×7474	0·55	UIC151=5×74151	0·55
UIC40=12×7440	0·55	UIC76=8×7476	0·55	UIC154=5×74154	0·55
UIC41=5×7441	0·55	UIC80=5×7480	0·55	UIC193=5×74193	0·55
UIC42=5×7442	0·55	UIC81=5×7481	0·55	UIC199=5×74199	0·55
UIC43=5×7443	0·55	UIC82=5×7482	0·55	UICXI=25 Assorted 74's	1·55
UIC44=5×7444	0·55	UIC83=5×7483	0·55		
UIC45=5×7445	0·55	UIC86=5×7486	0·55		

Packs cannot be split, but 25 assorted pieces (our mix) is available as PAK UIC X1.

LINEAR I.C.'s—FULL SPEC.

Type No.	Case		1	25	100+
72702	DIL	14	0·50	0·48	0·45
72709P	DIL	8	0·33	0·31	0·29
72709	DIL	14	0·35	0·33	0·30
72710	DIL	14	0·45	0·43	0·40
72741	DIL	14	0·40	0·38	0·35
72741C	TO-5	8	0·45	0·43	0·40
72741P	DIL	8	0·38	0·36	0·34
72748P	DIL	8	0·38	0·36	0·34
SL201C	TO-5	8	0·50	0·45	0·40
SL701C	TO-5	8	0·50	0·45	0·40
SL702C	TO-5	8	0·50	0·45	0·40
TAA263	TO-72	4	0·80	0·70	0·60
TAA293	TO-74	10	£1·00	0·95	0·90
TAA350A	TO-5	10	£1·85	£1·80	£1·70
µA703C	TO-5	6	0·28	0·26	0·24
µA709C	TO-5	8	0·35	0·33	0·30
µA711	TO-5	10	0·45	0·43	0·40
ZN414	TO-18	4	£1·20	—	—
TBA800	DIL	14	£1·50	—	—

DTL 930 SERIES LOGIC I.C's

Type	1	25	100+
BP930	0·15	0·14	0·13
BP932	0·16	0·15	0·14
BP933	0·16	0·15	0·14
BP935	0·16	0·15	0·14
BP936	0·16	0·15	0·14
BP944	0·16	0·15	0·14
BP945	0·30	0·28	0·25
BP946	0·15	0·14	0·13
BP948	0·30	0·28	0·25
BP951	0·70	0·65	0·60
BP962	0·15	0·14	0·13
BP9093	0·45	0·43	0·40
BP9094	0·45	0·43	0·40
BP9097	0·45	0·43	0·40
BP9099	0·45	0·43	0·40

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BPS 16 „ „	17p	15p	13p
BPS 8 pin type	15p	13p	11p

NUMERICAL INDICATOR TUBES

Type	Description	
3015F	Minitron 7 Segment Indicator	£1·50
MAN 3M	L.E.D. 7 Segment Display 0.127" High Characters	£1·90
CD 66	Side Viewing 'Nixie Type' Tube 16 mm.	£1·87
GR 116	Side Viewing 'Nixie Type' Tube 13 mm.	£1·70

3 TERMINAL POSITIVE VOLTAGE REGULATORS

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µA7812/L130 12V (Equv. to MVR12V) £1·76
µA7815/L131 15V (Equv. to MVR15V) £1·76

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The 'Stereo 20' amplifier is mounted, ready wired and tested on a one-piece chassis measuring 20 cm. × 14 cm. × 5·5 cm. This compact unit comes complete with on/off switch volume control, balance, bass and treble controls, Transformer, Power supply and Power amps. Attractively printed front panel and matching control knobs. The 'Stereo 20 has been designed to fit into most turntable plinths without interfering with the mechanism or, alternatively, into a separate cabinet. Output power 20w peak. Input 1 (Cer.) 300mV into 1M. Freq. res. 25Hz-25kHz. Input 2 (Aux.) 4mV into 30K. Harmonic distortion. Bass control ±12dB at 60Hz typically 0·25% at 1 watt. Treble con. ±14dB at 14kHz.

£14·45

SHP80 STEREO HEADPHONES, 4-16 ohms Impedance. Frequency response 20 to 20,000 Hz Stereo/mono switch and volume controls £4.95

TRANSFORMERS

T461 (Use with AL10) £1·60 P. & P. 15p.
T538 (Use with AL20 & AL30) £2·30 P. & P. 15p.
BMT80 (Use with AL60) £2·75 P. & P. 25p

POWER SUPPLIES

PS 12. (Use with AL10, AL20 & AL30) 88p
SPM 80. (Use with AL60) £3·25

NOW WE GIVE YOU 50w PEAK (25w R.M.S.) *PLUS* THERMAL PROTECTION! The NEW AL60 Hi-Fi Audio Amplifier FOR ONLY £3.95

- Max Heat Sink temp. 90°C.
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- Distortion better than 0.1% at 1KHz
- Supply voltage 15-50 volts
- Thermal Feedback
- Latest Design Improvements
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- 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.

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STABILISED POWER MODULE SPM80 £3·25

SPm80 is especially designed to power 2 of the AL60 Amplifiers, up to 15 watt (r.m.s.) per channel simultaneously. This module embodies the latest components and circuit techniques incorporating complete short circuit protection. With the addition of the Mains Transformer BmT80, the unit will provide outputs of up to 1·5 amps at 35 volts. Size: 63 mm × 105 mm × 20 mm. These units enable you to build Audio Systems of the highest quality at a hitherto unobtainable price. Also ideal for many other applications including: Disco Systems, Public Address, Intercom Units, etc. Handbook available, 10p.

TRANSFORMER BMT80 £2·15 p. & p. 25p

STEREO PRE-AMPLIFIER TYPE PA100

Built to a specification and NOT a price, and yet still the greatest value on the market, the PA100 stereo pre-amplifier has been conceived from the latest circuit techniques. Designed for use with the AL60 power amplifier system, this quality made unit incorporates no less than eight silicon planar transistors, two of these are specially selected low noise NPN devices for use in the input stages.

Three switched stereo inputs, and rumble and scratch filters are features of the PA100, which also has a STEREO/MONO switch, volume, balance and continuously variable bass and treble controls.

SPECIFICATION:

Frequency response	20Hz—20kHz ±1dB	Bass control	±15dB at 20Hz
Harmonic distortion	better than 0·1%	Treble control	±15dB at 20kHz
Inputs: 1. Tape head	3·25mV into 50KΩ	Filters: Rumble (high pass)	100 Hz
2. Radio, Tuner	75mV into 50KΩ	Scratch (low pass)	8kHz
3. Magnetic P.U.	3mV into 50KΩ	Signal/noise ratio	better than +65dB
All input voltages are for an output of 250mV.		Input overload	+26dB
Tape and P.U. inputs equalised to RIAA curve		Supply	+35 volts at 20mA
within ±1dB from 20Hz to 20kHz.		Dimensions	292×82×35 mm

only £13·15

MK 60 AUDIO KIT

Comprising: 2×AL60, 1×SPM80, 1×BTM80, 1×PA 100, 1 front panel, 1 kit of parts to include on-off switch, neon indicator, stereo headphone sockets plus instruction booklets. Complete Prices: £28·75 plus 30p postage.

TEAK 60 AUDIO KIT

Comprising: Teak veneered cabinet size 16½"×11½"×3½", other parts include aluminium chassis, heatsink and front panel bracket, plus back panel and appropriate sockets etc. Kit price: £9·95 plus 30p postage.

AL10/AL20/AL30 AUDIO AMPLIFIER MODULES

The AL10, AL20 and AL30 units are similar in their appearance and in their general specification. However, careful selection of the plastic power device has resulted in a range of output powers from 3 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 car and at home.

Parameter	Conditions	Performance
HARMONIC DISTORTION	Po=3 WATTS f=1KHz	0·25%
LOAD IMPEDANCE	—	8-16Ω
INPUT IMPEDANCE	f=1KHz	100 kΩ
FREQUENCY RESPONSE ± 3dB	Po=2 WATTS	50 Hz–25KHz
SENSITIVITY for RATED O/P	Vs=25V. Rl=8Ω f=1KHz	75mV. RMS
DIMENSIONS	—	3"×2½"×1"

The above table relates to the AL10, AL20 and AL30 modules. The following table outlines the differences in their working conditions.

Parameter	AL10	AL20	AL30
Maximum Supply Voltage	25	30	30
Power output for 2% T.H.D. (RL=8Ω f=1 KHz)	3 watts RMS Min.	5 watts RMS Min.	10 watts RMS Min.
PRICE	£2·50	£2·85	£3·20

PA 12. PRE-AMPLIFIER SPECIFICATION

The PA 12 pre-amplifier has been designed to match into most budget stereo systems. It is compatible with the AL 10, AL 20 and AL 30 audio power amplifiers and it can be supplied from their associated power supplies. There are two stereo inputs, one has been designed for use with *Ceramic cartridge while the auxiliary input will suit most †Magnetic cartridges. Full details are given in the specification table. The four controls are, from left to right: Volume and on/off switch, balance, bass and treble. Size 152mm × 84mm × 35mm

PRICE £4·35

Frequency response— 20Hz–50KHz (—3dB
Bass control— ± 12dB at 60H
Treble control— ±14dB at 14KHz
*Input 1. Impedance 1 Meg. ohm Sensitivity 300mV
†Input 2. Impedance 30 K ohms Sensitivity 4mV

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VALVES

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		ECH35 1·50	EF183 0·40	EZ81 0·35	PC86 0·65	0·85	PY801 0·55	UF89 0·50	5Y3GT 0·65	6F23 1·05	7C6 1·00	30FL14 0·90	2AP1 4·00
AZ31 0·60	EABC80	ECH42 1·00	EF184 0·40	EZ90 0·40	PC88 0·65	PFL200 0·70	SP41 3·00	UL41 0·85	5Z4G 0·65	6J5G 0·45	7H7 0·80	30L15 1·05	3BP1 4·50
AX41 0·70	0·45	ECH81 0·35	EH90 0·60	GY501 0·90	PC900 0·55	PL36 0·63	SP61 0·85	UL84 0·50	6/30L2 0·90	6J5GT 0·55	7S7 2·25	30L17 0·95	3DP1A 3·50
CBL31 1·40	EAF42 0·75	ECH83 0·50	EL33 2·50	GZ30 0·65	PCC84 0·45	PL38 0·65	T41 1·00	UY41 0·55	6AL5 0·30	6J7GT 0·55	7Y4 0·80	30P12 1·05	3EG1 10·00
CL33 1·50	EAF801	ECH84 0·50	EL34 0·70	GZ32 0·65	PCC89 0·55	PL81 0·55	U25 1·00	UY85 0·45	6AQ5 0·50	6K6GT 0·80	12AC6 0·80	30P19 1·00	3FP7 2·00
CY31 0·60	0·65	ECL80 0·60	EL37 2·50	GZ34 0·75	PCC189 0·65	PL82 0·50	U26 0·85	VP4B 1·25	6AS7 1·00	6K7GT 0·35	12AD6 0·80	30PL1 0·95	3GP1 5·00
DAF91 0·30	EBC33 1·00	ECL82 0·42	EL41 0·90	H63 0·90	PCF80 0·40	PL83 0·50	U191 0·75	VR75/30	6AT6 0·60	6K8GT 0·50	12AE6 0·75	30PL13 1·20	5BP1 4·00
DAF96 0·60	EBC41 0·75	ECL86 0·55	EL42 0·90	HL41DD	PCF86 0·65	PL84 0·50	U404 0·75	0·48	6AU6 0·40	6P25 1·75	12AT6 0·45	30PL14 1·25	5CP1 5·00
DCC90 1·35	EBC81 0·41	ECLL800	EL84 0·35	0·70	PCF801 0·60	PL500 0·80	U801 0·80	UR105/30	6AV6 0·50	6Q7GT 0·50	12AT7 0·45	35L6GT 0·80	5FP7 5·00
DF91 0·30	EBF80 0·45	3·50	EL91 0·50	HN309 1·50	PCF802 0·55	PL504 0·85	UABC80	0·40	6BA6 0·38	6SG7M 0·50	12AU6 0·50	35W4 0·60	88D 10·00
DF96 0·60	EBF83 0·50	EF37A 1·20	EL95 0·50	KT61 1·75	PCF805 0·80	PL508 0·90	0·50	UR150/30	6BE6 0·45	6SJ7GT 0·30	12AU7 0·38	35Z3 0·80	CV429 22·0
DK91 0·45	EBF89 0·40	EF39 1·20	EL360 1·60	KL66 2·50	PCF806 0·80	PL509 1·55	UAF42 0·75	0·40	6BN6 0·75	6SL7GT 0·55	12AX7 0·38	35Z4GT 0·70	CV960 8·0
DK92 1·00	ELB31 2·00	EF41 0·75	ELL80 2·00	KT81 (7C5)	PCF808 0·90	PL801 £1·00	UBC41 0·75	Y63 1·50	6BJ6 0·75	6SN7GT 0·55	12BA6 0·50	50C5 0·70	DG7-5 12·00
DK96 0·75	ECC40 0·80	EF52 1·25	EM80 0·55	1·30	POCL82 0·45	PL802 1·00	UBF80 0·50	1R5 0·50	6BQ7A 0·65	6U4GT 0·80	12BE6 0·60	50CD6G 1·20	DG7/6 12·00
DL92 0·40	ECC81 0·45	EF80 0·35	EM81 0·60	KT88 2·90	PCL83 0·70	PY32 0·63	UBF89 0·50	1R5 0·40	6BR7 1·20	6U5G 0·75	12BH7 0·60	80 0·75	VCR138
DL94 0·48	ECC82 0·38	EF85 0·45	EM84 0·40	KTW61 1·50	PCL84 0·50	PY33 0·63	UCC85 0·50	1T4 0·40	6BW6 1·00	6V6GT 0·60	30C15 1·05	807 1·00	8·00
DL96 0·65	ECC83 0·38	EF86 0·50	EY51 0·45	KTW62 1·50	PCL85 0·60	PY81/800	UCH42 0·80	3S4 0·50	6BW7 1·00	6X4 0·45	30C17 1·10	6080 2·50	VCR139A
DM70 0·70	ECC85 0·45	EF89 0·35	EY86 0·45	N78 3·50	PCL86 0·50	0·50	UCH81 0·50	3V4 0·85	6C4 0·40	6X5GT 0·55	30C18 0·90	6146 2·25	8·00
DY86/7 0·45	ECC88 0·50	EF91 0·40	EZ40 0·75	OA2 0·45	PD500 1·50	PY82 0·45	UCL82 0·40	5R4GY 1·00	6CD6G 1·60	7B6 0·80	30F8 1·10		
DY802 0·47	ECF80 0·45	EF92 0·50	EX41 0·75	OB2 0·45		PY83 0·50	UCL83 0·70	5U4G 0·55	6CH6 1·40	7B7 0·80			

TRANSISTORS

		2N3709 0·10	AF116 0·25	BF195 0·13	CR83-40	GJ7M 0·50	NKT128	NKT403	OA95 0·07	OC26 0·40	OC71 0·15	OC84 0·30	ORP60 0·45
		2N3710 0·11	AF117 0·20	BF196 0·15	0·55	K8100A 0·20	0·45	0·70	OA200 0·08	OC28 0·70	OC72 0·25	OC123 1·10	ORP61 0·48
1N21 0·17	2N708 0·15	2N3711 0·11	AF139 0·33	BF197 0·15	CS10B 3·50	MAT101	NKT211	NKT404	OA202 0·10	OC29 0·65	OC73 0·50	OC139 0·40	SX640 0·75
1N23 0·35	2N1302 0·18	2N3819 0·35	AFZ12 1·50	BF861 0·25	CV102 0·25	0·25	0·25	0·60	OA210 0·20	OC30 0·40	OC74 0·30	OC140 0·65	SX642 0·80
1N4001 0·06	2N1303 0·18	2N4286 0·15	BC107 0·12	BF898 0·25	CV103 0·18	MAT120	NKT213	NKT713 0·30	OA211 0·35	OC35 0·55	OC75 0·30	OC141 0·80	SX643 0·75
1N4002 0·07	2N1304 0·22	2N4289 0·15	BC108 0·12	BFY50 0·20	CV253 1·00	0·20	0·25	OA5 0·60	OAZ202 0·45	OC36 0·65	OC76 0·30	OC169 0·20	Z821 0·30
IN4003 0·08	2N1305 0·22	AC126 0·25	BC109 0·12	BFY51 0·20	CV2154 2·00	MAT121	NKT214 0·24	OA6 0·12	OAZ210 0·40	OC41 0·35	OC77 0·55	OC170 0·25	Z822 0·20
IN4004 0·08	2N1306 0·28	AC127 0·25	BC115 0·20	BFY52 0·20	CV2155 2·00	0·25	NKT216	OA7 0·20	OAZ211 0·40	OC42 0·40	OC78 0·25	OC171 0·30	Z8170 0·10
1N4006 0·12	2N1307 0·28	AC128 0·20	BC116 0·20	BTY79/	CV7108 3·50	MJE370 0·68	0·40	OA9 0·20	OAZ242 0·15	OC43 0·70	OC78D 0·25	OC200 0·55	Z8178 0·40
1S111 0·25	2N2147 0·75	AC176 0·25	BC117 0·21	100R 0·75	CV7109 3·50	MJE520 0·65	NKT217	OA10 0·40	OAZ244 0·25	OC44 0·18	OC79 0·30	OC201 0·80	Z8271 0·18
1S131 0·18	2N2218 0·23	AC187 0·20	BC169 0·14	BY100 0·15	DD000 0·15	MJE2955	0·45	OA47 0·08	OAZ246 0·15	OC44M 0·17	OC81 0·28	OC202 0·90	ZT21 0·25
1S132 0·13	2N2444 1·99	AC188 0·20	BCY34 0·45	BY126 0·14	DD006 0·25	1·10	NKT218	OA70 0·10	OC16 1·00	OC45 0·18	OC81D 0·28	OC203 0·55	ZTX107 0·12
2G220 0·63	2N2646 0·50	ACY17 0·35	BD121 1·00	BY127 0·15	GET102 0·50	MJE3055	1·13	OA71 0·20	OC16T 1·00	OC45M 0·18	OC81M 0·20	OC204 0·65	ZTX108 0·10
2G301 0·40	2N2926 0·10	AD140 0·50	BD123 1·00	BZY88	GET103 0·40	0·75	NKT301	OA79 0·10	OC19 0·50	OC46 0·27	OC81DM	OC205 1·00	ZTX300 0·14
2G302 0·40	2N3702 0·11	AD149 0·50	BF115 0·22	Series 0·10	GET116 0·85	MPF102	0·85	OA81 0·10	OC20 2·00	OC57 0·60	0·18	OC206 1·10	ZTX304 0·25
2N696 0·15	2N3703 0·12	AD161 0·39	BF173 0·28	CR81/05	GET875 0·40	0·40	NKT304	OA85 0·15	OC22 1·00	OC58 0·60	OC81Z 0·45	OC207 1·00	ZTX500 0·15
2N697 0·15	2N3704 0·14	AD162 0·39	BF180 0·35	0·30	GEX66 1·25	MPF103 0·36	0·75	OA86 0·15	OC23 1·25	OC59 0·60	OC82 0·28	OCP70 0·50	ZTX503 0·16
2N706 0·10	2N3705 0·15	AF114 0·25	BF181 0·35	CR81-40	GEX541	MPF104	NKT401	OA90 0·07	OC24 1·10	OC66 0·50	OC82D 0·25	OCP71 1·00	ZTX531 0·25
2N706A 0·12	2N3707 0·13	AF115 0·25	BF194 0·13	0·45	0·75	0·35	0·75	OA91 0·07	OC25 0·40	OC70 0·18	OC83 0·25	ORP12 0·55	

Industrial Valves

1B3GT, 1B34, 1B35A, 1B63A, 1N21, 1N21B, 1N23B, 1N23CR, 1X2A, 1X2B, 2A3, 2A815, 2C26A, 2C34, 2C39A, 2C43, 2D21, 2D21W, 2E26, 2J31, 2J33, 2J50, 2J54, 2J56A, 2K25, 2K26, 2K28, 2K45, 2X2A, 3A/107A, 3A/108A, 3A/108B, 3A/109B, 3A/110A, 3A/110B, 3A/146J, 3A/167M, 3A5, 3B/240M, 3B/241M, 3B24

3B28, 3B29, 3C22, 3C23, 3C24/24G, 3C45, 3CX100A5, 3E29, 3J/121E, 3J/160E, 3J/170E, 3Q/150E, 3Q/195E, 3S4, 3V/340B, 3V/390A, 3V/390B, 4-125A, 4-250A, 4-400A, 4B32, 4C35, 4CX250B, 4E27, 4J50, 4J52, 4J52A, 4J53, 4X150A, 4X150D, 4X250B, 5B/251M, 5B/252M, 5B/254M, 5B/255M, 5B/256M, 5B/257M, 5C22, 5D21, 5R4GY, 5U4GB

5Z3, 5Z4G, 6AF4A, 6AK5, 6AM5, 6AM6, 6AN5, 6AN8, 6AR5, 6AS6, 6AU4GTA, 6AU5GT, 6AU6, 6AV5GTA, 6AW8A, 6AX5GT, 6B4G, 6BA8A, 6BK4, 6BK7A, 6BL7GTA, 6BN6, 6BR7, 6BS7, 6BX7GT, 6BZ6, 6CB6, 6CH6, 6CL6, 6CW4, 6DK6, 6DQ6B, 6EA8, 6F33, 6H6(metal), 6K7GT, 6U8A, 6V6GT, 11E3, 11E13, 12AY7, 12B4A, 12BY7A

12E1, 12E14, 13D1, 13E1, 28D7, 29C1, 53KU, 75B1, 75C1, 83A1, 85A1, 85A2, 90AG, 90AV, 90C1, 90CG, 90CV, 95A1, 100TH, 150B2, 150B3, 150C1, 150C2, 150C3, 150C4, 250TH, 328, 329, 631-P1, 705A, 715A, 715B, 723A/B, 725A, 801, 803, 805, 807, 808, 811, 811A, 812A, 813

815, 828, 829B, 830B, 860, 866, 866A, 866E, 827A, 881R, 891R, 954, 955, 956, 957, 1625, 2050, 2050W, 2051, 4003A, 4212D or E, 4242A, 4313C, 4328A, 4687, 5544, 5545, 5642, 5644, 5651, 5670, 5672, 5676, 5687, 5696, 5702, 5718, 5719, 5725/6AS6W

5726/6AL5W, 5727/2D21W, 5749, 5750, 5751, 5802, 5814, 5823, 5840, 5963, 5965, 6005/6AQ5W, 6021, 6057, 6058, 6059, 6060, 6061, 6062, 6063, 6064, 6065, 6067, 6072, 6073, 6074, 6080, 6097C, 6130, 6136, 6189, 6197, 6201, 6202, 6203, 6205, 6360, 6442, 6463, 6550, 6807

6923, 6939, 7193, 7203, 7360, 7586, 8013, 8025A, 9001, 9002, 9003, 9004, 9005, 9006, 13201A, A1834, A2087, A2134, A2293, A2426, A2521, A2900, ACT6, ACT9, B1C1E, B890, BS156, BT5, BT35, BT45, BT79, BT83, C1C, C1K, CAA322, CV5, CV25, CV26

CV28, CV31, CV45, CV53, CV73, CV74, CV85, CV118, CV121, CV124, CV128, CV131, CV132, CV133, CV135, CV136, CV137, CV138, CV140, CV144, CV160, CV173, CV187, CV188, CV190, CV220, CV261, CV273, CV284, CV286, CV287, CV315, CV329, CV337, CV342, CV345, CV354, CV359, CV360, CV371, CV372, CV378, CV391, CV395, CV397

CV404, CV415, CV416, CV417, CV428, CV434, CV447, CV449, CV466, CV469, CV488, CV491, CV492, CV493, CV717, CV808, CV1072, CV1076, CV1092, CV1219, CV1343, CV1475, CV1476, CV1477, CV1478, CV1794, CV1480, CV1481, CV1482, CV1787, CV1832, CV1833, CV1835, CV1994, CV2000, CV2131, CV2154, CV2155, CV2160, CV2179, CV2235, CV2237, CV2238, CV2253, CV2289

CV2325, CV2361, CV2466, CV2516, CV2519, CV2520, CV2522, CV2721, CV2901, CV3523, CV3929, CV3986, CV3988, CV3991, CV3998, CV4001, CV4002, CV4003, CV4004, CV4005, CV4006, CV4007, CV4008, CV4009, CV4010, CV4011, CV4012, CV4013, CV4014, CV4015, CV4016, CV4017, CV4018, CV4019, CV4020, CV4022, CV4023, CV4024, CV4025, CV4028, CV4033, CV4035, CV4038, CV4039, CV4040

CV4043, CV4044, CV4046, CV4048, CV4053, CV4056, CV4059, CV4060, CV4062, CV4063, CV4064, CV4079, CV4501, CV4502, CV4503, CV4504, CV4507, CV4508, CV5060, CV6004, CV6008, CV6045, DA30, DA41, DA42, DA100, DET22, E55L, E80CC, E80FC, E80F, E80L, E80T, E81CC, E81L, E82CC, E83CC, E83F, E88CC, E90CC, E90L, E91H, E92CC, E180CC

E180F, E181CC, E182CC, E186F, E188CC, EA50, EA52, EA76, ECC35, ECF804, EF50, EF54, EF55, EF804, EFP60, EL91, EN30, EN31, EN32, EN91, ESU74, ESU76, ESU77, F6057, F6060, F6061, F6063, FX219, FX225, FX227, G1/371K, G120/1B, G150/2B, G180/2M, G240/2D, G400/1K, GN4, GT1C, GTR120W, GTR150MS, GU18, GU20/21, GU50, GXU1

GXU2, GXU3, GXU4, GXU50, KT66, KT67, KT88, M8079, M8080, M8081, M8082, M8083, M8091, M8096, M8097, M8098, M8100, M8136, M8137, M8140, M8141, M8142, M8144, M8149, M8157, M8161, M8162, M8163, M8167, M8179, M8190, M8196, M8204, M8212, M8214, M8223, M8224, M8225, M8232, M8237, M8245, ME1400, ME1401

ME1403, ME1404, ME1500, ME1501, OA2, OA3, OA4G, OB2, OB3, OD3, OG3, OZ4, OZ4A, OT15, QA2400, QA2403, QA2404, QA2406, QA2407, QB3/300, QB3-5-750, QB4-1100, QF41, QF45, QQV02-6, QQV03-10, QQV03-20, QQV03-20A, QQV04-15, QQV06-40, QQV06-40A, QS70/20, QS75/20, QS75/40, QS75/60, QS83/3, QS92/10, QS95/10, QS105/45

QS108/45, QS150/15, QS150/30, QS150/36, QS150/40, QS150/45, QS150/80, QS1200, QS1202, QS1203, QS1205, QU37, QV03-12, QV04-7, QV05-25, QV06-20, QY3-120A, QY4-250A, QY4-400A, R10, R17, R18, S11E12, S130, S130P, STV280/40, STV280/80, SU41, SU42, TD03-10, TT15, TT21, TTR31MR, TZ40, U17, U19, U27, VLS631, Z300T, Z759, Z803U

Integrated Circuits

7400	0·20	7410	0·20	7437	0·45	7476	0·45	74107	0·51	74157	1·09
7401	0·20	7411	0·23	7438	0·43	7480	0·80	74110	0·57	74170	2·88
7402	0·20	7412	0·28	7440	0·20	7482	0·87	74111	0·86	74174	1·80
7403	0·20	7413	0·30	7441AN	0·85	7483	1·20	74118	1·00	74175	1·29
7404	0·20	7416	0·30	7442	0·85	7484	1·00	74119	1·92	74176	1·44
7405	0·20	7417	0·30	7450	0·20	7486	1·50	74121	0·57	74190	2·30
7406	0·40	7420	0·20	7451	0·20	7490	0·75	74122	0·80	74191	2·30
7407	0·40	7422	0·28	7453	0·20	7491AN	1·10	74123	1·44	74192	2·30
7408	0·25	7423	0·40	7454	0·20	7492	0·75	74141	1·00	74193	2·30
7409	0·33	7425	0·37	7460	0·20	7493	0·75	74145	1·44	74194	1·72
		7427	0·37	7470	0·33	7494	0·85	74150	2·30	74195	1·44
		7428	0·43	7472	0·38	7495	0·85	74151	1·15	74196	1·58
		7430	0·20	7473	0·44	7496	1·00	74154	2·30	74197	1·58
		7432	0·37	7474	0·48	7497	4·32	74155	1·15	74198	3·16
		7433	0·43	7475	0·59	74100	2·16	74156	1·15	74199	2·88

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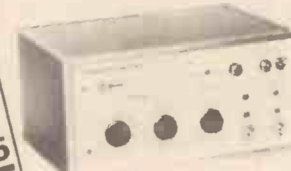

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Accuracy ± 4%, ± 1% F.S.
MAIN OUTPUT 20mV–1V into 50 ohm external termination continuously variable.
Accuracy ± 5%.
Maximum output on open circuit 2V.
RISE TIME less than 1nS up to 500mV.
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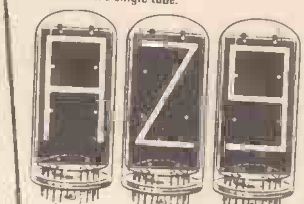

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FOUR INTERNATIONAL PATENTS – SENSITIVITY 20,000 Ohms per Volt 10 FIELDS OF MEASUREMENT AND 80 RANGES. ACCURACY 1% in D.C. 2% in A.C.

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Taut suspension movement. Simple multimeter combined with audio/I.F. Test Oscillator providing AC and DC Voltage ranges. D.C. current ranges and resistance ranges. 1kHz and 465kHz oscillator output makes the instruments suitable for general tuning of receivers etc.
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Sensitivity: 20,000Ω/V. Resistance ranges: 5–1000Ω mid-scale reading 50Ω 50Ω 10k; mid-scale reading 500Ω, 500Ω–100kΩ; mid-scale reading 5kΩ 5kΩ–1mΩ mid-scale reading 50kΩ.
Accuracy: 5% of F.S.D. Internal battery: 3V dry cell.
Oscillator output: 1kHz squarewave. 465kHz sinewave modulated by 1kHz squarewave signal. Output voltage: 1V minimum.
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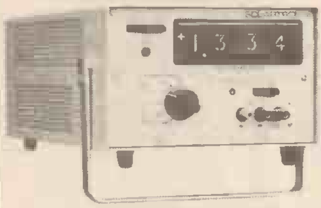

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Chart speeds 90" per hour **£39**

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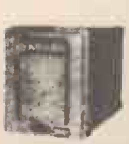

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5K		Relcon	07–10	£2·50
5K		Colvern	CLR2503	£3·00
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15K		Colvern	CLR2402	£3·00
25K	0·5	Helipot	SAJ337	£3·00
29K	0·05	Beckman	SA1244	£4·50
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30K	0·5	Beckman	SA1692	£3·00
50K		Reliance	07·10	£2·25
50K			07·5	£2·25
50K	0·5	Beckman	A.	£3·00
100K	0·1	Beckman	A.	£3·50
100K		Colvern	2501	£2·25
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300		Beckman	9303	£2·25
1K		Fox	PX2/H3	£2·25
10K	0·5	Beckman	C.s.s.	£2·25
20K/20K	0·1	Beckman	C.S.	£3·00
10K/10K	0·1	Beckman	C.	£3·00
50K	0·5	Beckman	C.S.	£1·75

FIFTEEN TURN 5400° ROTATION

Res Ohms	Manufacturers	Model	Price
25K/25K	Beckman B	10 watts	£6·50
46K/46K	Beckman B	10 watts	£6·50

AC CLAMP VOLTAMMETER

Clamp-on Voltammeter is used for measurements of AC voltages and currents without breaking circuits.

Specification

Measurement ranges:—Current 10–25–100–250–500 Amps. Voltage 300. 600 V. Accuracy 4%. Scale length 60mm. Overall dimensions 283 X 94 X 36mm. Weight 1.5 lbs.

£12.50

SPECIAL PURCHASE OF ADVANCE EX-DEMONSTRATION TEST EQUIPMENT

Advance PG56 Double Pulse Generator

Independently variable. 2Hz–3MHz Pulse Width. Delay 70nS–0.2 secs. in 19 steps. Rise Time better than 10nS. External trigger and internal rate generator. **£120**

Advance PG52 Pulse Generator

Repetition frequency up to 20MHz and output pulses up to 20V into 5 ohms with rise and fall times of 5nS. Also produces complex ramp wave forms not obtainable from conventional pulse generators. Fully protected against short circuit. **£275**

Advance T.V. Dot and Cross Hatch Generator SG73

Output in form of modulated signal at VHF and UHF at level suitable for aerial sockets of receiver.

Two Ranges

Band III on fundamental (MOD)

Band IV & V On Harmonics (−MOD)

Modulation 405 Lines or 625 Lines

£49.50 EX-DEMONSTRATION BRAND NEW

Carriage and packing charge extra on all items unless otherwise stated.

Please note: all instruments offered are second-hand and tested and guaranteed 12 months unless otherwise stated.

NEW CATALOGUE AVAILABLE EARLY IN THE NEW YEAR. WRITE IF YOU WISH TO RECEIVE A COPY.

ADD 8% VAT TO ALL PRICES

ELECTRONIC BROKERS LIMITED

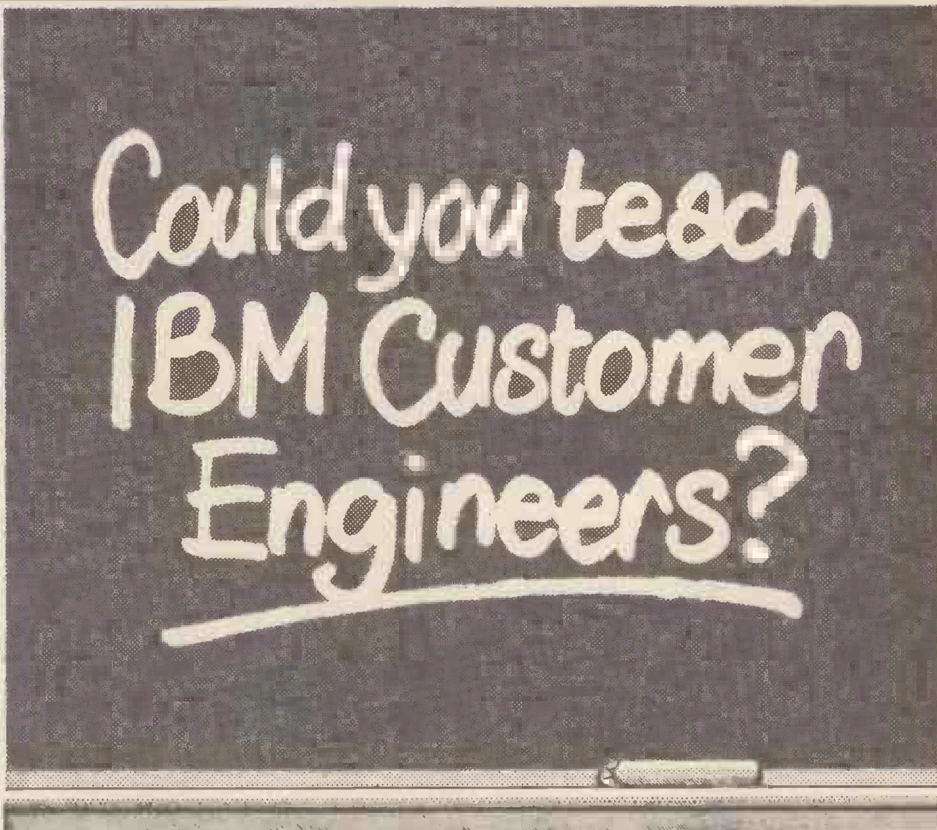
49–53 Pancras Road, London NW1 2QB. Telephone 01-837 7781

PROMPT DESPATCH MAIL ORDER. CALLERS WELCOME MON–FRI 9 A.M. to 5.30 P.M.

APPOINTMENTS VACANT

DISPLAYED APPOINTMENTS VACANT: £4.68 per single col. centimetre (min. 3cm).
LINE advertisements (run-on): 66p per line (approx. 7 words), minimum two lines.
BOX NUMBERS: 30p extra. (Replies should be addressed to the Box number in the advertisement, c/o Wireless World, Dorset House, Stamford Street, London, S.E.1.)
PHONE: Allan Petters on 01-261 8508 or 01-261 8423.
Classified Advertisement Rates are currently zero rated for the purpose of V.A.T.

Advertisements accepted up to 12 noon Wednesday, December 4th for the January issue subject to space being available.



We have a number of opportunities for instructors to train our customer engineers to service and maintain data processing equipment including the latest 370 Systems and Software.

If you're an experienced or potential instructor with a background in software and/or electronics, educated to HNC, C & G standard or perhaps you've had similar service experience – now's the chance to find out more about these secure, well paid positions, offering excellent salaries, career development prospects and in depth training.

If you are interested please write to:
Anne Dare, IBM United Kingdom Limited,
389 Chiswick High Road, London W4 4AL.
Quoting ref: WW/92414.

IBM

14276

T.V. Test Engineers & Technicians

As one of the largest manufacturers of T.V. and audio equipment, ITT can offer excellent opportunities to experienced Test Engineers as a result of continuing expansion of the colour T.V. Test Department at their Radlett Works.

These are responsible positions involving diagnosis of faults on colour T.V. chassis; assessing performance of chassis against specifications and standards; maintaining fault records and reporting quality trends.

ONC Electronics or C & G Final Certificate with colour endorsement is desirable coupled with several years' experience in a T.V. Test or Service Department. The ability to supervise and co-ordinate the work of a team of Test Technicians and assist in their training would be an advantage.

Test Technicians are also required to carry out testing, alignment and fault finding on chassis.

A good salary will be offered together with generous additional benefits including assistance with relocation, where appropriate.

Write with details of your experience to Mrs. J. D. Calnan, ITT Consumer Products (UK) Limited, Radlett Works, Colney Street, St Albans, Herts, AL2 2EG.

Colour Television **ITT**

4206

Radio Operators. How to see more of your wife without losing sight of the sea.

Join the Post Office Maritime Service. We have openings for Radio Operators at several of our coastal stations.

The work is just as interesting, just as rewarding as aboard ship, but you get home to see your wife and family more often. You need a United Kingdom General or First Class Certificate in Radiocommunications, or an equivalent certificate issued by a Commonwealth Administration or the Irish Republic.

Starting pay for a man of 25 or over is £2,270, plus cost of living allowance with further annual increases after that. Though we're happy to take people from 19 up.

In addition to your basic salary, you'll get an average allowance of £450 a year for shift duties and there are opportunities for overtime.

Other benefits include a good pension scheme, sick pay and prospects of promotion to Senior Management.

For more information, write to: ETE Maritime Radio Services Division (L529), ET 17.1.1.2., Room 643, Union House, St. Martins-le-Grand, London, EC1A 1AS.

Post Office Telecommunications

Customer Engineers

As one of the largest and most successful computer manufacturers, we place particular importance on the maintenance of a high level of customer service. Our equipment is among the most advanced in the world today. Highly sophisticated hardware used by top companies and organisations in commerce, industry, science and government.

Our Customer Service organisation is, therefore, immensely important to us if we are to maintain the high standards we have set ourselves over the years, during which we have pioneered much of the advanced technology in use today throughout the industry.

We're looking for Customer Engineers to carry out, to a high professional standard, all electronic and electro-mechanical work concerned with installation, modification, refurbishing, preventive and remedial maintenance on Sperry Univac equipment in the UK.

We require men with a knowledge of electronic or mechanical fault-finding techniques. In addition to technical competence, essential requirements are a pleasant personality and the ability to maintain a good relationship with customers. Full product training will be given.

To Engineers looking for the best in salaries, vacancies exist in most parts of the country. Conditions and fringe benefits are what you would expect when you join a company within the international Sperry Rand organisation. Future career prospects in the computer field are excellent.

For vacancies in London or the South write with full personal and career details to Personnel Manager, Ref. WW, Sperry Univac, Univac House, 160 Euston Road, London NW1. Telephone 01-387 0911. For vacancies in the Midlands and North write with full personal and career details to Personnel Manager, Ref. WW, Sperry Univac, Lynnfield House, Church Street, Altrincham, Cheshire. Telephone 061-928 7731.

SPERRY UNIVAC

PROFIT FROM EXPERIENCE

13733

Test Gear Engineers

Consumer Electronics

ITT, one of Europe's leaders in the field of consumer electronics, has achieved an enviable reputation for the high quality of its range of audio products and monochrome and colour TV.

At Hastings we can offer excellent scope to Test Gear Engineers within the Industrial Engineering Department.

Assistant Chief Engineer

To deputise for the Chief Engineer – Test Gear and co-ordinate the Test Gear Department in respect of appraisal of test gear requirements for new R & D designs; design, development and manufacture of all test gear and its installation in the factory and at sub-contractors. In addition, he will be responsible for budgeting and project appropriation and all maintenance activities on test gear installations.

This position calls for an HNC and at least five years' experience in the organisation and design of complex test equipment in the consumer electronics industry.

Senior Test Gear Engineer

Reporting to the Chief Engineer –Test Gear, he will be responsible for supervising a team of test gear engineers engaged in installation and both routine preventative and emergency breakdown maintenance of all test equipment at Hastings and satellite locations.

Essential requirements are HNC coupled with several years' experience at senior level maintaining electronic equipment, covering audio to UHF frequencies and pulse techniques.

Attractive salaries will be offered together with a wide range of benefits including pension/sickness schemes and assistance with relocation expenses, where appropriate, to this particularly pleasant area. The Company is situated close to the sea with some of the most attractive countryside in the South East on the doorstep.

Write with details of your qualifications and experience to David Harris, Personnel Officer, ITT Consumer Products (UK) Limited, Theaklen Drive, Hastings, Sussex.

The heart of Hastings ITT

[4278

SONY®

V.T.R. Service Engineers

Our expanding Video Tape Recording business creates vacancies for experienced V.T.R. Service Engineers.

Based at our Central Service Division, Ascot Road, Bedfont, near Ashford, Middlesex, successful applicants will carry out service repairs in the workshop to Video Recorders, Video Cameras and Professional Microphones. Preference will be given to those with previous V.T.R. experience, but, alternatively, we would be interested in top quality Colour TV Engineers with Tape Recorder experience.

Attractive salaries will be commensurate with experience and qualifications. Interested service engineers are invited to apply with details of past experience and current salary, or ask for an application form, to:

The Personnel Officer, SONY (U.K.) LIMITED, Pyrene House, Staines Road West, Sunbury-on-Thames, Middlesex. Tel: Sunbury 87644.

[4218

SENIOR TELEVISION ENGINEER

for

OB Unit for horseracing

We need a qualified and experienced TV Engineer to take engineering charge of a travelling OB Unit employed on the surveillance of horseracing. Must be familiar with broadcast standard OB practice and VTRs.

Salary £3,600-£4,200 p.a. depending on experience plus expenses on location.

Write or telephone for application form to:

Frank Dixon,
Racecourse Technical Services Limited,
88 Bushey Road, Raynes Park SW20 0JH
Tel: 01-947 3333

[4251

Papua New Guinea

Radio Technical Officers

Applications are invited from suitably qualified and experienced personnel for the posts of Technical Officer (Radio) and Senior Technical Officer (Radio) with the Civil Aviation Agency of the Department of Transport. There are twelve positions available working on the installation and maintenance of a variety of electronic communications equipment and appointments will be made at three levels of seniority based on experience and qualifications.

Candidates should have successfully completed City and Guilds Technician Courses, Part III Full Technological Certificate or HNC. A minimum of 6 years' relevant experience is required, with at least 3 years' involvement in a field of radio work closely related to civil aviation communications.

Conditions of service

Period of engagement is for two years (renewable in most instances). General entitlements are very attractive and include a generous gratuity (approx. 25% of salary combined with attraction allowance), education allowance for dependent children attending school overseas, return air passages with personal effects and luggage allowance, low cost married and single accommodation, and generous leave conditions.

Pay per annum

Expressed in $A. Current rate of exchange $A1.76 = £1.00 approx.

Level	*Salary*	*Attraction Allowance*	*Gratuity*
TO1	2385	4460	1910
TO2	2625	5205	2230
STO1	3105	5225	2230

Please write or telephone immediately for an application form and full details of the posts. The Papua New Guinea Public Service Board Representative, 22 Garrick Street, London W.C.2. Telephone: 01-240 1780.

Papua New Guinea

[4277

T.V. Engineers for New Zealand

Are you dissatisfied with your present position, feeling like a change of scene? Do something about it now! Be our guest—come down under and join the Tisco Team, N.Z.'s largest service organisation.

We are in service only and our engineers are all important people, every one of our 30 managers is an ex engineer.

We are now selecting staff to sponsor under the Immigration Scheme to arrive in N.Z. mid 1975.

If you,

- Have 5 years experience, preferably some in colour.
- Single or married with 3 children or less.

write now enclosing a photograph and details of past experience to:- **The Technical Staff Supervisor, Tisco Ltd, Private Bag, Royal Oak, AUCKLAND, NEW ZEALAND.**

[4070

CHELSEA COLLEGE

University of London

ELECTRONICS TECHNICIAN GRADE 2B required for the construction and maintenance of equipment and apparatus and to assist in the running of Electronics Undergraduate Teaching Laboratory. Day release for approved courses. Salary scale (under review) £1,752—£2,022 per annum including London Allowance, plus payments under a Threshold Agreement (at present approximately £146 per annum). 37½ hour week, generous holidays. Application forms and further details from Mr. M. E. Cane (2B. ET) Chelsea College WW, Pulton Place, Fulham, London SW6 5PR.

[4230

ANGLIAN WATER AUTHORITY

Lincolnshire River Division

ELECTRONIC INSTRUMENT TECHNICIAN

Grade T7 (£2,715—£3,018)

Plus Threshold Payments

Applicants should have a recognised qualification in electronic engineering preferably registered as a Technical Engineer and have obtained experience in workshop techniques, servicing and design practice. Experience in experimental work and a knowledge of measuring techniques would be an advantage.

Local Government Conditions of Service apply. Removal expenses and lodging allowance in appropriate cases. Application forms from the undersigned to be returned by 2nd December, 1974.

50 Wide Bargate, Boston, Lincs.

D. I. Rollett, Divisional Manager

[4269

BRUSSELS

The Technical Centre of the European Broadcasting Union is seeking an

EDITORIAL ASSISTANT

for duties entailing the processing of English editions of the E.B.U.'s technical periodicals from source material to publication.

This post with good prospects would suit a young Engineer or Technician of English mother-tongue, with experience in telecommunications—preferably broadcasting—and the ability to produce documents in faultless English from English and French material, as well as translations of technical reports and correspondence. A higher-than-average proficiency in the French language is evidently essential.

The starting salary will be not less than 400.000 Belgian francs per annum, depending upon age and experience. Candidates should write giving details of education and experience to:

The Director
Technical Centre of the European Broadcasting Union,
Avenue Albert Lancaster 32
B-1180 Brussels (Belgium)

[4236

LEEDS CITY COUNCIL
Department of Education

AUDIO ENGINEER

(Ref. 13/20)

T3 £2187–£2538

Plus £3.20 per week Threshold

**Leeds Polytechnic
Educational Technology Unit**

To work with production team in the operation of the colour television studio and related recording facilities and to assist with the maintenance of equipment.

Application forms (quoting (Ref. No.) together with further details from the

**ADMINISTRATION OFFICER
LEEDS POLYTECHNIC
CALVERLEY STREET
LEEDS LS1 3HE**

to whom the forms should be returned.

[4243

Electronics Engineers up to £5000

Many jobs which would suit you down to the ground – either in the U.K. or overseas – are never advertised. Yet it will cost you nothing whatever to give yourself the opportunity to be considered for them.
Join the Lansdowne Appointments Register – used by hundreds of employers to select electronics engineers. You have nothing to lose, everything to gain – and it's all conducted in strict confidence. So post the coupon – find out exactly how you can make use of a service which is all the more valuable for being free !

To: Stuart Tait, Lansdowne Appointments Register, Design House, The Mall, London W5 5LS. Tel: 01-579 6585 (anytime – 24 hour answering service).

Please send me further details.

Name ....

Age (20-45 only) ....

Address ....

....

.... WW/18/11

lansdowne
Appointments Register
97

Electronics Test Engineers: career openings that affect all sorts of people...

. . . you most of all, naturally. Mainly because, by joining the world's largest exporter of radio-telephone equipment you will inevitably open up for yourself career advantages that very few companies can provide. Pye Telecom is growing at an ever-increasing rate – and the potential for its products has as yet been only fractionally utilised.
But the work you do will also be vital to an incredible number of others. Very frequently, life itself depends on the efficiency of the UHF and VHF equipment you'll be working on. Police, firemen and ambulance staff are a small sample of the extensive range of users. Which explains the exacting specifications of the test procedures in operation – and why previous fault-finding and testing experience is an essential requirement. If it relates to communications equipment, so much the better, but this is not absolutely essential. More important is practical proficiency, which may well have been gained in the armed forces. Relocation assistance is available and there is the possibility of Local Authority Housing being available.
Find out more right now by phoning or writing to Mrs Cath Dawe at:

Pye Telecommunications Ltd
Colne Valley Road, Haverhill, Suffolk CB9 8DU
Telephone: Haverhill 4422

A member of the Pye of Cambridge Group

[4249

BBC

ENGINEERING DESIGNS DEPARTMENT

A number of posts are available in Central London for enthusiastic and forward thinking young students to train as

TECHNICIANS

in the laboratories of the BBC's Designs Department. Their work will include assisting engineering and laboratory staff in the development, construction and testing of units of sound and television broadcasting equipment.

The successful candidates will probably be aged 18-20 and have a keen interest in, and possibly some experience of, electronics. They will have some 'O' levels—two preferably will be scientific—and they will be either recently qualified to O.N.C. or City & Guilds Part II standard, or have recently commenced the final year of such a course. Day release to complete the course will be given. Subsequent training to I.E.E.T.E. standard is by full time BBC courses at its Engineering Training Centre.

The salary offered would depend upon experience and qualification on appointment and would be between £1,872 p.a. and £2,064 p.a. It would rise by £96 p.a. to a maximum of £2,352 p.a. Satisfactory trainees could expect to be selected within two years for more senior Laboratory Technician posts whose salaries can progress to £2,697 p.a. £3,054 p.a., or £3,507 p.a. (These figures include £120 p.a. London Weighting, which is under review.)

Request for application forms to The Engineering Recruitment Officer, BBC, Broadcasting House, London, W1A 1AA, quoting reference 74.E.4092/WW and enclosing self addressed envelope at least 9in. x 4in. Closing date for completed application forms is 14 days after publication.

[4211

FOREIGN AND COMMONWEALTH OFFICE

COMMUNICATIONS DIVISION

Has a continuing commitment for

BROADCAST RELAY ENGINEERS

To serve a one year (unaccompanied) tour of duty on the island of Masirah (off the coast of Oman). Applications are invited from engineers with experience of the operation and maintenance of high-powered radio transmitters, and who hold a third year City and Guilds Certificate in Telecommunications or its equivalent.

SALARY: £6,563 per annum, plus a tax free allowance of £480 per annum for a single officer, or £985 per annum for a married unaccompanied officer.

Free furnished accommodation and passages are available.

For an application form and further details, please write to:

Recruitment Section
Foreign and Commonwealth Office
Hanslope Park, Hanslope
Milton Keynes MK19 7BH

[4215

COUNTY OF SOUTH GLAMORGAN
DEPARTMENT OF ENVIRONMENT AND PLANNING

Senior Assistant ENGINEER

SO/PO(1) £3201–£3729 p.a.

Plus Threshold Payment

This senior post is in the County Surveyor's Division and applicants will be required to assist in the design of an Area Traffic Control Scheme for the City. Applicants should preferably be familiar with computer systems, data transmission and closed circuit television, and must hold an appropriate qualification in this field in accordance with the National Scheme.

A contribution of up to £500 toward removal and associated expenses will be considered in appropriate cases.

Application forms are obtainable from: The Personnel and Management Services Officer, Floor 9, County H.Q., Newport Road, Cardiff. (0222 499022). Closing date 2nd December, 1974 and applicants should quote reference S212.

[4221

CHIEF ENGINEER

The North West State of Nigeria requires a chief engineer, based in Sokoto, for a new Colour Television Service.

Candidates should have experience in the operation and maintenance of P.A.L. Colour Television Studio, Outside Broadcast, Microwave Link and VHF Transmitters equipment.

Apply in writing to:

DWA

DAVID WHITTLE ASSOCIATES
Communications, Electronics & Television Consultants

Grays Redlynch Salisbury Wiltshire UK

[4227

VID COM LTD

VIDEOTAPE EDITOR

Vid-Com, New Zealand's rapidly growing independent video facility require an additional VTR Editor.

Facilities include four Ampex 1200c VTRs, Mark I Editec, an EECO Time Code system, HS-100 Video Disc, Fernseh studio and hand-held cameras, a Grass Valley N1600 Vision Mixer and a self-contained mobile OB VTR unit. Present staff size—26 people.

Major activities involve production of commercials and programmes for broadcast as well as various CCTV projects.

The applicant must be a fully trained skilled VTR operator/editor and experience as a technician would be helpful though not essential.

Salary is negotiable in the range of $NZ 7,000 per annum and overtime and meal allowance will apply.

As an independent facility we are not subsidized by Government or advertising revenue and it is the end result of our production efforts that counts.

The successful applicant must be willing to offer a sense of responsibility and service to our customers as well as providing technical ability. The applicant, if qualified, will also have the opportunity to assume the position of Deputy Chief Engineer.

Enquiries should be directed to:

The General Manager,
Vid-Com Ltd.,
P.O. Box 1409, Auckland, New Zealand. 4209

TONGA
SUPERVISING BROADCASTING TECHNICIAN

required by the Tonga Broadcasting Commission to be responsible for the operation and maintenance of the Commission's two 10 Kilowatt sound transmitters, to install and maintain studio equipment, to run a radio retail store involving technical supervision in purchasing, selling and repairing of receivers and other equipment.

Candidates, under 55 years of age, MUST have a City and Guilds Telecommunications Technician Final Certificate Course 271 or equivalent with ten years' experience in the operation of studio and transmitter equipment as well as in all aspects of a small broadcasting station with particular emphasis on sound transmitters. Salary in scale £2,125 to £3,400 pa which includes an allowance normally tax free in scale £504 to £1,404 pa and 20% Cost of Living Allowance. Gratuity 20% of Local Salary. Tour of two years.

Benefits include free passages, Government housing at moderate rental. Holiday visit passages and generous paid leave. An appointment Grant of £300 and Car Loan of £600 may be payable.

The post described is partly financed by Britain's programme of aid to the developing countries administered by the Ministry of Overseas Development.

For further particulars you should apply, giving brief details of experience to

crown agents

M Division, 4 Millbank, London SW1P 3JD, quoting reference number M2K/740928/WF.

[4258

CHELSEA COLLEGE
University of London
TECHNICIAN GRADE 4

required to run Physics Second and Third Year Undergraduate Teaching Laboratory. Duties include the development, construction and maintenance of Physics teaching apparatus and a good knowledge of electronics is required.

Salary (under review) £2,076 to £2,391 including London Allowance, plus payments under a Threshold Agreement (at present £167 per annum).

Application forms and further details from Mr. M. E. Cane (4.PT), Chelsea College, WW, Pulton Place, Fulham, London SW6 5PR.

[4250

FIELD SERVICE ENGINEER

required for the Electronics Department of Lithographic Printers. Good rates and prospects of promotion for the right man.

KINGPRINT LTD.
Electronics Division,
ORCHARD ROAD, RICHMOND, SURREY. Tel: 876 1091

[4265

Public Address Engineer

Experienced man with high standards required in the Public Address and Sound Recording field, capable of organising and operating temporary P.A. Systems covering conferences etc. Basic knowledge of electronics, tape editing and recording useful. Smart appearance (conventional dress) essential. Reliable driver—living central London—Age 24-40. Salary negotiable—Full details to:

G. HANSEN,
Griffiths Hansen (Recordings) Ltd,
12 Balderton Street,
London, W1F 1TF.
Telephone 01-499 1231/2. [4225

DEVELOPMENT ENGINEER

required for an expanding company servicing the printing industry. First class rates of pay. Pension scheme and good prospects for the right man.

KINGPRINT LTD.
Electronics Division,
ORCHARD ROAD, RICHMOND, SURREY. Tel: 876 1091

[4266

TELEVISION ENGINEER

A vacancy occurs for an additional TV. Engineer with an expanding Rental and Retail company. Applicant will preferably have some colour experience. Large s/c flat available after trial period. Salary according to experience.

Hydes of Chertsey Ltd.,
56/60 Guildford Street, Chertsey 63243

[39

£2,000—£2,500
p.a. BASIC to

REPAIR ENGINEER
ACCORDING TO ABILITY

for servicing audio and photographic (electronic flash) equipment, etc.

AXCO INSTRUMENTS LTD.

(Tel: 01-346 8302)

228, Regents Park Road, Finchley N3 3HP

[4210

INTEROFFICE TELEPHONES LIMITED

An opportunity exists to join our Sound and Time Section to maintain in London/H. Counties various types of Radio/Amplifiers. Some knowledge of Impulse Clock Systems and direct speech installations would be an advantage.

Please telephone for an appointment.

01-274 3214/5
01-274 5091 [4275

REQUIRED—EXPERIENCED ENGINEER

for high quality tape recorders as well as sound projection equipment. Salary negotiable.

Apply:
AV DISTRIBUTORS (London) LIMITED,
26 Park Road, London NW1 4SH
Phone: 01-935 8161.

[4213

APPOINTMENTS

ELECTRONIC EXPERIENCE WANTED. Engineers, technicians or testers required to assist teams preparing electronic equipment manuals. Writing experience preferable but not essential. Interesting work on sites in London and Home Counties. Impex Publications, 37, Alexandra Street, Southend-on-Sea, Essex. [4273

REDIFON TELECOMMUNICATIONS LTD., London, SW18, have a vacancy for an enthusiastic, practical man with some experience of Volume Production Testing in the electronics industry. Phone: 01-874 7281 and ask for Len Porter. [4212

SITUATIONS VACANT

HI-FI AUDIO ENGINEERS. We require experienced Junior and Seniors and will pay top rates to get them. Tell us about your abilities. 01-437 4607. [19

TV FILM Dubbing Theatre requires experienced engineer, professional sound recording techniques. Write stating experience and salary expectations. Box No. W.W. 4226.

WANT A PAID HOBBY? We are a London T.A. Regiment with vacancies for morse operators. Telephone 01-247 5594 or 8749. [4217

ARTICLES FOR SALE

AARVAK ELECTRONICS, 3-channel sound-light converters, from £18. Strobes, £25. Rainbow Strobes, £132.—98A West Green Road (Side Door), London N15 5NS. 01-800 8656. [23

BRADLEY BAND pass filters. No. 4 450-650MHz. No. 5 650-1000MHz 2 each. Coax switch type 256 6 way 50Ω'N'. Offers. Finch, 6 Cherry Tree Way, Penn, Bucks. Penn 4483. [4247

COLOUR T.V.'s—Bush CTV25 displayed working £90+VAT. Large discounts for 3-up. Non-workers available. Rediffusion wired Mono T.V.'s all screen sizes, new condition. Sumiks, 1532 Pershore Road, Birmingham. 30. Tel. 021-458 2208. [12

FOR SALE Racal 100Mhz Universal counter timer type 5A 550 and handbook, good working order, only £80. Smith, "Cracknells", Hempstead, Nr. Saffron Walden, Essex. Telephone Radwinter 493 evenings or weekends. [4264

WE SELL CONSTRUCTION PLANS

Phonevision, Television Camera, Police Radar Detector, Voice typewriter, Scrambler, Answering machine, Wireless quarter mike. Plans; $7.50 each.

COURSES

Detective-Electr, $36.50. Security-Electr, $43.50. Telephone Eng, $59.

OVER 750 ITEMS

Ask for Catalogue—Airmailed $0.75

T. STRIK,
Postbox 618, Rotterdam, Holland.

[44

Classifieds continued on page 106

Find your place in British Gas

COMMUNICATIONS AND INSTRUMENTATION MAINTENANCE

Eastern Gas wish to recruit a Maintenance Technician to be based at their Communications and Instrumentation Workshop at Hertford.

The duties, which are both varied and interesting, involve all aspects of maintenance on their Region's Integrated Communications System which incorporates the use of microwave radio, telemetry and electronic pneumatic instrumentation.

ONC or equivalent qualification plus a knowledge of one of the above is desirable but not essential for applicants with proven ability in Communications or Instrumentation.

The salary will be in the range £2,025–£2,532 per annum and there are excellent opportunities for promotion on merit to a salary grade rising to £2,865 per annum; in addition to these figures a weekly supplement will be paid in accordance with the pay code under the Industry's Threshold Agreement.

Considerable travelling within the Eastern Region of British Gas will be necessary and a current driving licence is therefore essential.

Please write with full details of age, qualifications and experience to J. M. Pinney, Recruitment Officer, Eastern Gas, Star House, Potters Bar, Herts or telephone Potters Bar 51151.

EASTERN GAS

[4262

RADIO TECHNICIANS

Are you a Radio Technician with a City & Guilds, Intermediate Telecommunications Certificate or equivalent? If so then why not join the Home Office. There are vacancies in Central London (near Waterloo Station) but you may also be liable for employment at the Home Office Laboratory at Canons Park, Stanmore.

PAY: Inclusive of an interim addition is £1,695 at 19 rising to £2,575 plus a cost of living supplement which is at present £12.18 a month. In addition a London Weighting Allowance of £228 which at present is subject to review.

A SECURE FUTURE with a good pension scheme, prospects of promotion and a generous leave allowance. Five day week of 41 hours.

EXPERIENCE: Two years practical workshop experience of maintenance and the use of radio/electronic gear.

INTERESTED: Then telephone or write for an application form (to be returned by 29 November, 1974) to:

Miss C. S. E. Phillips, Home Office, Whittington House, 19-30 Alfred Place, London WC1EA 7EJ.

Telephone 01-637 2355 Extn. 87.

[4253

Join the EMI Service Team at Hayes

We urgently require

Electronic Repair & Calibration Engineers

required for the repair and calibration of a wide range of electronic instrumentation, including oscilloscopes, DVMs, pulse generators, power supplies etc.

Applicants should be aged at least 18 years and should have had at least two years background in electronics. Further training will be given in appropriate cases.

Close Circuit Television Engineers

for the servicing and commissioning of CCTV, VTRs etc.

Applicants should be aged at least 19 years, and must have had some experience in television receiver servicing.

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EMI

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Classifieds continued from page 105
Articles for Sale continued

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[4259

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[40

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Classifieds continued on page 107

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ALL PLUS VAT 8%

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Articles for Sale continued

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Articles for Sale continued

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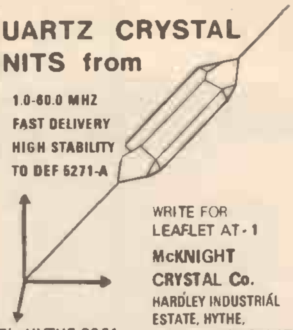

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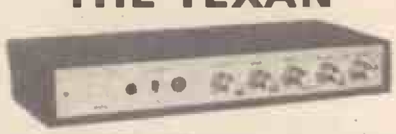

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