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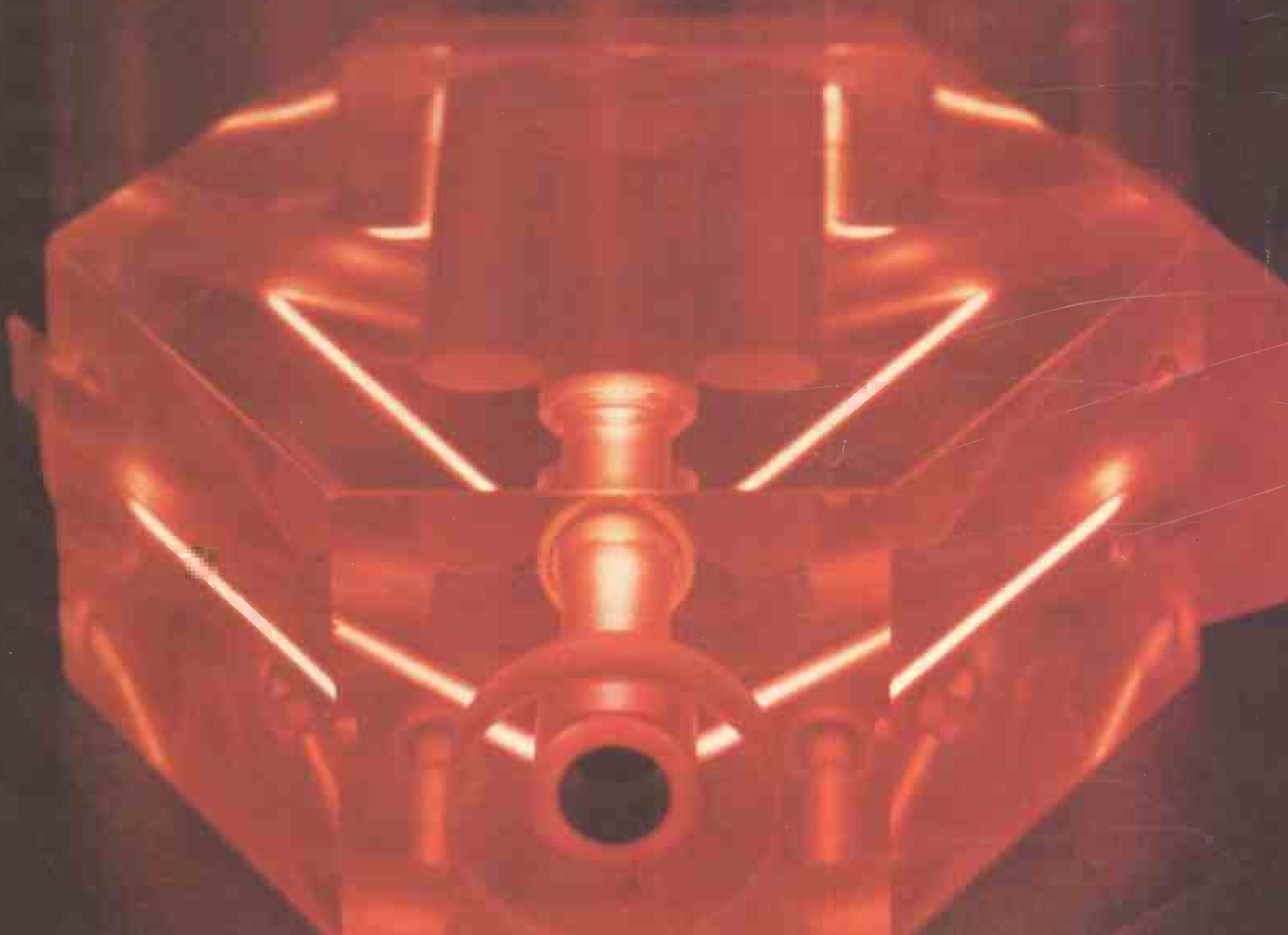

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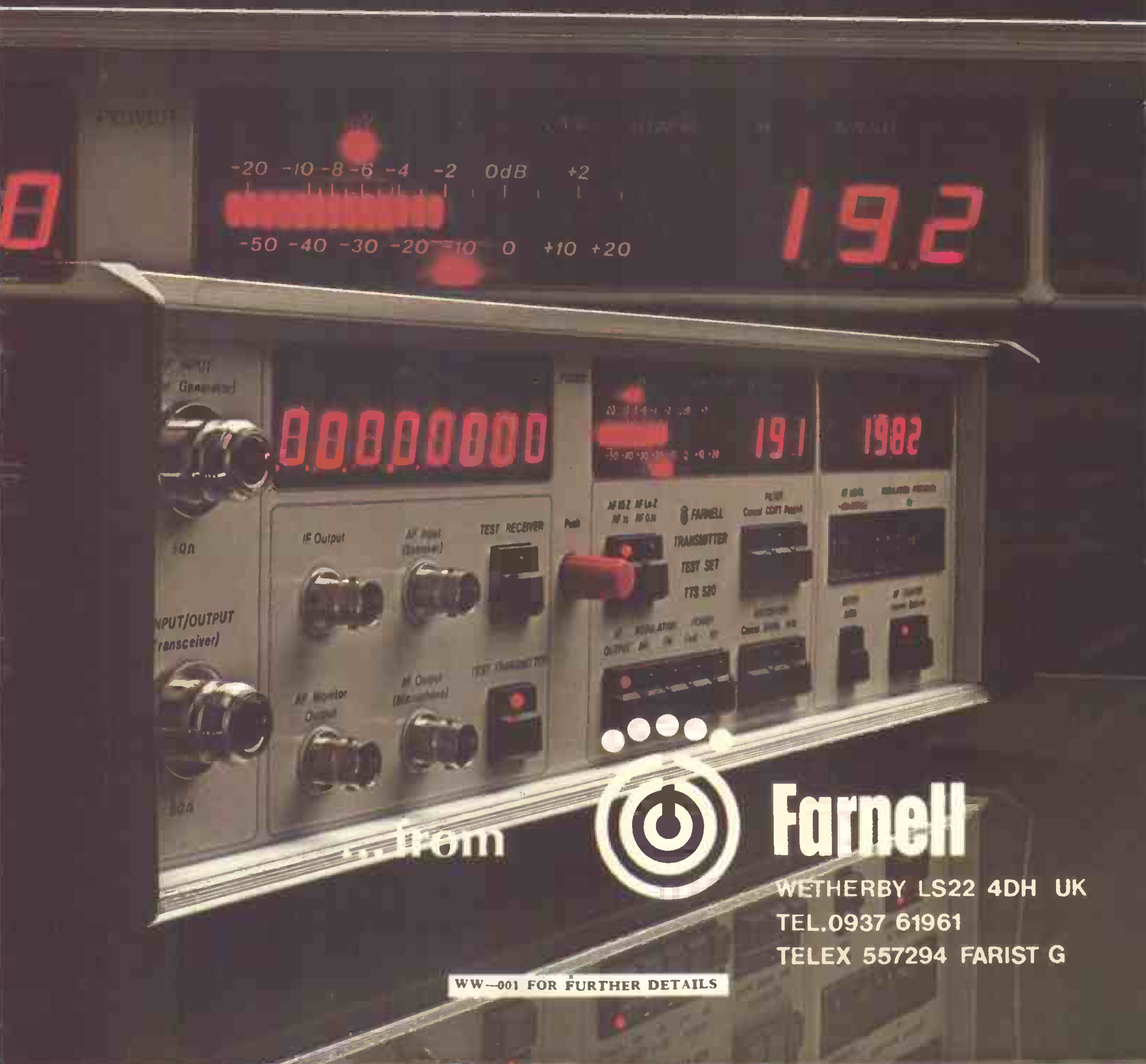


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*Front cover is a laser gyro, used in strap-down inertial navigation systems. Picture supplied by SFENA, Villacoublay, France.*

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**Modular preamplifier. The first of three articles in which John Linsley Hood describes his new preamplifier, which is modular in form and which features several novel ideas.**

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**Editorial & Advertising offices:** Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS.
**Telephones:** Editorial 01-661 3500. Advertising 01-661 3130.
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**Subscription rates:** 1 year £14 UK and £17 outside UK.
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SEPTEMBER 1982

Vol 88 No 1560

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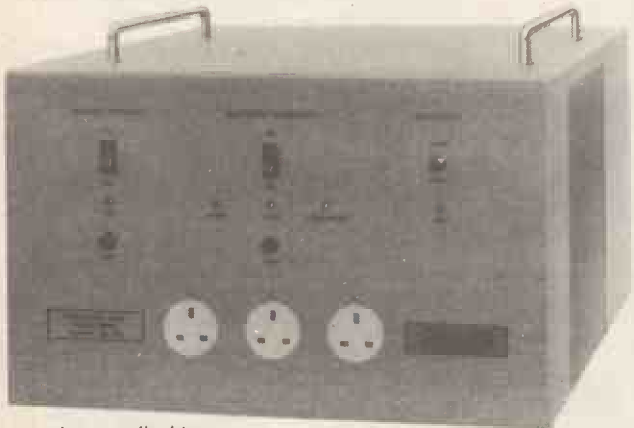

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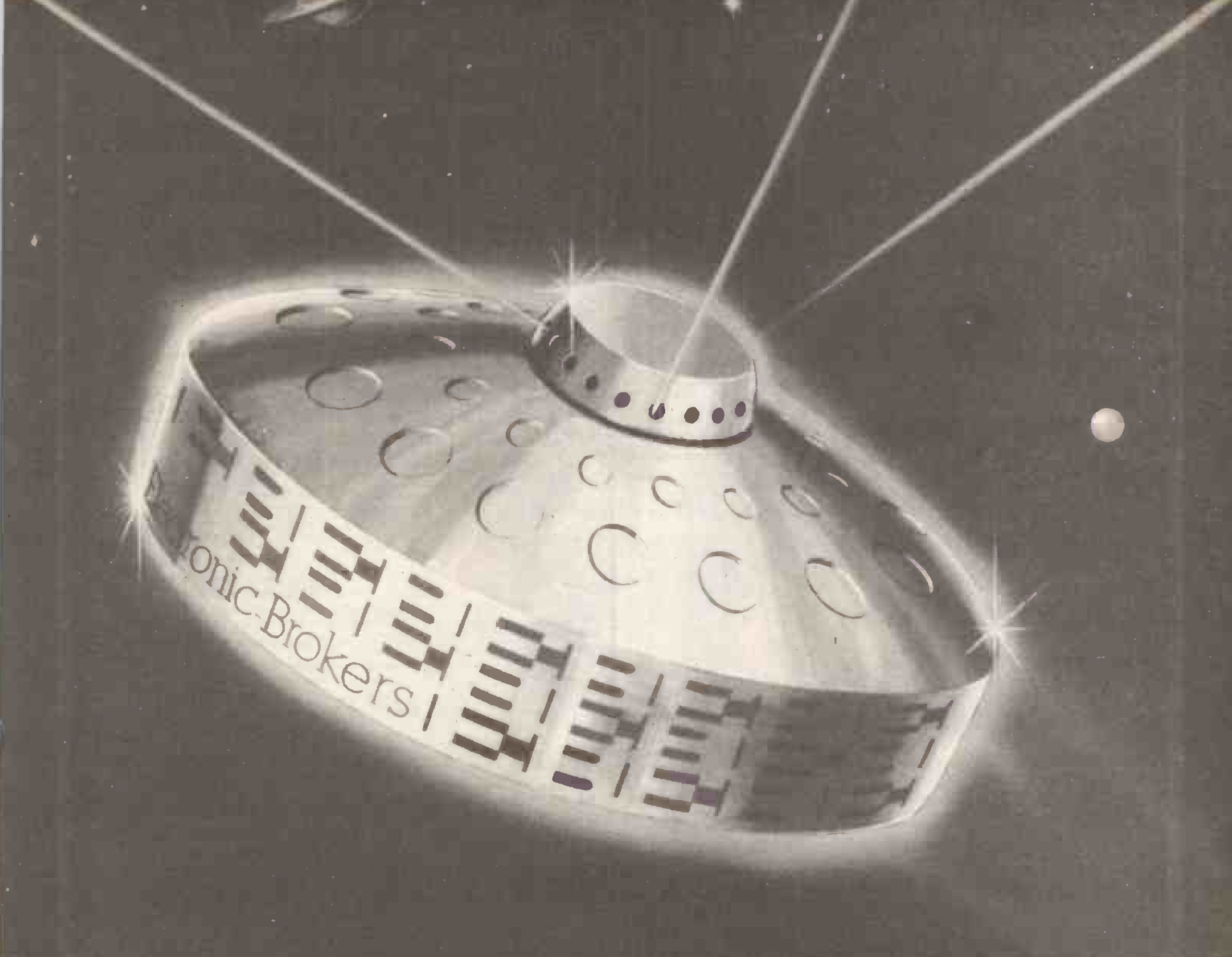

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J. L. Linsley-Hood Amplifier designs have always led the field. The latest and greatest is the new 100 watt MosFet power amplifier recently described in this magazine. We are of course preparing kits for this and the matching separate Pre-amplifier to be described later.
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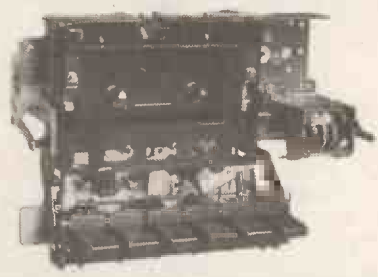

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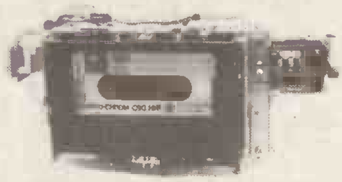

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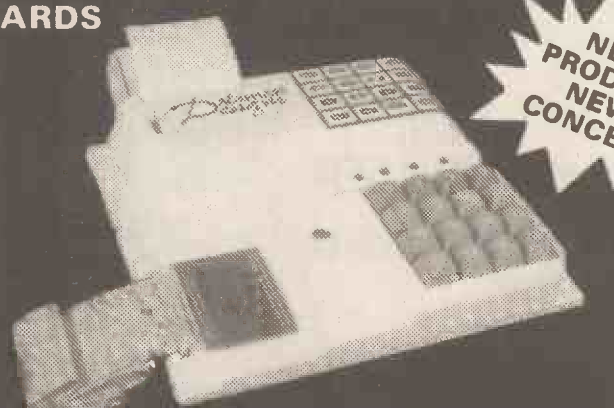

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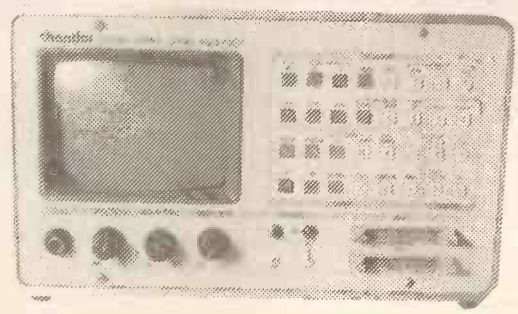

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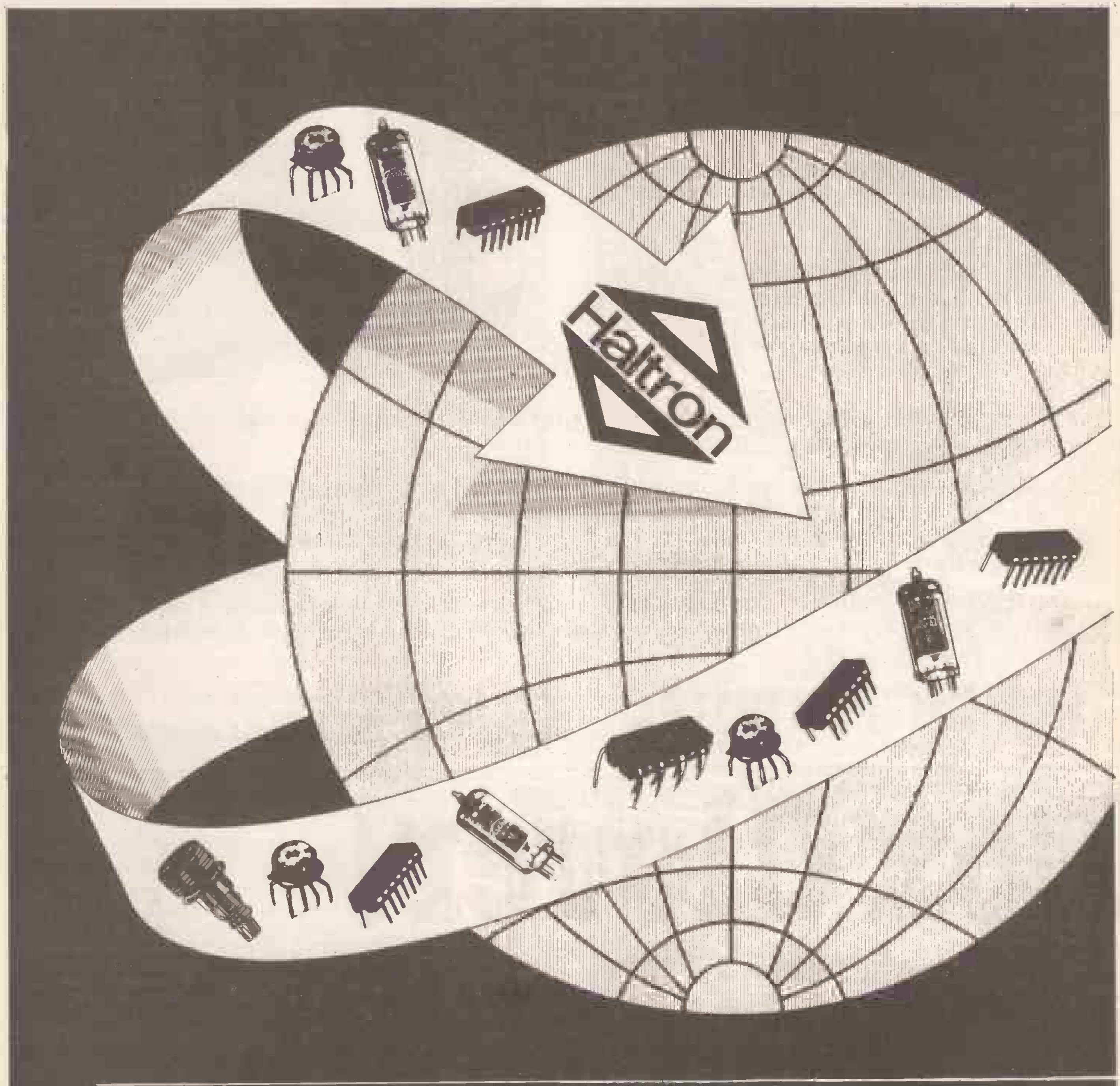


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74216A Noise Generator 300
74261A Psophometer 300
74262B White Noise Generator & Receiver 2000
74307C Level Measuring Set 175
74834C Distortion Measuring Set 500
96016 Selective Null Detector 200
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PM6624/02 520 MHz 9 Digit Counter Timer TCXO 750
PM6661 80 MHz 8 Digit Counter 180

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371 18 GHz 11 Digit Counter with Source Locking facility 4950
8110 50 MHz 8 Digit Counter Timer 320
9025 1 GHz 8 Digit Counter 450
9903 50 MHz 7 Digit Counter Timer 310
9905 200 MHz 8 digit Counter Timer 360

### SYSTRON DONNER
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5103B Strip Printer for 6053/6054 375

### TEKTRONIX
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1600S Logic Analyser 32 ch 20 MHz 2250
1602A Logic Analyser 16 ch 10 MHz 900
1615A Logic Analyser 24 ch 20 MHz 4850

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833 As 832 plus BERT/BLERT feature 1300

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616 2ch AC 1ch DC Volts/Av/Spike/Time/Printer 3500

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MJ4 1 kV 0 – 200 mΩ tester. Hand Drive 160

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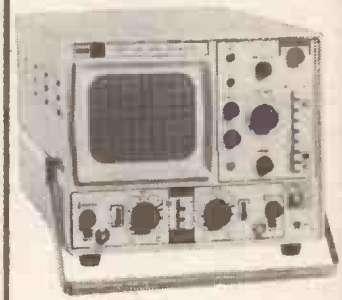

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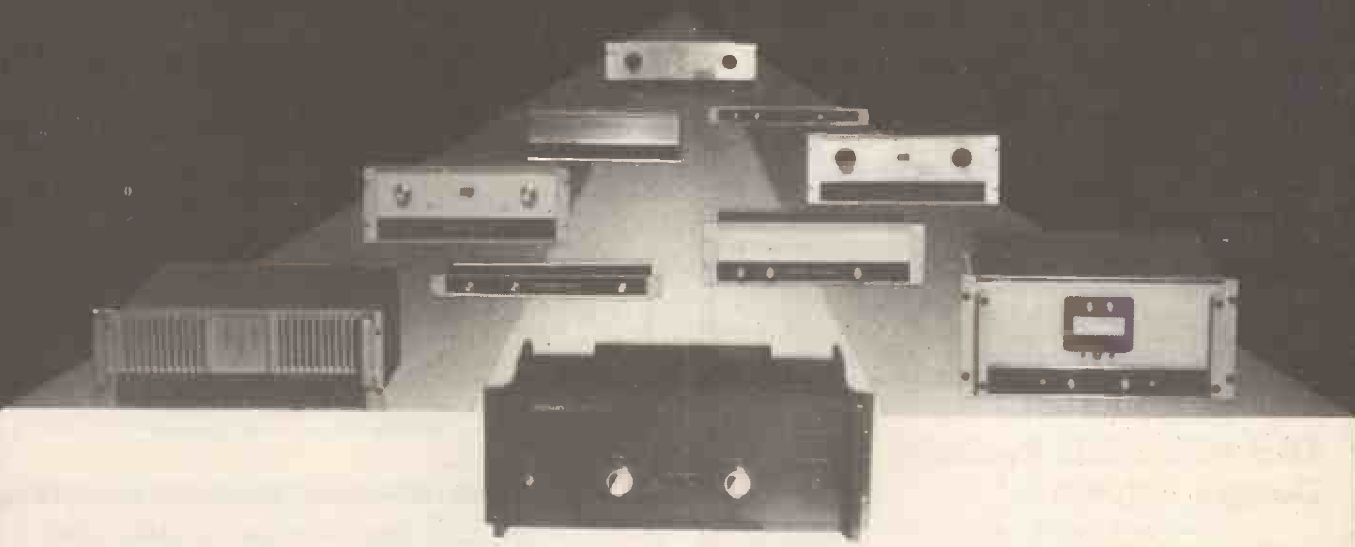

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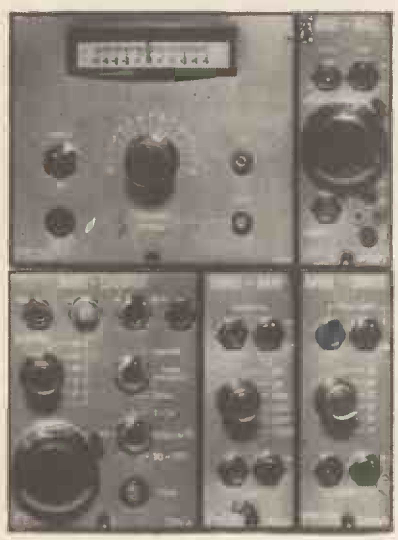

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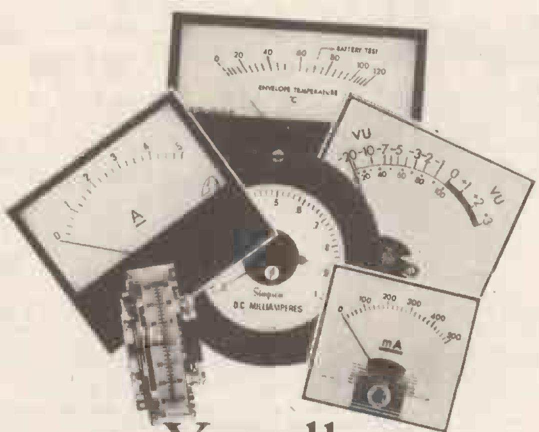

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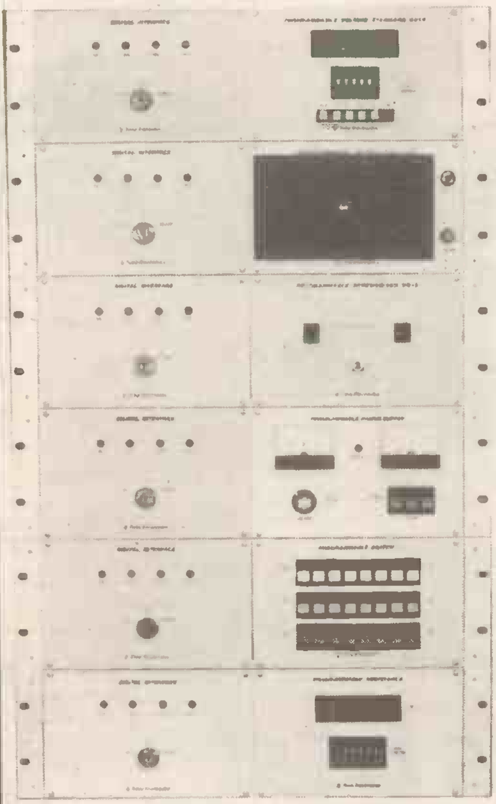

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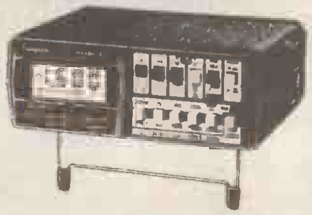

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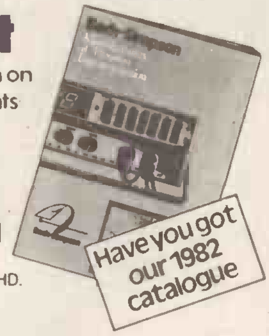


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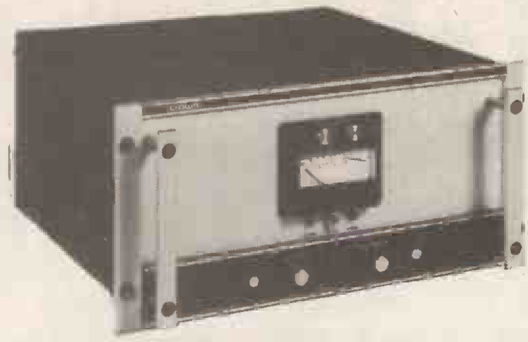

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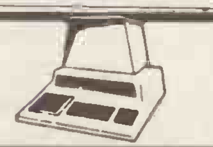

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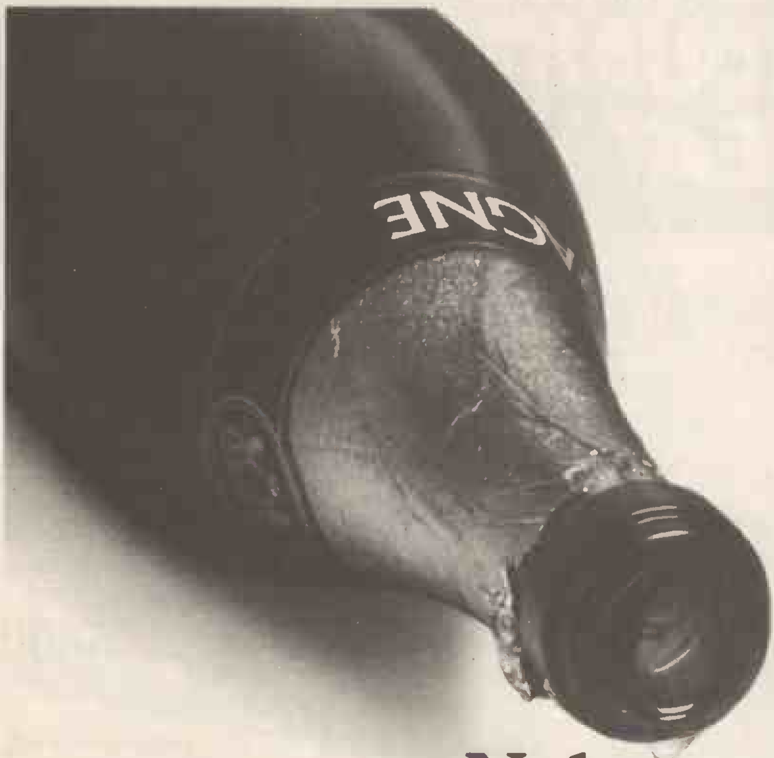



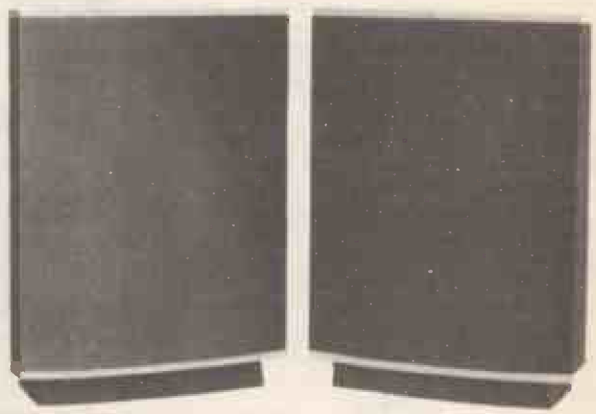

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# I.T. and M.I.S.S.

One of the aims of Information Technology Year and the Microelectronics Education Programme is to involve schoolchildren in the use of microcomputers and related electronic devices. There are the M.E.P., the Micros in Schools Scheme, exhibitions and events throughout the year and beyond. It is, perhaps, fortunate that Mr Callaghan happened to be watching television on the evening the programme "Now the Chips are Down" was broadcast and was spurred into action then, or we would probably find the propaganda even more frenetic than that now being put out by the energetic Mr Baker, the prophet of IT.

Information Technology is a curiously diffuse name for a Year. The official definition, "the acquisition, processing, storage, dissemination and use of vocal, pictorial, textual and numerical information by a microelectronics-based combination of computing and telecommunications" appears to encompass most of the activities of the average person, except eating and one or two other processes, although the use of a computer is not often considered essential to the more basic of these.

So far as its involvement of schoolchildren is concerned, the publicity is decidedly shrill, the Minister's aim being to have a computer in every secondary school by the end of the year and even to think about providing them for primary schools.

There can be no argument that young people must be aware of computers and how to use them, but it does seem possible that the present blaze of publicity tends to obscure the point that computers are a means, not an end. There is also the question of how the micros are to be used in schools.

According to the fifth edition of the Concise Oxford Dictionary (now, admittedly, modified), a computer is "a calculator – an electronic calculating machine" – an unfortunate description, taken too literally by at least some of those responsible for introducing youngsters to computing, with the result that the school micro is often given to the senior maths teacher to guard with his life, presumably on the grounds that computers are electronically mathematical and possess no relevance to any other subject.

In other schools, the computer is treated as a kind of totem, and the pupils are taught "Computer Studies". As a subject, computing (meaning programming) is a singularly empty one, unless the pupil learning it intends to become a programmer. A computer is an aid to the process in which it is used – in this instance, learning – and an element of transparency to the user rather than an obscuring of the subject by undue attention to the computer must be the aim.

Clearly, an overnight transformation, after which every teacher would be using a micro as to the manner born, is hardly feasible. But, until the school micro (or one of its terminals or even a micro owned by a pupil or teacher) can be used naturally, as is a dictionary or pocket calculator or a video recorder, it will dominate the learning process. Utmost priority should be given to teachers from all disciplines, from home economics to athletics, to use the computer as an aid, rather than as a distraction, so that pupils who are not to specialize in science or engineering can see that it is of advantage to them to be at ease with computers, but no more than that.

The Inner London Education Authority is aware of these problems and is educating teachers in the use of computers so that, even though there may be only one micro or terminal in the classroom, the pupils will learn the place of a computer by, to use ILEA's word, "osmosis". However, there is evidence aplenty that education authorities in other areas are either hypnotized or revolted by the new equipment and, accordingly, either enshrine it or pass it to the school computer fanatic to impress people with.

In short, a computer is a useful tool, but that is all it is: it can help or it can dangerously hinder learning, and only the education of teachers in its natural use as an aid can decide which.

# DIGITAL FREQUENCY STABILIZATION OF A V.F.O.

*Using a single crystal, the unit stabilizes the output of a variable-frequency oscillator at a large number of points by means of a counting technique. This article traces the development of the design and points out further avenues to explore*

by W. Trapman, jr.

Most radio receivers and transmitters use at least one variable oscillator, coupled with the turning dial. Such an oscillator, usually called a v.f.o., must be easily tuned, exhibit high frequency stability and provide a pure sinusoidal output. For s.s.b. communication, the stability requirement cannot be met with LC oscillators, at least not in the higher h.f. bands or the v.h.f. frequencies. Use is often made of a mixing scheme, the variable oscillator running at a lower frequency, but purity of output and simplicity suffer with this method. Ease of tuning has always been the hall-mark of good communication receivers, leading to the familiar looks and appreciable cost of a very long tuning dial, with very fine divisions, coupled to the tuning capacitor by means of slip-free reduction gear without backlash.

Of course, a digitally-set frequency is very useful in a test-oscillator, but useless when one wants to tune in with the 'handwheel'.

## A simple stabilizer

Proposals have therefore been made to accomplish the old-fashioned continuous tuning while stabilizing the generated frequency at discrete spots. A simple method, now well known to amateurs, is given in Fig. 1. Since we are not interested in displaying the frequency digitally, only the first decade from the usual chain of counters is needed and its output used to correct the v.f.o. frequency.

To get a good mental picture of what happens, consider an example. The measuring period is exactly one second, the v.f.o. frequency is about 5 MHz, say, 5,123,456.78 . . Hz. The counter, being reset before the measuring time starts, contains after one second a 6 or 7. Because the digital output is taken from the fourth flipflop, a 1 only results when the counter contains an 8 or a 9, all other numbers giving a 0 at this point. The 1 may be regarded as the 'too high' signal, the 0 standing for 'too low'. This digit is stored in a buffer, so the counter can be reset and a new measurement initiated. A large time-constant smoothes the control signal from the buffer to the Varicap v.f.o. In the working system, the frequency of the oscillator is kept around 5,123,457/8 MHz and wobbles around this value. The next points for stabilization are 5,123,467/8 when tuning upwards and 5,123,447/8 when going downwards. Any drift of the v.f.o. is taken care of by changing the ideal equal number of ones and zeros to some other proportion, for instance five ones against four zeros in a sequence like 01010110101, etc. (To say *any* drift is compensated for is fine, so long as it is taken to mean 'any small drift'. A very bad oscillator equipped with the stabilizer will not 'creep' but 'jump'. It is a very simple system, compared with other possibilities.

Besides a crystal-controlled (one-second interval) time-base, few i.cs are required and its elegant simplicity appeals to constructors.

There are drawbacks, however, all connected with the long measuring time: to get a reasonably smoothed control signal, the integrating time-constant has to be very large. A further point to think about is the delay in the system – even if the large RC product could be avoided, the information about the frequency becomes available every second and this is a somewhat elusive way of saying that some of it is almost one second old. The system just described needs at least several seconds to stabilize after the tuning knob is touched.

So, the first thing one tries to do is to shorten the measuring time to 0.1s. This is

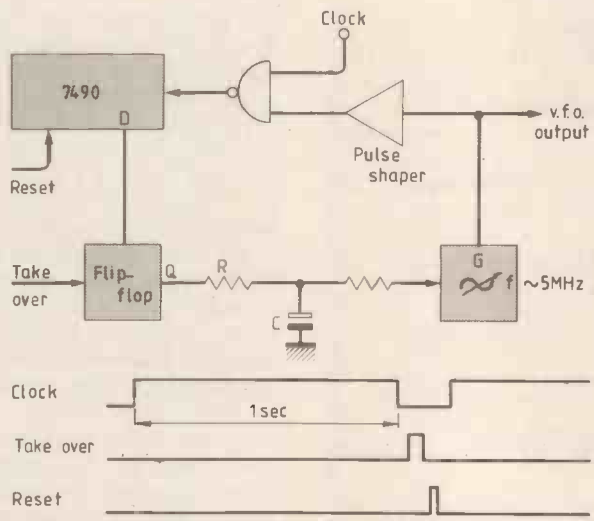


*Fig. 1. Simple frequency-stabilized v.f.o.. When crystal-derived one-second period ends, 'high' or 'low' information from the decade counter is stored in the flip flop until next measuring period is completed. Clock and logic to provide the timing and controlling pulses not shown. R and C give large time constant.*

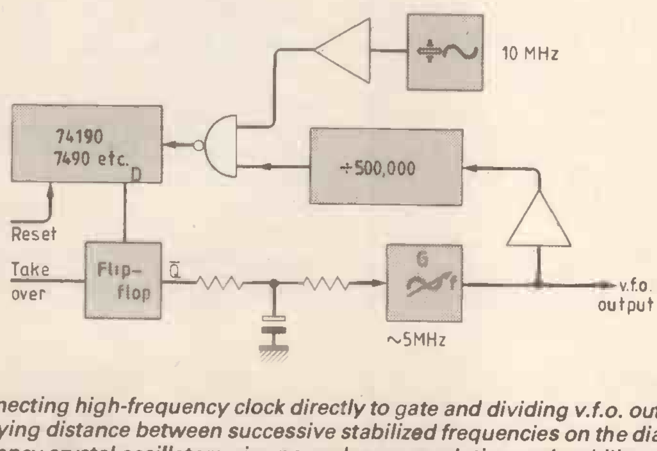


*Fig. 2. Connecting high-frequency clock directly to gate and dividing v.f.o. output down gives a varying distance between successive stabilized frequencies on the dial. Because high-frequency crystal oscillators give no probems, resolution and stability can be high. Integrator is now connected to $\overline{Q}$ on storage flip flop. Speed of logic elements forms limit for higher clock frequencies.*

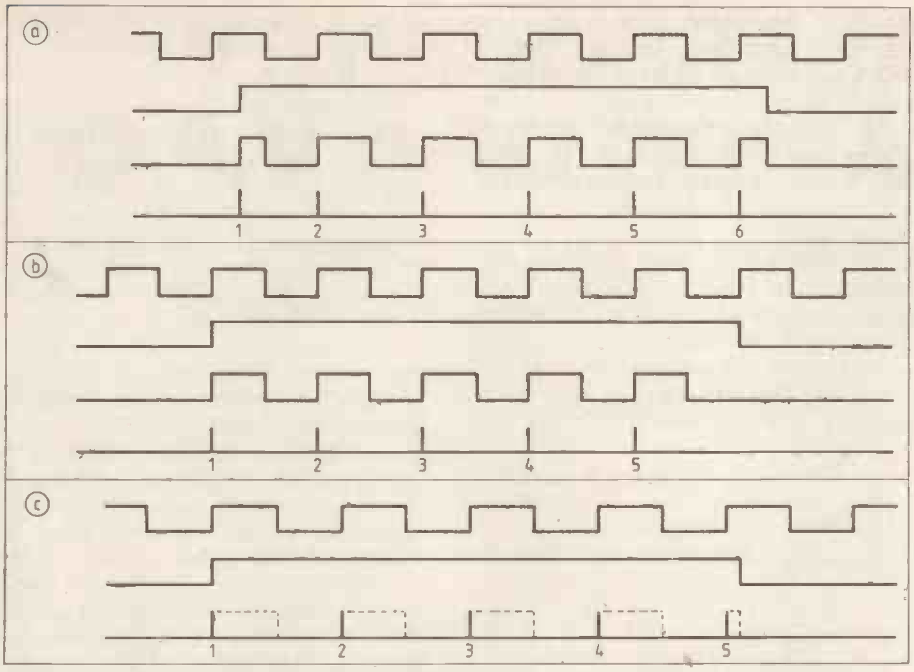


*Fig. 3. (a) Shows 5 Hz square wave giving six positive going slopes per second, seen as pulses by the counter. In (b) only five pulses are seen. With some regularity this situation may alternate or not with (a). All depends on the relative position of the two waveforms. (c) shows that even an input frequency of 4.1 Hz gives five pulses to counter.*

not a good idea, however, because the digit now contained in the buffer store represents not Hertz but tens of Hertz. In our example, with an initial frequency of 5,123,456.789 . . Hz, the counter contains that five and the feedback will arrange to make it alternate between 7 and 8 as before. The next higher stabilization (centre) point will be 5,12357/8, which is no less than 100 Hz from the previous one. The resolution of measurement is ten times reduced and the 'ripple' on the v.f.o. frequency is the same factor enlarged. The integrator time-constant can be ten times smaller now and the speed of response is subjectively very much improved – the only benefit of the change in measuring time.

The problem still remains: how to improve the resolution without lengthening the time for each measurement. When discussing this point with friends (one of them the prototype of *Homo digitalis*) one answer came up again and again: raise the frequency, so that the relative accuracy remains high enough when you shorten the gate time. In theory this is a way-out, because the high and stabilized frequency of, say, 51 MHz is divided by ten to get our original 5.1 MHz and the frequency variations are divided too. In practice, if you can build an oscillator that does not drift 10 Hz in 0.1 second at 50 MHz, frequency stabilization is probably not necessary. This approach did not seem attractive. Instead I pondered for some time, wondering whether it is at all possible to measure a frequency with an accuracy of 1 Hz in less than a second.

## Period counting

Just to be complete, one may recall the 'period counting' method of measuring low frequences. When the rôles of the clock and the unknown frequency in a frequency counter are reversed the unknown period is measured in units of the clock period and this takes only one period of the unknown frequency. If the unknown is about 5 MHz we could count off 500 000 periods in about 0.1 second, during which time the gate would be open. The single decade connected to its output would receive the clock signal, let us say 10 MHz. The resolution is still plus or minus one pulse in (about) a million and the grid of stabilization frequencies is now nonlinear: the distance between grid points at 5 MHz is 50 Hz. This is twice as good as the 100 Hz grid obtained with 0.1 second measuring time when counting the frequency direct and solely due to the clock frequency being twice as high as the v.f.o. frequency: a block diagram is given in Fig. 2. This is a good set-up when high-speed logic is used and the clock frequency can be raised to 20 or preferably 50 MHz (no prescaling: the gate and the counter following it must discriminate between those fast pulses).

To conclude the period-counting line of thought, the change of the distance between stable points over the dial is often not important. The ratio of the divider between oscillator and gate might well be a power of 2. Frequencies like f/2, f/4 are then available, all stabilized.

## Counting reviewed

The above stabilizations work well, but there is an extra irregularity not yet described, which is caused by the counting process itself. The specifications of commercial counters usually give the measurement error as ± 1 count + time base error. The time base is not important for this discussion: the reference crystal oscillator drifts a little, but presents no problem. The real problem is with the last digit of the counter, which in successive counts (if it were provided with a display) would show two values – it would 'jitter'. The stabilizing counter does the same thing,

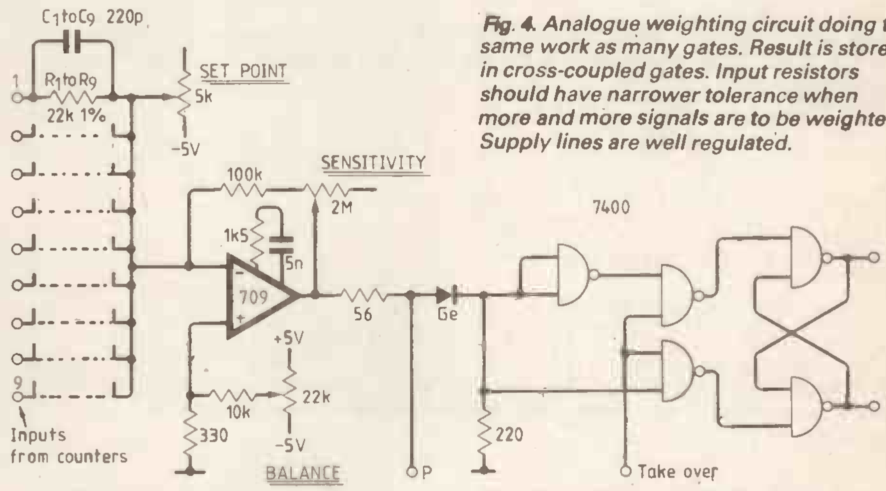


*Fig. 4. Analogue weighting circuit doing the same work as many gates. Result is stored in cross-coupled gates. Input resistors should have narrower tolerance when more and more signals are to be weighted. Supply lines are well regulated.*

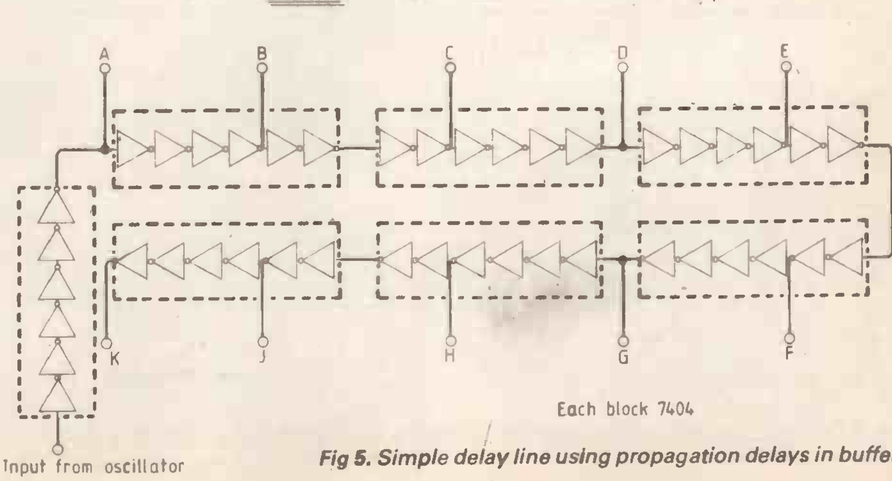


*Fig 5. Simple delay line using propagation delays in buffers.*

even when the incoming frequency is perfectly stable since there is no phase relationship between the reference oscillator and the v.f.o. This is most disturbing and leads to noise on the correcting voltage to the oscillator.

To get a clear picture I drew a few pulses on graph paper, as in Fig. 3, which represents a 5 Hz signal as it appears before and after the gate of a frequency counter. The flip-flops in the counter toggle on the positive-going slope. When a window of exactly one second moves over the 5 Hz pulse train, we see immediately what happens: half a pulse has just the same positive-going slope, which is what is counted, when the two waveforms glide past each other. Only when the situation is exactly stable (no gliding) do we get consistent answers from the counting process. Figure 3 (c) shows that stretching the pulses out (by lowering the frequency to 4.5 Hz) does not produce a different result; even 4.1 Hz does not make the fifth pulse 'fall out of the window'.

The only way to make this one-pulse ambiguity less important is to count more pulses, for instance by counting during ten seconds or by making ten, separate, one-second counts and averaging the answers. The last method was used very often when counters had no switch position for 'multiple frequency' and the resolution was just one decimal place too low.

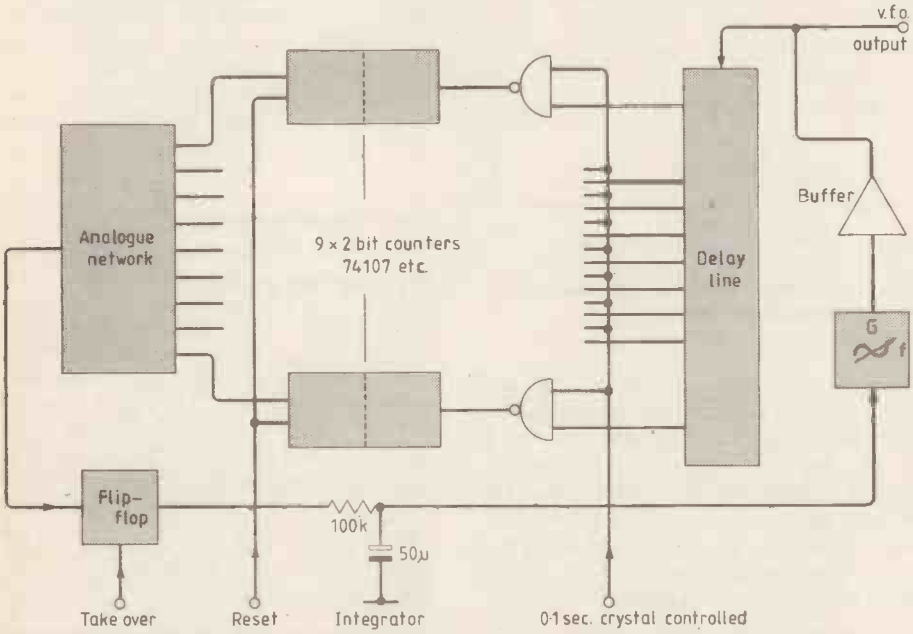


*Fig. 6. Block diagram of frequency-stabilized v.f.o. Each of odd number of counters gets a slightly different 'cut' from continuous pulse train from the oscillator. Counters work simultaneously.*

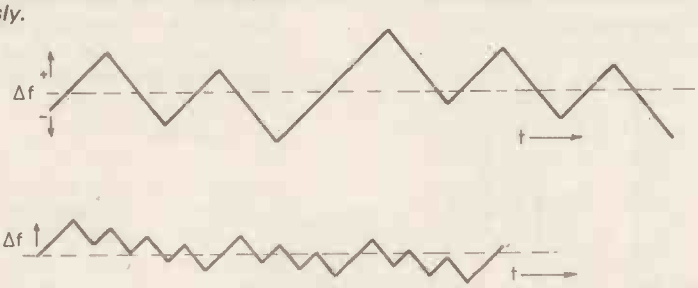


*Fig. 7. Frequency variation of output is reduced when corrections come faster, drift being equal in both cases. Even a three times faster correction rate is a worthwhile improvement.*

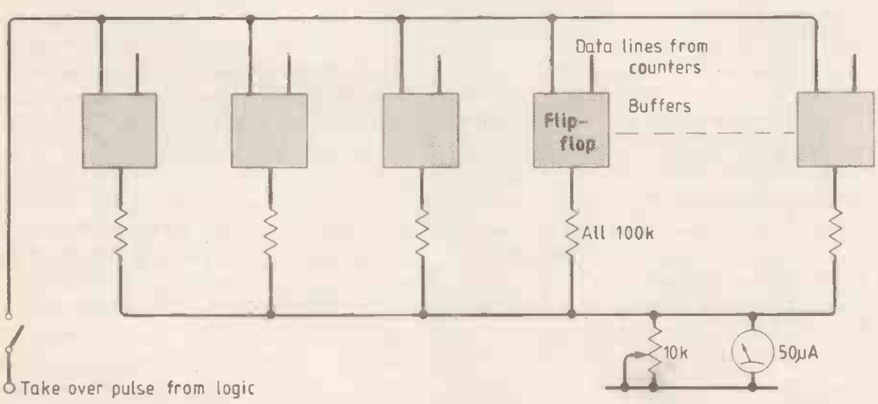


*Fig. 8. Adding digital information without clipping is much better. Digital store is 'frozen' when switch is open.*

## A new method

All this may be interesting but does not look very promising for our v.f.o., until a new idea is brought in. It is not necessary to do the individual one-second measurements one by one: the measuring times may overlap. The aim is to average out the one-pulse variation and obtain the high resolution that may be expected from a long counting time, but before placing endless rows of decades on the breadboard it might well be asked why one should use four flip-flops to get a single 0 to 1 out of them? Well, it depends largely on the stability of the oscillator when the controlling loop is disabled, and on the nature and magnitude of any impulsive noise that might enter the system. With a simple four-bit counter there is plenty of margin on both sides of the dividing line between 7 and 8, but with a decade counter one side is limited; two pulses extra make a zero from that 8 to give a 'correction' in the wrong dirction.

Because the decade on the breadboard worked well once the starting time was over, I decided that two-bit counters were all I needed. There were times I wished I had used the SN 7493 four-bit counter, but some of the problems turned out to be hardware-oriented and not so much a system fault.

## Voting logic

The majority-vote is taken by the analogue circuit of Fig. 4, which works easily with 21 inputs – an odd number to get a majority in all situations. The input resistors are of the carbon-film type, selected for close tolerances for a larger batch with the circuit of Fig. 4 itself (without $R_1$-$R_9$). A voltmeter at point P indicates output voltage during the selection; the setpoint and sensitivity potentiometers are partly incorporated for this occasion. Even this circuit is a simplification from the breadboard circuit, where the digital outputs of the counters were stored by 'buffer' flip-flops. These buffers are not required if a reasonable amount of time is available for the voltage at P to take on the proper value. If take over and reset must take place in 1 or 2 μs, it becomes necessary to use the buffer store.

Counting in the parallel, but delayed, counting operation, it is immaterial

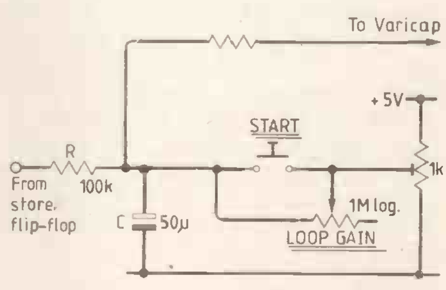


*Fig. 9. Push button is pressed 10 seconds after power is switched on, reducing loop gain while charging capacitor to average value. H.f. decoupling of control line not shown.*

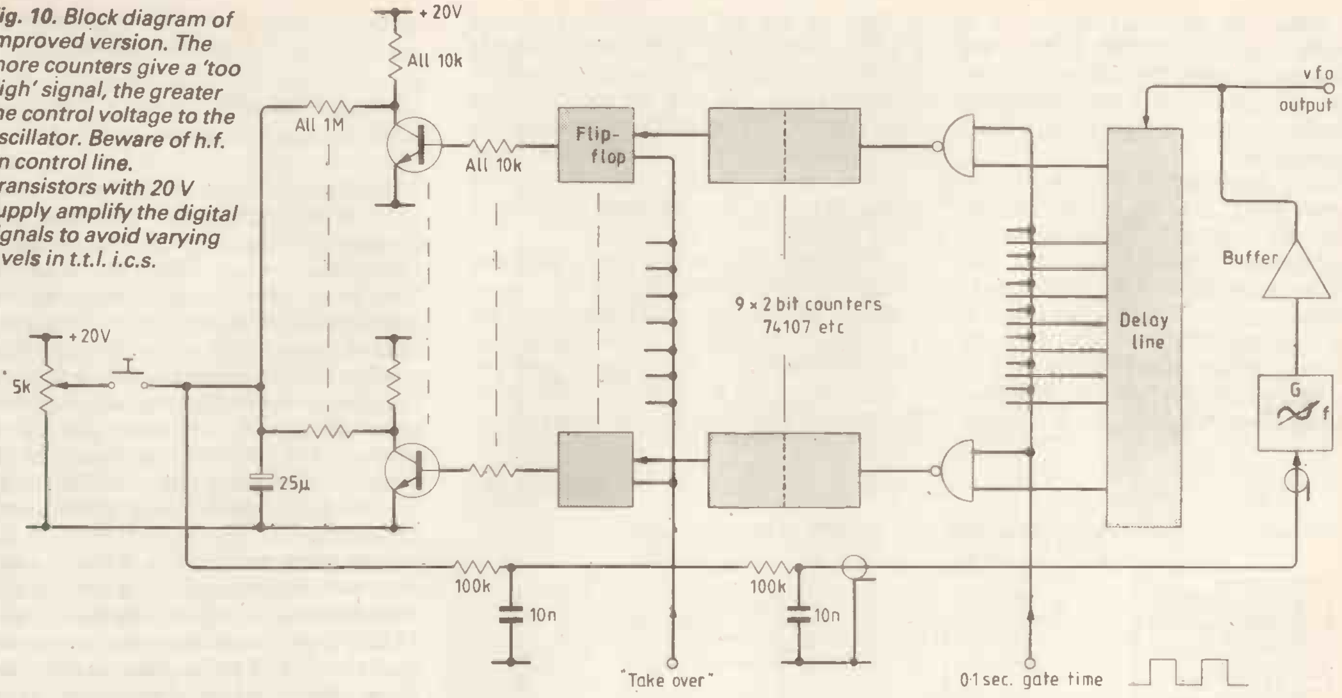


*Fig. 10. Block diagram of improved version. The more counters give a 'too high' signal, the greater the control voltage to the oscillator. Beware of h.f. on control line. Transistors with 20 V supply amplify the digital signals to avoid varying levels in t.t.l. i.c.s.*

whether the clock is delayed or the v.f.o. signal. For oscilloscope testing, it is very pleasant to be able to delay the highest frequency (the v.f.o.): it would take a storage oscilloscope or one with dual timebase to display 10 Hz signals with small delays. The end of the counting, take over and reset and start can now be the same for all counters, which keeps matters simple. The last question to resolve is, with a 5 MHz v.f.o., over what period must the delays be extended and how many counting systems are needed? In a practical system, with cheap t.t.l. building blocks, there are only two possibilities for building a delay line. The first one to think of is a series of 'monostable' delays, SN 74121 being the monostable block. A second way to achieve delay is the use of the intrinsic propagation delay of logic elements, the standard inverter SN7404 giving, in pairs, a delay of about 20 nanoseconds, according to the data sheet, although measurement shows the delay of n pairs often to be shorter than n times 20ns. To get a maximum delay of at least one period of the 5 MHz, the delay line consists of a series string of inverters with outputs every two pairs, which takes six blocks, one more being used to make sure the input to the delay line has the appropriate switching times.

## Complete system

A block diagram of a complete system gives Fig. 6. The v.f.o. frequency of 5,123,456.789 Hz is counted during 0.1 second in a modulo-four counter which is another way of saying that it contains, when the counting is over, the remainder of the division-by-four of the number of input pulses. if the remainder is 0 or 1 a 0 level is presented to the analogue weighing network, a count of 2 or 3 producing a 1. The nine counters get a 0.1 second gate signal, the closing of the gates immediately being followed by storing a 0 or 1 in the flipflop, depending on the dominance of the counts 0 and 1 ('too low' signal) or 2 and 3 ('too high' signal). The integration time constant is related to the repetition rate of the measurements, which is ten per second.

The stabilization points (the grid on the tuning dial) have such frequency values that the average remainder in the counters wobbles between 1 and 2. The next grid point is one cycle of the counters further, or four more counts. Four counts in one tenth of a second means 40 in a second, so the grid points have 40 Hz spacing: the +0/+1 irregularities are not so well averaged out as I had hoped. A little calculation and comparison with other processes where a random disturbance is reduced in prominence by a form of averaging leads to the unpleasant conclusion that these variations are reduced by $\sqrt{N}$, where N is the number of counters. This is disappointing and means that the nine counting systems give only three-fold reduction in 'randomness'.

This should be regarded as a by-product of the process, the main advantage being the faster response of the loop. In the system of Fig. 6, drift of the oscillator leads to *all* counters giving the same signal, e.g. 'too high', and this leads to a consistent 1 in the buffer, which is something different from the random 1 appearing occasionally. Before examining this more closely, it is necessary to remember that the v.f.o. stabilizer is not perfect – not only is the number of counters N very low, but the delay-line sections do not have equal delays. Then there is the question of the length of the delay line: one feels by intuition that the discrete length of the line is important, and the same intuition tells us that when N is really high, this discreteness is not quite so important.

Another point to remember is the fact that the 'feel' of the turning knob is so much better, because of the improvement in response speed, compared with a one-second gate period. The ripple on the frequency is probably as shown in Fig. 7 and even a 3× improvement looks good.

## Further development

At this stage of the experiments a set of flipflops was in place, and for a reason I cannot remember now these storage flipflops were reinserted between the counters and the weighting network. Instead of the v.f.o. a crystal oscillator was connected to the input and a digital-to-analogue converter with a set of equal resistors feeding an indicator in the form of a 50 μA meter (Fig. 8). The frequency of this oscillator can be varied slightly by varying the supply voltage so, by breaking the line controlling take-over of information at certain times by means of the switch and changing the oscillator frequency by small amounts, the effects of a drifting oscillator can be seen on the meter. There is no closed loop and we see just the information-gathering part of the process.

The demonstration was set up without thinking very much of it, but it became apparent that this 'analogue' method of adding the information from the counters is very good; the occasional +0/+1 variation is much smaller than the swing of the pointer when a small frequency shift occurs, several counters responding in the same direction. It really come down to the fact that the limiting applied by the 709 in Fig. 4 to the sum signal should be avoided. What is needed is linear amplification, which can be done with the left-hand part of Fig. 4, the storage in the right-hand part now being redundant. The control line to the v.f.o. may not go negative, but little d.c. amplification is required.

Some amplification can be had before the d-to-a conversion takes place by providing a higher voltage difference between logic levels. The SN 7406 or discrete transistors may be used, connected between the buffer flip-flops and the summing resistors. This was not tried, but seems an easy way to get some gain when a well-regulated supply of 20 V or more is already available. This method gives well-defined voltage levels for 'high' and 'low', but the system is very tolerant of faults in

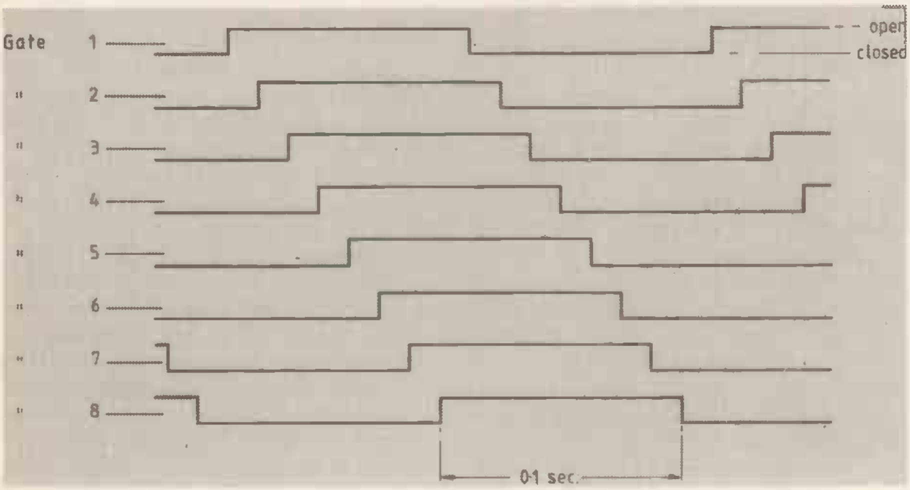


*Fig. 11. Delaying clock (with gates) is easy but does not lead to anything useful.*

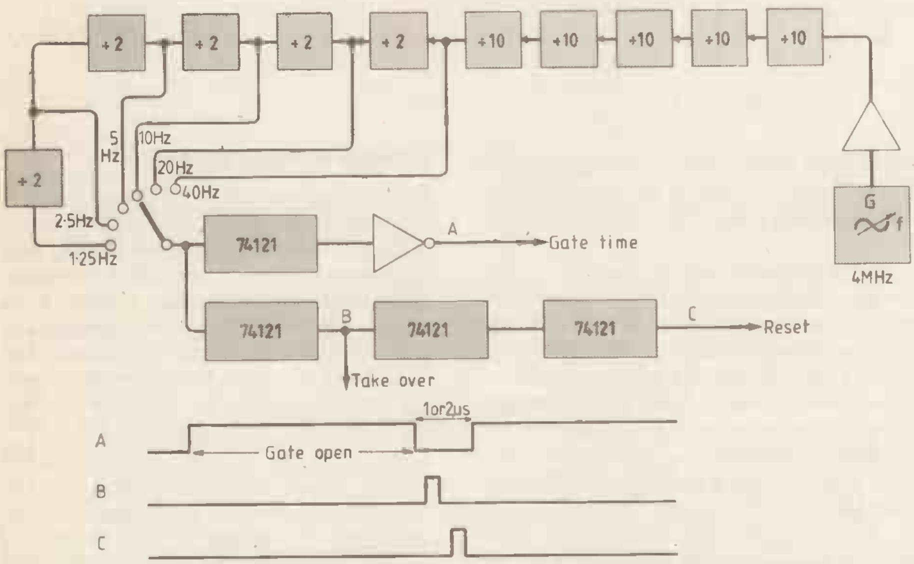


*Fig. 12. Command pulses are derived with monostable delays. Exact value of gate time is not important and any odd crystal may be used.*

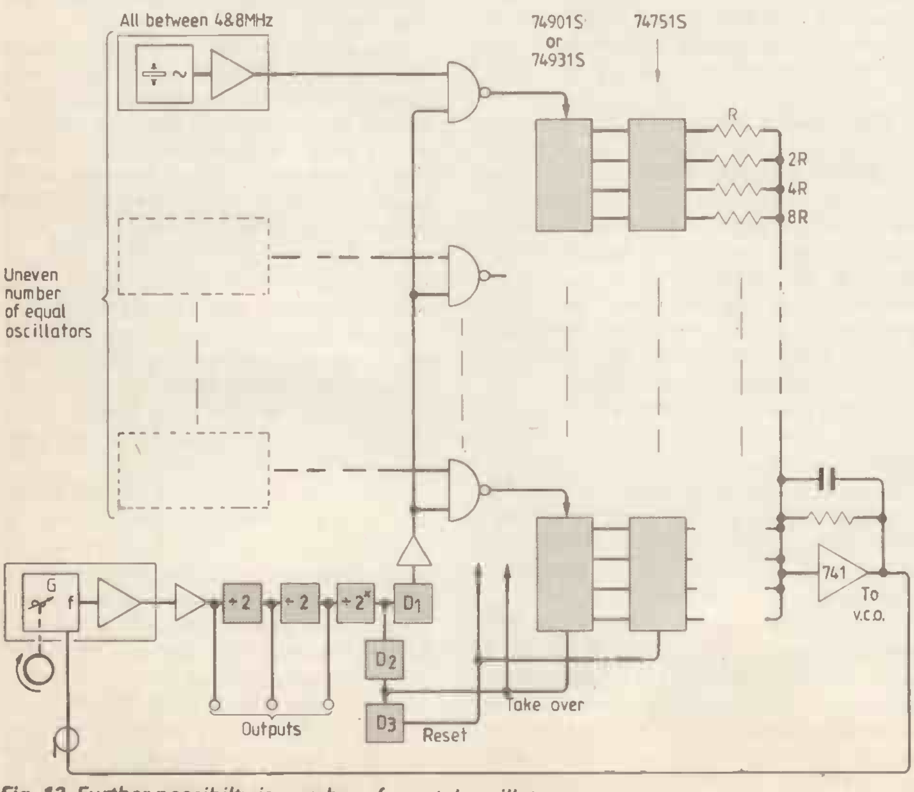


*Fig. 13. Further possibilty is number of crystal oscillators.*

the logic levels and even a distinct fault of one of the t.t.l. blocks feeding the resistors must be more than 0.3 volt to become a nuisance. (I know this very well as a user of out-of-specification i.cs.)

## Starting-up

There is a small problem to be solved in connexion with the starting conditions: the integrating capacitor should be charged to the average value on the line and the loop disconnected when starting up. The large drift of the oscillator in the first minute or so after the power is switched on is often not due to the oscillator itself, the transistor taking only a few milliwatts, but to settling down of the regulated power supply, where more power is dissipated, the threshold voltages being temperature-dependent.

During the experiments, a push button was used, as shown in Fig. 9, its contacts connecting the capacitor to the slider of the 1 kΩ preset potentiometer across the power supply. The low impedance of the potentiometer reduces the loop gain when the button is pressed. When the voltage on the slider is set to the average value of the voltage on the capacitor the loop gain can be adjusted with the impedance across the button without undue frequency shift. Further refinements like suppressing the output of the v.f.o. during warm-up are possible.

## Delayed clock

The combination of Figs. 6 and 8 (shown in Fig 10) work well. There is still the feeling left, however, that the subject of the parallel working counters should be looked upon from another point of view. This is stimulated by a remark made by one of my friends that the number of packages is not very high, after all. Besides, a v.f.o. with several frequency bands and a long dial is always a fairly large part of any telecommunications apparatus, and who would object to the number of i.cs used if a better performance is obtained? So I started to trace the decisions made (and reported here) and found a badly argued one in the preference for a delay line connected to the v.f.o. signal.

Knowing now it can be done that way, I wondered if I could delay the clock with equally good results. Schemes using a long delay, like the one with the timing diagram of Fig. 11, all seem to use more time without any improvement in performance, compared to that of Fig. 10. The idea behind such schemes is that when the first gate closes, some information about the unknown frequency is available, this information getting improved every time a gate closes. Here is still an opportunity for thought and experiment as I can see no practical way to achieve something useful along these lines.

## Clock oscillator

The clock used in the experiments consists of a crystal oscillator, buffer amplifier and pulse shaper, followed by a chain of counters. When experimenting with longer or shorter gate times, complicated switching to get the command pulses at the right times was avoided by taking the exact repetition frequency used from the divider in question (e.g. 0.1 Hz, 0.2 Hz, 0.4 Hz, etc.), and triggering a 74121 monostable block with it. The time between monostable pulses is used as the gate time. A few more monostables produce the command pulses 'take over' and 'reset' as in Fig. 12. The gate time is now not exactly 0.1 second, etc., but this is unimportant. The stability of the gate time is still good, as the 1μs from the 74121 is only a small part of it and a drift to 1.1 μs is unlikely to happen in a short time.

### Further possibilities

Next to waiting for the proper integrated circuit to appear on the market, containing a large number of fast gates and counters, the most straightforward approach would be to use a number of nominally equal crystals, as in the scheme of Fig. 13. This is especially attractive in countries where ex-second world war supplies are available and cheap. Of course, very efficient decoupling and buffering is necessary to prevent the oscillators from locking on to each other. The v.c.o. frequency may be chosen freely, taking into account the division ratio N of the divider chain.

This should preferably be a power of 2, providing symmetrical output waveforms from all intermediate tap points. The number of flip flops in the divider should be such that the output frequency of the divider is, say, 10 to 20 Hz. As outlined before, there is no need for separate flip-flops controlling the gates, this being done just as easily with monostable circuits.

The use of 27 MHz crystals was not successful, these being probably less stable than the surplus types, which were around 5 MHz. The lower oscillator frequency makes the isolating problem less severe, too. It is not necessary to make the frequencies of the crystal oscillators very nearly equal when the weighing network is large, as it is here. Starting from a nominal v.c.o. frequency (e.g., the one that gives exactly 0.1s gate time) it is easy to find out what is the maximum allowable spread in crystal frequencies, the limits being given by the size of the counter. Obviously, one requirement is that all counters overflow the same number of times. as can be expected, a better alignment of the crystal oscillators makes it possible to reduce the number of resistors in the network.

Reducing the size of the counter from modulo 16 or modulo 10 to modulo 4 or even modulo 2 is worth thinking over, if the v.c.o. is extremely good. Starting up and locking is going to be much more troublesome; this makes other components necessary (automatic loop gain reduction when turning the v.c.o. wheel). With modulo 2 counting no working system is obtained, however, because in theory *no* frequency difference is allowed that leads to a zero in some counters and a one in the others. In this case there is no discrimination between a higher and a lower v.c.o. frequency. For some frequencies, or grid points, this is not true, a form of stabilization is taking place near certain points of the dial – more a drift reduction than true stabilization. WW

# BOOKS

## Computing

**Apple Interfacing,** by J. G. Titus, D. G. Larsen and C. A. Titus. 206 pp., paperback. Prentice-Hall International, £7.65. ISBN 0-672-21862-3.

Interface control signals between the Apple II and external devices are thoroughly explained in theory and practice by the use of experiments. A general-purpose breadboard assists in circuit construction and there is enough information to enable the experimenter to build a printed-board type. Only a nodding acquaintanceship with digital electronics is assumed.

**The Logic Design Of Computers,** by M. P. Chinitz. 413 pp., paperback. Prentice-Hall International, £11.15. ISBN 0-000-218-006.

Neither hardware nor software are the province of this book, but rather the logical processes which are performed by the former when instructed by the latter. A short historical section and a piece on number representation are followed by chapters on programming and switching theory. Logic elements are treated in outline and the final chapter deals with microprogramming.

**The 6809 Companion,** by M. James. 88 pp., paperback. Bernard Babani, £1.95. ISBN 0-85934-077-5.

A discussion of the characteristics of the 6809 microprocessor from the programmer's point of view. This is a small book, but nonetheless a very useful contribution. A slight drawback is that the text was produced by a Centronics printer, which is good for its purpose but not, perhaps, for a book.

**16-bit Microprocessor User's Manual.** 231 pp., paperback. Prentice-Hall International, £11.20. ISBN 0-13-566695-3.

This is the third edition of what is effectively Motorola's handbook for the MC68000 series of microprocessors. Full information on all aspects of instruction, signal and bus operation and memory management are provided, with all characteristics.

**The Explorer's Guide to the ZX81,** by M. Lord. 120 pp., paperback. Timedata, £4.95.

In the words of the author, this "attempts to carry the reader on from where the ZX 81 manual leaves off". There is no introduction to Basic or the ZX81, although the first chapter does provide some programming aids which help to use the limited r.a.m. available more economically. A number of games are included as illustrations of techniques. There is a chapter on machine language, which is included to help the inexperienced, and the final section deals with practical matters, such as loading from cassettes and connecting a monitor. Timedata Ltd, 57 Swallowdale, Essex SS15 5BZ.

## Analogue design

**Analog Instrumentation Fundamentals,** by V. F. Leonard, jr. 318 pp., paperback. Prentice-Hall International, £13.95. ISBN 0-672-21835-6.

Anyone looking for an explanation of the principles of a.c. and d.c. pointer-type instruments, bridges, transducers, RC filters and attenuators will probably find this book useful. Those needing practical help will not find it here since, as the title clearly states, these are fundamentals, which are attractively treated in a readable style.

**Applications and Design with Analog Circuits,** by J. M. Jacob. 498 pp., hardback. Prentice-Hall International, £22.45. ISBN 0-8359-0245-5.

Essentially practical design information on the use of operational amplifiers in most of their relevant roles, including power supplies, active filters and non-linear circuits. Although written for engineering degree students, the treatment is such that less advanced readers will find it accessible.

**Operational Amplifiers and Linear Integrated Circuits,** by R. F. Coughlin and F. F. Driscoll. 376 pp., hardback. Prentice-Hall International, £16.45. ISBN 0-13-637785-8.

Written at a slightly less advanced level than the previous book, this is even more practical and a little wider in scope. It is intended for a one year course, all the circuits described having been tested. Students not specializing in electronics will find the book helpful and the practical approach is ideal for amateurs.

## Radio frequencies

**Introduction to Radio Frequency Design,** by W. H. Hayward, 383 pp., hardback. Prentice-Hall International, £20.95. ISBN 0-13-494021-0.

Students and amateur electronics engineers commonly find their way into electronics by way of digital circuitry and components, r.f. design being well in the background. This is an attempt to do for r.f. what thousands of texts at this level do for digital design. It is practical, with many examples, mathematics up to about A level being used. A working knowledge of simple circuit theory is needed to make full use of the book. All the components of a modern receiver are described in detail, including a chapter on transmission lines and the Smith chart.

**H. F. Antennas for All Locations,** by L. A. Moxon, G6XN. 260 pp., hardback, RSG1. £5.00. (£6.67 by post, from RSGB, 35 Doughty Street, London WC1N 2AE. ISBN 0-900612-57-6.

This is a remarkably helpful book, which deals with a subject often regarded as being akin to black magic, in a throrougly practical manner. That is not to say that theory is neglected – it is not – but it is kept in its place. The author has been well served by his publishers, who have turned out a well-produced book at an extremely low price – well under half the price of many technical paperbacks of half the size.

# CLASS 'S'

# A novel approach to amplifier distortion

*If the load presented to the voltage amplifier by the power output stage appears very high, crossover distortion can be reduced and the voltage amplifier is much easier to design.*

**by A .M. Sandman,**
M.Phil.(London),M.I.E.R.E.

A basic cause of distortion in power amplifiers is quite simply that they have to drive loads, something which is clearly seen in Fig. 1 (b), when the higher resistance load of 2.4Ω can have ±25 volts of swing generated across it whilst the low resistance load of 0.8Ω can have only ±10 volts across it before it limits. Another way of looking at the situation is to try and generate ±25 volts across the 0.8Ω resistor, when severe distortion in the form of limiting will occur. In other words, it is much easier to drive a high-resistance load than a low-resistance one.

The object of Class 'S' is to perform the task of making a low-resistance or impedance load appear to the voltage amplifier as a high, ideally infinite impedance.

### Basic configuration

Let $V_o$ (Fig. 2) represent the voltage output of the voltage amplifier and $I_{L'}$ the output of the subsidiary current amplifier which also provides load power. $R_m$ is a small resistor which develops a voltage $V_m$ proportional to the load current $I_L$. $R_L$ is the load resistance.

If $V_m$ is used to make the subsidiary amplifier develop a current $I_{L'}$ as close in value to $I_L$ as possible then $I_L - I_{L'} = 0$ and $Z_{in}$ will tend to infinity.

This is the simple idea behind a whole family of circuits, one of which will now be described.

### Basic circuit

This consists, as seen in Fig. 3, of a voltage amplifier, comprising a standard operational amplifier with feedback ($A_1$,$R_1$,$R_2$) and a voltage-controlled, high-impedance-output current amplifier ($A_2$ with its associated bridge of $R_m$, $R_{m'}$, $R_G$, $R_{G'}$).

As the non-inverting (+) and inverting (−) inputs to $A_2$ are virtually at the same potential, irrespective of what this potential is (a basic property of operational amplifiers), it follows that the bridge must be in balance and that, ideally, since $I_L = I_{L'}$, $A_1$ sees an infinite load.

### Demonstration circuit

The circuit of Fig. 4 works on the principle of the basic circuit, with the addition of a complementary push-pull pair at the output ($Tr_1$, $Tr_2$) to provide more current than the second 741 and its voltage follower $Tr_3$ is a capable of.

During the crossover region time when, say, $Tr_1$ stops conducting and $Tr_2$ has not yet started to conduct, $Tr_3$ provides the output voltage and the impedance it sees

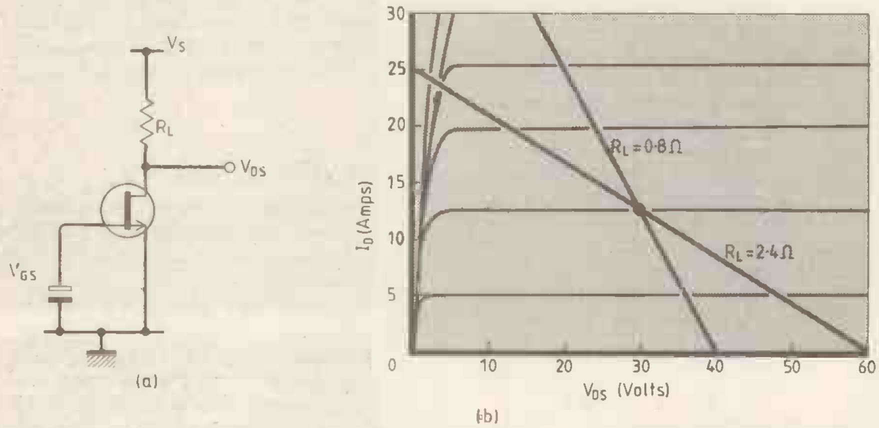


*Fig. 1. In the basic voltage-amplifier stage, a high-resistance load provides a larger swing with less distortion.*

**The author**

*Mr Sandman was born in 1933 of Jewish parents and almost become a tailor! After gaining City and Guilds Full Technological Certificate in 1957, he obtained his M.Phil. degree from London University in 1978.*

*Many years ago, he published a scheme for automating the railways as part of a scheme for road traffic automation – he tells us that his chief pleasure lies in the invention of new schemes such as a bandwidth compression system, currently in the pipeline, and "Error Take Off," a method of reducing amplifier distortion published in Wireless World in October 1974.*

*A deeply held, though hardly novel, belief is that we shall never resolve our problems as a country until, we pay our engineers about twice as much as we do now.*

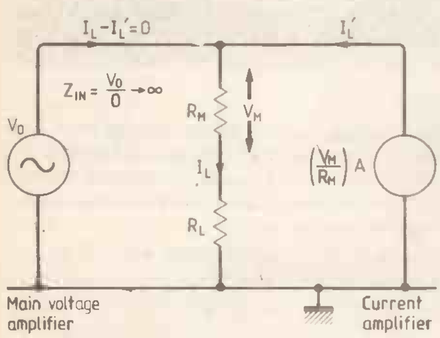


*Fig. 2. If the current from the current amplifier equals that into the load $R_1$, the voltage amplifier sees an infinite impedance. Voltage $V_M$ controls the current amplifier.*

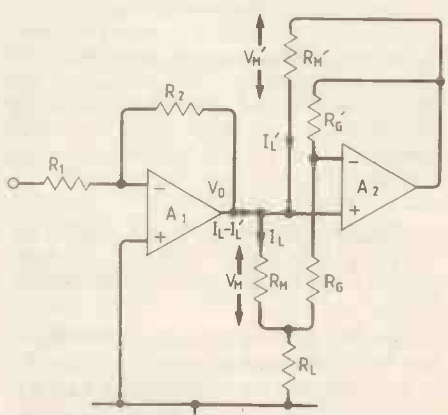


*Fig. 3. Basic circuit of Class A amplifier. $A_2$ is current amplifier.*

drops from, ideally, infinity to 122Ω. However, this is only for a small excursion voltage and current and so $Tr_3$ can easily handle it. What is more important is that when the transition is completed, the impedance seen switches from low to high impedance, which will produce a voltage spike at the output.

However, this spike is of very low amplitude due to the low output impedance of the first 741 and its voltage follower and, more to the point, at least one other class 'S' circuit, which will not be described at this time, exists in which this minor problem does not occur to a measurable degree.

Resistor $R_2$ may be taken to the junction of the 22Ω, 100Ω and 6.2kΩ resistors, so reducing the output impedance to zero.

The crossover distortion of $A_2$, $Tr_2$, $Tr_1$ (W1) has a very small effect on the output (W2) and this effect (W3) is less than 6mV (spike voltage) at the virtual earth of A, corresponding to 12mV at the output (allowing for attentuation by the two 10kΩ resistors). That is 12mV in 24V p-p, or 0.05%.

## Circuit analysis

Referring to Fig. 3,

$$V_M' = V_M\left(\frac{A_2}{1+A_2\beta}\right) - V_M$$

where $\beta = \frac{R_G}{R_G+R_G'}$, (1)

$$\text{whence } V_M' = V_M\left(\left[\frac{1}{\beta\left(1+\frac{1}{A_2\beta}\right)}\right]-1\right)$$

$$\text{and } I_L' = \frac{V_M'}{R_M'}$$

$$= V_M\left(\left[\frac{1}{\beta\left(1+\frac{1}{A_3\beta}\right)}\right]-1\right)\left(\frac{1}{R_M'}\right).$$

$$\text{But } V_M = V_0\left(\frac{R_M}{R_M+R_L}\right),$$

$$\text{therefore } I_L' = V_0\left(\frac{R_M}{R_M+R_L}\right)$$

$$\left(\left[\frac{1}{\beta\left(1+\frac{1}{A_2\beta}\right)}\right]-1\right)\left(\frac{1}{R_M'}\right).$$

$$\text{Now} \quad I_L = \frac{V_0}{R_M+R_L}$$

$$\text{and} \quad R_{in} = \frac{V_0}{I_L - I_L'}$$

whence $R_{in} =$

$$\frac{R_M+R_L}{1-\left(\frac{R_M}{R_M'}\right)\left(\left[\frac{1}{\beta\left(1+\frac{1}{A_2\beta}\right)}\right]-1\right)} \quad (2)$$

**Approximations**

$A_2\beta \gg 1$

$$\beta = \frac{R_G}{R_G+R_G'},$$

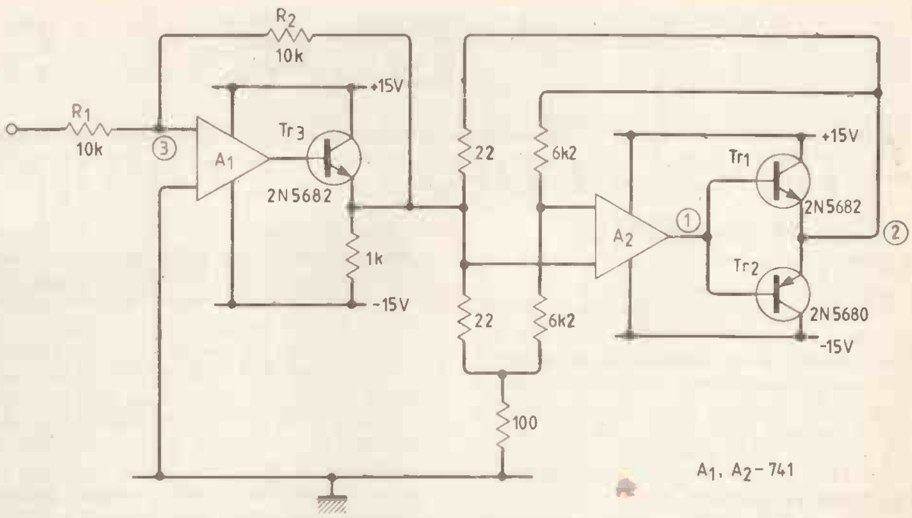


*Fig. 4. Addition of power stage to augment $A_2$ output current forms working circuit.*

Let $R_G = R_G'$ and $R_M = R_M'$

$$\text{whence } R_{in} = \frac{R_M+R_G}{1-\left[\left(\frac{1}{\frac{1}{2}\left(1-\frac{2}{A_2}\right)}\right)-1\right]} . (3)$$

$$\text{Therefore } R_{in} \approx \frac{A_2(R_M+R_L)}{4} \quad (4)$$

from (3), and applying Binomial Theorem.

$A_2 \to \infty$

$$R_M R_G' = R_M' R_G \quad (5)$$

$$R_{in} = \frac{R_M+R_L}{1-\left(\frac{R_M}{R_L'}\right)\left[\left(\frac{1}{\beta}\right)-1\right]} \quad \text{from (2),}$$

$$\text{whence} \quad R_{in} = \frac{R_M+R_L}{1-\frac{R_M R_G'}{R_M' R_G}},$$

therefore $R_{in} \to \infty$

$A_2 \to \infty$

$$R_G = R_G'(1+\Delta)$$

$$R_M = R_M'(1+p)$$

whence, from (1) and (2),

$$R_{in} = \frac{R_M+R_L}{1-\left(\frac{R_M'(1+p)R_G'}{R_M' R_G'(1+\Delta)}\right)}$$

and thus, by binomial approximation,

$$R_{in} \approx \frac{R_M+R_L}{\Delta - p} \quad (6)$$

which, for $\Delta = -p = 0.01$ (1% resistors), gives $R_{in} \simeq (R_M+R_L)/0.02 = 50\,(R_M+R_L)$, so that for $R_M + R_L = 8+1 = 9\Omega$, the load appears as 450Ω to $A_1$. The formulae (4) (5) and (6) are useful as initial design guides, but the full formula (2) should be used for the final calculations.

The circuit is a stable one and has the great advantage of dealing with the problem of crossover distortion whilst not needing any setting-up, even though a class B amplifier is employed in the subsidiary amplifier. It is also insensitive to the effects of temperature, specimen and ageing variations on cross-over performance, unlike the standard class B amplifier.

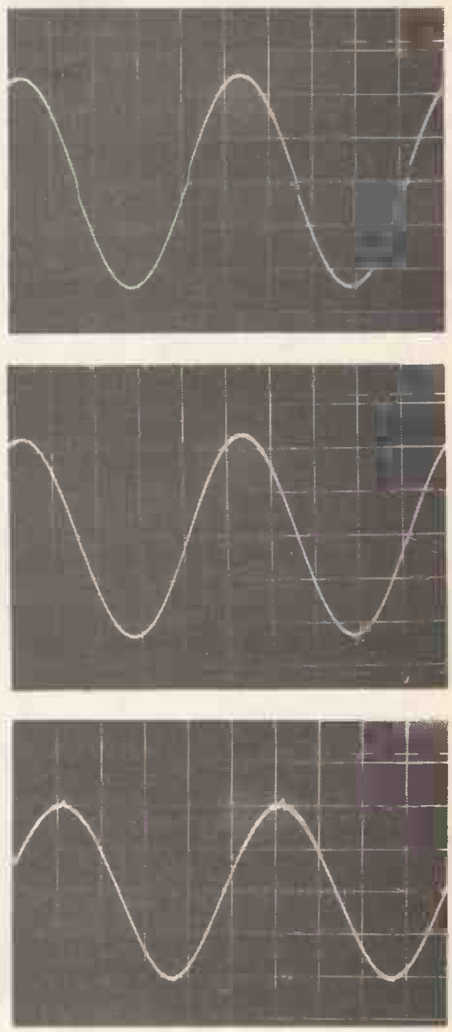

*Fig. 5. Waveforms in circuit of Fig. 4. Top shows crossover distortion at output of driver stage, middle picture showing that output of current amplifier is clear. Bottom trace shows small spike at input of voltage amplifier caused by both output transistors coming back into conduction after being cut off during crossover.*

# LETTERS

## TOUCH-SENSITIVE V.D.U.

I read with interest News of the Month, *Wireless World*, p.69, July 1982, to be informed that Tony Booth and his engineering staff of British Telecom, London, have 'invented the system' called City Business System, described as a v.d.u. terminal with a touch-sensitive screen, the senitivity being obtained using a matrix of infra-red beams which can sense which part of the screen is being touched.

Worthy of note as this may be, I feel I should bring to your attention that an identical system to that described was designed and built (invented?) by myself as part of a computer-controlled system on a large research particle accelerator called Nimrod back in 1971, and was in use until the machine shut down in 1978.

A report containing sufficient information to make such a device was available to anyone, price 20p., from HMSO or through any good bookseller entitled:

A Transparent Touch-Screen Device for Interactive Computer-Graphic Displays. R.H.E.L./R 248 1972.

Sorry, it's all been done before.

E. M. Mott
Rutherford and Appleton
Didcot Laboratories
Oxfordshire

## LAWS OF MOTION

Mr Frost (July 'Letters') should consider the difference between science and poetic imagination. The views of Lucretius were unsupported by experiment, not open to test by others, (there being in any case no instruments about at the time to test them with) and, as matters of opinion, have in fact about the same scientific status as the views of flying saucer nuts; perhaps less. If Mr Frost will read Aristotle he will rapidly realise that sloppy theorizing is sloppy even when 2,000 years old, and that good science is good even when five hundred years older still.

I suggest that the briefest survey of human history shows up the truth that an idea may be said to have arrived when the engineers stop using rule of thumb and apply mathematics. Cannon had been around for hundreds of years before Newton, demonstrating all three of his laws with classical elegance. The ballistics experts had it all in front of them but missed it. Newton didn't. Newton was a genius. Even so, he needed an intellectual climate in which to function; Galileo, perhaps the greater scientist, just missed it.

Newton's great work is called the Mathematical Principles of Natural Philosophy, and that is the indicator of his achievement; he synthesized the known physical world in mathematical terms. It may be that the central problem of modern physics is either that 1) we are thinking about everything all wrong, or 2) the right maths has not yet come along, or 3) the right maths is available but lying about unnoticed. For Mr R. G. Young, however, the rot has already set in. He doubts Special Relativity because he thinks of electrons as peas in a drainpipe bouncing around at c. Peas aren't charged, electrons are.

M. D. Bacon
New Milton
Hants

## DESIGN EXHIBITION

I have been asked to help organize an exhibition of 'Design Since 1945', and as one of the exhibits, I require a 1948 Ekco P63 'Princess' personal portable valve radio in green plastic case. I wonder if any of your readers could perhaps help me to locate one of these radios.

Gordon Bussey,
64 Pampisford Road,
Purley,
Surrey.

## LEAKY FEEDER RADIO SYSTEMS

I have read with interest the recent articles on underground radio systems by my former colleague, Dr David Martin.

Whilst I am in general agreement with most of his paper, I feel that it would be desirable to clarify the position of the National Coal Board.

There are about 130 leaky feeder radio systems installed underground, the majority of which are of the daisy-chain type. This technique, which requires separated transmitter and receiver, and which makes spurs difficult to achieve is now considered obsolescent. Over the past few years, experimental installations have been made of a number of alternatives, including the BDR system (one installation) the back-i.f. system (one installation) and the forward-drive system (two installations). The two-way repeater is, however, now being installed routinely, and there are currently 15 installations of this type operating successfully underground, the largest being at Easington Colliery with a total length of about 10 km. The repeaters used are more expensive than comparable unidirectional repeaters, but the difference does not significantly effect total system costs; and their performance is entirely adequate even in terms of cumulative noise and intermodulation distortion for any NCB requirement expected over the next few years. In addition, the technique is conceptually simple and needs only two types of line module; a normal repeater, and a splitting repeater at each branch point.

In the medium term (say 5 to 10 years) underground mobile communications systems may need to provide additional services such as high speed data or vision signals. Such requirements would involve considerable changes to our current systems, which fully meet present needs. It is our intention to embark on further development as future needs become clearer.

R. J. Parsons,
Head of Communication
Applications Group,
National Coal Board.

## 3D TELEVISION

The publication of your article on 3D tv, following the 'Real World' programme on TVS on May 4th prompts me to write and reiterate that this country could have had 3D tv 30 years ago, without the need for colour spectacles.

You published a letter of mine on the subject some three years ago when I mentioned that my father (the late Granville Bradshaw who, though designing in many fields, was better known in that of the internal-combustion engine, examples of which are to be seen in the Science and other museums) had developed in the 1930s a system of 3D photography, which was widely used in advertising displays.

With this system in mind I designed for him a system for television. Both the BBC and the ITA were extremely interested but had to admit in the end that they had no brief to proceed with 3D, let alone the money with which to experiment.

The result – another British invention stifled at birth for being, so it would now appear, at least 30 years ahead of its time.

Geoffrey Bradshaw
Leatherhead
Surrey

## INTENTIONAL LOGIC SYMBOLS

Referring to the latest Letter (July '82), why keep bickering about old BS symbols, now defunct or otherwise unknown this side of the Channel? There exists a set of ANSI/IEEE/IEC approved logic symbols, that provides throughout diversification, ease of drawing (no circles, no bows) *and* intentionality if one wishes. Please refer to e.g. the 1981 Supplement to The TTL Data Book by Texas Instruments (2nd edition), pp. 318/343.

Of course, in a manufacturer's handbook, all of the functions provided should be fully documented, so the schematics look a bit weird. But practice shows that a little pruning here and there yields drawings that are very intentional indeed, and easy to read.

Ing. J. Eyckmans
St.-Truiden,
Belgium.

## S-100 BUSES

Do you know if anyone has made a comparison chart between the various S100 computers in terms of the bus definition? Some of the early 'S100' equipment differs with that designed after the specification was finalised. Can your readers help?

S. B. Hayes,
Toltec Computer,
Cambridge.

## IT'LL DO – OR WILL IT?

I am involved in various aspects of electronics including design, application, trouble-shooting, repair and construction. Like many people who have a general knowledge of the subject, I have an appreciation of the principles of each aspect and a respect for experts in each field. Some of my spare time is given to private repair work, tv, calculators, electronic musical instruments, hi-fi, etc, so that I consider myself not inexperienced in the area of consumer electronics. Recently I completed two jobs that provided real food for thought.

The first was a Goodman's 'One-Ten' tuner amplifier, which sports a very elaborate power amplifier with several transistor stages in d.c. connection. Only the output pair proved to be damaged, but the underlying cause was the fuse-holders, one of which had become high resistance, due to oxidation. This is not incomparable to a safety belt causing a car crash.

The other job involved a Ferguson (Thorn) 'Revolver' radio/cassette player, given as a Christmas present only six months ago. This had become erratic and finally stopped altogether. The problem was simply traced to the amplifier power switch, which had simply burnt itself out. The machine boasts a very large power-output stage requiring (I calculate) about an amp. of current, but this was switched by a small-signal switch just not up to the job.

These exemplify the Great British "It'll do" attitude that has made Japan what it is today. While years of soak testing are clearly not feasible for such products, only a little more care would result in machines as dependable as the valve radios of the '50s that I still use, and worthy of the remarkable development that has gone into the i.cs that are put into products of amateurish design.

Mike Feeney
North Gosforth
Newcastle-upon-Tyne

Presumably Mr Feeney is aware that depending upon environment, possible mis-use of equipment and any number of other variable factors, it is possible for oxidation to occur in similar situations which have nothing to do with "amateurish design". This is the only such case that we have been made aware of on this product and many thousands are still in operation, providing excellent performances to their very satisfied users.

I would further point out that the last One-Ten tuner/amplifier was manufactured some eight years ago.

T. E. W. Bennett
Goodmans Loudspeakers Ltd

I have total sympathy with the point that Mr Feeney is making. The recent sad contraction of the British consumer electronics industry is generally acknowledged as having been considerably influenced by lack of attention to quality matters. By the same token I believe it is also widely acknowledged that Ferguson were one of the first to read the signs and, later with their 'Queen's Award for Technological Achievement', were one of the more successful in reversing the trend. At least we are still here to respond to his letter!

Having said this, I do not feel that Mr Feeney illustrates his case well. The Goodmans unit to which he refers was engineered by one of the country's leading hi-fi designers of the period, the late Frank Rodwell, no less than 12 years ago. Perhaps more significantly the last ones were actually made about 8 years ago. If corroded fuse holders were a general fault on these models, then it would worry me more, but they are not, and I am sure that there must be many reasons apart from intrinsic bad quality why isolated cases of contamination might emerge over so long a period.

The 'Revolver' falls into an entirely different category. This is an o.e.m. product sourced for Ferguson by a leading Japanese-owned manufacturer. This is not to say that we divorce ourselves from its technical standards; quite the reverse, and as it happens power and switch areas always get particular scrutiny for safety reasons apart from anything else.

It is quite impossible to judge the rating of a switch merely by looking at it. Approval specifications run to many pages, and tests take hundreds of hours to conduct over tens of thousands of cycles of operation. A switch handling an amp. or so on low voltage in a small audio product would very likely be lighter in appearance than a television mains component which could be rated at over 100 A surge; but it should not be condemned for it.

This failure may well be a symptom of Far Eastern manufacturers having chinks in their armour too!

D. R. Topping
Director of Engineering
Thorn EMI Ferguson Ltd.

## THEORIES AND MIRACLES

My initial reaction to the article by Dr Murray in the June issue of *Wireless World* was 'Why all the fuss?'. All scientific theories can be shown to generate anomalies if pushed far enough, indeed one would be suspicious of one that did not. Anomalies are not the catastrophe that Dr Murray seems to think, they serve only to indicate the limits of present theories and are therefore the starting point for the next development. Dr Murray also attacks 'pragmatism' in science; as I shall show below it is the only measure, of which we can be certain, that can be applied to a scientific theory.

Dr Murray seems to believe that there is an absolute truth or ultimate scientific theory towards which we should be moving, that we can measure our theories against the real world, and so improve and up-grade them, that one day we will achieve this absolute truth. In this he is sadly mistaken, for two reasons. Firstly in testing our current theories we must observe the world, and in doing so we must also accept as true other theories that explain the operation of our observing apparatus (including the physical bases of our own sense organs), and those theories may in turn depend on the truth of other theories, including in some cases, the theory we are testing. Secondly (and much more fundamentally) not only must we observe via our senses (and other apparatus) but we must also interpret what we observe, and these interpretations are, at base, limited by our human psychology, we are, as it were, bounded by our humaness. We can never observe the world directly, but only a human version of it.

There is nothing we can do about this limitation, no advance in our observing apparatus can affect it. Any interpretation we care to put on our observations, no matter how obtained, must be human centred, but there will always be the possibility that the same observations could be interpreted by a non-human thinking entity in another but equally valid way. Even if we extend our mental capacities by building artificial or machine intelligences that can interpret observations of the world in other ways, they could not explain what they perceived directly to us without translating it into human terms.

Dr Murray may have, if he wishes, his belief in the simple truths of nature, but as I have shown above, they are (and must always be) limited and biased truths.

John W. T. Smith
Hatfield
Herts

## RF RADIATION HAZARDS

I read with interest the two articles referring to r.f. radiation hazards; the first, *WW*, October 1981, page 42 and the more recent article *WW*, April 1982, page 58.

There are, in Australia, many hundreds of small craft fitted with microwave radar. The majority would be professional fishing boats. However, privately owned pleasure craft are being equipped in increasing numbers. Many of the installations that I have seen have been installed with the rotating antenna barely above the head of the helmsman. This applies in particular to those vessels which have a fly bridge above the main super-structure.

I would be interested to know if any of your readers have observed, or have knowledge of, any adverse effects resulting from exposure to micro-wave radiation in the situation outlined above.

John Allan, VK5UL
Ovingham
South Australia

## NIKOLA TESLA

Nikola Tesla is a fascinating subject for study and I join with Desmond Thackeray (May 'Letters') in the toast "Tesla Lives!". But surely the centennial for Tesla was in 1956 and wasn't the Tesla Society formed for the celebration?

As for Tesla's claim to having invented wireless telegraphy, his patent 645,576 was upheld by the US Supreme Court against the claims of the Marconi Wireless Telegraph Company of America on June 21st 1943. Ironically, Tesla had died in January of that year.

A factual account of what Tesla accomplished, particularly towards the wireless transmission of power would make most interesting reading; may we hope for an article along these lines?

Martin W. Berner 9Y4TAM
Trinidad, W.I.

# LETTERS

## COST EFFECTIVE IGNITION

Far from being criticised (Letters, June), Mr Cooper is to be congratulated on producing a design for electronic ignition using components that can be obtained by the home constructor.

*Wireless World* has never claimed to be a magazine merely catering for the amateur constructor and in the course of demonstration the latest technology has, quite rightly, published circuits using components not generally available, and requiring alignment equipment found in only the privileged laboratories.

However, certain designs are still clearly intended to be built even though articles with the constructional detail of, for example, the Dinsdale high-quality audio amplifier of January/February 1965 are no longer published. Designers should therefore consider carefully whether any component they are fortunate enough to have available may not be available to the majority of readers.

Before quoting past numbers, Mr Pickavance should consider the attitude of many firms, and perhaps also his, to requests from private individuals for the less-common components in small quantities.

C. G. Gardiner
Chelmsford
Essex

I have read Mr Cooper's article on electronic ignition in March *Wireless World* and wonder if I might be permitted to summarize my own experiences and views on alternative ignition systems?

If the cause of bad starting is not in the ignition system but, say, in the fuel supply, as it often is, no alternative form of ignition system will help. Unless you want to be able to start your car with a nearly flat battery, I do not think changing the ignition system will help. It is not in starting the car that the failings of the Kettering system have most effect.

As Mr Cooper points out, if your engine only has a 6,000-6,500 r.p.m. maximum (as most have), there is nothing the Kettering system can't achieve if kept in good order.

I have used many different systems for many years but have never really noticed any significantly better fuel consumption. I have not made any detailed tests but over say a tank full, no change is noticeable. I would love to think that better consumption resulted – it is a tangible and worthwhile benefit in these days of high fuel costs – but I have grave doubts whether it exists.

In their freedom from maintenance, alternative systems can, I think, produce benefits. The first task is to relieve the contact breaker of the high current demanded by the Kettering system. Contrary to Mr Cooper's opinion, I believe this alone is worthwhile. If the system chosen also obviates adjustment of the dwell angle, so much the better. This leaves any residual mechanical weaknesses of the ordinary contact breaker. These do not manifest themselves under say 7,000 r.p.m. – probably more – save for wear. The contacts may not wear but the fibre block on the cam can and does and this wear is not compensated for by contact wear. The contact gap may not be important in alternative systems but there must be one! Do alternative systems affect the plugs? Those which produce more energy in the spark (i.e. C.D. systems) do but only in the sense that the plugs will go on working long after they would misfire with the Kettering system. I have never noticed any reduced wear and it would be interesting if Mr Cooper could elaborate on the short paragraph in his article on this aspect (what is an electronic spark?) I have noticed that wide gaps (up to 60-70 thou) still work and so do sooted plugs – due, I have always assumed, to the greater energy available with C.D. Incidentally, has anyone noticed smoother running at minimum throttle openings just to maintain speed, with wide plug gaps?

On the subject of current consumption, does it really matter (within limits) how much current the ignition system uses unless you are in the habit of leaving it on without the engine running?

C. E. H. Benson
Market Drayton
Shropshire

I had to abandon any idea of constructing Watkinson's Opto-electronic contact breaker (*WW*, April 1981) simply because I was unable to obtain the i.c. specified through normal retail channels. In the light of Rod Cooper's remarks about using readily available components contained in your letter in the June issue, I approached the construction of his ignition system with more hope. Alas, I have come up against the same problem of supply in respect of the Mullard FX 3720 ferrite power transformer.

Of two main stockists tried, Phillips and Marshalls, the former would only supply for their own equipments, and the latter, whom I rang, said they did not stock the item! So far as I can see none of the usual suppliers who advertise in *WW* and elsewhere stocks the FX 3720, and I am beginning to suspect that it is again one of those desirable components available only to industrial users and electronic engineers through privileged channels of supply.

As to the circuit itself, this seems to have suffered somewhat in the reproduction process for publication and I would appreciate your help in my difficulties of intepretation. You will have noticed that $D_7$, unlike $D_{1-6}$, has not been specified. This may be a misprint for a 3A fuse, or possibly a decoupling capacitor. The capacitor values in the multivibrator have been omitted. Perhaps Mr Cooper would confirm that ½W resistors were intended throughout the circuit.

J. E. Stevenson,
Purley, Surrey.

*The author replies:*

I agree with Mr Stevenson's comments about components for construction articles: such components should be available through accessible supply channels and not just to professionals, but it's a fact that some of the most interesting items remain relatively obscure because they are only available via the privileged channels, which I think is a pity. It needs a change of heart on the part of certain British component suppliers and manufacturers to alter this situation.

However, this is not the case with the FX3720, which is a Mullard ferrite available through their stockists. My local Mullard stockist is Hawnt Electronics Ltd., Firswood Road, Garretts Green, Birmingham B33 0QT, and they will be pleased to supply this ferrite, which they stock in depth. The FX3720 is 44p per piece (you need two pieces to make a transformer) and the bobbin DT2723 to suit is 35p. This firm has a minimum charge of £2, which should cover a transformer, bobbin, v.a.t. and postage.

There is a world of difference between the non-availability of silicon diodes as discussed in the *WW* 'Letters' column and the limited availability of a more specialized component through manufacturers' selected agents, such as Hawnt Electronics. Unfortunately it is all too easy for an author to slant his constructional project towards the professional supply channel without realising it. In this case, I checked that the FX3720 was available without spotting that there might be a problem for people like Mr Stevenson who may not know the supply channel.

Regarding the other comments, corrections appeared in the August issue. As for resistors, I did not give wattage ratings for resistors because I think most readers of *WW* will see at a glance what is needed; it is quite easy to use the formula $V^2/R$ and then make an allowance for ambient temperature and duty cycle. My view is that a constructional project should not be a cookery-book type recipe to be followed blindly, but should involve at least a little thought by the constructor about what he is doing. In the same vein, I hope you will read about r.f. suppression before winding a transformer, as suggested in the article.

The 3 A rectifier diode, $D_7$, was not specified because it is non-critical; its only function is to provide reverse-polarity protection and it can be by-passed with a shorting link once the unit is installed and working correctly.

## POOR DEAL FOR AMATEUR RADIO

I feel I must reply to G3DRN's letter criticising my own letter 'A poor deal for amateur radio'. Like him, I shall endeavour to answer and comment on his 'points' in turn.

Firstly, his 'All Fools' comment – Is this the best he can manage? Likewise, his claims to impartiality can be dismissed with little (or better still) no comment.

As a member of the RSGB (fighting from within) I feel that I have every right to question its actions and expect a reply. As regards my claims to speak for many others, for three evenings after the publication of my first letter I was inundated with 'phone calls agreeing with my comments, including four suggestions that I should stand for a Regional Rep. post.

His comments on the RSGB's neutrality are no more valid to me than mine are to him. As I see the facts, the RSGB is an anti-c.b.; they will not even allow the advertising of c.b. sets in *Rad Com*.

The fact that 70 MHz is a national allocation is hardly relevant to the morse argument – and what about 28 MHz? I acknowledge the introduction of the new u.h.f. bands and *one* of the new h.f. bands. With regard to the American case, G3DRN is comparing bad with worse – never a good defence. Remember, the Americans have 220MHz and 50 MHz, easy repeater licencing, sel. call, third-person message rights etc., etc.

His analogy of 'phone abuse and repeaters is quite amusing. We, as a society, have come to need 'phones: we do not need repeaters, nice as some of them are.

His comments on the RAE, in general reinforce my own. However, his attack on my standing as a licenced amateur is quite unjustified. Firstly, my RAE was obtainable under the old system and I am an engineer by profession. Many A licencees (possibly G3DRN included) never took the RAE, which was introduced in about 1947. Any person who held an experimental licence before the war (as G3DRN said he did) was exempted from the RAE. His contention that morse makes you a better operator defies comment – the first 'Squeaky' on GB3LO was a G3. Japan has no morse test and few would disagree that the Japanese are impeccable operators.

Amateur radio is a technical hobby and a statement implying this is included in the licence. I do not say that amateurs must build their own equipment, but I do believe they should take a serious interest in how it works. The RAE (even now) does not include p.1.1s and it certainly did not in 1947. In my view, some amateurs have their licences under false pretences.

I do not deny that the RSGB is strong and vigilant, but I also believe it does not pursue the interests of the majority of amateurs, just the select few who run it. His 'wood and trees' comment – well soon, if not already, the majority of amateurs in this country will be B licencees, many of them discontented. Soon, the new trees will outnumber the old.

B. Reay, B.Sc., G8OSN
Woolwich
London S.E.18

From recently published letters it would seem that a number of RSGB members are becoming sufficiently frustrated with the Society to consider recording their dissatisfaction elsewhere, in journals unaffected by RSGB inertia. Surely the Society's behaviour has been at its most astonishing, but probably most revealing, over the lamentable, and inexcusable radio regulations farce. One might have expected that the Society journal, *Radio Communication*, would have been filled with expressions of digust that the Home Office should perpetrate such a blunder. Many a society in such circumstances would demand that heads should roll. However, in the pages of "*Rad Com*" there was not to be found the gentlest rebuke; instead they were filled with much mutual back slapping and an account of the splendid way the Society machine sprang into action, to rectify the faults of the Home Office. One might well ask why a society watching over the interests of its membership was not making itself involved with production of regulations from the outset. The Society gives the impression of a lackey who fears to offend his master.

The Society seems constantly to proselytize for new members, stressing the great benefit membership will confer. The new RAE is producing vast numbers of amateurs, but since most will continue to operate on v.h.f. they will, in general, find little use for a QSL card bureau. Moreover, the majority may be expected to use "black boxes" and would make little use of the constructional projects found in *Rad Com*. In its present form it would seem that the Society will be seen by new amateurs as benefitting them only by producing a journal containing a few advertisements, which could probably be found elsewhere.

We are told that a country gets the government it deserves. It certainly looks as if the Radio Society of Great Britain has got the Government Department it deserves.

Peter Naish
Reading
Buckinghamshire

## THE RIGHT FORMULA

Two points of information. First, regarding Mr Young's letter in the July issue "The Right Formula", the super-luminal velocities he mentions in astronomical objects are adequately explained as illusions created by high-energy beam phenomena (see, for example, *Scientific American* June 1982).

Secondly, having consulted several dictionaries of a range of authorship, even one dating back to 1932 (Nuttall's Popular Dictionary of the English Language), I find that every one gives the pronunciation of "patent" as being acceptable with either long or short "a". I object to Mr Fox's tone in his article in the same issue and will continue to pronounce "patent" similar to "latent".

K. Wood,
Ipswich,
Suffolk

Ronald G. Young of Peacehaven asks in his July 1982 Letter to you "How come wires don't weigh heavier when current flows?" In Einstein's Special Theory of Relativity one of the end results is that mass is energy, gravity is acceleration and time is space. Units of mass and units of energy are therefore related and it comes about that 1 gram is $9 \times 10^{20}$ ergs.

Now, if one passes 1 amp through a wire of resistance 1 ohm with a potential difference of 1 volt the energy required to do so is 1 watt, which is equal to $10^7$ ergs per second.

According to physicists, 1 gram is equivalent to $9 \times 10^{20}$ ergs. Now $10^7$ ergs are expanded by $6.2 \times 10^{18}$ electrons per second and this corresponds to a mass of $1.1 \times 10^{14}$ grams per second. The confusion between mass, amps and ergs lies in their "Relativity" and different frames of reference perhaps. One may measure the distance of a star from earth in feet, miles, seconds or light years or even angles. Mass is a measure of resistance to a change of velocity.

O. B. Balean,
Chatham,
Kent

In July, R. G. Young wrote, ". . . . all such 'theories' [e.g. Theory C, *WW* Dec. 1980] are purely human artifacts, designed to make predictions of the way things work!"

Young is describing the reigning philosophy in science today, called "instrumentalism" by Karl Popper, see "Conjectures and Refutations", RKP, 1963, p100. As Popper says on page 101, instrumentalism is used in a defensive mood – to rescue the existing theory. The instrumentalist view is that the winning theory is the theory which has produced practical results, and that since there is no such thing as absolute truth (which last remark is held to be absolutely true!), we should not modify our theories if they are serving well enough.

The flaw in the instrumentalist argument is that the decision on whether the old theory serves well enough is a value judgement based on experience, and if (as is the case) the guardians of the faith – professors, lecturers, Nobel prize winners and text book writers – have no experience of high speed logic (and have never used a sampling oscilloscope), they will reject (and in my case suppress) theories which help in that field. Instrumentalism is the philosophical rationale for a general clamp-down on progress in science into new fields by those whose experience, careers and prestige are based on the old (analogue) experience.

Young writes, "Does Mr Catt find his theories enable him to do better design work?"

The pre-Catt pot-pourri which served as electromagnetic theory (see for instance D. B. Jarvis, "The effects of interconnections on high-speed logic circuits," *IEEE Trans. Electronic Computers*, vol. EC-12, pp476-487, Oct. 1963), could not help me to successfully design high speed systems (see Fall Joint Computer Conference, 1966). The new Catt theories were developed in order to make possible the reliable interconnection of high speed (1 ns) logic gates.

The refusai to publish my theories by instrumentalists in the IEE, the Institute of Physics and elsewhere led to a collapse in the use of fast (1 ns) logic gates already available in 1964 and a decline back to slower t.t.l., and then to the very slow microprocessors of today. The computer industry has paid a heavy price for the suppression of theoretical advances by means of instrumentalist arguments. Still today, hardly anyone can successfully assemble 1 ns logic as I did in 1964.

Similarly, in the field of computer architecture, the suppression of the content addressable memory by instrumentalists who only know (and who live off) von Neumann has blocked advance towards more practical machines for a third of a century.

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Ivor Catt
St Albans
Herts.

## FIRE SHIPS

The Falklands conflict has shown up a fire problem in some of our war ships. Part of the trouble is caused, we are told, by the p.v.c. insulation on the cables. This must mean the multi-core signal cables, since the power cables would be mineral insulated.

Silicone rubber would clearly be better than p.v.c. It remains an insulator after it is burnt, and it contains no chlorine, so cannot produce phosgene.

However, it occurs to me that it might be possible to use fibre optics for communications between the different locations in the ship. This may seem at first a silly suggestion for distance of a few metres, because the cost of the terminations would be large. But if the idea proved practicable, there would be great advantages. A single fibre could carry all the signals for the whole ship, and there could be many parallel routes, so that if several were damaged, the signals could still get through. And of course the fibre cannot burn, though it would melt in a fire.

C. Q. Keiller
Heathfield
Sussex

# LETTERS

## MICROCHIPS AND MEGADEATHS

As both an electronics engineer and occasional disarmament activist, I have been following the correspondence in *WW* on military electronics and the responsibility of the engineer, both before and since the November 1980 editorial, with more than a passing interest. The Falklands/Malvinas crisis has thrown the issues raised in your May 82 editorial into sharp focus.

10% of Argentina's armaments, including a great deal of radar and communications equipment, came from British companies. In the media this is usually described as "ironic" – but it is no irony, merely the logic of the international arms trade. The Defence Sales Organisation, a 400-strong government department, exists purely to ensure that whenever someone is blown up, burned, drowned or maimed, it's done with quality British equipment and none of your foreign rubbish. And still it goes on, with *WW* readers (unless they've all cancelled their subscriptions) making their own contribution – for example, Plessey, Racal-Decca and Ferranti between them supplying systems for four new Brazilian corvettes, and Marconi selling China £14m of electronics for their fighter aircraft.

Much of the correspondence opposing the theme of the 'Microchips and megadeaths' editorial has dwelt on the well-worn bogey of the Perceived Soviet Threat, with various refinements such as Defending our Democracy (what democracy?) and Maintaining Technological Superiority. In fact, the motivation which keeps these people beavering away at improving their killing capacity, and which keeps their opposite numbers in the U.S. and the Soviet Union doing the same, has little to do with any of these. It has to do with lack of imagination. They cannot imagine the reality of a full-scale nuclear war, or even a full-scale "conventional" one; the most they can stretch to is a brace of foreign tanks rolling down the High Street, and they cling to this image with patriotic fervour. The Russians (or any other aggressor) can have no desire for Britain powerful enough to justify invading it. We have enough trouble managing it ourselves, and we live here; imagine how a foreigner would fare.

Where do engineers stand in all this? The usual prescription – to refuse as a matter of principle to work on military electronics – is glib, and not so easy to put into practice. (Though the if-I-don't-do-it-someone-else-will argument is no more than a cop-out, at individual or national level.) Where do you draw the line between military and non-military work? Does the manufacture of Mil-spec components count as a crime? How about production control systems for weapons factories? Or for the nuclear fuel cycle, which has a dual-purpose role?

This is not to denigrate those (of whom I am one) who will not work in overtly military industry. But it should be realised that often the main effect of such an individual stand is simply the amelioration of the individual's conscience – and to achieve an end to the technological arms race we need much more than that.

One aspect that needs constant effort is information. Much, if not most, military work is shrouded in secrecy, some of which may be justifiable but a great deal of which is not. For example, how many people know that France is still conducting nuclear weapons tests on the Muroroa atoll in the Pacific (the most recent on December 8, 1981) and that in March 1981 several pounds pf plutonium and other radioactive wastes were swept out to sea by a tropical storm? This information was leaked to the Australian press by a group of French engineers working on the island, who were concerned about their government's apparent decision to ignore the problem. Closer to home, Jock Hall's letter in June 1981 *WW* cites another example of this kind of action; part of the social responsibility we are talking about is a willingness to take the risk in exposing such harmful activities.

Another aspect that needs more work is conversion – the conversion of military companies to manufacturing socially useful products, with a concomitant increase in job security and job satisfaction. The classic example here is the Lucas Aerospace Shop Stewards Combine, who devised a detailed plan for such a move for their company. Predictably perhaps, the management were uncooperative, eventually sacking the most active figure in this project. This has not deterred employees of other firms from producing similar plans.

Finally, there is the most positive action of all – applying your engineering skills to relieve the *real* needs of the world and the human race. H. M. Butterworth, in November 1981 letters, described agricultural electronics as an order of magnitude more difficult, and two orders of magnitude more satisfying, than military electronics. Professor Meredith Thring, in his recent James Clayton lecture Engineering for Humanity, argued that planners of the future can only plan with the machines that engineers have already developed; he went on to say that "it is the prime responsibility of the engineer to envisage the machines that will be needed to give our grandchildren a stable peaceful world in the twenty-first century." (Digital watches and video games?) He identified appropriate technologies for the energy, food and transport requirements of the Third World to be the urgent priority.

There is no shortage of prognoses. Why then, since the problem is generally accepted, do we still have the arms race, are there still starving billions? From the engineering point of view, a clue can be found in Dr Peter Hartley's excellent piece "Educating engineers" in December 1981 *WW*, where he argues that engineering has been dominated by humanist values which are inherently antisystemic – the system in this case being global in nature. In the context of the arms race and the North/South divide, political and technical forces have concentrated on fragmented solutions, usually nationalist or economic, without reference to the global system in which they are embedded – as a direct result of the humanist world-view. But the solution he proposes, that of educating future engineers towards an ecological outlook, is far too long-term. The problems are with us now. If we do not face them now, by educating *ourselves* towards ecology and a systemic view and acting from that perspective, we won't have to worry about educating a future generation.

Tim Williams,
Wadhurst,
East Sussex

As a subscriber to *Wireless World* for over 30 years, I read with interest the correspondence on Microchips and Megadeaths, but had no intention of entering into the debate, but the letter in your April issue from R. Whitehead was more than I could take without reply.

Perhaps I could plead in mitigation for my unreasonableness, the excuse, that I was born soon after the first world war, and in common with most of my generation, watched the rise of Hitler and Mussolini, and then served in the 39-45 war albeit in a non-combative job with the R.A.F.

I doubt if any member of my generation would subscribe to the view that the Japanese were on the point of surrender when the atom bomb was dropped. We all thought, perhaps wrongly in Mr Whitehead's view, that we were fighting for our survival, and there were times when I wondered if we would win or be subjugated. It should also be remembered that in 1945, that our enemies were also working on the atomic bomb – recall our raids on Norway to destroy heavy water plants – and a delay in ending the war might have given Japan the advantage in dropping the bomb first.

However, my main point is that I believe there is no record, official or otherwise, which pointed to the possibility of the Japanese being on the point of surrender. This word was not in their dictionary, and though they treated many of our prisoners most cruelly, their own courage and patriotism was never in doubt. If they fought well on foreign soil their tenacity in defending their homeland was expected to far greater. It should also be recalled that they did not sue for peace when the first bomb was dropped. Despite its devastation, it took another bomb to convince them to surrender.

G. S. Curry,
Ashley, New Milton,
Hampshire.

The wisdom of your editorial ('Arms and the Man', May 1982) is not to be doubted by anyone who has an intelligent concern about the future of our species and the environment we inhabit. But how are we to escape from the senseless militarist cycle which our society, East and West, is caught in? You suggest that it is the responsibility of engineers to refuse to work on the production of armaments. This proposition misses the fundamental problem of our present social order which is that engineers, and other producers of wealth, do not own or control the means of production and distribution, i.e. factories, mines, farms, docks, offices, etc. Wealth producers can only begin to seriously use productive machinery for rational uses when we commonly own and democratically control it. Such a transformation of society (which I would call a socialist revolution) would have two direct consequences: firstly, it would put an end to rivalries over the possession of property and thus eliminate one of the principal causes of war; secondly, it would allow humanity to produce wealth solely for use, not for profit. Political organisation to establish a society of common ownership and free access seems to be a more scientific and less risky course than to rebel against employment in the armaments industry and gain for oneself a place in the dole queue.

Stephen Coleman
Clapham
London

*This correspondence is now closed. – Ed.*

# DIGITAL PHASE CONTROL OF THYRISTORS

*Easy computer interfacing for power control devices is provided by this digital circuit. Adjusters are eliminated and a definite off-case ensures no motor creep or light flicker.*


**by B. H. Pardoe**
Ph.D., M.I.E.E.


Phase control of thyristor and triac devices using analogue techniques is a well-established method. The input analogue signal may be generated by a rheostat or a digital-to-analogue converter. This input is compared with a ramp and a pulse generated when the ramp voltage is greater than the input. Such circuits are usually provided with two adjustments, one for absolute level of the ramp and one for the rate of rise. This circuit eliminates these potentiometers and makes the control circuit easy to interface to a computer.

The power supply circuit, see diagram, is a conventional design, except for $D_1$, giving a stabilized 12V output. Diode $D_1$ ensures a full-wave rectified signal appears at the output of the bridge rectifier. This is attenuated by $R_9$ and $R_8$ with $R_9$ also acting as a current limiter to an input of $IC_6$. The output at $IC_6$ pin 3 is broad pulse with long rise and fall time. This signal is differentiated by the next two gates combined with $R_6$ and $C_3$. The output, $IC_6$ pin 10, is a positive-going pulse with duration $\tau$ where $\tau \approx C_3 R_6 \log_e 2$. The duration must be sufficient for gate output $IC_5$ pin 10 to discharge capacitor $C_1$. The discharge takes time $\approx 1000C_1$ in a c.m.o.s. circuit running on 12 volts. The sync-generator and power supply are only required once per line phase in a system where there could be many triacs running off each line phase.

The sync-generator pulse occurs every 10 ms on the zero crossing of the mains supply and clears bistable $IC_{5a}$ which removes the reset signal from the counter $IC_2$ and the hold signal from the oscillator. The oscillator drives counter $IC_2$ whose eight least-significant bits are connected to an eight-bit comparator made up from two four-bit comparators. A second eight-bit input to the comparator comes from the eight-bit store $IC_1$. The input to this is fed in asynchronously and may give an incorrect pulse in the first half cycle in which the data has been placed in the store by the external strobe pulse.

The counter output value rises until it equals the store output. This creates a one on the equal line which turns on the transistor TIP121 and sets the bistable $IC_{5a}$. The bistable clamps the oscillator thereby holding the equal signal at the comparator output. The bistable output causes the reset to $IC_2$ signal to rise exponentially. When the reset passes the threshold, the counter output goes to zero and the equal signal disappears. The output to the power amplifier is switched for a time set by $R_1$ and $C_1$

$$t_{on} = R_1 C_1 \log_e 2.$$

The counter $IC_2$ remains reset until the next sync pulse arrives at the end of the half cycle. This hold ensures only one pulse is generated per half cycle.

The case of zero in the store is used as turn-off guarantee. When the counter reaches zero for the first equality a positive transition is sent to the power amplifier. The bistable $IC_{5a}$ stops the oscillator and after a delay a reset level appears on the input to $IC_2$. This tries to create zero which already exists and reinforces the equal signal. The sync pulse removes the reset at the end of each half cycle, but not for long enough to give one half clock cycle. The counter therefore remains at zero and there is no output as the d.c. signal is blocked by $C_7$ and $R_{10}$.

The clock must go through 256 cycles in 10ms which sets the frequency at 25.6kHz and the standard values for $R_2$ and $C_2$ are given by*

$$R_2 C_2 = 1/2.2 \times 25600.$$

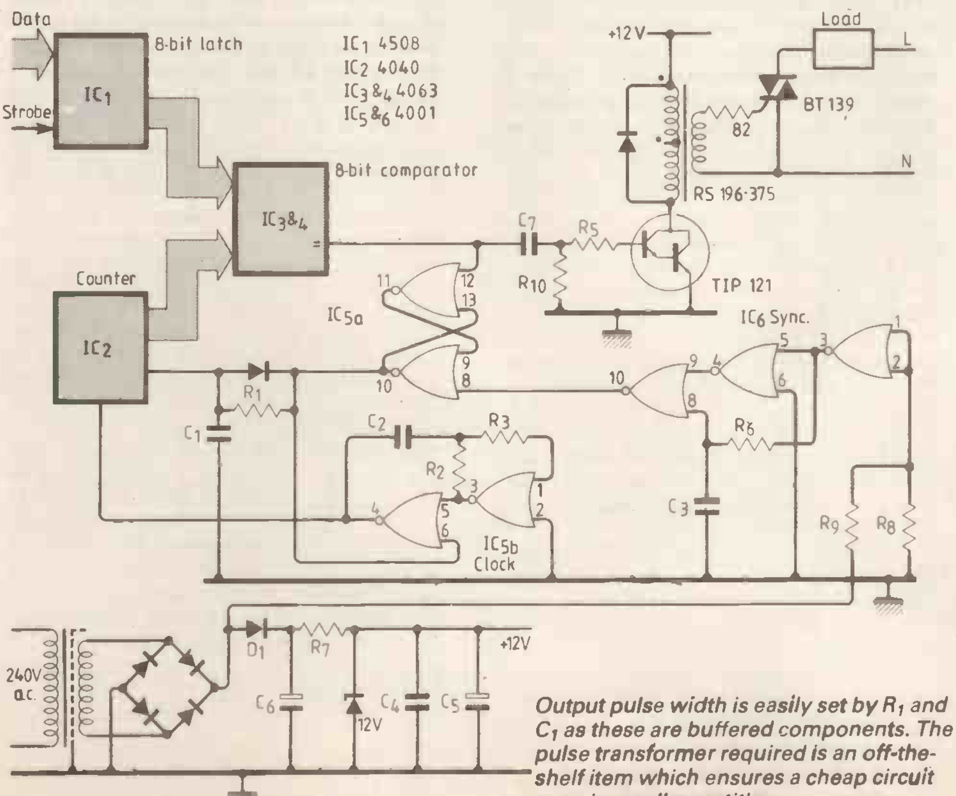
The choice of both triac and pulse transformer require some care. The pulse length required on the triac gate depends on the holding current of the device and the load. This circuit was designed to handle 500 to 2000 watt loads. The supply voltage and load can be used to predict the time taken from the zero crossing for the current to rise to the holding current. This gives a worst case figure and turns out to be about 135μs, set by $R_1 C_1$.

The pulse transformer connections are arranged to give the most sensitive operation of the triac device. The pulse transformer has 12 volts switched across it by Darlington transistor TIP121 for a time equal to $t_{on}$. The final current in the primary is

$$I_{max} = \frac{12}{2r}(1 - e^{-t/\tau L})$$

where $\tau_L = 4\pi/2\tau\, L$ is the inductance of one primary winding and $r$ its resistance. For the coil specified $I_{max}$ is 133mA, whilst the saturation current is 200 mA which ensures there is no excessive collector current. Collector current of the TIP121 will be 133 mA plus half the gate current. The value of $R_5$ can be fixed by the minimum gain of the TIP121 and its maximum collector current. Components $C_7$ and $R_{10}$ are only used for d.c. blocking and should be chosen to be transparent to a 135 μs pulse feeding the load $R_5$. WW

*RCA Data Handbook, 1977.




*Output pulse width is easily set by $R_1$ and $C_1$ as these are buffered components. The pulse transformer required is an off-the-shelf item which ensures a cheap circuit even in small quantities.*

# DIFFERENTIAL DIRECT CONVERSION

*Poor pre-detection selectivity, second-order mixer intermodulation and high-gain amplification problems are all reduced by using differential circuitry for direct frequency conversion*

**by Paul E. Gili,** WA1WQH

In single-ended transmission systems, the signal voltage is taken with respect to a reference (usually "ground") which is assumed common to all stages of the receiver. Unfortunately this assumption cannot be realized in practice. In the differential mode, by which I mean that connections from one stage to the next are made with two wires and the signal information is contained in their voltage difference, with proper device selection and circuit design, push-pull type circuits naturally evolve which reduce second-order intermodulation products and untuned signal detection. Induced hum and power supply ripple can similarly be reduced by using the high common-mode rejection ratios available in modern op-amps. The beneficial side-effects are at least these three

- a balanced receiving antenna such as a small directional loop can be directly interfaced to the receiver without the phase and gain inaccuracies attendant with baluns
- r.f. circuit layout problems are drastically reduced because in a differential mode we don't worry about maintaining a constant impedance to ground (there is no "ground")
- if we ever cared about transmitting with a balanced antenna we would need both + and − drive signals --these are automatically available with a differential layout.

I have built the receiver whose block diagram appears in Fig. 1, and found that it does indeed achieve all of the advantages outlined above. I wouldn't waste your time describing something that doesn't work, so at this point you can either go ahead and duplicate my circuit, shown in Fig. 2, or read on and find out why it works.

I used a tuned-loop antenna to differentially drive the balanced inputs to $IC_1$, an MC1590 untuned video amplifier with a voltage gain of about 10 and a 10kΩ differential input impedance. A collection of small loop-antenna design equations is given in the appendix, which also explains why you should be using a loop antenna on the h.f. bands. The receiver's first stage performs two functions: it provides constant input and output impedances and acts as a buffer between antenna and mixer, and it provides about 20dB gain for the inefficient loop antenna. Due to atmospheric noise in the h.f. bands for which this receiver was designed, noise figure and antenna efficiency or G/T are unimportant factors. The important consideration is dynamic range, and for the direct conversion receiver, second-order intermodulation products. They must be low to reduce untuned signal detection. In the circuit, the MC1590 operates in a push-pull mode which suppresses this type of non-linearity by generating two equal and opposing non-linearities (when the device is driven non-linear) and cancels even-order harmonics.

After the antenna is amplified, it is differentially converted to the audio frequency range by a doubly balanced mixer circuit incorporating a CA3049. In fact, this circuit could be considered "triply-balanced" as there are no unbalanced ports at all (don't fall over on that one). The CA3049, to be described later, operates as a differential amplifier with its outputs switched in polarity at the local oscillator rate. The fact that gain is available in the upper switching transistors whose bases are at pins 1, 4, 7 and 10 and also the fact that the l.o. signal is a square wave ensures fast switching transitions from positive gain to exactly the same but negative gain. Lack of symmetry during the short switching transition time is known to cause intermodulation products. At h.f. relatively faster switching can be achieved with active devices using squared-up drive waveforms than can be achieved with diode ring-type balanced mixers. Up to 30 MHz, therefore, I think that the integrated bipolar transistor type of balanced mixer driven by a square wave is superior to other types of mixers. It will, however, respond to signals at odd harmonics of the l.o. almost as well as it does to the fundamental; these can be easily filtered out as they are widely separated in frequency.

At points C and D of Fig. 2, then, there is a differential audio signal which is amplified differentially by $IC_2$. These are the two op-amps connected in the classical differential instrumentation amplifier configuration with a differential gain of 40dB. This is where power line hum gets rejected and the amount of rejection depends on how closely you can match the gains to maximize common-mode rejection. You might want to make the gain of $IC_{2(b)}$ slightly variable (±10%) by using a 910-ohm feedback resistor in series with a 200-ohm potentiometer instead of the fixed 1kΩ resistor shown. Residual power supply ripple from the 6.2-volt zener diode is in-phase at the inputs to $IC_2$ but the desired signals are 180° out of phase with each other at these points. With the circuit shown, differential signals get amplified by 40dB, whereas changes in the zener diode reference voltage come through unchanged. A 40dB improvement in signal-to-ripple ratio over a single-ended design is therefore effected.

At the output of $IC_2$ the signal has been amplified and filtered to a level where it is relatively impervious to the interference effects important to a direct-conversion receiver. From here on, we can use standard single-ended operational amplifier circuitry with one input, one output, and ground as a reference. I used a three-section Tchebychev 0.1dB ripple lowpass active filter with cutoff at 500Hz for c.w.

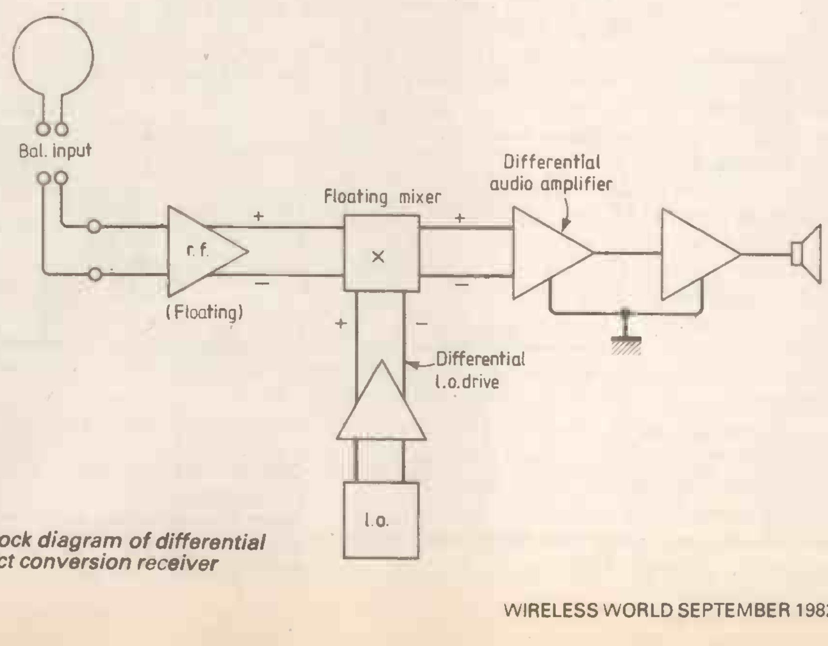
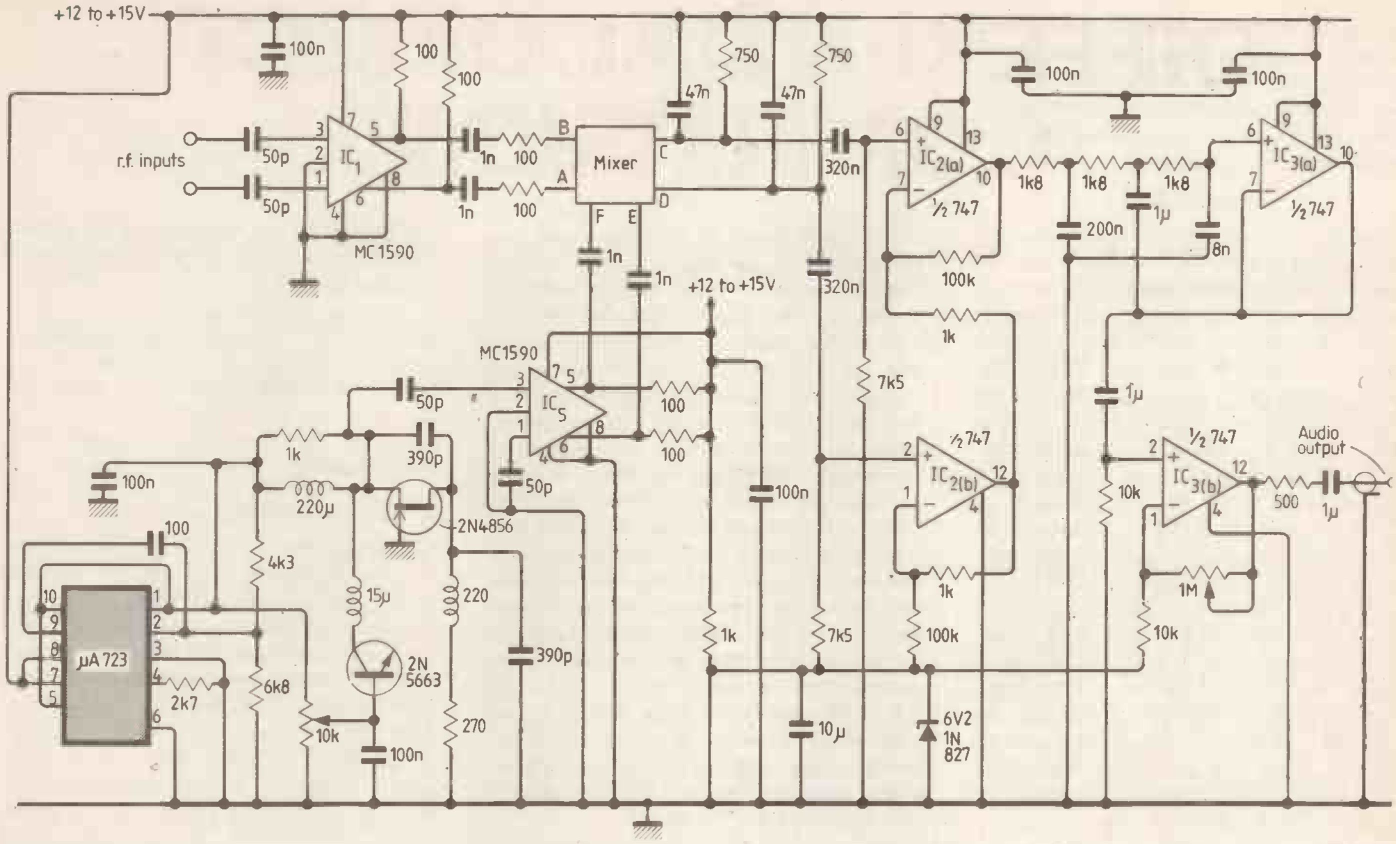



*Fig. 1. Block diagram of differential direct conversion receiver*




operation to drive the output stage. The lowpass filtering results in better c.w. copy than a high-Q, narrow-band-single, section active filter because of less ringing.

The local oscillator has to be stable, yet simple. In this circuit, oscillator transistor and integrated circuit provide an adequately stable differential local oscillator signal over about a 30% bandwidth centred at 3.6MHz. As the circuit shown is electrically tuneable, frequency stability depends on how stable a tuning voltage you can generate. After building and using the receiver, I came to the conclusion that unless some type of closed-loop frequency synthesis technique is used to stabilize a free-running wide-band v.c.o. mechanical tuning is preferable. I am, therefore, presently looking at electronically switched L-C networks which may be the subject of a future article.

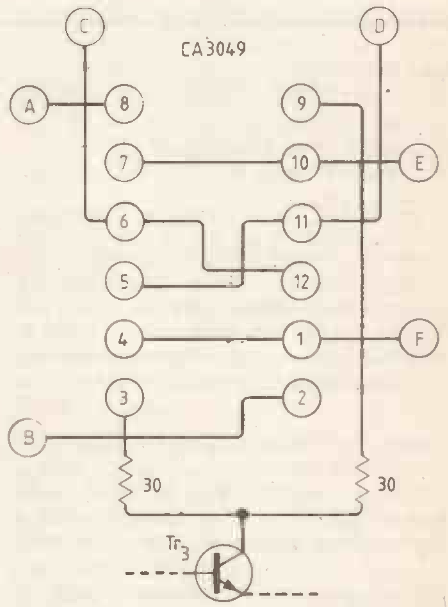
With the differential signals available, we can take a very different perspective on circuit layout. By maintaining relatively high common-mode impedances compared with differential-mode impedances, we can do without a ground plane. Actually, the presence of a ground plane may negate some of the advantages achieved by the differential concept. If you intend to build a circuit of this type, feel perfectly confident that you can do it on perforated board with no decrease in the performance attributes outlined here. In fact, the further away you can get the balanced r.f. circuitry from a ground plane, the better off you will be.

Integrated circuits should still be bypassed at their supply voltage terminals. All differential signal leads should be tightly twisted pairs, as short as possible, and as far away from chassis or circuit ground as possible. This applies particularly to the following four transmission paths:

*Fig. 2. Differential direct conversion receiver shown uses only five i.cs and three discrete transistors.*

- connections from the balanced antenna outputs to pins 1 and 3 of $IC_1$
- connections from pins 5 and 6 of IC, to the A and B inputs of the mixer
- connections from points C and D of the mixer to pins 6 and 2 of $IC_2$
- l.o. connection from pins 5 and 6 of $IC_5$ to points E and F of the mixer.

The CA3049 should be laid out and wired as shown in Figs 3 & 4 which relate to the terminal connections of Fig. 2. This device is a high-frequency, layout sensitive component and we are using its high frequency capabilities to reduce intermodulation distortion, as described earlier. (The no-




*▲Fig. 4. Mixer block in fig. 2 and shown in Fig. 3, can best be laid out as shown above. This will result in good high frequency performance and intermodulation reduction as discussed in the text. Using this layout will also insure a stable non-oscillating active h.f. mixer.*

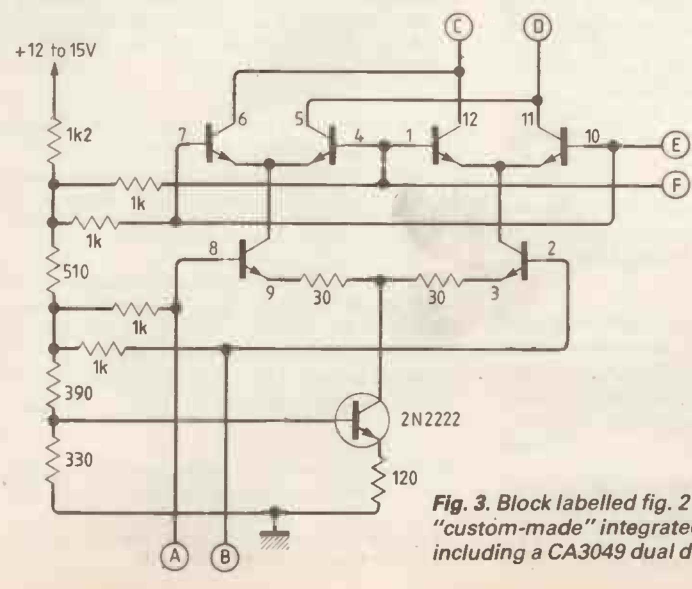
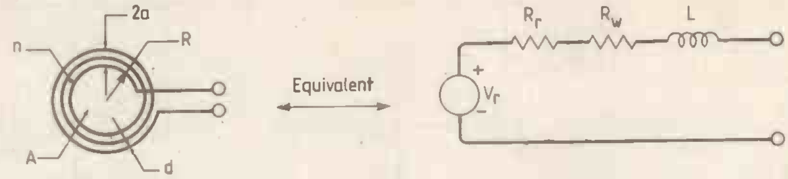



*Fig. 3. Block labelled fig. 2 is really a "custom-made" integrated circuit including a CA3049 dual diff-pair.*

menclature of points A, B, C, etc, on the mixer of Fig. 2 has been generated mainly to reduce the clutter which would appear on a detailed circuit schematic, but which is much more simple in an actual physical realization, as Fig. 4 shows.)

## Appendix

Small loop antennas are useful for receiving systems in the h.f. band because their dipole-like directional characteristics are preserved even though their size is orders of magnitude smaller than an actual dipole at these frequencies. Their efficiency is extremely low, but at h.f. where most of the receiver noise is due to random atmospheric disturbances, it doesn't matter if you have a lossy, noisy receiver front end. A small loop's main attribute is its ability to easily null out a coherent man-made interfering signal by simple physical re-orientation of the loop. A 3.5MHz receiving loop antenna can be as small as two feet in diameter and have the same directional properties as a rotatable 80-metre dipole which would be about 130 feet long. Null depths of around 20dB can be achieved if phase and gain of the balanced antenna output are preserved. Naturally, you'll need a differential direct conversion receiver to do a good job at this.




For convenience in building small loop antennas, I've put together a number of design equations from various sources, shown on the right. Included is one relationship assembled by me which allows you to calculate the approximate r.f. voltage received from a transmitter as a function of the transmitter's range, power, frequency, and your receive loop antenna parameters. Of course the range depends on how the signal got to you, i.e. how many ionospheric bounces it took and how high the reflecting ionospheric layer was at the time. Polarization of the received wave also plays a part, as does the angle of arrival from the sky with respect to the loop's orientation (elevation as opposed to azimuth). One can easily get carried away trying to account for more variables than can be measured or even defined; however, the equation does give an answer which probably is within an order of magnitude of the actual number.

The small loop antenna has an equivalent circuit which may be derived from its physical parameters.

$R_r = 31{,}200\,(nA/\lambda^2)^2$ ohms
$R_w = 2.61\times10^{-7}\sqrt{f}(2nR/d)$ ohms for copper
$L = n^2\mu_o R(\log_e(8R/a)-2)$ nanohenries
$V_r \approx (\lambda/4\pi D)\sqrt{8P_tR_r}$ volts

### Definitions

R mean radius of loop
A area of loop, $\pi R^2$
d wire diameter
n number of turns in loop
a radius of bundle of wires in loop or d/2 if n=1
$V_r$ peak amplitude of received signal
$R_r$ radiation resistance
$R_w$ conductor loss resistance with skin effect
L inductance of loop (nH)
f frequency (Hz)
$\lambda$ free space wavelength
$\mu_o$ 12.56 nH/cm
$P_t$ transmitted power (watts)
D range (same units as $\lambda$)

WW

# LITERATURE RECEIVED

**"Phase-locked Upconverters for Pulse-compression Radar"** is the title of a booklet containing three re-printed papers by Microwave Associate's principal engineer. The articles are extremely well presented and form a useful collection of information on the subject. Publication available free from Microwave Associate Ltd, Dunstable, Bedfordshire LU5 4SX. WW401

**Timers, controllers, relays and connectors** are all fully illustrated and described in a 60-page Tempatron catalogue, now freely obtainable from the Sales Department, Tempatron Ltd, 6 Portman Road, Reading, Berkshire. WW402

Characteristics and mechanical details of **microwave and r.f. power transistors**, working in the range 1MHz to 4CHz at up to 500W peak pulse power are given by a catalogue for Acrian. There are, in addition, paged on reliability, testing and a glossy of transistor terms. March Microwave Ltd, 112 South Street, Braintree, Essex. WW403

A leaflet on **relays and timers** of all types, which provides both electrical and mechanical information, is available from Appliance Components Ltd, Cordwallis Street, Maidenhead, Berkshire SL6 7BQ. WW404

A selection guide giving brief details of all **transistors and integrated circuits** made by Raytheon can be obtained from Raytheon distributors and sales offices. Raytheon Semiconductor UK, Howard Chase, Pipps Hill Industrial Area, Basildon, Essex SS14 3DD. WW405

The Philips LDK 14SL **colour television camera system** is briefly described in a colour leaflet, available from Pye TVT Ltd, P.O. Box 41, Coldhams Lane, Cambridge CB1 3JU. WW406

**Semiconductors made by Plessey** are listed, with salient characteristics, in a short catalogue, obtainable from Plessey Semiconductors Ltd, Cheney Manor, Swindon, Wiltshire SN2 2QW. WW407

Test signals for audio equipment are described in a Standard from the International Electrotechnical Commission. A weighted noise test signal with a mean power spectral density is close to the average mean power of programme signals is described. The Standard includes the specification of the frequency weighting, together with filters for deriving signals from pink-noise and white-noise sources. Publication 268-1C available from IEC, 1 Rue de Varembe, 1211 Geneva 20, Switzerland. WW408

National Semiconductors have issued a leaflet describing their NSC 800 $P^2$CMOS microprocessor and associated devices. The double layer of polysilicon connections (hence the $P^2$ are claimed to provide very high speed at low power consumption for the 8-bit m.p.u. family. Details from ITT Electronic Services, Edinburgh Way, Harlow, Essex. WW409

The Pro-Audio Yearbook 1982/83 contains 686 pages of information and pictures to do with the various aspects of professional recording and sound broadcasting. Link House Magazines, Dingwall Avenue, Croydon CR9 2TA. WW410

High power **thyristors** in small packages are detailed in **Bulletins** E2515 and E2516 from International Rectifier. Bulletin E2746A describes the IRK series of thyristor/diode combinations. Details from IR, Holland road, Hurst Green, Oxted, Surrey. WW411

Electrically-Small HF Transmitting Antennas is the title of a Technical Note from Technology for Communications International Ltd, Kingston House, Stephenson Way, Three Bridges, West Sussex RH10 1TN. WW412

Wilmslow Audio charge £1.50 for their new catalogue which includes details of their d-i-y loudspeaker kits and components as well as a range of ancillary equipment. There is a lot of useful information about loudspeakers and enclosures. Wilmslow Audio Ltd, D.A.T.A. books have published new editions of their **Transistor, Diode and Thyristor D.A.T.A.** books. along with the listings of the available devices and their characteristics, there is a new section which lists the replacements for components. Any replacement listed can, of course, be compared in detail in the device listings. Other recent additions to the 24-volume D.A.T.A. series are ones on Modules and hybrid i.cs and others on discontinued linear devices. D.A.T.A. International Inc., Portman House, 16-20 Victoria Road, Romford, Essex RM1 2JH. WW414

BS 6204 is a new British Standard for **Safety of Data Processing Equipment**. It specifies the requirements of data processing and associated electronics units intended to be connected to a supply system having a maximum nominal system voltage of 600V and designed for continuous operation. The Standard has been drafted to avoid the risk of personal injury or damage to equipment or buildings arising from electric shock, fire, energy hazards, mechanical and heat hazards, radiation and, chemical hazards associated with the installation of such equipment. British Standard Institution, 2 Park Street, London W1A 2BS. WW415

A massive catalogue of **Linear Integrated Circuits** lists the products of Precision Monolothics Inc. It includes op. amps, comparators, voltage reference, d-to-a converters, multiplexers, telecommunications chips and much more. Each entry gives a full specification, a schematic diagram and applications notes. The PMI 1982 Catalogue is available in the UK from Bourns Electronics, 17 High Street, Hounslow TW3 1TE. WW416

# SIMPLE, LOW-FREQUENCY OSCILLOSCOPE

*A simple oscill[illegible] based on the old ex-Go[illegible]ernment radar tube VCR517, which is still avail[illegible]le [illegible] together with its v[illegible]ions VCR97 and small screen VCR138.*

by R. J. Taylor

The circuit was designe[illegible] performance suitable [illegible] low-frequency measureme[illegible]. It [illegible] far as possible, components which [illegible] readily available, and the circ[illegible] straightforward with no critical adjust-ments or line-up. The total cost of components including the tube should not be more than about £35-£40.

## Circuit description

The tube is run at about 2000 V e.h.t., which gives adequate brightness and spot size and at the same time eases the deflection-plate drive requirements. The X and Y amplifiers drive the deflection plates directly at a mean voltage of +100 V and the tube cathode is at a potential of −2000 volts.

For good focus, the potential on $A_3$ of the tube must be the same as the deflection plate potential and therefore a preset control is used to set $A_3$ potential, and acts as a second focus control.

The e.h.t. is generated by a voltage tripler, driven by a 500 V transformer winding.

The $A_2$ and $A_3$ focus controls are preset potentiometers. $A_2$ focus should be suitably insulated, since it is at about −1500V. Similarly, the brightness control should have a nylon spindle and the body should be fixed to an insulating mounting.

## Y amplifier and input attenuator

The Y amplifier is a fully balanced, d.c.-coupled circuit with the Y input connected to one side and the Y shift to the other. The LF357 operational amplifier was chosen to drive the long-tailed pair, as it has a 20MHz [illegible] gain [illegible]andwidth and fet input. The [illegible] gain from the Y input to th[illegible] each operational amplifier is ×12 a[illegible] to each Y plate ×300.

The input attenuator gives accurate input attenuation with a constant 1 MΩ input impedance using a moulded, single-pole, 10 position switch. This type of switch, which is also used for the X speed control, is available in a plastic moulded form which gives good insulation resistance. A ring on the fixing bush is used to limit the rotation to 10 positions for the Y attenuator, or is left off if all 12 positions are used, as in the X sweep circuit. Non-standard resistor values can be made up from two resistors, for example, 470 k and 33 k give 500 kΩ, using 2% tolerance if possible.

Note that the simple input attenuator has no high-frequency correction, which this results in the full Y amplifier bandwidth only being obtainable at the 0.05 V/cm setting. At other settings of the attenuator (except 0.1 V/cm) the bandwidth is between 200 and 300 kHz. At 0.1 V/cm the bandwidth is 100 kHz.

The Y amplifier gain may be adjusted by the 1 kΩ resistor between the inverting inputs of the two operational amplifiers.

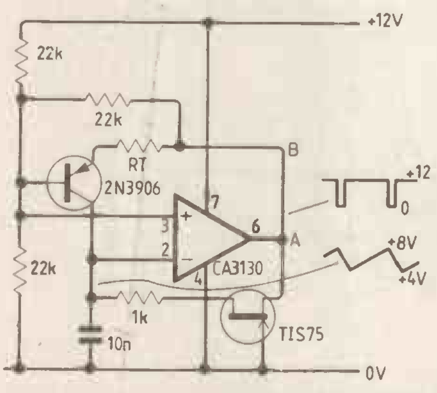



*Fig. 1. Basic form of sawtooth generator. Circuit is seen in final form in main circuit diagram, where logic gates are used to inhibit free-running mode for triggering.*

## Sawtooth generator and X amplifier

The sawtooth oscillator is based on a CA3130 operational amplifier which has a c.m.o.s. output stage and permits the output voltage to reach the rail voltages (0 or +12 V). The basic sawtooth oscillator is shown in Fig. 1, in which the operational amplifier operates in a switching mode with the output at either ground or positive rail potential.

At switch-on, the capacitor is discharged and the output (A) will be at +12 V. The positive input of the amplifier will therefore be at +8 V and the transistor will be supplying current to the capacitor. The current will be defined by $V_e/R_T$ where $V_e$ is the voltage across $R_T$. In the basic circuit, this will be about 3.3 V when the amplifier output is at +12 V.

The capacitor charges up linearly until the voltage on the negative input of the amplifier equals that on the positive input (+8 volts). At this point the output will rapidly fall to ground potential, turning the transistor off and turning the fet on, discharging the timing capacitor through the 1 kΩ hold-off resistor. The positive input of the amplifier is now at +4 V. At the point at which the negative input is the same as the positive input the output voltage switches to the positive rail again and the whole cycle repeats. In the final circuit, a logic gate is used between points A and B, so that the sawtooth oscillator can be inhibited, ready to trigger.

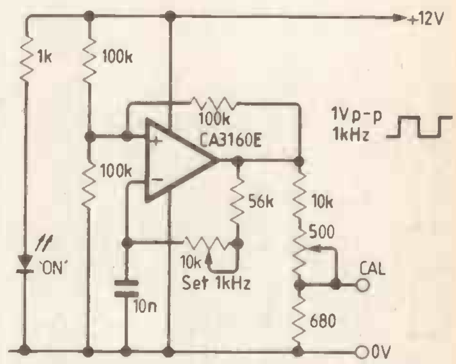



*Fig. 3. Square-wave calibration oscillator.*

The emitter resistor $R_T$ is used to set the sweep speed and is replaced in the final circuit by the sweep-speed switched resistors, which vary the current supplied by the transistor into the timing capacitor between about 0.8 mA 0.2μA.

The X amplifier takes the same form as the Y amplifier. There is a voltage gain of 2 to the output of each operational amplifier (8 V p-p sawtooth) and a further gain of about 30 to each X plate (240 volts p-p).

## Trigger circuit

This circuit, comprising the three integrated circuits 4011, 4070 and 4013, takes

*continued on p.87*

### Specification

**Sweep speeds** 5 μs/cm to 20 ms/cm.

**Vertical** 0.05 V/cm to 50 V/cm ac/dc

**Bandwidth:** 1 MHz at 0.05 V/cm
100 kHz at 0.1 V/cm
200-300 kHz at other settings

**Input impedance:** 1 MΩ // <20 pF

**Triggering** free run or trigger from +ve or -ve edge of input

**Calibrate waveform** 1 volt p-p square-wave, 1 kHz

* The bandwidth could be improved to 1 MHz on all settings using a more complex input attenuator with compensating capacitors. However, the simple input attenuator shown gives accurate low-frequency performance.

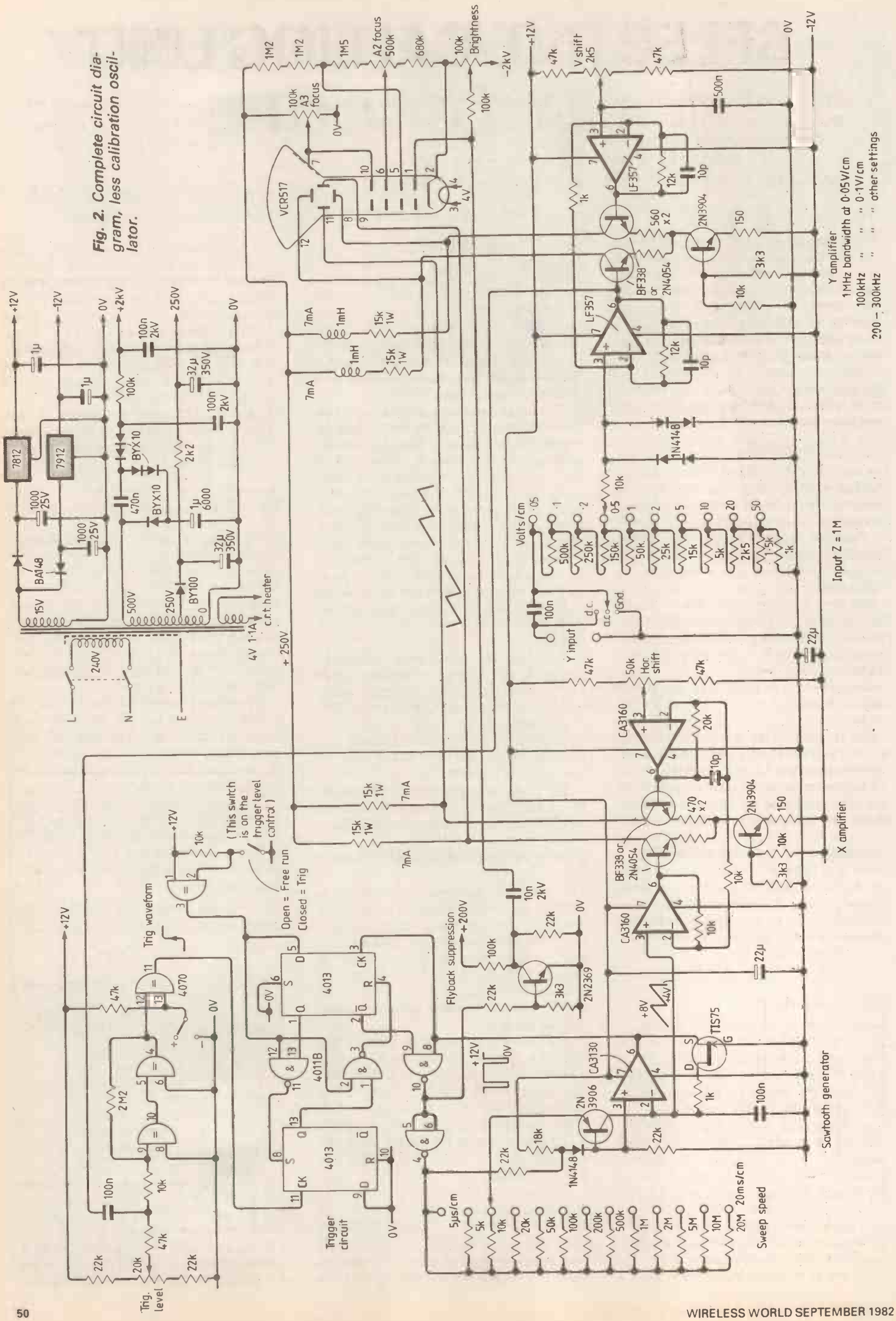


Fig. 2. Complete circuit diagram, less calibration oscillator.

# SELECTIVE-CALLING UNIT

*Designed for use with citizens'-band radio, this pocket-sized unit can be programmed to accept one of 65 536 different four-digit codes, and can call as many individual stations from values entered on a hexadecimal keypad. Coupling to the transceiver may be acoustical in both directions or through the radio's external loudspeaker socket for receiving. This unit could be adapted for use in electronic combination-lock applications.*

**by Brian Drury**

The concept of selective calling for private-mobile, citizens'-band and amateur radio is not new, but existing systems are usually incorporated in the transceiver and often use expensive components. Also, the number of individual codes available is more often than not inadequate, especially where citizens' band is concerned.

Described here is a unit housed in a calculator-sized case, which can handle up to 65,536 different codes and uses readily available components. The received signal can be acoustically coupled to the selective-call unit by placing the latter near to the receiver's speaker, should the preferable method of connecting the unit directly to the receiver's external loudspeaker socket be undesirable.

Basically, a four-character hexadecimal number entered on the unit's keypad results in the generation of a sixteen-bit serial signal which is used to modulate the transceiver's carrier. This allows the user to selectively call any of up to $16^4$ receivers, and means that potential recipients only need to listen for a 'bleep' – rather than having to constantly monitor conversations on what may be a busy shared channel.

All the i.cs used are c.m.o.s. types, the main element being the Intersil IM6402 uart (universal asynchronous receiver/transmitter), so operation from nickel-cadmium cells small enough to fit into the calculator-sized case is practical. Also, the components used are readily available and at moderate cost. The unit was designed to be small and versatile to allow it to be modified for other purposes, particularly in security applications, where it might be used to permit access to information, or to a telephone-answering machine, or, say, to unlock a garage door. In transpond mode, the unit may also be used for remote data interrogation.

## Circuit description

**Board A.** This board, shown in Fig. 1, provides an interface between the keyboard and main logic board, board B, which is described separately. Hexadecimal codes are entered on a 16-key matrix-type keypad which is connected directly by eight wires to a keyboard encoder, $IC_2$. This i.c. responds to closed-contact resistances of up to 5kΩ, and provides a contact-debounce period proportional to the value of $C_1$; here, 1μF is used, giving a debounce period of around 1ms.

A clock signal applied to pin 5 of the keyboard encoder determines the keyboard-scan rate. The frequency at pin 5 in this case is 3.2768kHz, derived from a crystal oscillator, $IC_5$, and divide-by-ten circuit, $IC_1$. Half of a dual D-type flip-flop, $IC_4$, further divides this signal to provide the main 1.6384kHz clock used on the second board. The remaining half of $IC_4$ is used to steer the keyboard encoder's strobe output either into the 4-bit latch, $IC_3$, or off board A as $\overline{STB}$.

When the unit is switched on, circuit elements $R_2$, $D_1$ and $C_3$ ensure that the steering logic starts out in the correct state, and provide a system-reset signal, RST, for the second board. Immediately after power-up, the first hexadecimal character entered on the keypad will be held at the Q outputs of $IC_3$. Entry of the second character will result in an eight-bit byte being shifted off board A by the $\overline{STB}$ signal. This board, while specifically designed for use with the 6402 uart, could be used in any application requiring manual entry of an eight-bit-wide data byte.

**Board B.** The main component on this board, shown in Fig. 3, is the previously mentioned 6402 uart, $IC_6$, which is used in its eight-bit mode, with even parity and

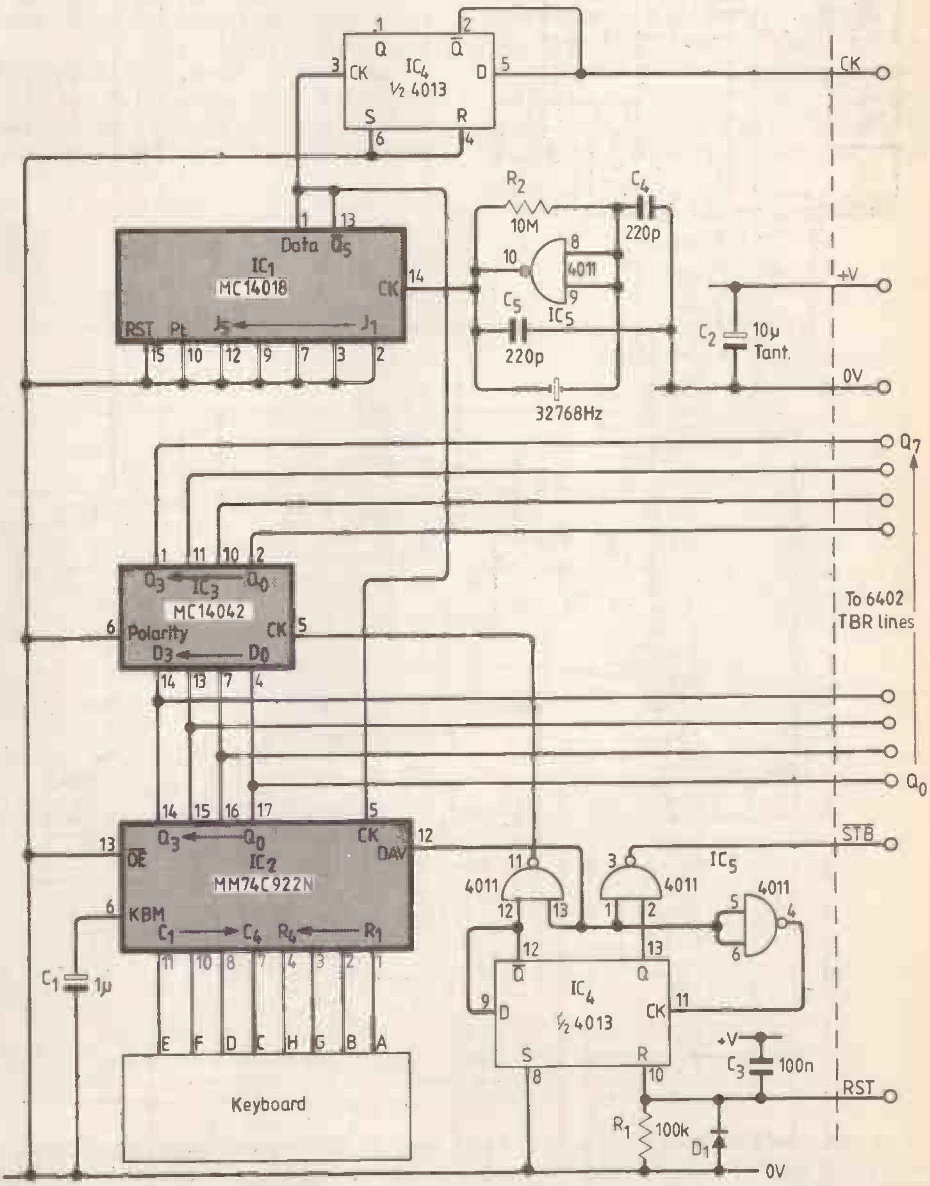



*Fig. 1 Board A. This board produces an eight-bit parallel word from two entries on a hexadecimal keypad and may be used in any application requiring such. $IC_1$ divides by ten and $IC_4$ by two, to produce a clock signal of 1.638kHz for use on board B, Fig. 2.*

one stop bit. More information on this can be obtained from the appropriate Intersil data book.

$IC_4$ divides the 1.638kHz clock signal from board A by two to provide receiver and transmitter clocks for the uart. Within the 6402, these clocks are divided by 16, giving a bit rate of 51.2 baud.

In transmit mode, a zero at the buffer-register load input, pin 23, transfers data at inputs $TBR_1$-$TBR_8$ to the transmitter buffer register. A low-to-high transition on pin 23 results in a request to transfer data to the transmitter register. If the register is free, the two hexadecimal characters are sent to the TRO output, pin 25, in the form of an 11-bit frame consisting of eight data bits, one parity bit and two framing bits.

For receiving, the unit may be electrically coupled to the loudspeaker output of a radio, or acoustically coupled, when the unit is placed near to the radio's loudspeaker. As an aid to testing both transmitting and receiving functions, the unit may also be connected so that it monitors its own transmissions.

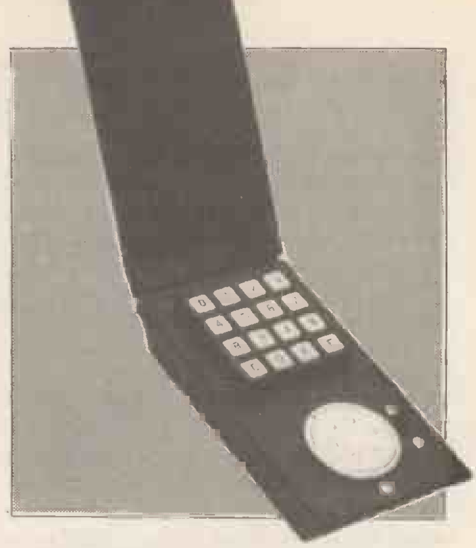
Although the signal source may vary, amplification in each case is provided by $Tr_1$ and $IC_5$. $Tr_1$, used as a grounded-base voltage amplifier, has a low input impedance well matched to the moving-coil transducer and its parallel resistor, $R_9$. When a jack plug is inserted in socket 2, however, switch $S_2$ opens and the source impedance rises, reducing the gain of the amplifier.

Capacitor $C_5$ couples the output of $Tr_1$ to the inputs of one quarter of a c.m.o.s. Nand gate, $IC_5$, used as a linear amplifier. The resulting modulated square-wave version of the carrier signal is then applied to $Tr_2$, where data is recovered by removal of the carrier.

Recovered serial data is fed directly into the serial input of $IC_6$, pin 20. When a complete frame has been received, a data-available signal, DR, appears at pin 19. This signal is used to gate the parity and framing error signals, hence, if a valid, errorless frame is received, pin 10 of $IC_1$ will go high while DR is high; in practice, this period is around 10ms long, determined by $R_{18}$ and $C_4$.

A monostable, half of $IC_3$, is triggered by the 10ms pulse to give an output for 2.2s. This signal, the duration of which was found by experiment to be the most convenient, is required in the event that a valid two-character data frame is received, but not followed by a second within 2.2s. The Q output at pin 6 of $IC_3$ is connected to one clock input of a dual D-type flip-flop, $IC_4$. On the rising edge of the signal at this input, the D input's state is transferred to the Q output, pin 1.

Logic used to compare a 'call number' stored in a diode memory with the first-received, valid data byte determines states at the flip-flop's D input. Figure 3 is used



to help explain how the comparison circuit works. In the example, the diodes are drawn to represent a stored call number of 55 hexadecimal, and any binary-bit pattern other than 55 applied to the data input will result either in a logic 1 at point A or a logic 0 at point B. In either case the output will be 0. But when 55 is applied, point A will be at 0 and point B at 1, resulting in a 1 at the output.

Two such roms are used to store the 16-bit call word. If the first byte of the selective-call signal is equal to the value stored in the first rom, which has its output connected to point X, Fig. 2, the Q output of $IC_4$, pin 1, will go high. If a

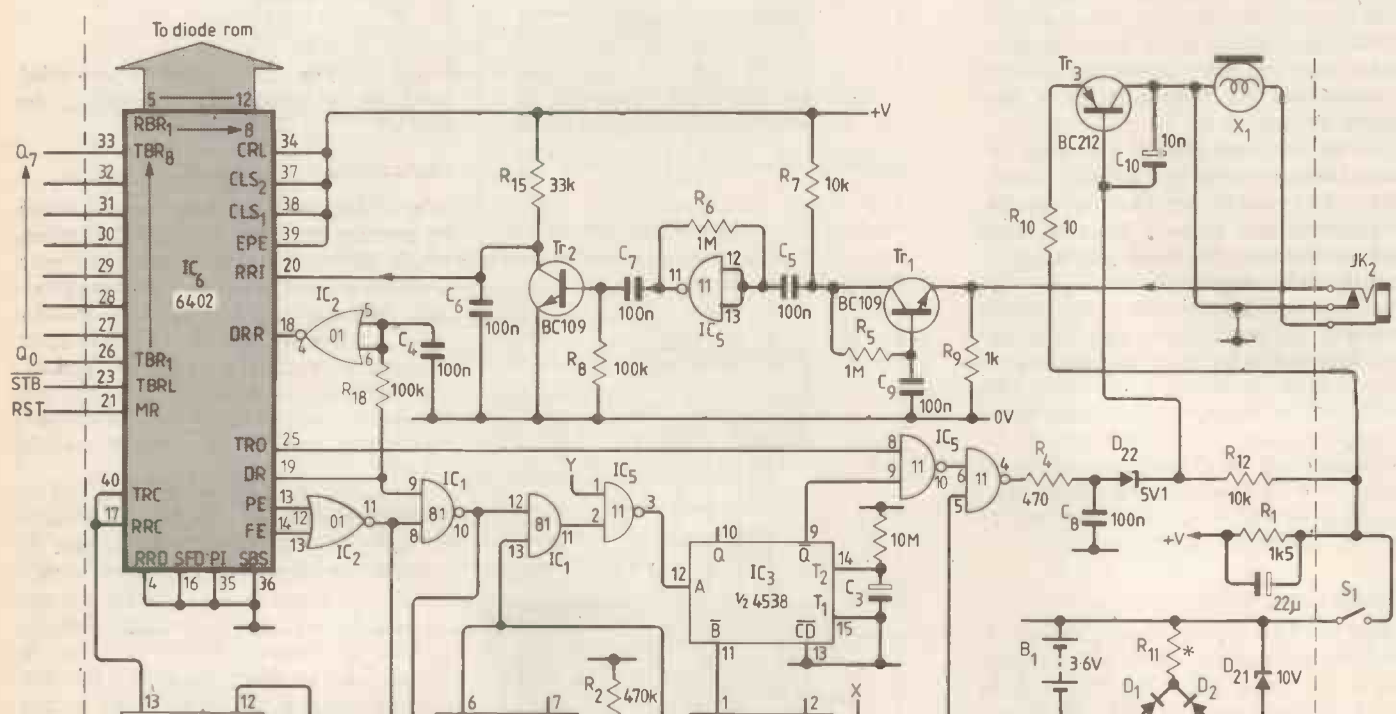



*Fig. 2. Main board B, based on the 6402 u.a.r.t. Here, eight-bit parallel words are turned into serial words and used to modulate an audio carrier in transmit mode. On receive, serial words are demodulated, converted to parallel and compared with hexadecimal values set on diode roms. If two received eight-bit words correspond with two words stored in diode roms, an audible alarm is sounded for 10s ($C_3$). Pins 5-12 of $IC_6$ should be reversed.*

second byte is received within 2.2s of the first, it will be compared with the second diode rom, whose output is connected to point Y of Fig. 2. Where the stored and received bytes are equal, the second monostable of $IC_3$ will be triggered for around 10s and gate the 1.638kHz carrier to produce an alarm.

Power for the rechargeable batteries is supplied through a jack socket to a bridge rectifier, so that a.c. or either polarity of d.c. may be used. $R_1$ provides current limiting and $D_{21}$ overvoltage protection.

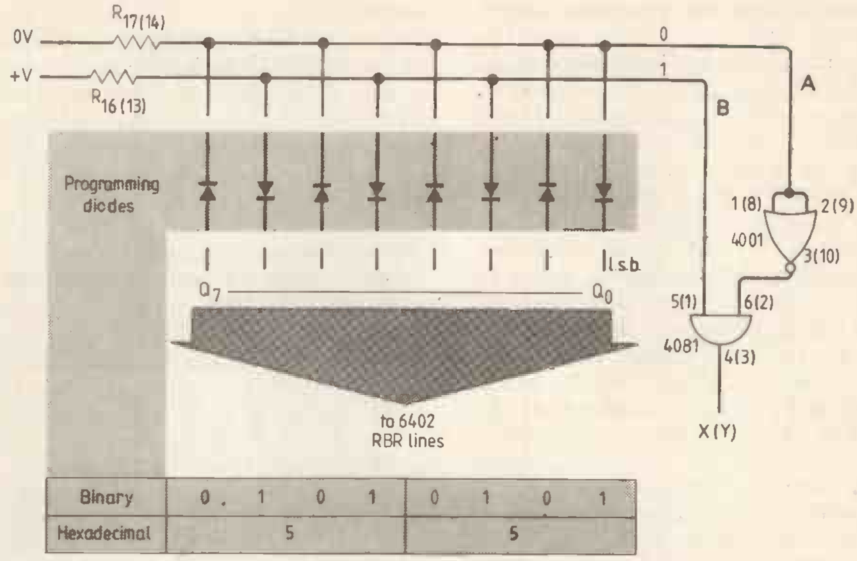



*Fig. 3. Diode roms for storing two eight-bit words in hexadecimal form. Two of these circuits are used, with their outputs connected to the appropriate points on board B, Fig. 2.*

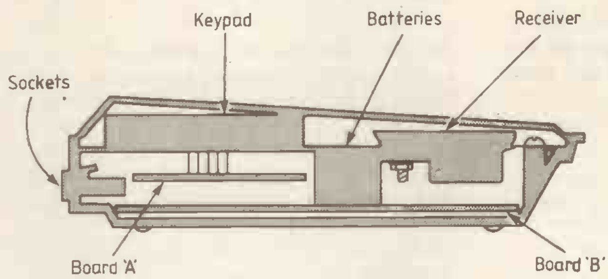



*Fig. 4. Cross section of the selective-calling unit. Components on board A must be carefully mounted as height is limited.*

## Construction

A small, calculator-sized plastic case is used to house various components of the unit, as shown in Fig. 4. An aluminium facia, supplied with the case specified, must be accurately drilled according to the dimensions given in Fig. 5, especially in the case of the retaining-stud holes, as the studs are only 1mm away from the keypad. A position for an on/off switch is not given since the type of switch used and its placing are not critical. If rechargeable batteries are not used, the on/off switch may be omitted.

The moving-coil transducer is pressed into place and fixed using one or two drops of an epoxy-type adhesive applied from behind. A ¼in drill was used to remove the plastic supporting pillars in the plastic case and the keypad was fixed in place on the facia by 'riveting' the retaining studs using a warm soldering iron. Dimensions for the jack-socket holes are given in Fig. 6 and for board A in Fig. 7. Board B measured 4.15in by 2.35in.

Components on board A must be mounted as close to the board as possible, otherwise, problems will be encountered when attaching the facia assembly. When assembling board B, the batteries should be mounted last because an accidental short will probably cause damage to either the batteries or components.

When determining diode positions for the roms, it is best to write the bit pattern of the chosen number with the most significant byte on the right. In my version, only 5mm was available between the surface of the board at the position where the diode roms were situated, and the moving-coil transducer. Internal wiring is best done with flat cable since it gives a neat finished product. It is practical to wire the two boards together before mounting the keyboard and facia plate.

Finally, current consumption is measured and should be approximately 1.5mA in standby mode and over 20mA when an alarm is given. If the alarm is triggered each time that power is applied to the unit, an additional tantalum-bead capacitor should be connected in parallel with $R_{11}$ on board B. The alarm may be cancelled manually by momentarily switching the unit off.

## Operation

When completed, the unit is easily tested by entering its own selective-call number, which should result in the alarm being given for around 10s. If two units are available, they may be placed side by side and a rigid reflector positioned directly in front of the two transducers to provide acoustical coupling: each unit's selective call number is entered on the other's keypad, whereupon the relevant alarm should sound.

Normally, the unit will be used with a transceiver and be coupled electrically through $JK_2$. Sufficient voltage gain is provided to cope with the lowest anticipated input signal so in most cases, a resistor will be needed in the signal line to provide a potential divider with $R_9$. A typical value for this resistor when the unit is connected to a loudspeaker output, and the radio's volume control is set at 50%, is 100kΩ, but some experimenting will probably be required.

If a call is unsuccessful, it is not possible to judge whether the failure is due to the potential recipient not being at home, or due to the signal not reaching its intended destination. This problem may be overcome using a third jack socket to tap the alarm monostable's signal, pin 10 of $IC_3$, which may be used to activate the potential recipient's transmitter in transpond mode. Modulation is provided

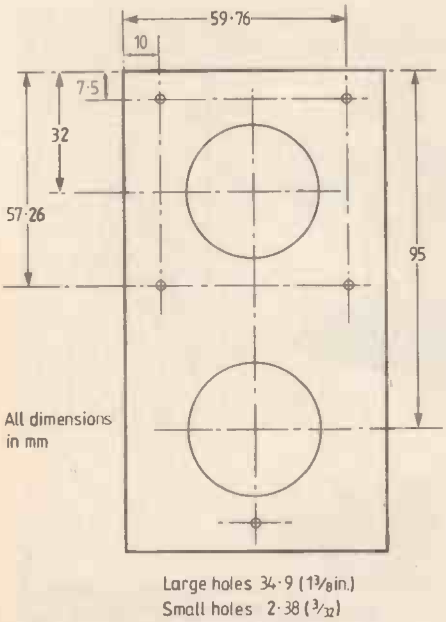



*Fig. 5. Dimensions for the facia are critical. Four of the small holes are for the keyboard's mounting studs, which are riveted using a warm soldering iron. The transducer should preferably be a push fit in its hole, and fixed from behind using one or two drops of epoxy adhesive.*

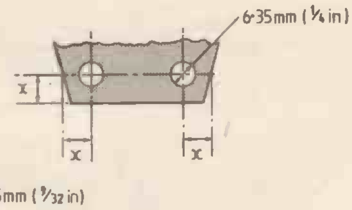



*Fig. 6. Dimensions for the jack-socket holes. A third jack socket may be used, as described in the text.*

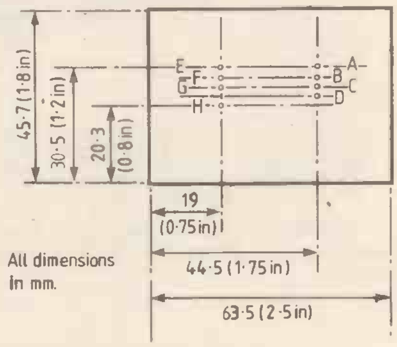



*Fig. 7. Dimensions for board A and positions of the keyboard connection holes. Board B measures 4.15in by 2.35in.*

**Table 1. Mnemonics for the 6402 universal asynchronous receiver/transmitter.**

| | |
|---|---|
| VCC | positive supply |
| N/C | no connection |
| GND | ground |
| RRD | receiver register disable |
| RBR | receiver buffer register outputs |
| PE | parity error |
| FE | framing error |
| OE | overrun error |
| SFD | status flags disable |
| RRC | receiver register clock |
| $\overline{DRR}$ | data received reset |
| DR | data received |
| RRI | receiver register input |
| MR | master reset |
| TBRE | transmitter buffer register empty |
| $\overline{TBRL}$ | transmitter buffer register load |
| TRE | transmitter receiver empty |
| TRO | transmitter register output |
| TBR | transmitter buffer register inputs |
| CRL | control register load |
| PI | parity inhibit |
| SBS | stop bit select |
| CLS | character length select |
| EPE | even parity enable |
| TRC | transmitter register clock |

by the alarm signal.

This additional socket could be used to activate any remotely controlled device requiring a high degree of security. A transpond signal could be used to relay information relating to the status of the remote device.

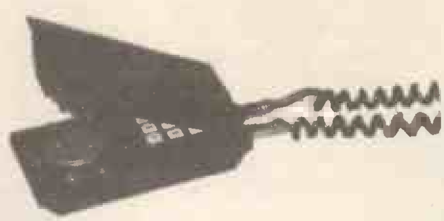
During tests, whether or not squelch was used made no difference to the unit's operation. It is advisable to radiate an unmodulated carrier for about 3s during transmission to ensure that the first-monostable section is clear. Modulation depth and deviation will be determined by the distance between the unit and the radio's microphone, so some experimentation may be required to determine optimum positions.

Although it is not advisable to use the unit when the background-noise level is high, a degree of success has been obtained under adverse conditions, including operating the unit from a noisy mini-van using simple moving-coil microphones.

If microphones with automatic-gain controls are used, it is possible that noise during the 'quiet' period preceding the first data byte will be sufficient to trigger the uart. Should the noise initially provide the correct parity and framing signals, it is unlikely that further noise will follow with the same correct parity and framing signals, in which case, the monostable will be reset through a negative-going signal at its CD input. Such a microphone was not available to test this theory.

## Comments

This selective call unit was designed with the sure knowledge that the facility it would provide could not be relied upon in the same way that the telephone service can. However, tests so far conducted suggest that the unit is useful even in less than ideal conditions, and generally the operational range is the same as that achieved with normal speech. Further improvement could no doubt have been achieved had a filter been added to bandpass the 1.638kHz carrier signal, but this idea was rejected because of the extra test equipment needed to align the unit. Also, the bulky components required for a passive filter would not fit in such a small case. A phase-locked-loop was rejected because of the need for passive pre-filtering and power-supply dependent oscillator frequency problems.



The design was based upon a standard c.m.o.s. uart in view of its low cost and availability; also, the use of eight-bit bytes provides for easy interface to microcomputers should the need arise. Modular construction allows the unit to be used as a byte-wide parallel-data entry terminal for microprocessor applications when board B is omitted. Alternatively, the unit may be used for serial data-entry applications using both logic boards, but with some components omitted. WW

*Photo-copies of the p.c.b.-foil patterns and components positions can be obtained by sending a s.a.e. to Wireless World, Selcall, Room L303, Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS. Requests for printed-circuit boards, whose price will depend on demand, should be sent to the same address.*

## Components

**Board A**

**Resistors**

| | |
|---|---|
| 1 | 10M |
| 2 | 100k |

**Capacitors**

| | |
|---|---|
| 1 | 1µ tantalum |
| 2 | 10µ tantalum |
| 3 | 100n |
| 4,5 | 220p |

**Integrated circuits**

| | |
|---|---|
| 1 | 4018 |
| 2 | MM74C922N |
| 3 | 4042 |
| 4 | 4013 |
| 5 | 4011 |

**Diodes**

| | |
|---|---|
| 1 | 1N914 |

**Crystal**

| | |
|---|---|
| 1 | 32768Hz type QRT-38 from Interface Quartz Devices |

**Board B**

**Resistors**

| | |
|---|---|
| 1 | 1,5k |
| 2 | 470k |
| 3 | 10M |
| 4 | 470 |
| 5,6,13,14,16,17 | 1M |
| 7,12 | 10k |
| 8,18 | 100k |
| 9 | 1k |
| 10 | 10 |
| 11 | see below |
| 15 | 33k |

**Capacitors**

| | |
|---|---|
| 1 | 4,7µ tantalum |
| 2 | 10µ tantalum |
| 4-9 | 100n |
| 10 | 10n |

**Integrated circuits**

| | |
|---|---|
| 1 | 4081 |
| 2 | 4001 |
| 3 | 4538 |
| 4 | 4013 |
| 5 | 4011 |
| 6 | IM6402IPL |

**Diodes**

| | |
|---|---|
| 1-20 | 1N4148 |
| 21 | 10V zener, 400mW |
| 22 | 5,1V zener, 400mW |

**Transistors**

| | |
|---|---|
| 1,2 | BC109C |
| 3 | BC212 |

**Other components**

Batteries, MP3-100 from Ever Ready
Case, 75-3018C from Verospeed Ltd
Moving-coil transducer, 3T from Besson, Hove, Sussex
Keypad, Grayhill 83BB1-002 Highland Electronics Ltd, 8 Old Steine, Brighton.
3.5mm jack sockets
For continuous charging, R11 should be chosen to provide 1mA charge current, or 10mA for rapid charging.

WW – 070 FOR FURTHER DETAILS

# Fifth-generation computers

The government has recently announced that it will be financing research into the development of 'Fifth generation computers'. The need for this is illustrated by the peculiar effect of the tumbling cost of large-scale integrated circuits. The very cheapness of the hardware means that we are using computers to solve bigger and more difficult problems and this results in an escalating cost in the writing of the programs. The situation has been referred to as the 'software crisis'.

The principal reason for the software crisis is that the internal structure of the computer allows it to operate on one piece of data at a time, using only one instruction at a time – the von Neumann architecture. The next step is to allow the computer to operate by overlapping the various stages that make up the execution of an instruction, so that a number of consecutive instructions are simultaneously active in various stages of partial execution. This is called 'pipelining', first used in Manchester University and is employed in large, fast computers such as the Cray 1. From a programmer's point of view there is little difference – it just runs faster.

An 'array processor' uses an array of similar processing elements but still has a single stream of instructions emanating from a central point. Each instruction is simultaneously carried out by all the processing elements in the array. Finally in this catalogue of existing computer architecture, we come to the multi-processor multi-instruction machine. These are still at the experimental stage. The CYBA-M computer, built at UMIST has a number of independent processors arranged around a common memory. Each processor has its own tasks to perform and is coordinated with the others through the shared memory. The shared memory when built normally can cause a bottleneck as it can only be accessed by one processor at a time. This may be overcome by having a number of separate memory elements, connected to the processors through a switching network.

This brings us to the Dataflow computer, the next, 5th, generation. The basic plan for a dataflow machine is that there are two main components; a block of processing units and an activity store (where the program is kept). They are interlinked by a high bandwidth communications path in the form of a ring. At any given time the processing units will be performing a number of tasks, each of which might be quite simple such as a multiplication. A packet of data complete with its instruction arrives at the processor from the activity store. The processed result is transmitted back to the activity store and its arrival there triggers the release of further tasks to be transmitted to the processing units. Many of the tasks may be performed independently and therefore asynchronously, the only time that operations need to be sequential is when one operation depends on the results of another. A program consists of a very large number of small tasks, coordinated only through their data dependencies.

As all the existing program languages are based on von Neumann architecture, completely new programs need to be developed. One such is KRC, The Kent Recursive Calculator, developed at the University of Kent. An interesting distinction is that once a value is a assigned to a variable (i.e. X=A+B), this cannot be altered as there is no sequential order. So an assignment such as X=X+1 is not valid. The left-hand side of each assignment equation must be unique. In KRC there is a SORT operation and if we want to sort the elements of list X we could write Y=SORT X. Y is the name for the new sorted list while X remains unaltered. All data structures are built using lists including such elements as 'infinite lists' for example (1,3..), the list of all odd numbers. Many such lists constitute mathematical sets so elements of the language can be built by obeying the rules of set theory.

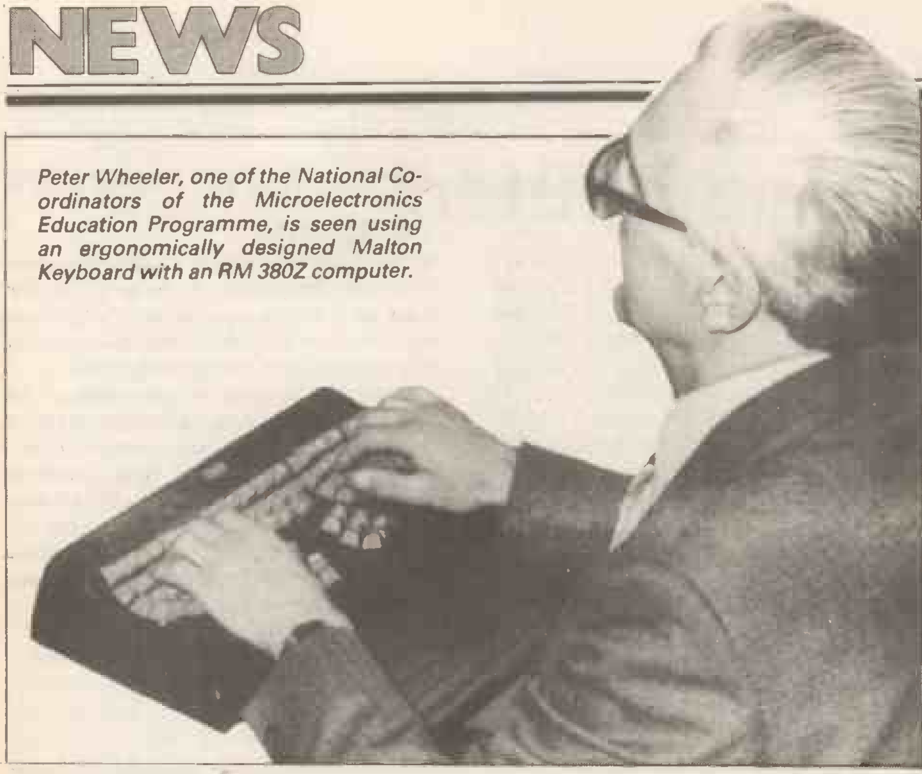
Such languages have still a long way to go as at the moment they actually take *longer* than conventional programs.

Much of the above has been extracted from a paper presented by David Turner of the University of Kent, presented at a recent seminar on the Fifth Generation.

*This micro-cassette drive comes from Hungary and is a low-cost alternative to many rivals. Each 2½-inch disc is housed in a rigid plastic cassette which offers some advantages in that it is better protected from the environment and can be provided with a solid core to improve the drive. It is claimed that the single-sided disc can hold up to 200Kbytes of data and can read or write its entire contents in less than a second. The bare drive costs £60 for one-off or is available in an applications kit with five discs, a head tuning disc, instructions and an interface cable for £100 (+v.a.t.). The UK agents are BATS-NCI Ltd, in London.*

# For QWERTY read QPYCB

After an exhaustive computer analysis of the frequency of the use of letters in keyboard operations, and of the ease finger movements, PCD Maltron Ltd. have rearranged the positions of letters on the keyboard. They claim that their keyboard has 90% of the letters of the 100 most commonly used words on the 'home' row, which on the usual typewriter is ASDFGHJKL. On the Maltron keyboard this becomes ANISFDTHOR. The analysis also suggested that the distribution of the letters could be arranged so that the same finger is used less often successively and that there could be a lot less hopping up and down the rows of keys. In these two respects the improvement claimed is in the ratios of 9:1 and 256:1 respectively. Not only are the keys altered in their relative positions but they have been arranged so that the keys operated by each hand are physically separated and instead of being on a single plane are adjusted so that the keys operated by the longer fingers are sunk into the plane of the keyboard and all the keys require a



*Peter Wheeler, one of the National Co-ordinators of the Microelectronics Education Programme, is seen using an ergonomically designed Malton Keyboard with an RM 380Z computer.*

minimum of movement to be operated.

New learners can be trained faster than on traditional keyboards, according to trial tests. Even those already skilled in QWERTY operation can be supplied with the ergonomically moulded keyboard but with the traditional order of the keys. Error rates have been shown to be reduced to one tenth while speed can be increased by up to 40%. This could be very important as the keyboards for computers seem to be invading every aspect of our lives, at least until there is an efficient voice recognition system.

## BT up for sale

As predicted in our May issue, the Government has at last announced its plans for the 'privatization' of British Telecom. The process started with the granting of a licence to Project Mercury. Then there was the opening of the doors to allow private-sector selling of telephone apparatus direct to the public. Patrick Jenkins, in a Statement to the House of Commons, said that the liberalisation of telecommunications had started and that he intended to see it through.

He pointed out that 90% of BT's investment programme was financed by BT, or rather by their customers. Consequently, costs to the customer had risen to an 'unacceptable level'. Selling BT would generate capital for investment: the proposed sale would take place after the next General Election. Any legislation would keep BT as a single enterprise.

The Board of British Telecom has been very cautious in its response. Until detailed proposals are put forward, the Board is unwilling to express any general view on the proposals. They welcomed the Secretary of State's commitment to full consultation and would be seeking to ensure that BT would have a stable basis for future development.

## Engineers surveyed

The Institution of Electrical and Electronics Incorporated Engineers (formerly the IEETE) have conducted a salary survey of their members which showed that there has been an average increase in income of 30% over their last survey two years ago. The most noticeable difference is that the difference between salaries in the public and private sectors of industry has increased with Incorporated Engineers now taking home an average of £1,190 more than their counterparts in the private sector, compared with a difference of £410 in 1980. For the technician who was better off by £50 in the private sector, he is now worse off by £300 compared with his publicly employed peer.

Incorporated engineers can expect to break the five-figure barrier. Technician Associates on average get £8,000 in the public domain and for graduates the figure is £8,400 (their private-sector counterparts get £1,000 less).

The best paid members work in General Administration, the next best in Broadcasting, Telecommunications and Postal Services. After them come the workers in Electricity Generation and Distribution (and for technicians the Armed Forces). Where they used to earn most, in the chemical and processing industries, they have now been relegated to fourth place.

The predominant qualification for members is still the HNC.

*British Rail's R&D Division at Derby is using a Dataport 5 hand-held microcomputer to record the measurements of the effects that vehicles have on rails. The Dataport can retain the data and then at a later stage transmit it to a host computer, by telephone if needed. It is hoped that the research will lead to improved passenger comfort and into a better understanding of rail and wheel maintenance. The Dataport 5 is produced by Data Recognition in Earley, Berkshire.*

*The 50th ACR 430 airfield control radar has been installed by Plessey at the British Aerospace private airfield in Hatfield. The cost-effective X-band system is easy to install and maintain and will be used in connection with the flight testing programme of the new BAe HS 146 Feediner aircraft.*

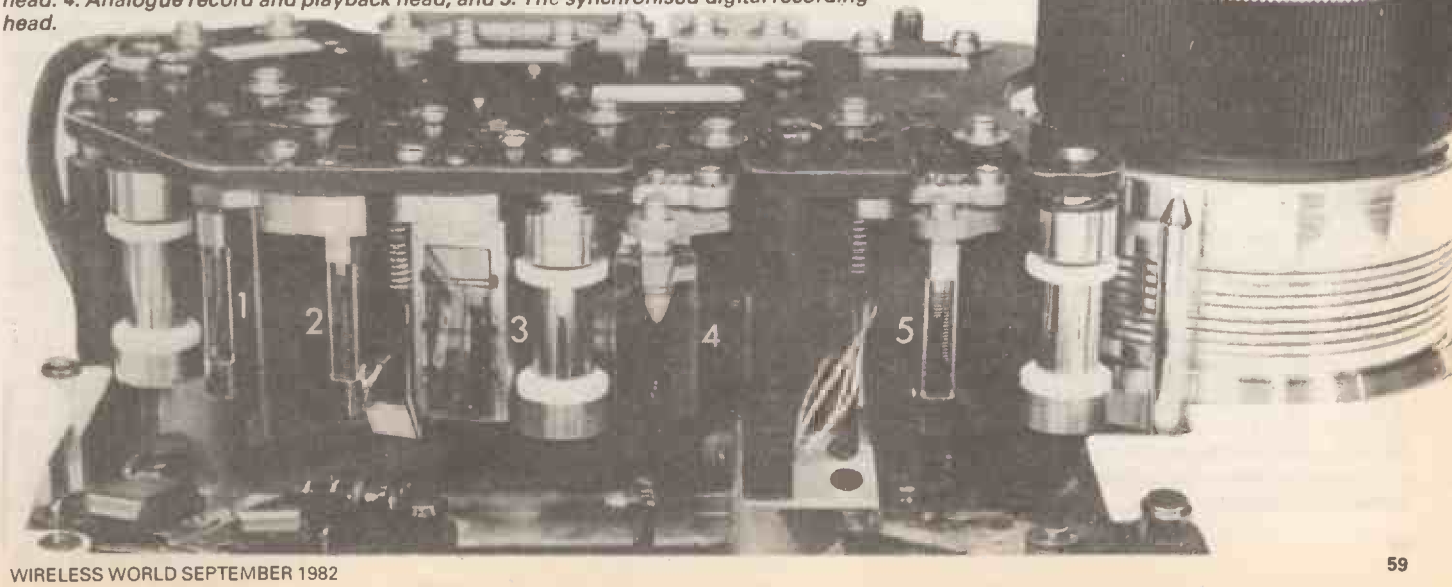
## 24-track digital recorder

Sony have launched their PCM 3324 recorder which offers many of the advantages usually associated with analogue machines. Spliced joins or punch-in recordings are simplified by means of a computer-generated cross-fade over the join to give a continuous signal round the insert or edit point.

At a recent demonstration, Sony transferred a recording from the first track to the second and then to each of the 24 tracks in turn and then played the 24th recording in stereo with the original. There was no audible difference. In addition to the 24 digital tracks there is a stereo pair of analogue tracks, a control track and a time-code track. There is a long catalogue of features and operations; one that appealed to us was the ability to rehearse an edit; to be able to hear what it would sound like without losing the originals.

There is a claimed dynamic range in excess of 90dB and all 28 tracks fit onto ½in tape.

*The head configuration of a Sony PCM 3324 digital tape recorder. The heads from left to right are 1. Advance digital recording head. 2. Digital play-back head. 3. Analogue erase head. 4. Analogue record and playback head, and 5. The synchronised digital recording head.*




## Micros in primary schools

At last Clive Sinclair has a foot in the door. The ZX Spectrum microcomputer has been accepted as suitable for use in primary schools. This is an extension of the 'Micro in schools' project which is part of Information Technology campaign of the Government, through the Department of Industry. Like the scheme for secondary schools the DoI is offering 50% of the cost of the computer to schools which can raise the other 50%.

Other systems selected for the scheme are the BBC Model B and the Research Machines Link 480Z.

## Recording medium

The needle-like particles used in magnetic recordings have a limitation. Because of their physical length, there is a minimum distance between the two points where a change of magnetic flux can be recorded. The current maximum density for data storage is about 15,000 bits per inch; with multi-track recorders it is possible to get a large amount of information onto the magnetic medium. However there is a limitation and any attempt to increase bit-density can lead to a loss of data. One solution has already been mentioned in these columns; the EMI Watermark system orients the magnetic needles across the magnetic track – transverse instead of longitudinal. Another system proposed by Vertimag of Minnesota, USA (co-incidentally the home of 3M), is to get the magnetic particles to stand on end, perpendicular to the surface.

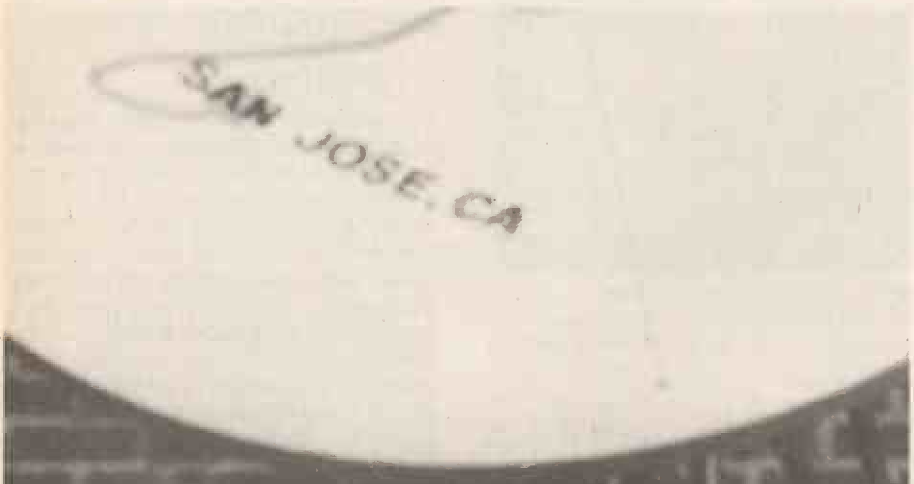
With the vertical system, each particle can be shorter and thinner without losing its magnetic coercivity. In fact by some quirk of nature it is found to improve the coercivity.

This leads to a tenfold increase in the bit density. 100,000 bits per inch is already achieved and experiments have shown that 400,000 will be possible. This may be compared with 25k b.p.i. for an optically read laser disc and in terms of bits per square inch can even compare favourably with a 64K, random-access memory, which can hold $10^6$ bits in a square inch while the vertical magnetic recording can have $10^{10}$.

Vertimag are concentrating their development into the production of computer memory discs. First the 'floppy' variety where a disc will offer three to five times the capacity of an equivalent conventional disc. One drawback is that the medium is produced by using a sputtering technique to deposit the chromium cobalt crystals on to the backing. This is expensive and discs are likely to cost up to 75% more than the conventional ones.

Further advantages will become apparent when the technique is applied to hard disc memories of the Winchester type. With their sealed environment and more precise mechanisms it is possible not only to improve the linear density but also the number of tracks on the disc. Similar advantages will accrue to digital tape and disc recording for audio and video applications.

The vertical magnet idea was developed in Japan but Vertimag are hoping to beat the Japanese at their own game and be able to sell products ahead of them.




*Satcom 1200 is a 12GHz receiver for direct broadcasts from satellites. Signals received from the dish aerial are amplified by a low noise downconverter using Gallium Arsemide fets and hybrid i.cs. To give a stable low-drift performance across a minimum 500mHz bandwidth. The signals are fed to an indoor tuner with a further downconversion to normal broadcast frequencies, which are demodulated to PAL – G/625 line standard. For use on future DBS the dish size may be as small as 700mm but for current satellite transmissions, dishes of 2 to 3 metres are offered. The system is marketed by March Microwave in Braintree, Essex.*

## News in Brief

British Aerospace has been appointed prime contractor for the European Space Agency's Giotto scientific satellite which will intercept Halley's Comet in 1986. Giotto will be Europe's first space explorer when it begins its eight month journey to the interception some 150 million km from Earth. Data will be transmitted back in the s and X bands.

Other news from the ESA is that the Marecs-B Inmarsat satellite and Sirio-2 the Italian communications satellite are to be launched together from Ariane L5 – the first fully operational launch of Ariane. The two satellites will be put into orbit by a dual launch system developed by Aerospatiale known as Sylda.

Video coverage of the attempt at the land speed record is to be provided by lightweight tv colour camera and a portable tape recorder to be installed in the cockpit of the jet-powered Thrust 2 car, driven by Richard Noble. The equipment supplied by Sony will be subjected to foces up to 6½G and it is not yet known if it can stand up to it. Sony are quietly confident.

Two fibre-optics experts, Dr George Newns and Dr Keith Beales have been awarded the Martlesham Method by their employers, British Telecom. They developed a method of cladding one type of glass in a sheath of another type to improve its internal reflectivity along the fibre. Their 'double-crucible' technique is a versatile process, capable of producing most types of fibre.

After seven years of producing professional audio equipment Monogram are seeking a buyer. Don Purkis, the company's founder, says the unexpectedly high development costs, spent on an as yet unexploited new product, have lead to the downfall of Monogram. Now Mr Purkis is looking for a buyer prepared to spend, we believe, around £12 000. He can be contacted by ringing London 573 3362.

The Home Office has set up an Independent Review of the Radio Spectrum under the chairmanship of Dr. J. H. H. Merriman. The first area of enquiry is to be the use of tv Bands I and III once the 405 line services are withdrawn.

Channel 4 commences broadcasting in November and already some 31 transmitters are ready to provide the service to about 87% of the population. The task of converting all the main IBA transmitter and 600 relay station will not be completed until 1984.

# TRANSMITTING AERIALS ON MODERN MERCHANT SHIPS

*Following a lengthy correspondence in our Letters pages on the deficiencies of modern marine communications, John Wiseman presents photographic evidence of what he calls "the insanities of ships' aerials".*

**by J. Wiseman**

Mr Wiseman is a freelance marine radio officer

In the early days of marine radio, almost every merchant ship had two tall masts for the very practical purpose of supporting the cargo derricks, the principal method of cargo handling of those days. This fortunate circumstance provided, at no extra cost, a ready made means of supporting a transmitting antenna for operation in the band 400 to 525 kHz, a band chosen to take advantage of the 24 hour, long-distance, ground-wave propagation characteristic of low frequencies, while still permitting the erection of a reasonably efficient aerial in the space available on-board ship.

The aerial provided was invariably a capacitive "flat-top", inverted "L" or "T", resonating with the transmitter tank inductance at the transmitted frequency, heaviest current up, and omni-directional radiation from, the vertical section, rising to a good height and clear of the superstructure.

Textbooks of those days had whole chapters on antenna theory. For example, the Textbook of Wireless Telegraphy, by Rupert Stanley, 1919, makes the following observations: ". . . . the range of transmission, or the energy radiated, depends on the (height)$^2$ for a given aerial current . . ." and ". . . the greater the capacity of the aerial the less will be the maximum voltage strain on its insulation for a given aerial current and frequency . . . the capacity of the aerial is increased by having two or more wires in parallel . . . the greater the capacity of the aerial, the more energy it will take from the closed circuit for a given voltage strain . . .".

The wisdom of Stanley's words is echoed by the Admiralty Handbook of Wireless Telegraphy, 1931, according to which: ". . . the greater the capacity of the aerial, the less inductance will be required for tuning to any particular wave, and consequently the less will be the oscillatory potential of the aerial above that of the deck insulator. $V = I/\sqrt{L/C}$ . . . .". and ". . . . defective insulation will account for a considerable loss in efficiency, especially on long wave . . . leakage to earth in this way is equivalent to having a resistance in parallel across the aerial capacity, and this can be replaced by an *equivalent series resistance*, whose value (approx) is given by $1\omega^2C^2R$, where R is the resistance of the leakage path . . .".

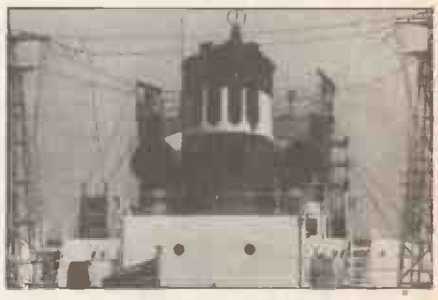
The following table will illustrate that aerials of low capacity are less tolerant to problems of parallel leakage. It is compiled for antennas of 500,250 and 150 pF operating at 500 kHz.

| parallel leakage | series equivalent at 500p | series equivalent at 250p | series equivalent at 150p |
|---|---|---|---|
| 10kΩ | 40.5Ω | 162Ω | 450Ω |
| 100kΩ | 4.05Ω | 16.2Ω | 45Ω |
| 1MΩ | 0.405Ω | 1.62Ω | 4.5Ω |
| 10MΩ | 0.0405Ω | 0.162Ω | 0.45Ω |

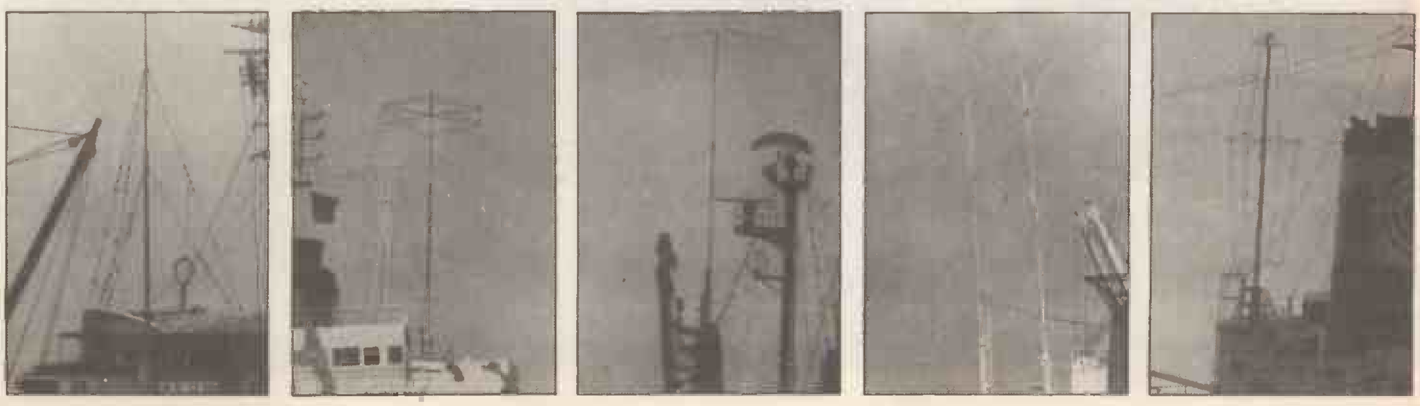
I only mention these elementary matters to show that all necessary information on good aerial design has been readily available for 50 or 60 years.

Times have changed: only passenger ships have long aerials now. Since the early 1960s, bulk-carriers, container ships, supertankers, chemical and gas tankers, with their specialized, shore-based loading gear and gantries, have done away with masts, changed the shape of ships, and created a whole new menagerie of aerials. Some of the problems they have given have

*Australian flag, 21,731 g.r.t. B.1974, pictured Yokohama, October 1981. ". . . a few years ago a ship would be fitted with a good T or inverted L aerial, often extending the entire length of the ship and as high as the masts would allow. Nowadays, we are lucky to have 80 feet of wire round the funnel . . .". (Letter to the Editor, Nov. 1979). Insert shows size of ship in relation to space for aerials.*



*Liberian flag, 10,430 g.r.t. B.1974. Photograph W. Africa, March 1981. Efforts to increase capacitance offset by wet weather leakage offered by 11 insulators on one aerial and seven on the other. Does not rise above funnel, a vertical ground.*



*Five mast aerials. From the left: Greek flag, 14,383 g.r.t., B.1966, taken W.Africa, Sept. 1980; Japanese flag, 15,967 g.r.t., B1979, taken W.Africa, Sept. 1981; U.S.A. flag, 11,000 g.r.t., B.1963, photographed W.Africa, Sept. 1981; German flag, taken W.Africa, Aug. 1981; Liberian flag, 20,713 g.r.t., B.1972, taken Nagoya, Oct. 81. Latter is of Japanese design, perhaps inspired by a Japanese lantern – note the rope propping it up. Other aerials in this strip have extraneous ropes or wires hanging from their radiating parts.*

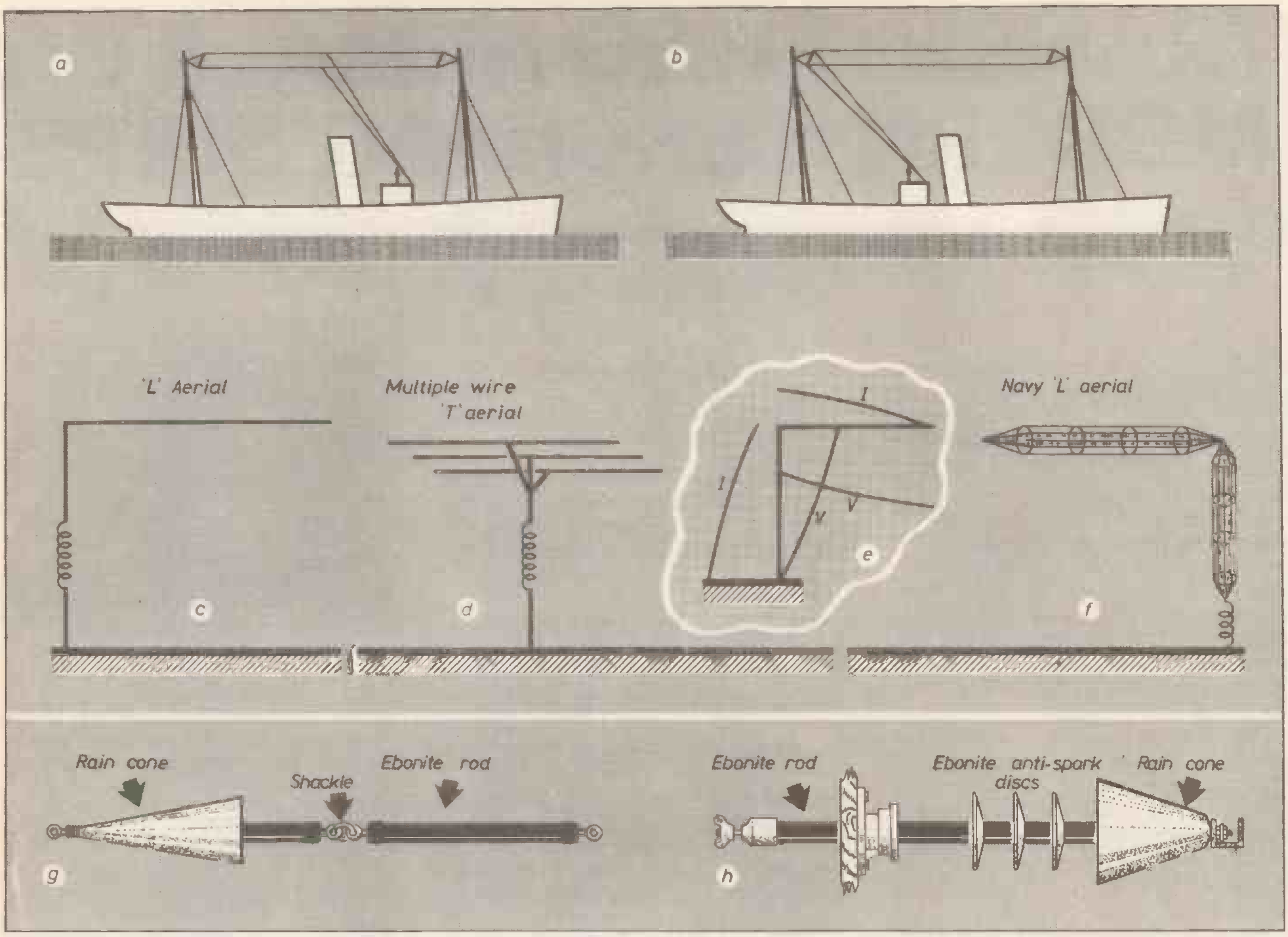
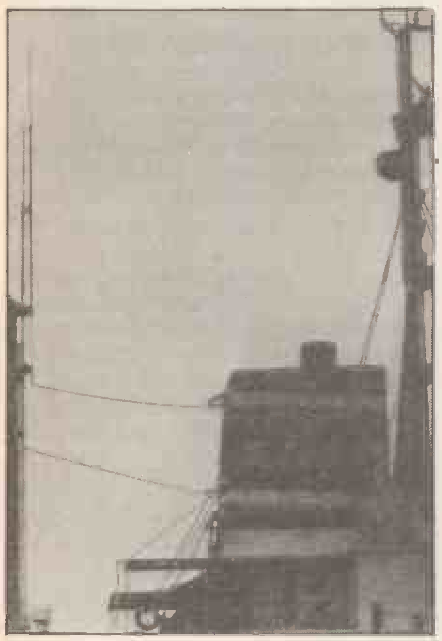



*Fig 1. Collection of diagrams on sound marine aerial design from early textbooks. Inverted L and T aerials at (a) and (b) are from "The Maintenance of Wireless Telegraph Apparatus", P.W. Harris, 1917. Diagrams (c) to (f) show 'capacity aerials', taken from "Wireless Principles and Practice", L. S. Palmer, 1928, and the insulators at (g) and (h) come from "Handbook of Instruction for Wireless Telegraphists", Hawkhead and Dowsett, 1918.*



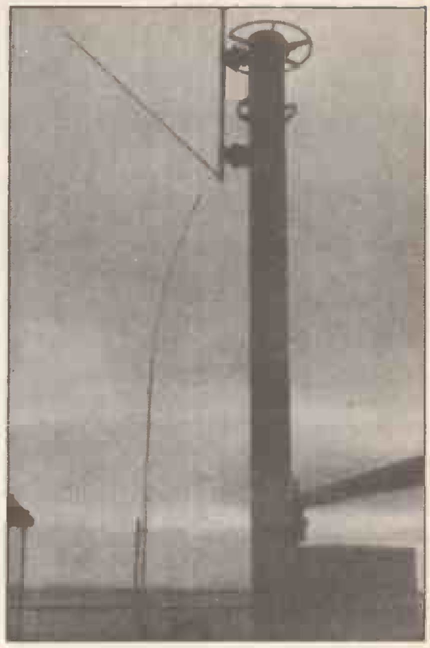
*British flag, 11,897 g.r.t., B.1973, taken at Kobe, Oct. 1981. Parts of aerials radiating most are two horizontal wires, hanging from bottoms of whips below funnel and optimistically described as 'feeders'. Whips look very 'modern'. Insulators are inaccessible for inspection and maintenance. These are really mini inverted L aerials rotated through 90 degrees. To obtain sufficient capacity for full power operation, both are operated in parallel, frustrating the concept of main and reserve aerials. No use is made of signal mast to obtain good aerial height. Works well at h.f.*

been discussed in the Letters to the Editor columns of *WW* over the past three years, under the heading "Failure of distress signals at sea". The photographs reproduced here have not been specially selected. They are by no means an exhaustive collection, but they are typical enough. There is a 'Murphy's Law' about photographing aerials: the most interesting and splendid examples sail past during a tropical thunderstorm, or are seen in ports where persons with telephoto lenses are likely to be shot on sight.

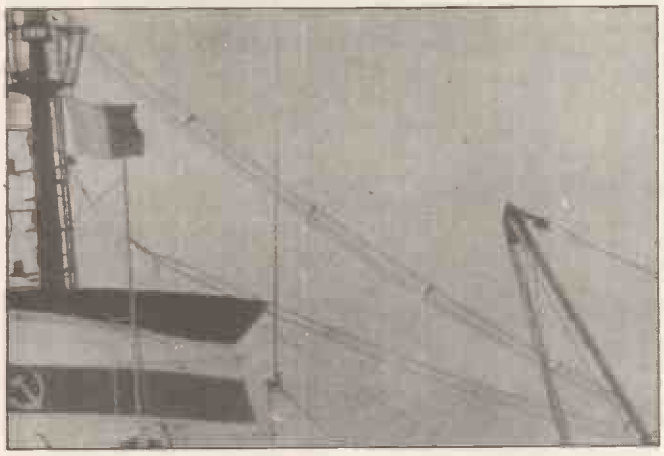
There are neither "good" flags nor "bad" flags. The "designers" of these aerials appear to be (a) d.i.y. enthusiasts, (b) practitioners of black magic, (c) persons who have not heard of Rupert Stanley, and who believe that "a more powerful transmitter will compensate for an inefficient aerial", or, in too few cases, (d) *real* radio engineers.

The commentary accompanying the photographs will refer in general to operation at 500 kHz. The Home Office 'Code of Practice for Ships' Wire Antenna Systems for Radio Telegraphy Transmissions in the Frequency Band 405 to 535 kHz", MPT 1270, published 1974, gives, as the "major objectives at the design stage", the following criteria: ". . . in order that the required antenna shall

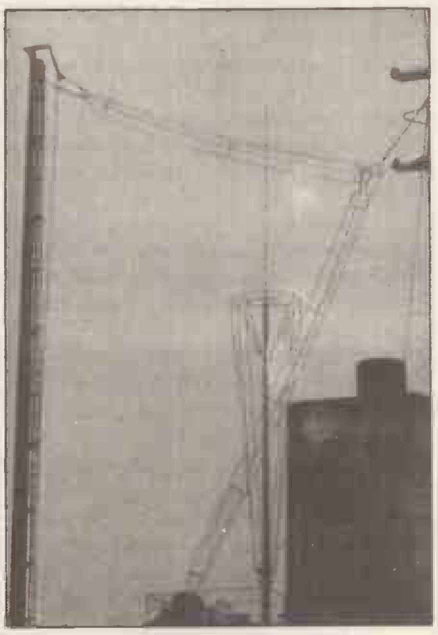
*From left: British flag – plywood lead-in-trunk for minimum shunt capacitance – brass bells shield lead through insulators from spray and rain, but they are shunted by unprotected strain insulators; Italian flag – steel mesh offers neither protection from weather nor reduction in shunt capacitance; British flag – no trunk at all – cheaper and quicker to cut holes in wall, but efficiency of shielding bells on horizontal insulators is doubtful – bells shunted by unprotected strain insulators (seems to be universal practice).*



*British flag. Receiving whip bends in strong wind, almost touching transmitting aerial.*



*USSR flag, 3236 g.r.t., B.1963. Photographed in W.Africa, Sept. 81. Maximized capacity, minimized leakage on a 19-year-old ship. Return to the basic principles, of 1919 and rational design.*



*East German flag, 11,127 g.r.t., B.1976. Photographed at Yokohama, Oct. 81. High capacity 'sausage' aerial with good height and only three possible points of leakage. Many splendid examples of this type can also be found on French, Belgian and Soviet vessels. The mast aerial in the background is a standard model widely used on eastern bloc merchant ships.*

radiate efficiently, it is necessary that:

(1) It should be suitably dimensioned.
(2) The electrical connection between the radio transmitting apparatus and the antenna is of such design that only a small part of the radio energy is 'lost'.
(3) a principal part of the antenna is vertical or near vertical.
(4) the principal part of the antenna is not in close proximity to any substantial part of the ship's superstructure.
(5) the uppermost part of the antenna is of adequate height above the topmost deck or superstructure.
(6) the antenna is not shielded unduly by parts of the ship's superstructure.
(7) the radioroom be situated on the top deck or second deck so the feeder connecting the radio apparatus to the effective part of the antenna is short.
(8) the vertical part of the antenna, which is of principal importance for radiating energy, is close to the radio room.
(9) attention be especially given to the means necessary to avoid the high loss of radio energy which can occur when the lower part of the antenna includes a substantial amount of open conductor in close proximity to metallic portions of the ship. In such cases the measurement of antenna current at the radio transmitter could be misleading and would not give a good indication of the radiation from the antenna.
(10) the radio installation is efficiently earthed to the ship's hull.

How would the aerials depicted measure up to these requirements? WW

## Linsley Hood 100W amplifier – corrections

Several errors and omissions made the circuit diagrams of the amplifier – given on p.28 of the August issue – misleading. We apologize for them and give the corrections below.

Ordinary small-signal transistors (high-voltage, where necessary) are suitable for the early stages, and it was not intended to tie them down too specifically, but the types used in the prototype are: $Tr_1$–BC447; $Tr_{5,6}$–MPSA93; $Tr_{4,7}$–MPSA43; $TR_{13}$–BC212; $Tr_{10}$–BC182; $Tr_{11}$–2SK134; $Tr_{12}$–2SJ49. The output transistors should be n-channel ($Tr_{11}$) and p-channel ($Tr_{12}$).

The negative supply to $Tr_3$ should be negative, the Zener and $C_3$ being shown upside down. Capacitors $C_9$ and $C_{10}$ can be reduced to 100μF.

Resistor values in Fig. 25 are not shown, since they are the same as those in Fig. 24: $R_{5,8}$ are 1M5, $R_{6,7}$ are 3M9 and $R_{1-4}$ are 2M2. Care should be taken to connect the pins of $Tr_3$ to the correct pads on the p.c.b., since the case outline is shown 'twisted' from the correct position.

# CES CHICAGO

*A thousand exhibitors demonstrated the consumer electronics they will sell to America this year*

**By G. W. Tillett**

This year, a record number of well over 72,000 visitors attended the Consumer Electronics Trade Show in Chicago. There were more than 1,000 exhibitors dispersed in the huge McCormick Center and various hotels in the city. In general, the mood was one of cautious optimism and most dealers were looking for increased business in the future when the political and economic climate improves.

As with the last three Shows, the emphasis was very much on video – which in this context includes computer-based electronic games, many now embellished with "speech".

## Video discs

Big news from RCA was the introduction of a new video disc player which features an infra-red remote control, a fast search speed (16×) in both directions, rapid access (120×) and stereo audio tracks with CX noise reduction. Similar models using the RCA CED system were being demonstrated by Zenith, Toshiba and Hitachi. RCA's Vice-President, Thomas Kuhn said: "Despite the recession, US consumers spent more than $90 million for CED players and discs in the product's first year". Although the VHD players were being heavily promoted by Panasonic and JVC with programs in NTSC, Pal and Secam formats, release has been postponed-again. Rumour has it that work is proceeding on a recordable disc although many experts believe this is unlikely. However, it *is* known that the Japanese broadcasting Corporation (NHK) has developed a video disc that can be recorded and erased any number of times. It uses a thermomagnetic principle for recording and the Kerr optomagnetic effect for laser playback. Prototypes have a carrier-to-noise ratio of only 38 dB but work is proceeding on methods of improving it.

The third system-LaserVision, was represented by Pioneer and Magnavision among others and the new models also use CX noise suppression. At the January Show in Las Vegas, Kenwood caused a minor sensation with the introduction of the first audio-video amplifier which features a video enhancer circuit, switching for VCR's and V-Disc players, provision for mic dubbing and more, all combined with a 50 watt integrated amplifier. This model really heralded the coming audio-video 'marriage' caused by the enormous number of potential video program sources and the need for better sound quality.

## Television

Although as yet there is no stereo tv in the US, apart from some cable systems, most of the new VCR's and video disc players have this facility, usually with some kind of noise reduction system, so the tv set with its poor quality loudspeaker is just not good enough. In addition there are the electronic games, computers and satellite tv signals – all requiring connections to the tv. There is no question that the tv of the future, the near future, will be just a monitor, part of a component system needing only a video signal for direct application to the tube. Sony's Profeel system is one of the first and similar units were shown by nearly all the other tv manufacturers. Some have amplifiers built in to the monitor while others like Jensen, offer a combined audio-video receiver. Model AVS-1500 combines a a.m.-f.m. digital tuner, a 133-channel tv tuner and a stereo 50 watt amplifier with a microprocessor controlled switching unit – all in a single unit. There is a choice of 51cm or 67cm colour monitors. The smallest monitor comes from Hitachi: it has a 10cm screen and there are two built-in 6.5cm loudspeakers.

There is a definite trend towards larger tv screen sizes: Sony were showing a prototype with a new 80cm picture tube and there were a number of new projection models. GE unveiled a 110cm rear projection model which has a built-in stereo amplifier rated at 10 watts per channel – plus two loudspeaker systems. A switch panel allows connection to external video sources. Other rear projection systems with similar size screens were shown by RCA, Sony and RCA. Pioneer's LS-501 is a forward projection model and the screen size is about 130cm. Zenith claim to eliminate picture distortion in their 100cm projection models. The red, green and blue tubes are mounted side by side but the faceplates of the left and right tubes are tilted to cancel out distortion caused by the angle of projection.

## Video cassettes

Now for a look at some of the new video cassette recorders. With the appearance of the T-160 long-playing tapes, most of the new VHS recorders can record up to eight hours. At the other extreme, a number of mini-portables were seen using a new format called UCM, for Ultra Compact Machine. These mini-VHS models were shown by RCA, Sharp and JVC, the average weight being only 4½lbs. Playing time of the cassettes – which are slightly smaller than a cigarette pack – is 20 minutes. Adaptors permit them to be used with standard VHS machines as ½ inch tape is used. Apparently the UCM format was developed to meet competition from Grundig, Funai and Technicolor who make small portables using 6mm tape. Discussions are being held among some Japanese manufacturers concerning an entirely new format employing 8mm tape for portables but production might be two, or even three years away.

Marantz were demonstrating a Beta VCR which was specially designed for high quality sound reproduction and among the features is Dolby C and stereo sound. Panasonic's VHS model PV-1780 also has a similar specification with Dolby and Stereo but, like many VHS models it employs four video heads. This means that field-by-field scanning is used for the "still" mode instead of frame-by-frame.

Sony had a new Video Special Effects Kit which includes an effects generator, a monochrome video camera which, when

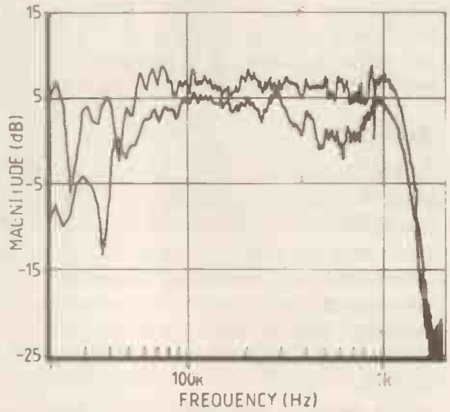



*Fig 2. Before and after curves for the AR room acoustic adjuster below*

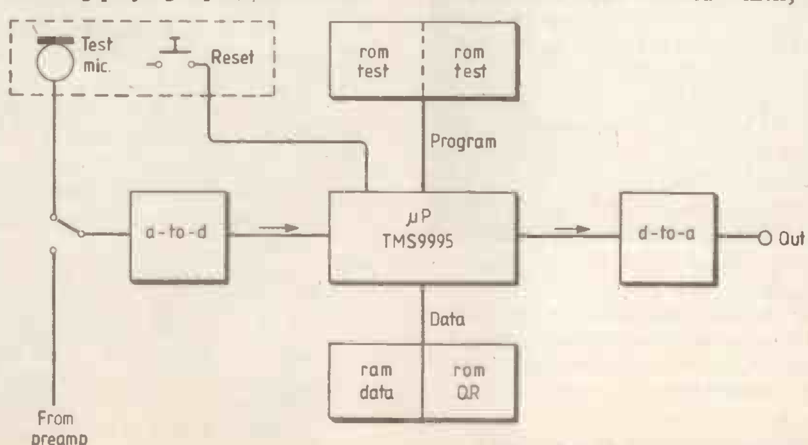



*Fig 1. The AR room-acoustic adjuster*

combined with a colour camera and VCR can provide such effects as superimposition, colour keying alteration in up to six colours, monochrome reversal, plus remote control of VCR transport functions. The kit also has a close-up lens, camera stand and title holder. For the professional, Sony introduced a waterproof "marine pack" designed to protect portable Betamax video equipment during under water shooting. It is equipped with a built-in microphone.

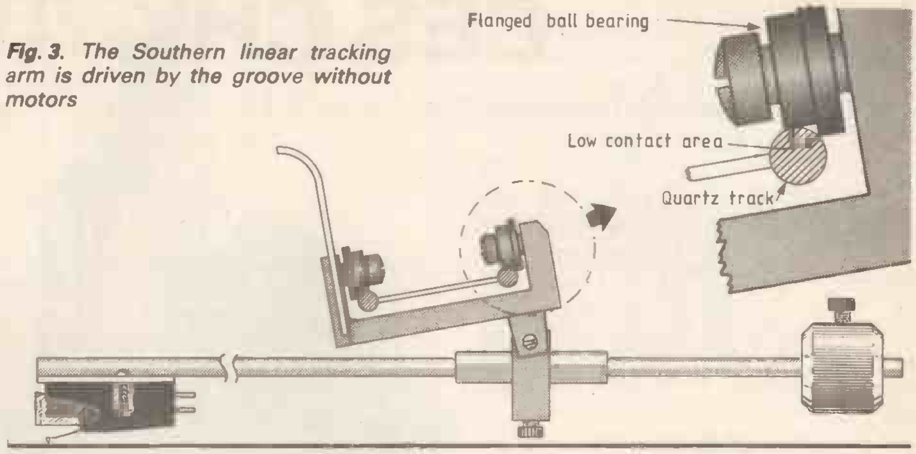
## Audio

Although audio seems to be taking second place to the more glamorous video products, there were plenty of new items in all price ranges. Here are some of the most interesting: AR were demonstrating their new digital signal processor which compensates for loudspeaker-room acoustic deficiencies. Figure 1 shows the basic circuit: the listener presses the re-set button and a random noise-like signal from the m.p.u. memory is sent to the loudspeakers via the a-to-d convertor. This signal is picked up by a microphone located in the remote hand-held module and stored as ram data under control of the m.p.u. The data is analyzed and compared with the original to produce a filter which is then inserted into the preamp circuit. Each channel is analyzed separately so there are really two filters. The system operates to 1 kHz and a typical pair of before-after response curves are shown in Figure 2.

Last year Onkyo introduced a double cassette deck, this has now been joined by a "second generation" model with other twin decks from Sansui, Hitachi, Sharp, JVC and Technics. Most offer a fast speed for dubbing so a single side of a C.60 can be copied in 15 minutes. Perhaps the most significant development in cassette decks is a revival of interest in microcassettes. Panasonic make a miniature model using dbx, while Sony's TC-MR3 is described as "the first home microcassette deck." One of its advertised functions is to make tapes for the Sony Walkman and similar models. Few pre-recorded microcassetes are available at present but this situation is likely to change soon. Meanwhile, blank cassettes using metal formulations are being marketed by Sony, Fuji, and TDK among others.

Denon were showing a 'Pure Class A, No-Feedback' 200 watt amplifier last year and now they have a matching preamplifier. This is the PRA-6000 which also uses no feedback. Equalization and tone controls use passive circuits while input switching is electronic. The price is pretty steep at $3,000. Another interesting amplifier comes from Harman-Kardon, the Citation XX which was designed by the Finnish engineer, Matti Otala. It includes an instantaneous current capability of 200 amps so the amplifier can deliver 14,000 watts per channel into a 0.35 ohm resistor under transient conditions; a low value of negative feedback; dual power supply with a total capacitance of 80,000 mfd; three thick copper plates are used to form a low impedance transmission line from the power supply to the output transistors.

*Fig. 3. The Southern linear tracking arm is driven by the groove without motors*




Rated output is 440 watts per channel into 4 ohms with no more than 0.1% THD. A special feature is a three-position switch for bias so the current can be adjusted according to the power level desired.

The new Quad ESL was attracting a lot of attention – so was the latest electrostatic loudspeaker from Acoustat, the Model Eight which stands 94 inches high. It has a radiating area of over 23 square feet and is capable of a s.p.l. of 125 dB at a distance of 25 feet. The impedance is said to be "an extremely peaceful 6 ohms". At the other extreme; in terms of size B & W were making some impressive sound with a new mini system measuring 240mm by 155mm by 190mm which was designed for domestic or car use.

New turntables caused no great excitement among dealers; although there were several new linear tracking designs from manufacturers like Sansui, Luxman, JVC and Technics. The most unusual was a precision linear arm from Southern: unlike all the other models now on the market, it doesn't use a servo-drive mechanism as the record groove pulls the cartridge across, just like a conventional pivoted arm. In order to do this, arm friction needs to be very low indeed, as does the mass. The arm is actually made from a glass composition and weighs only 1¼ grams. A three-point suspension is used with stainless steel and sapphire bearings and it runs on pure quartz rods. Price is about $600. Yet another unusual arm was the Townsend Elite which is a pivoted design with a difference. An extension section near the cartridge floats on an arc-shaped trough filled with silicone to provide damping and the turntable base can be hit quite hard before mistracking occurs.

## Radio

One of the issues causing some arguments among engineers is the proposed a.m. stereo transmissions. There are no less than five systems contending for acceptance: Magnavox, Kahn, Belar, Harris and Motorola. All employ some kind of phase modulation but the Kahn system has independent left-right sidebands. The Belar approach is to frequency modulate the carrier while the other three systems phase modulate the carrier. Most of the Japanese manufacturers appear to favour the Magnovox system although the Harris system which was demonstrated at the Show has several advantages. These include a wider bandwidth, separation up to 15 kHz and the smallest occupied bandwidth. As shown in the block diagram, (fig 4) the Harris system amplitude modulates two RF carriers separated by 30 degrees and 90 degrees phase difference. The left channel modulates one of the signals while the right modulates the other. A pilot tone is varied from 55 to 96Hz to enable the receiver to track this varying phase difference and provide normal stereo decoding. Although this means that channel separation can only be maintained down to 200 Hz, this is not considered a serious drawback. The block diagram shows the decoder arrangement: unmodulated i.f is generated with the phase locked loop to quadrature detect the l-r stereo difference information. After attenuating the L+R to match the L-R, both are fed to an audio matrix to recover the left and right audio channels. The basic circuit will be available in a 24 pin ceramic DIP (HS-3604) later this year. Harris say that orders for over 150 transmitter adaptors have already been received, but these will obviously be cancelled if one of the other systems is adopted. It is now up to the broadcasters to make a decision. At the Show, Sansui were demonstrating a receiver equipped to receive signals from a local transmitter in the Kahn, Harris and Magnavox modes.

Arguments are still going on concerning the compatibility of the CBS CX noise reducing system. Fewer than two dozen CX records have been released although some 200 are promised by the end of the year. Several receivers were to be seen featuring CX and a number of decoders are now available while the system is being used in video disc players and VCR's.

I counted 17 compact digital disc players at the Show but only one company, Cybernet, claim that units are being actually produced. The software situation is not too clear although Polygram claim that they will release 200 to 300 records by the end of the year.

## Electronic music

Casio's new musical keyboard lets the user create 1000 different sounds which are stored in 10 memories. Arpeggio patterns can be programmed to match the music by reading in up to 127 steps, 9 note pitches and rests. There is a built-in "sequencer" which allows the user to program a series of notes, play the sequence and create other sounds – all at the same time. Other features include digital frequency display, vibrato, sustain, delayed vibrato and preset sounds for such instruments as a bassoon, pipe organ and flute. The keyboard is a full-size 61-key model and the instrument has a built-in loudspeaker. Another musical instrument from Casio is the CT-701 computerized electronic player piano. It uses a "miracle scanner" and the user just passes a wand over a printed bar code music sheet and the tune is instantly put into the keyboard's memory for instant playback. The instrument can store up to 345 melody notes and up to 201 accompaniment chords.

### Home computers

The Commodore MAX machine uses a new m.p.u., the 6510, to produce a variety of music and sound effects. There are three "voices" each with a 9 octave range and the instrument is said to, "command amazing orchestration when used with a good quality audio system" With a BASIC language cartridge, MAX users can learn the fundamental language of computing and write their own programs which can include maths functions. Commodore also introduced a home computer, the Model 64, which the American Express said, "could be the m.p.u. industry's outstanding new product introduction since the birth of the industry" It can use VIC 20 peripherals and the addition of an IEEE-48 cartridge will enable it to run other peripherals including CBM printers and disc drives. Another feature is its capability of using a Z-80 add-on processor board to run CP/M. The 40 column by 25 line screen and 16 colours, plus its 64K of RAM help to give it one-third more computer power than the Apple II at $595.00 – less than half the price.

The most inexpensive computer at the Show was the Timex-Sinclair, which sells at less than $100. It is a modification of the Sinclair ZX81 and manufactured in Scotland.


An interesting telephone adaptor was shown by International Mobile Machines Corporation and it is intended to screen phone calls, tell you who is calling and it also features a memory. It works like this: whenever someone dials your number, the phone will not ring but a pleasant synthesized female voice asks the caller to enter their personal access code by pressing the appropriate buttons. If the code you've authorised is entered, the number appears on a digital display so you know who is calling and who the caller wants to speak to. A touch of a button and the Access codes of all those callers who tried to reach you will be displayed. The system is called "Privecode" and one of its uses is to stop people from being bothered with wrong numbers, obscene calls and slick salesmen.

Mitsubishi were demonstrating what they called a "Micro Robot Minicomputer system" which consisted of a keyboard computer with display, plus a "mechanical arm". This was a jointed structure mounted on a base and powered by six drive motors. There are five degrees of freedom with independent rotation around six independent axes and a multi-location memory. The device, called a Move-Master can be controlled by a number of standard computers but the Mx-6000 was specially designed to interface. It has a 5 inch green display, 64K dynamic RAM, floppy disc, 640 character display and an impact type dot matrix printer. Programming languages include BASIC, assembler and a new robot-oriented language called M-Roly. What can this robot be used for? Well, the makers say it is useful for getting practical experience in robotics either for the hobbyist or for educational.

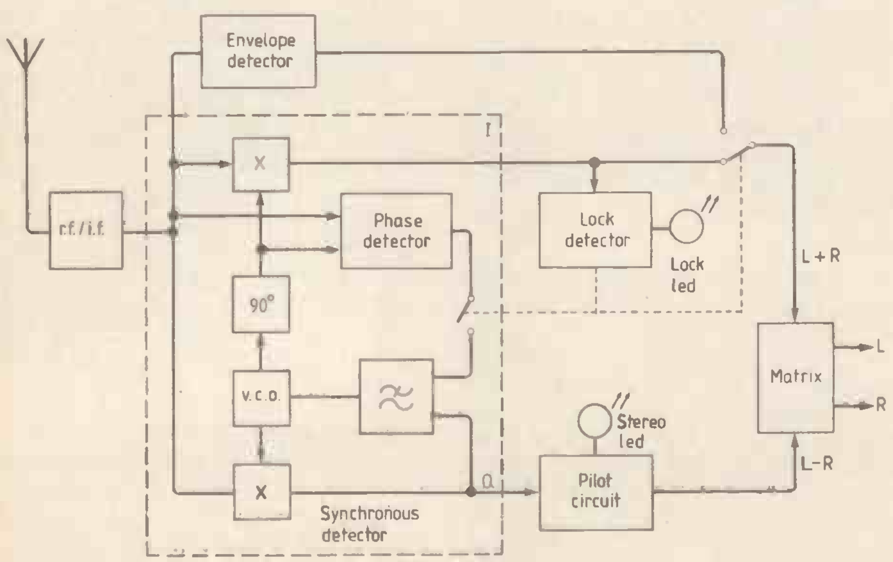



*Fig 4. The Harris system for receiving stereo a.m. radio*

### Etc.

Do you play golf? If so, Mitsubishi have just the gadget for you – the GL-500 Golf Trainer. It consists of a computerized display unit mounted on an artificial grass


mat base. As the club passes over this base, the shot is detected by four sensers and the data displayed. This includes head speed, head angle, hitting area of club, shot direction and the difference in distance between the aimed and actual point at which the ball would land. Now if they would only make a similar device for cricket . . . Prize for the smallest radio must go to Sony's wrist watch model which uses on-chip technology. A four-function LCD displays time, alarm time and AM station frequency. Loudspeaker is a one-inch model . . . Marantz were demonstrating the "Sing Along System" which uses a cassette deck with special tapes so the lyrics of popular songs are displayed on a screen . . . Texas Instruments were showing the "Magic Wand" reader designed for young children. It features an optical scanner built into a "Magic Wand" to read talking book codes which are translated into "human-like" voices. The vocabulary consists of 200,000 words and there are various sound effects and music songs.

## Air data links

During recent years there have been several major disasters that appear to have been brought about, or at least assisted to happen, by misunderstanding of air traffic control messages in circumstances which suggest that poor speech intelligibility may have played some part. The hazard, if hazard there is, occurs less on routine messages than where there is some marked departure from message formats that follow a pattern familiar to the pilot.

Voice communication with aircraft involves achieving intelligibility in a very difficult environment, and it is this factor rather than basic distortion that appears to account for some of the problems. Whatever the cause, aircraft communications still fall a long way short of high fidelity.

One approach would be to replace voice communications with a data link, provided that this would not add to the load already imposed on the eyes of a pilot. An alternative would be voice assisted by data. G. Bennelli of Florence University has put forward proposals for simultaneous voice-data links over a simple radio channel by using combined amplitude-phase modulation of a single carrier, rather akin to some of the proposals for medium-wave stereo broadcasting in America. He suggests (*Electronics Letters*, June 24, 1982) that this could provide a simple and economic method of introducing a certain degree of automation into air-traffic-control functions without the need for entirely new equipment, so opening the way to extend data-link operations to small as well as large aircraft.

Computer studies suggest that problems of mutual interference between voice and data in a narrow bandwidth need not be excessive with AM-MSK (m.s.k. – minimum shift keying, or in other words f.f.s.k. – fast frequency shift keying) modulation systems which, it is suggested, have greater potential than AM-PSK (p.s.k. – phase shift keying).

Engineers at the Nippon Telegraph & Telephone Public Corporation have reported the fabrication of a single-chip c.m.o.s. coherent demodulator for m.s.k./f.f.s.k. working at an i.f. of 455 kHz at bit rates up to 32 Kb/s, a considerably higher bit rate than proposed by the Italian team for ground-air-ground communications, for which bit rates of from 300 to 2400 b/s were considered in the simulation tests.

## E.m.c. and c.b.

The Home office radio interference report for 1981 underlines the large increase of complaints made by viewers and listeners during the year, many relating to the operation of illegal 27 MHz amplitude-modulated transceivers in the months leading up to the licensing of 27 MHz f.m. equipment. However, a reading of the report shows that many of the arguments publicly used for a number of years by the Home Office to oppose allocating 27MHz for c.b. were based on the false premise that the prime cause of r.f.i. to domestic equipment is harmonic radiation. The report shows that not harmonics but "direct audio break-in arising from the close proximity of the c.b. transmitters" is the main problem. It could thus be argued that c.b. operators have been (and still are being) blamed for the poor electromagnetic compatibility of modern domestic electronic equipment.

Of the 14,359 complaints ascribed after investigation to illicit c.b.; over 3000 referred to m.f. radio and more than 9200 to Band IV-V u.h.f. television – few of these appear likely to have been caused by "harmonic radiation". The statistics do, however, lend support to the view that f.m. transmissions cause less problems than a.m. (though listening in the London area reveals that widespread use of illegal a.m. is continuing).

There can be no doubt that there are many home-entertainment equipments, such as cassette recorders, that are vulnerable at distances up to 50-100 ft or so to interference from low-power a.m. (or s.s.b.) transmitters of the type marketed for c.b. operation. The vulnerability undoubtedly increased significantly when solid state devices replaced valves in domestic equipment; it was also made worse by "unit" audio equipment with interconnecting leads that act as aerials. Yet there is also little doubt that domestic equipment could have much improved electromagnetic compatibility at relatively little added cost. For many years, British and American manufacturers have resisted suggestions that tv sets could be made far more resistant to r.f.i., although some European firms have been more responsive.

The recent showing at CETEX of "unit-video" systems by Sony and Phillips may raise the question once more, since there is evidence that a number of separate units tends to be more vulnerable to r.f.i. than a single unit; for example the combination of a video recorder with a tv set tends to increase e.m.c. problems.

Interference complaints in 1981 rose sharply over 1980 – from 35,790 to 70,452. This near doubling in numbers appears to have overwhelmed the system with 28,490 uncompleted cases carried over to 1982. Nevertheless the number of completed investigations rose by 47 per cent from 41,086 to 60,571. Although much of this large increase is due to 27 MHz c.b. operation, there appears to have been a general increase in complaints of interference from other causes, although there was a significant drop of 16.57 per cent in complaints identified as due to contact devices, from 10,684 in 1980 to 8,914 in 1981 – almost wiping out the very large jump in such interference recorded in 1979.

Despite the increase, the complaints amounted to less than one for every 500 tv licence holders; on the other hand, over 11 per cent of licence holders for the two-way land mobile radio services reported interference, though it should be stressed that 18,048 licences cover 340,830 l.m.r. receivers.

Radio complaints were sharply up (24,648 compared with 20,345) but this puts radio back on the ascending curve of the past decade with 1980 the odd-man-out. The v.h.f./f.m. service accounts for about half the number relating to l.f./m.f.

## In the news

British Aerospace are building the largest solar generator yet announced for non-military space applications. Designed to provide 5 kW of electrical energy, using almost 50,000 solar cells made by AEG-Telefunken, it represents a cost of about £300,000 per kilowatt, underlining the limitations on the number of d.b.s television channels that could be provided in the near future on a single satellite.

The firm of Daini Seikosha, Tokyo, is reported to have developed a new photolithographic technique for the manufacture of GT-cut quartz crystals to provide tiny crystal resonators in the megahertz region.

With a number of British communications and electronics firms noticably absent from the 1982 British Army Equipment Exhibition (more from megacost than megadeath considerations) it is interesting to note that Racalex '82, the private exhibition of the Racal Electronics Group, is to be opened by the Secretary of State for Defence, John Nott, MP, next October. But Racal continue their unbroken record of expansion, announcing a pre-tax profit to March 1982 of over £100 million from a turnover that has climbed in ten years from £25 million to £644 million.

The recent joint presentation by NHK and RTE (with encouragement from CBS) of the NHK-developed high-definition television system having 1115 lines, 5:3 aspect ratio and 60 fields per second undoubtedly impressed all those who saw the excellent quality pictures at Killarney. It should encourage the use of electronic techniques in the production of cinema material (remember the 1000-line black-and-white system developed by High Definition Films in 1951?) but it would set broadcast engineers the almost impossible task of finding spectrum space transmitting 20MHz of luminance plus 7MHz and 5.5MHz of chrominance – and keeping these as separate components! Electronic production for cinemas could undoubtedly reduce costs but it may prove difficult to convince film production teams that they should switch to video.

# AMATEUR RADIO

## Solar upset

Sunspot Cycle 21 developed a square wheel during June that gave a very bumpy ride on the h.f. bands – and posed the interesting question once again of what triggers off Sporadic-E propagation conditions. From early to mid-June there was a succession of solar flares, sudden ionospheric disturbances, magnetic storms and the largest X-ray event for several years. These gave rise predictably to very disturbed h.f. conditions including some daylight "black outs".

This period also witnessed two Sporadic-E openings extending up to 144 MHz, the first on May 25 when Scandinavian amateurs, including many in Finland, were heard and worked by British amateurs. The second on June 5 when the 144 MHz band opened to the Central Mediterranean area, including Malta, Sicily, Southern Italy, Corsica etc. Although it is not common for Sporadic-E conditions to extend as high as 144 MHz, there seems little reason to link these openings with the solar disturbances on h.f.

## 50MHz

Long-distance openings in a generally north-south direction continued to occur in early June on 50 MHz, including reception by Gordon Pheasant, G4BPY of the Brazilian beacon station PY2AA, in the afternoon of June 4 and the FY7THF beacon on June 5. A number of South African signals also continue to come through on 50 MHz.

British amateurs have for long sought use of the 50 MHz band available in the other WARC Regions, and have recognised that such an opportunity could arise in the UK with the phasing out of the BBC 405-line television service in Band 1 (due to be completed about 1986). This objective has become a live issue with the setting up of the independent review, under the chairmanship of Dr J. H. H. Merriman, charged with producing an interim report by September on the future use of Bands 1 and 111 "taking account not only the need to provide for expansion of the land mobile services but also of various possibilities for the continued use of these bands for broadcasting". The main review, by June 1983, is to examine the present occupancy and utilization of frequencies from 30 to 960 MHz, and thus covers the 70 MHz, 144 MHz and 430 MHz amateur bands. The RSGB will make a submission to the Merriman committee.

Less formally, it is hoped by many amateurs that the committee will note how much more generous are the frequency allocations to amateurs and broadcasters in North America than in Europe, with not only the 50 to 54 MHz band but also the allocation of 220-225 MHz and the much wider 430 MHz band; yet at the same time extending the v.h.f./f.m. broadcast band right up to 108 MHz and continuing to use Band 1 (except Channel 1) and Band 111 as the main television bands plus 55 u.h.f. television channels. The sometimes-heard premise that the valid needs of the land mobile service can be satisfied only by whittling away the frequencies allocated to existing non-military users needs to be challenged.

## CQ out?

Those who, like myself, operate c.w. on h.f. bands normally listen until we hear a reasonable signal calling CQ and then reply. It is considered bad form to reply to European stations calling "CQ DX" or "CQ Africa" etc. Just occasionally one puts out a CQ call.

On s.s.b. much the same procedure applies although the growth of multistation "nets" means that there are far fewer CQ calls than on c.w.

But from an editorial by Gary O'Neil, N3G0 in *Ham Radio* one learns that launching a CQ call on 144 MHz f.m. is now regarded in the States as an unusual and peculiar event. Instead a station announces it is listening "on channel" in a rather forbidding manner that does not invite a random reply but suggests only a wish to be called by known friends or members of a particular organization or someone with a positive reason for seeking contact. The tendency for amateurs to form élitist coteries, cold-shouldering all outsiders, is not entirely unknown this side of the Atlantic.

## Here and there

The effects of inflation, the less-strong exchange rates, the growing use of frequency synthesizers, up-conversion, digital readout and the like have all combined to push up the price of amateur radio equipment. The Yaesu "FT-ONE" h.f. transceiver retails around £1300, the latest Trio (Kenwood) TS930S is over £1000, and some American-built models such as the KWM380 and the Signal/One (built to a military specification) tend to be well over £2000. One notes that more and more advertisers, particularly in the USA, are becoming very coy about disclosing prices and this appears to conceal substantial discounting as the market becomes rather more sluggish. Though it would seem that sales of the lower cost transceivers, both h.f. and v.h.f., are suffering more than the "top-of-the-range" models.

The GB3SWH 10.368 GHz beacon at Bushey, North London, has been rebuilt and now provides 22mW output to an omnidirectional aerial (6dBi gain). It has been heard in Hampshire over a difficult 80 km path. The 10 GHz beacon at Martlesham, like the British Telecom Research laboratories with which it is associated, is changing away from GB3BPO that linked it with the British Post Office.

A Scottish Amateur Convention will be held at Aberdeen University (Nat.Phil.Dept), St. Machar Drive, Aberdeen, on September 11, from 10 a.m. to 5 p.m., with trade stands. Among the speakers will be Professor R. V. Jones, M. C. Hately, GM3HAT, John Nelson G4FRX and members of the Moray Firth Amateur Television Group.

A Midlands VHF Convention is planned for October 9 and will be at Wolverhampton Polytechnique, near the centre of the town.

Reminder of the British Amateur Television Club convention at The Post House, Leicester on September 5 and the British Amateur Radio Teleprinter Group rally at Sandown Park Racecourse, Esher, Surrey on August 29.

## In brief

Launch date for the Phase 3B satellite could be any time between September and March 1983 depending on the completion of the main load for the Ariane launcher . . . Proposals for five amateur television repeaters in Leicester, Luton, Stoke-on-Trent, Bath and Worthing are being put to the Home Office. . . The Home Office is introducing an annual fee for "experimental v.h.f. licences" which permit holders to use powers up to 1kW and are considering the provision of other forms of experimental licence . . . Members of the Barry College of Further Education Radio Society are to operate GB2F1 on Flatholme island in the Bristol Channel from August 27 to 30. Flatholme was the site of Marconi's first radio transmisson across water in 1897. Since the island is administered from South Glamorgan it also represents the southernmost point of the Principality . . . Mobile rallies: August 22 Avoncroft Art Centre Bromsgrove. August 29 ITT Social Centre, Old Brixham Road, Paignton. September 12 Telford New Town Centre Malls, Telford, Shropshire and Nicholas School, Basildon, Essex. September 19 Wirrina Sports Stadium, Bishops Road, Peterborough. . . Chris Chisholm, G2CX, who died recently, played a prominent role in R.S.G.B. activities in the 1930s including a long spell as QSL Manager and also as a Council Member. He was also one of a number of radio amateurs who played a role in secret radio activities during World War II. He was licensed in the 1920s. Another loss has been Jack Box, G6BQ for long an outstandingly successful 1.8MHz contest operator.

PAT HAWKER, G3VA

# CIRCUIT IDEAS

## Simple divider

The GAP-01 general-purpose analogue processor, primarily intended for synchronous demodulation, may be used as the basis of a versatile divider.

In the first circuit diagram, two CA3080 transconductance amplifiers are shown, each with a $g_m$ of $I_B/2V_T$, where $I_B$ is the bias current and $V_T$, the thermal voltage at 23°C, is 26mV. Given that $I_{B1}=aV_1$ and $I_{B2}=aV_2$, and further, $V_{x1}=V_{in}\ k/(k+1)$ and $V_{x2}=V_{out}\ k/(k+1)$, where a and k are constants, the equation

$$g_{m1}V_{x1}+g_{m2}V_{x2}=0$$

yields

$$\frac{V_{in}}{V_{out}}=-\frac{I_{B2}}{I_{B1}}=-\frac{V_2}{V_1}$$

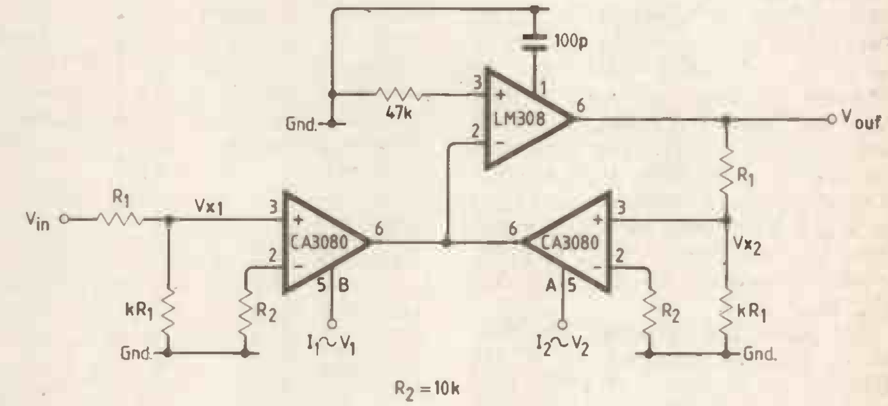
and hence

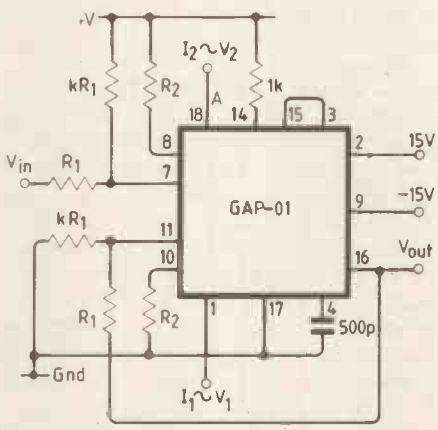
$$V_{out}=-V_{in}\frac{V_1}{V_2}$$

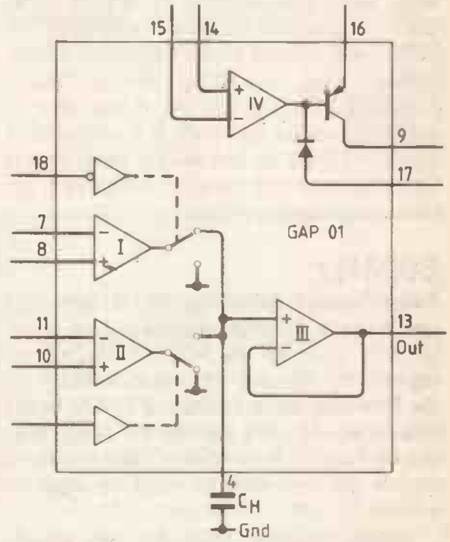
This equation demonstrates the advantages of this circuit over others, i.e., that errors resulting from temperature variations do not influence the output voltage.

The first circuit may be simplified by replacing the two amplifiers by a GAP-01, as shown in the second diagram. This i.c. consists of two differential-input transconductance amplifiers, two 'low-glitch' current-mode switches, an output buffer and a comparator. Values for $R_1$ and $R_2$ are 50 and 15kΩ respectively and k is 0.01.

Kamil Kraus
Rokycany
Czechoslovakia



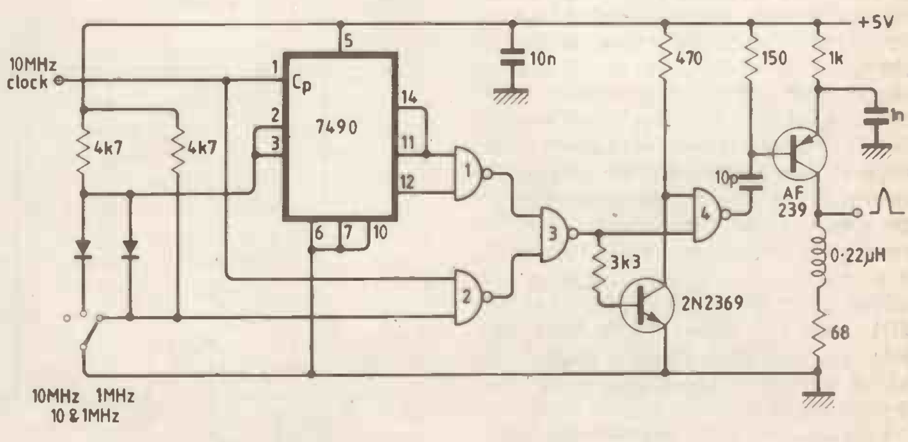




## 10+1 MHz comb generator

A 1 MHz frequency comb with every tenth spectrum line raised by 10 dB is very convenient for use as a spectrum analyser calibrator or sweep generator marker. It can be generated using the simple logic and pulse shaping shown, by gating out every tenth pulse of the incoming 10MHz clock. The resulting pulses, of nearly 1.4 ns duration, ensure an essentially flat spectrum to 250MHz into 50 ohms. A faster, larger-signal p-n-p transistor such as BF479 or MM4018 and a higher supply voltage for the second transistor might raise this limit to 400 or 500MHz.

The principle works for any other ratio N, with the exception of N=2, by having the counter divide by N and selecting its outputs to enable gate 3 during N−1 clock pulses.

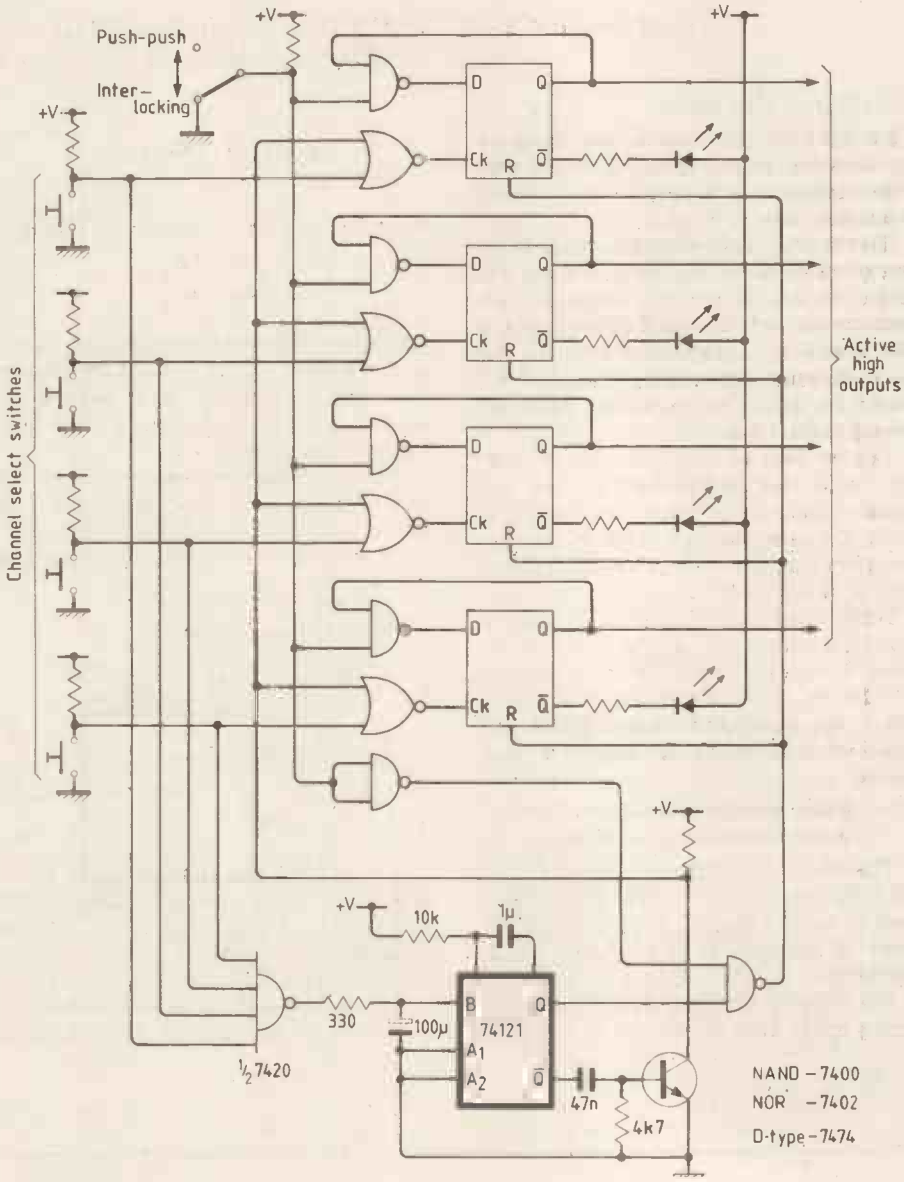
J. C. Baumeister
Chantraine, France



## Analogue-channel switching

Logic signals to control analogue gates in channel select/mixing applications are provided by this circuit. A series of single-pole push-buttons are arranged to operate either independently in push/push (latching) mode, or as an interlocking bank. When the mode switch is set to "interlocking", a common-reset pulse is generated by pressing any switch, resulting in the appropriate channel flip-flop being clocked high, thus ensuring break-before-make operation. In push/push mode, the reset signal is gated off and each flip-flop is toggled by its associated push-button. The 330Ω/100μF RC network, together with the 74121's Schmitt input, provide switch debouncing. The circuit may be expanded to any reasonable number of channels and only minor modifications are required if c.m.o.s. i.cs are to be used.

Tim Williams
Wadhurst
East Sussex



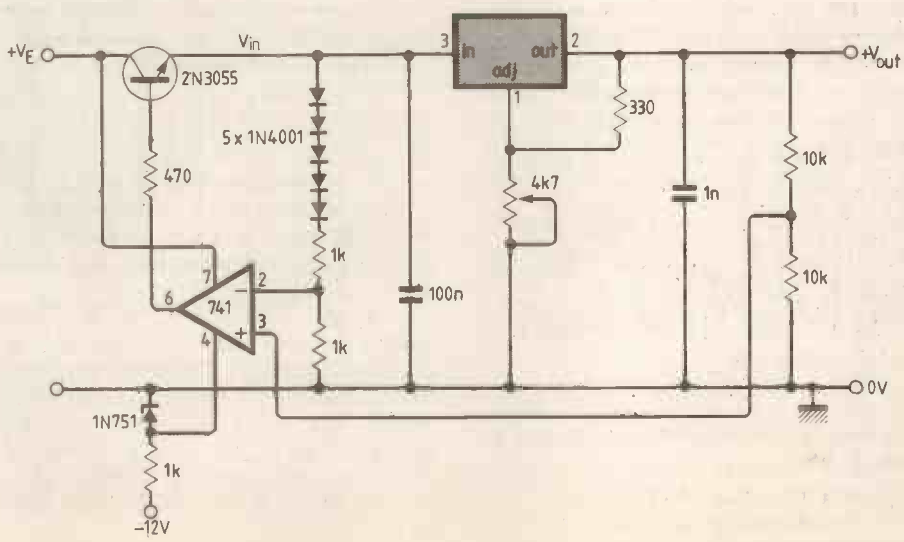

## Improving adjustable-regulator performance

Three-terminal regulators in general function best when their input/output-voltage differential is just above the specified minimum, especially where high currents are being drawn and the device is subject to large temperature changes. On average it is simpler, more economical and more practical to design a regulator-input supply so that it just exceeds the regulator's minimum input/output differential requirement when the anticipated load is maximum, but with adjustable regulators, such as the LM317 shown, the minimum requirement can only be obtained for one output voltage when the supply voltage is fixed.

The circuit shown keeps the variable regulator's input voltage close to its output voltage throughout the circuit's operating range using a preregulator consisting of an op-amp and series-pass transistor, keeping the regulator's performance optimal. Curves given are for an output current of 1A.

Supply voltage to the 741 must not exceed 36V; for the circuit shown, $V_E$ is 30V and the op-amp's negative supply is −5.1V, determined by the zener. As can be seen from the graph, without the negative supply, the circuit still performs fairly well.

Czeslau L. Barczak
Escola Federal de Engenharia de Itajuba
Brazil



# NETWORK ANALYSIS WITH A ZX81

*This second part details the method used to compute insertion loss and group delay of a network.*

**by L. E. Weaver**

First it is desirable to define what is meant by insertion loss. The concept arose in communication engineering where there is a frequent need to break a circuit to insert a filter or other network. More recently, it has given its name to a class of filters designed so that the response when inserted between the correct resistive terminations can be accurately predicted. Because of the great advantages this brings, many of the filters for video purposes, for example, belong to this type.

For the sake of simplicity assume that the input and output terminations are equal. Although this is not necessary, it is by far the most common situation. A more complete treatment will be found in chapter 2 of Skwirzynski[3].

Now consider the illustration in which a generator with e.m.f. $e_i$ and source resistance R feeds a network also terminated in R. The loss from input to output is $|e_i/e_o|$, but if the network is removed and the junctions reconnected the output is $e_i/2$. Hence

$$\text{insertion loss} = 20\log_{10}|e_i/2e_o|$$
$$\text{insertion phase shift} = \angle e_i/e_o.$$

The use of the reciprocal ratio to determine the phase shift has no effect other than to make a lagging angle positive instead of negative, as is the more usual convention.

For computational purposes the circuit shown needs to be considered in terms of the input and output voltages and currents, in fact it is completely described by the Kirchhoff equation

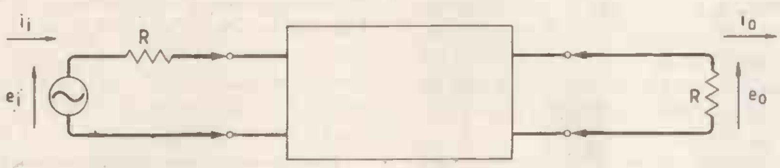
$$e_i = a_{11}e_o + a_{12}i_o$$
$$i_i = a_{21}e_o + a_{22}i_o \qquad 1$$

provided the system is linear. In general, the a's are complex numbers. The next step is to consider the output termination as forming an integral part of the network, which is perfectly justifiable. Then the system is open-circuited at the output making $i_o=0$, and the above equations reduce to

$$e_i = a_{11}e_o$$
and
$$i_i = a_{21}e_o \qquad 2$$

It follows that the insertion loss and phase angle are now

$$\text{insertion loss} = 20\log_{10}|a_{11}/2|$$
$$\text{insertion phase} = \angle a_{11}.$$




Equation 1 can be written in matrix form

$$\begin{vmatrix} e_i \\ i_i \end{vmatrix} = \begin{vmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{vmatrix} \times \begin{vmatrix} e_o \\ i_o \end{vmatrix}$$

The array of a's is known as the A-matrix of the system. Its particular virtue is that the combined response of two networks in series is given by the product of their individual A-matrices.

In the simplest case this second network can take the form of a single series or parallel network branch. Then for a network with an A-matrix having coefficients $z_{11}$, $z_{12}$, $z_{21}$, $z_{22}$:

addition of a series branch $z_s$

$$\begin{vmatrix} z_{11} & z_{12} \\ z_{21} & z_{22} \end{vmatrix} \times \begin{vmatrix} 1 & z_s \\ 0 & 1 \end{vmatrix} = \begin{vmatrix} z_{11} & z_{12}+z_s \cdot z_{11} \\ z_{21} & z_{22}+z_s \cdot z_{21} \end{vmatrix} \qquad 3$$

addition of a shunt branch $z_p$

$$\begin{vmatrix} z_{11} & z_{12} \\ z_{21} & z_{22} \end{vmatrix} \times \begin{vmatrix} 1 & 0 \\ 1/z_p & 1 \end{vmatrix} = \begin{vmatrix} z_{11}+z_{12}/z_p & z_{12} \\ z_{21}+z_{22}/z_p & z_{22} \end{vmatrix} \qquad 4$$

The A-matrices of a single series or shunt arm can be determined by inspection from equations 1. The method of matrix multiplication appears in a wide range of standard texts [4].

Equations 3 & 4 can now be considered as recurrence relationships from which $z_{11}$ and $z_{21}$ may be determined, starting from the input termination $R_i$. As this is always in series, see illustration, its A-matrix is

$$\begin{vmatrix} 1 & R_i \\ 0 & 1 \end{vmatrix} \qquad 5$$

The process can be continued for any number of branches, limited only by the capacity of the program. Finally, the output termination $R_o$ must be added as a shunt branch, otherwise equations 2 become invalid.

Although it has not so far been mentioned specifically, the coefficient $z_{21}$ is not unimportant for some purposes. From equations 2 we have $z_{11}/z_{21}=e_i/i_i$, that is the input impedance as seen through $R_i$, giving the input impedance of the terminated network. The original program listing in fact included this facility.

Nevertheless the input impedance is not always needed, and if the computation of the insertion loss only can be accepted then a considerable simplification can be introduced. Equations 3 and 4 reveal that the lower row of the A-matrix does not enter in any way into the calculation of $z_{11}$. It can therefore be removed entirely with a consequent halving of the amount of complex arithmetic which needs to be performed.

Equations 3 & 4 now reduce to the extremely simple recurrence algorithms

addition of series arm $z_s$

$$(z_{11}, z_{12}) \rightarrow (z_{11}, z_{12}+z_s.z_{11})$$

addition of shunt arm $z_p$

$$(z_{11}, z_{12}) \rightarrow (z_{11}+z_{12}/z_p, z_{12}).$$

Incidentally, even including the complex arithmetic the first only occupies two program lines and the last three lines.

Now that the basic algorithm has been established, it becomes possible to examine the actual program listing. Although the number of REM statements has been kept small for obvious reasons, some notes have been added to the listing which should make it possible to follow most of the procedure without too much difficulty.

The component values of the ladder are stored in sequences as L(N) and C(N) where N is the branch number. The auxiliary arrays G(N) and T(N) indicate the type of impedance in branch N, and direct execution to the appropriate one of the four routines contained in lines 900 through 1140. The output in each case is in the form Re+jIm, where these are the real and imaginary parts of the branch impedance.

The single reduced matrix row corresponds to the two-dimensional array A(I,4), i.e. $z_{11}$=A(I,I)+jA(I,W), and $z_{12}$=A(I,3)+jA(I,4) where I=1 and W=2. Accordingly the initial matrix line has A(1,3)=RI and A(I,I)=I (lines 750,760). The indispensable information on whether the first network branch is series or parallel is provided by M(N) being I or −I respectively. Subsequently, M(N) reverses sign with successive values of N so as to ensure alternating series and parallel branches.

The next step after N has reached its maximum value MN is the addition of the output termination RO (lines 1330, 1340), which completes the computation of $z_{11}$ and allows the insertion loss in dB to be derived in lines 1400, 1410. The insertion phase shift is also available in the form of arctan β=A(I,W)/A(I,I), and is stored in the array P(S) as this is only part of the necessary information.

The group delay is defined as dβ/dω which is not calculable by purely numeri-

```
10    REM LADDER
15    LET CHECK = 2040
20    LET LOSS = 700
25    LET EQU = 1770
30    LET I = VAL "I"
35    LET W = I+I
40    PRINT "FO?"                          (F min)
50    INPUT FO
60    CLS
70    PRINT "FM?"                          (F max)
80    INPUT FM
99    CLS
100   PRINT "DF?"                          (step in F)
110   INPUT DF
120   CLS
130   PRINT "D?"                           (dissipation)
140   INPUT D
150   CLS
160   PRINT "FD?"                          (frequency of max.D)
170   INPUT FD
180   LET FD = FD*W*PI                     (2*π*FD)
190   CLS
200   DIM L(20)
210   DIM C(20)
220   LET O = I<>I
230   DIM P(W+I)
240   LET N = O
250   DIM B(W)
260   DIM T(10)
270   PRINT "RI?"                          (input termination)
280   INPUT RI
290   CLS
300   PRINT "RO?"                          (output termination)
310   INPUT RO
315   CLS
320   PRINT "NO OF BRANCHES?"
330   INPUT MN
340   DIM M(10)
350   DIM G(10)
360   CLS
370   LET N = N+I
380   PRINT TAB 1; "L+C?"; TAB 16; "N =  "; N
390   INPUT W$
400   IF W$ = "NO" THEN GOTO 545
410   PRINT "SER OR PAR?"
420   INPUT W$
430   IF W$ = "SER" THEN LET G(N) = I
440   IF W$ = "PAR" THEN LET G(N) = -I
440   PRINT "L?"
470   INPUT L
475   PRINT
480   LET L(N) = L
485   PRINT TAB 16; "L= "; L(N)
490   PRINT "C?"
500   INPUT C
505   LET C(N) = C
510   PRINT TAB 16; "C =  "; C(N)
520   PAUSE 1E2
530   IF N <>MN THEN GOTO 360
540   IF N = MN THEN GOTO 650
545   CLS
550   PRINT TAB 1; "L?"; TAB 16; "N = "; N
555   PRINT
560   INPUT L
565   LET L(N) = L
570   PRINT TAB 16; "L = "; L(N)
575   PRINT "C?"
580   INPUT C
585   LET C(N) = C
590   PRINT TAB 16; "C =  "; C(N)
595   PAUSE 1E2
600   IF L = 0 THEN LET T(N) = I
610   IF C = 0 THEN LET T(N) = -I
630   GOTO 530
640   LET N = N+I
650   PRINT "SHUNT IN?"
660   INPUT W$
670   IF W$ = "YES" THEN LET M(I) = -I
680   IF W$ = "NO" THEN LET M(I) = I
685   LET MN = N
690   CLS
695   STOP
700   LET N = MN
710   DIM X(20)
715   LET R = I
720   LET F = FO
730   LET S = I
735   LET A = W*PI*F
740   DIM A(I,4)                                        (start matrix)
750   LET A(I,3) = RI
760   LET A(I,I) = I
790   FOR N = I TO MN
830   IF T(N) = I THEN GOTO 940
840   IF T(N) = -I THEN GOTO 900
850   IF G(N) = I THEN GOTO 1020
860   IF G(N) = -I THEN GOTO 1070
900   REM L ONLY
910   LET RE = FD*L(N)*D/W                              (real part)
920   LET IM = L(N)*A                                   (imaginary part)
930   GOTO 1150
940   REM C ONLY
950   IF A = O THEN GOTO 990
960   LET RE = D/(W*FD*C(N))
970   LET IM = - I/(A*C(N))
980   GOTO 1150
990   LET RE = D/(W*FD*C(N))
1000  LET IM =-1E8
1010  GOTO 1150
1020  REM SERIES LC
1030  LET H = SQR(I/(L(N)*C(N)))
1040  LET X = A/H
1050  IF A = O THEN LET X = 1E-8
1055  LET RE = H*D*L(N)
1060  LET IM = H*L(N)* ( X - I/X)
1065  GOTO 1150
1070  REM PARALLEL LC
1075  IF L(N) = O THEN GOTO 2150
1080  LET H = SQR(I/(L(N)*C(N)))
1090  LET X = A/H
1100  IF A = O THEN LET X = 1E-8
1110  LET J = (X-I/X)*(X-I/X) + D*D
1120  LET L1 = H*L(N)
1130  LET RE =  L1*D/J
1140  LET IM = -L1*(X-I/X)/J
1150  IF M(N) = I THEN GOTO 1250
1160  IF M(N) = -I THEN GOTO 1170
1170  LET DE = RE*RE + IM*IM
1180  LET A(I,I) = A(I,I) + (A(I,3)*RE + A(I,4)*IM)/DE      (shunt arm)
1190  LET A(I,W) = A(I,W) + (A(I,4)*RE - A(I,3)*IM)/DE
1220  LET M(N+I) = - M(N)
1230  GOTO 1300
1240  STOP
1250  LET A(I,3) = A(I,3) + A(I,I)*RE - A(I,W)*IM           (series arm)
1260  LET A(I,4) = A(I,4) + A(I,I)*IM + A(I,W)*RE
1290  LET M(N+I) = - M(N)
1300  NEXT N
1310  LET RE = RO
1320  LET DE = RE*RE
1330  LET A(I,I) = A(I,I) +  A(I,3)*RE/DE                   (add RO)
1340  LET A(I,W) = A(I,W) + A(I,4)*RE/DE
1400  LET LO = A(I,I)*A(I,I) + A(I,W)*A(I,W)      (insertion loss)
1410  LET B(S) = 10*(LN(LO/W*W))/ LN 10                (dB)
1420  LET P(S) = A(I,W)/A(I,I)                        (tan β)
1430  LET S = S+I
1440  IF S = W+I THEN GOTO 1500
1450  IF S = W THEN LET F = F + .001             (add frequency
                                                   increment)
1460  LET A = W*PI*F
1480  GOTO 740                                   (repeat computation)
1500  LET F = F - .001
1510  LET F =(ATN((P(W) - P(I))/(I+P(W)*P(I))))/(.002*PI)   (dβ/dω)
1520  LET X(R) = F
1530  PRINT "F="; F; " MHZ "" "; B(I); " DB "" "; X(R); " US"
1540  LET R = R+I
1550  PRINT
1560  LET F = F+DF
1570  IF F > FM THEN GOTO 1590
1580  GOTO 730
1590  STOP
1600  LET DISS = 2100
1620  CLS
1630  DIM Z(20)                                  (group delay values)
1640  DIM E(5)
1650  DIM F(5)
1660  LET M = I
1670  PRINT "V?"                                 (number of sections)
1680  INPUT V
1685  PRINT TAB 16; "M = "; M
1690  PRINT "FR?"                                (resonant frequency)
1700  INPUT FR
1710  LET F(M) = FR
1720  PRINT "K?"                                 (shape factor K)
1730  INPUT K
1740  LET E(M) = K
1745  CLS
1750  LET M = M + I
1760  IF M < V+I THEN GOTO 1685
1770  FOR R = I TO 15
1780  LET Z(R) = X(R)                            (group delay values
                                                    into array Z(R))
1790  NEXT R
1800  LET R = I
1810  LET F = FO
1820  LET M = I
1830  IF E(M) <> O THEN GOTO 1880                (if 2nd order section)
1840  LET T =  F/F(M)
1850  LET S = PI*F(M)*(I+T*T)                    (1st order section)
1860  LET Z(R) = Z(R) + I/S
1870  LET M = M + I
1875  IF M = V+I THEN GOTO 1940
1880  LET Y = F/F(M)                             (2nd order sections)
1890  LET U = (I - T*T)*(I - T*T)
1900  LET S = (I+T*T)*E(M)/(U+E(M)*E(M)*T*T)
1910  LET Z(R) = Z(R) + S/(PI*F(M))
1920  LET M = M + I
1930  IF M < V+I THEN GOTO 1880
1940  LET R = R + I
1950  LET F = F+DF
1960  IF F > FM THEN GOTO 1980
1970  GOTO 1820
1980  PRINT "D(O)= "; Z(I); " US"
1990  FOR R = I TO 15
2000  LET F = FO+(R-I)*DF
2010  PRINT F; """; Z(R) - Z(I); " US"           (delay differences)
2020  NEXT R
2030  STOP
2040  PRINT TAB 1; "RI= "; RI; TAB 16; "RO= "; RO   (subroutine CHECK)
2050  PRINT
2060  FOR I TO MN
2070  PRINT "N= "; N; """ L= "; " UH"; "" C(N)= "; C(N); " UF"
2080  PRINT
2090  NEXT N
2100  FOR R = I TO 15                            (subroutine DISS)
2110  LET F = FO+(R-I)*DF
2120  PRINT F; " MHZ "; 17.37*PI*F*(Z(R)-Z(R))*D; " DB"
2130  PRINT
2140  NEXT R
2150  LET RE = O
2160  LET IM = O
2170  GOTO 1150
CORRECTION
50    should read LET I=?
2060  should read FOR N=I to MN
```

cal methods. The best one can do is to replace it by the approximation $\Delta\beta/\Delta\omega$, where $\Delta\beta$ is the change in insertion phase shift resulting from a small increment in angular frequency $\Delta\omega=2\pi\Delta f$, achieved by adding a small quantity to the current frequency value and computing $\beta+\Delta\beta$ (line 1450). The fact that this doubles the running time is unfortunate but inevitable, and it is a credit to the ZX81 that nevertheless the total execution time is still remarkably short.

The choice of the frequency increment poses a difficult problem. In principle one would like to make it extremely small, but too small a value would be self-defeating because the accuracy gained by approaching the theoretically infinitesimal $d\omega$ would certainly be outweighed by the arithmetical limitations of the ZX81. When two almost equal numbers are subtracted, rounding-off errors can result in a very large percentage error in the difference quality. On the other hand, too large an increment will give rise to inaccuracies where the rate of change of the group delay is high.

The compromise adopted was a frequency increment of 0.001, i.e. a 1kHz difference when frequencies are in MHz. It was checked by comparing the computed group delay with the calculated values in some special cases where it is available in closed form. This suggested a likely accuracy of 1 or 2 nanoseconds, which wouldbe acceptable. Nevertheless, such a compromise cannot be optimum for all cases, and simple modifications can be made to lines 1450, 1500 and 1510 to suit individual needs.

One possible source of inaccuracy could however be avoided. Truncation errors in the ATN algorithm might have a large effect on the value of $\Delta\beta$ if it were derived from expressions of the form arctan A$-$arctan B where A and B differ only slightly. It was replaced by arctan(A$-$B) $=$arctan $(\tan A-\tan B)/(1+\tan A.\tan B)$, executed in line 1510.

Such difficulties do not arise with the group delay equalizer sections whose group delay is available as closed expressions. These are

first order

$$d\beta/d\omega=1/\pi f_r(1+x^2)$$

second order

$$d\beta/d\omega=1/\pi f_r K(1+x^2)/((1-x^2)^2+K^2x^2))$$

where in each case $x=f/f_r$. These correspond to lines 1840 to 1860 and lines 1880 to 1900 respectively.

Furthermore, they are constant-resistance all-pass networks, so that in principle it should be possible to connect them between the filter and a termination with no change in loss, only added group delay. For convenience the filter group delay is held in the array X(R) and transferred to the working array Z(R) each time the EQU subroutine is called by GOTO EQU. Each pass is therefore executed very quickly.

The performance of these equalizer sections deviates from the ideal for two reasons. Assuming the component values are correct and that strays are negligible, the alignment may not be correct and the components will not be dissipationless. In point of fact the strays are usually by no means negligible, but this is too extensive a topic to be entered into here.

However, the extra loss due to dissipation in the delay equalizer components can easily be calculated by a little known, but extremely useful theorem due to Mayer[5]. This states that provided the dissipation is reasonably small, say no greater than about 0.02, then the loss is

$$\Delta\alpha \propto 8.686D.d\beta/d\omega.\omega \text{ decibels.}$$

As in the loss program, D is the sum of the capacitative and inductive dissipations, assumed to be equal, but in practice this condition need not be obeyed at all rigidly.

*Continued on page 79*

# DISC DRIVES

## Winchester technology

*Winchester drives are totally-sealed, high-density storage units, as opposed to floppy disc drives that provide low-cost data storage on a medium similar to ordinary magnetic tape. Electronic, electrical and mechanical aspects of these two quite different types of drive are discussed in two sections, starting with Winchester technology.*

**by J. R. Watkinson***

These offshoots of the conventional exchangeable-pack disc drive described in five preceding articles satisfy quite different requirements, as will be seen. First, Winchester technology is covered, followed by a description of floppy-disc drives in the next article.

Servo-surface disc drives, as dealt with in last month's article, permit a great reduction in disc-track spacing since the read/write head's position is determined by information on the disc's surface, rather than by an external reference. Winchester technology – initially developed near the Hampshire town of Winchester – is the next step forward.

Briefly recapping, there are two ways in which storage density may be increased

– by increasing the number of bits stored per unit length of track
– by increasing the number of tracks within a given radius.

It was shown in the second article (April) that an increase in writing density must be accompanied by a reduction in the head's flying height. But reducing the flying height magnifies the problem of providing a contaminant-free environment. A conventional disc is well protected while in its drive, but outside the drive, even when the disc is protected by a cartridge, the effects of contamination become intolerable.

In last month's article it was explained that the difficulty of aligning the heads increases as the tracks become closer together. There comes a time when it is not physically possible to make a mechanism which can provide the microscopic adjustments necessary, and compatibility between drives could not be achieved.

The essence of Winchester technology is that each disc pack has its own set of read/write and servo heads, with an integral positioner. The whole is protected by a dust-free enclosure, and the unit is referred to as a head/disc assembly, or h.d.a.

As the h.d.a. contains its own heads, compatibility problems do not exist, and no head alignment is necessary or provided for. It is thus possible to reduce track spacing to about one half that of exchangeable servo-surface drives. The totally enclosed assembly can ensure a clean environment for the heads and disc, permitting a reduction in flying height without loss of reliability, which leads in turn to an increase in the number of bits which can be recorded per unit track length. If the rotational speed is maintained, this increase in density leads to an increase in the data transfer rate. Ways in which high transfer rates are accommodated will be covered in a subsequent article.

*B.Sc., M.Sc., Digital Equipment Co.

The h.d.a. is completely sealed except for a small port covered by a filter, which equalizes pressure changes due to temperature and/or air transport. Into this sealed volume of air the drive motor delivers the majority of its power, and the resulting heat is generally dissipated by fins on the h.d.a. casing, in conjunction with an external fan. The disc is designed to circulate the air inside the h.d.a., Fig 1. Some h.d.as have a temperature sensor to monitor this dissipation. An alternative, for where it is not intended that the h.d.a. be exchanged by the operator, is to use a conventional blower and absolute filter for cooling. An exhaust filter is also necessary to protect the h.d.a. when no power is applied, Fig 2.

An exchangeable-pack drive must retract the heads so that the disc can be removed. With an h.d.a., retraction is not necessary as the heads are integral. An area of the disc surface is reserved as a landing strip for the heads. The disc surface is lubricated, and the heads are designed to withstand landing and take-off without damage. When the term retraction is used in this context, it refers to the process of positioning the heads over the landing area.

Disc rotation must be started and braked as quickly as possible to minimize the time for which the heads are in sliding contact. A motor with good starting characteristics is required. On small units, an extra winding may be used for starting, whereas on large units a three-phase motor will be necessary, consuming perhaps 10A per phase during startup. Running current will, of course, be much less – of the order of 1A per phase. Eddy-current braking cannot be used, since in the event of a power failure, the unbraked discs would turn for an extended period with the heads in sliding contact, resulting in damage. A mechanical friction brake is commonly used, actuated by a spring. The brake is held off by a solenoid, which makes the system failsafe in the event of a power failure. Figure 3 shows motor-brake assembly.

An advantage of contact start/stop technology is that the provision of more than one head per surface is easier in the absence of mechanisms for retraction and alignment. This leads to two gains, firstly that travel of the positioner is reduced in proportion to the number of heads per surface, reducing the average access time, and secondly that more data can be stored at a given detented position of the carriage, increasing efficiency on long transfers.

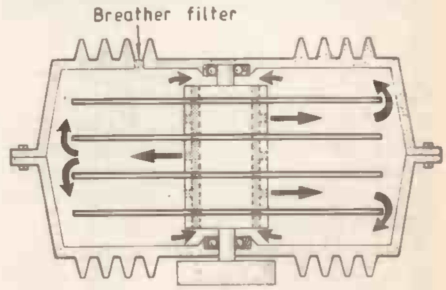



*Fig. 1. The sealed-head disc-assembly has to dissipate the power of the spindle motor. The hollow disc stack in this design circulates the air and brings it into contact with the finned case, whose exterior is fan colled. Note the vent which allows the internal pressure to equalise. The vent contains a filter to prevent dust ingress.*

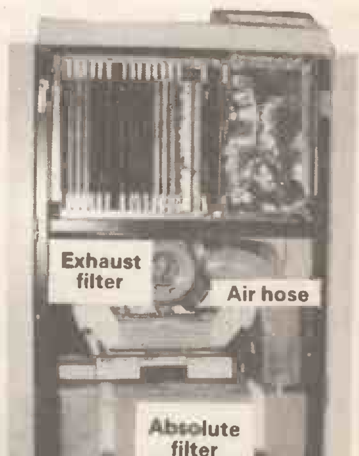



*Fig 2. A contact start/stop drive utilising a full flow air cooling system. The exhaust filter protects the medium from dust ingress when no power is applied.*


*Fig. 3. Contact start/stop drives require mechanical brakes to prevent damage to the disc or heads in the event of a power failure. The h.d.a. of this unit has a capacity of 500 megabytes, and is turned by a three-phase motor which has on the lower end of the shaft a brake.*

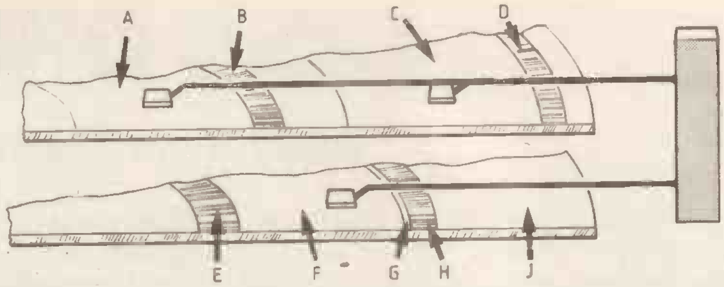



*Fig. 4. When more than one head is used per surface, the positioner still only requires one servo head. This is often arranged to be equidistant from the read write heads for thermal stability.*

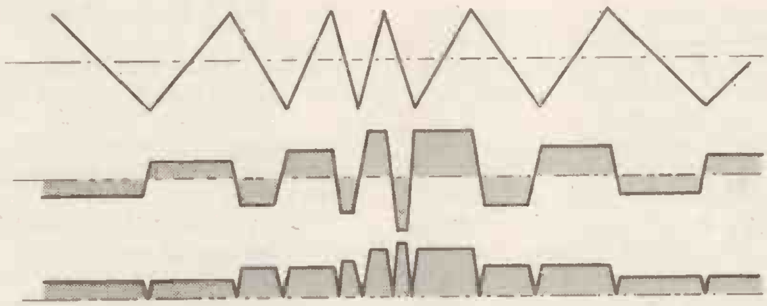


*Fig. 5. To generate a velocity signal, the position error from the servo head is differentiated and rectified.*

Figure 4 illustrates the relationship between various areas of servo and read/write surfaces.

**Positioning velocity and rotation sensing.** In preceding articles, several types of transducer used to monitor the velocity of the positioner and the rotation of the disc have been described. Whatever the principle of operation, these devices all share the drawback that they require both mechanical adjustment and electrical calibration, with consequent demands upon the skill and training of those who maintain them. With contact start/stop technology, the servo head is always over the disc surface, and can be used for positioner-velocity and disc rotation sensing.

Figure 5 shows the position-error signal generated by servo circuitry during a seek, which rises and falls as the servo head crosses servo information, and that the position-error signal's slope is proportional to the positioner velocity. The position error signal is differentiated and rectified, the resulting signal representing the magnitude of the positioner velocity. The process of differentiation exaggerates any h.f. noise present, and a low-pass filter is placed before the input to the differentiator to combat this. At high seek velocities, however, the filter would attenuate the position-error signal, and is therefore switched out when the velocity exceeds a certain threshold; since the differentiated signal is large at this time, the absence of the filter is of no consequence.

Owing to the sign change of the differentiated signal, the output waveform contains troughs where the position-error slope falls to zero at the peaks. These troughs prevent direct use of the signal by the velocity-feedback loop during a seek, as they would be interpreted by the servo amplifier as momentary, large-velocity errors, causing saturation of the output. The troughs cannot be filtered out, since this would introduce an extra pole into the open-loop response of the servo, causing instability.

In April's article covering read/write heads, it was shown that the area under a graph of electromagnetic actuator (e.m.a.) current against time represents the energy put into the positioner. As the mass of the positioner is almost constant, the velocity of the positioner is proportional to the integral of the e.m.a. current, neglecting losses due to friction and air resistance. Despite errors resulting from these effects, integrated e.m.a. current is sufficient to carry over the velocity signal when the troughs in the differentiated position error occur. Figure 6 shows that the e.m.a.-current integrator has a finite output impedance, whereas the differentiator has low output impedance in series with an analogue switch. When the position-error signal exceeds a reference voltage, the switch is opened and the trough is blocked. Now, the integrator signal is used. When the position error falls below the reference, the switch is enabled, and

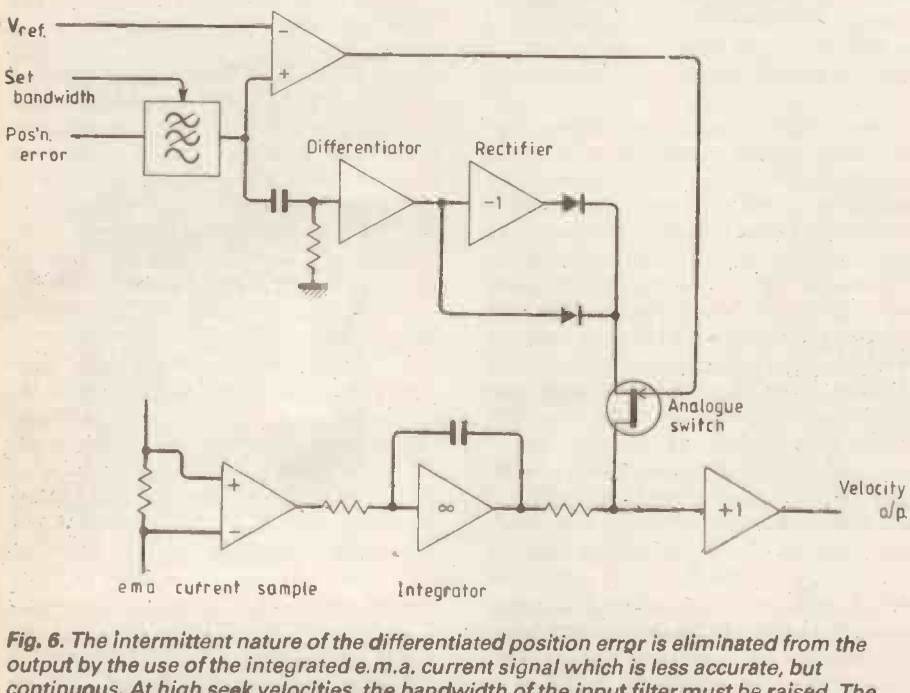



*Fig. 6. The intermittent nature of the differentiated position error is eliminated from the output by the use of the integrated e.m.a. current signal which is less accurate, but continuous. At high seek velocities, the bandwidth of the input filter must be raised. The control signal for this purpose can be derived from the cylinder difference.*

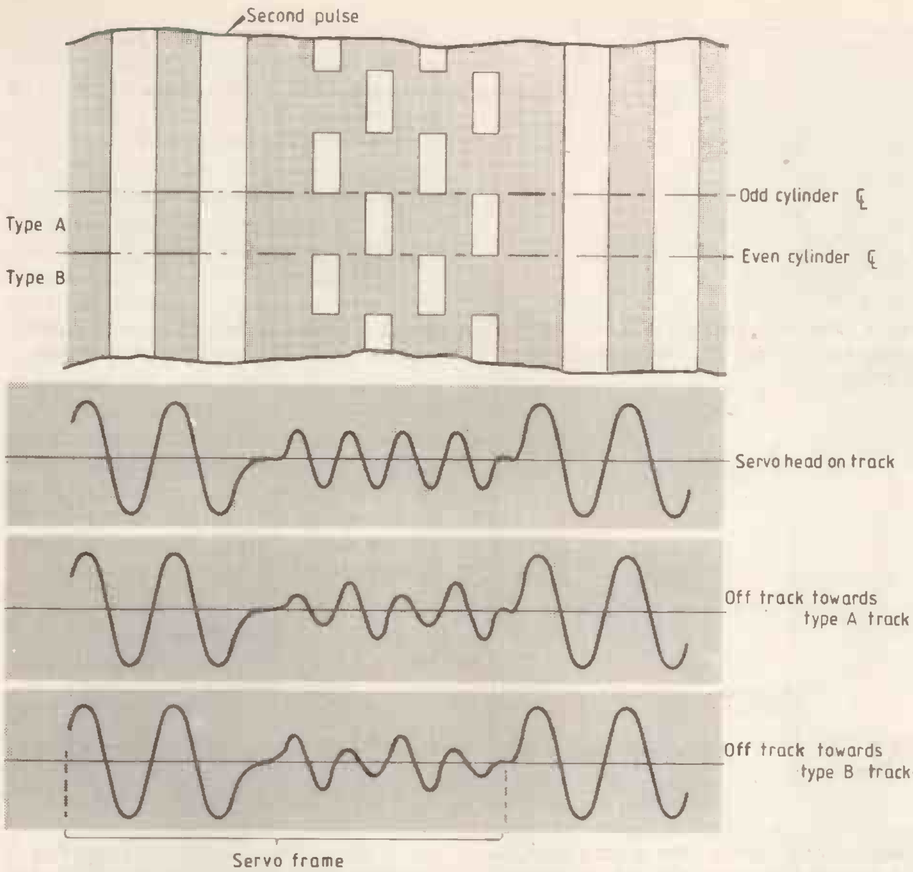



*Fig. 7. This type of servo surface pattern has a second pulse which may be omitted to act as a data bit. This is used to detect the guard brands and index.*

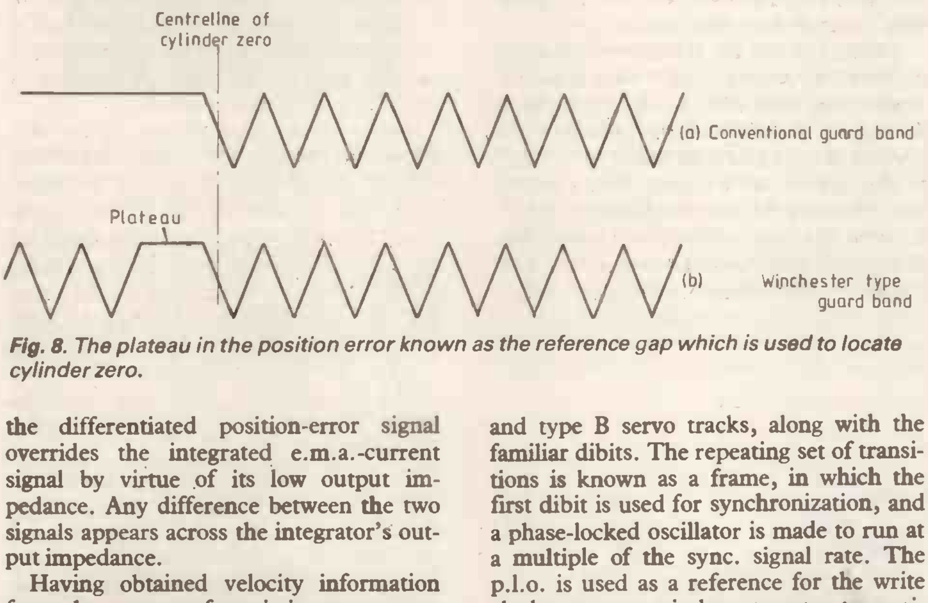



*Fig. 8. The plateau in the position error known as the reference gap which is used to locate cylinder zero.*

the differentiated position-error signal overrides the integrated e.m.a.-current signal by virtue of its low output impedance. Any difference between the two signals appears across the integrator's output impedance.

Having obtained velocity information from the servo surface, it is necessary to ensure that velocity feedback is available over the entire positioner travel. In the last article, it was shown that conventional servo-surface guard bands result in steady-maximum position-error signals at the extremities of the data area. Clearly this approach cannot be used when velocity feedback is derived from the servo surface, as there is no slope to differentiate in the guard band. With contact start/stop, the head landing area is defined by a guard band, and the servo must be capable of operating there and identifying its position.

A modification of the usual servo surface is used, shown in Fig. 7, where there are extra transitions, identical in both type A and type B servo tracks, along with the familiar dibits. The repeating set of transitions is known as a frame, in which the first dibit is used for synchronization, and a phase-locked oscillator is made to run at a multiple of the sync. signal rate. The p.l.o. is used as a reference for the write clocks, to open windows to extract a position error from the composite waveform and to provide a window for the frame's second dibit, which may or may not be present. Each servo frame thus contains one data bit, and successive frames are read to build up a bit pattern in a shift register. The parallel output of the shift register is examined by a decoder which recognises a number of unique patterns. In the guard bands, the decoder will repeatedly recognise the guard-band code as the disc revolves. An index* is generated in the same way, by recognizing a different pattern. In a contact start/stop drive, the repetition rate of index pulses is used to monitor safe rotational speed. eliminating a further transfucer. It must, however, be possible to detect index anywhere in the travel of the positioner, if speed errors are to be avoided. For this reason, index is still found in the guard bands, simply by replacing the guard-band identification pattern with the index pattern once per revolution.

An exchangeable-pack servo-surface drive locates cylinder zero using the steady position-error generated in the guard bands. In a contact start/stop drive, this form of guard band has been abandoned because of conflict with the requirements of velocity feedback, so the cylinder-zero position has to be established by different means.

A common solution uses a unique area of the servo surface known as the reference gap.

In the reference gap, which is adjacent to cylinder zero, there is a servo track which is three times the width of all others. In the reference gap and in several servo tracks outside it, is a third data pattern which is decoded by the index/guard-band circuits to indicate that the reference gap is close. Figure 8 shows position error in the cylinder zero area, which is generated as the servo head crosses that part of the disc. Note that there is a plateau in the position-error waveform. During the head load, which in the context of contact start/stop refers to the process of positioning the heads at cylinder zero, the heads move inward at fixed speed away from the head-landing area. When the reference code is detected, positioner velocity is reduced to typically 2in/s, and the position error is sampled repeatedly. When successive samples of position error are the same, the plateau due to the reference gap has been found, and if the servo is put into track following mode, the positioner will detent at cylinder zero.

**Rotary positioners.** Figure 9 shows the geometry of a rotary positioner with two heads per surface. As the positioner moves, the spacing between tracks will be different from one head to the other, and there will be a certain amount of skew between the flux gap in the head and a true radius of the disc. The tolerances involved in the manufacture of the cantilever are such that no two would generate the same pattern on the disc surface with both heads. None of these effects is of consequence with contact start/stop drives, since data is always read by the heads that wrote it; they are however reasons why exchangeable-pack drives are not found with rotary positioner, as compatibility would be impossible.

Having established that rotary positioners have no fundamental drawbacks for contact start/stop drives, advantages can be detailed. Firstly size – the rotary positioner can be tucked into a corner of the h.d.a. where it can easily be cooled by air thrown out by the disc. Secondly cost – a rotary positioner requires only two ballraces on the shaft, compared to six or more on a linear positioner, and a precision

*The term index refers to a once-per-revolution signal used to locate sector positions on the disc and was fully described in the July issue of WW.

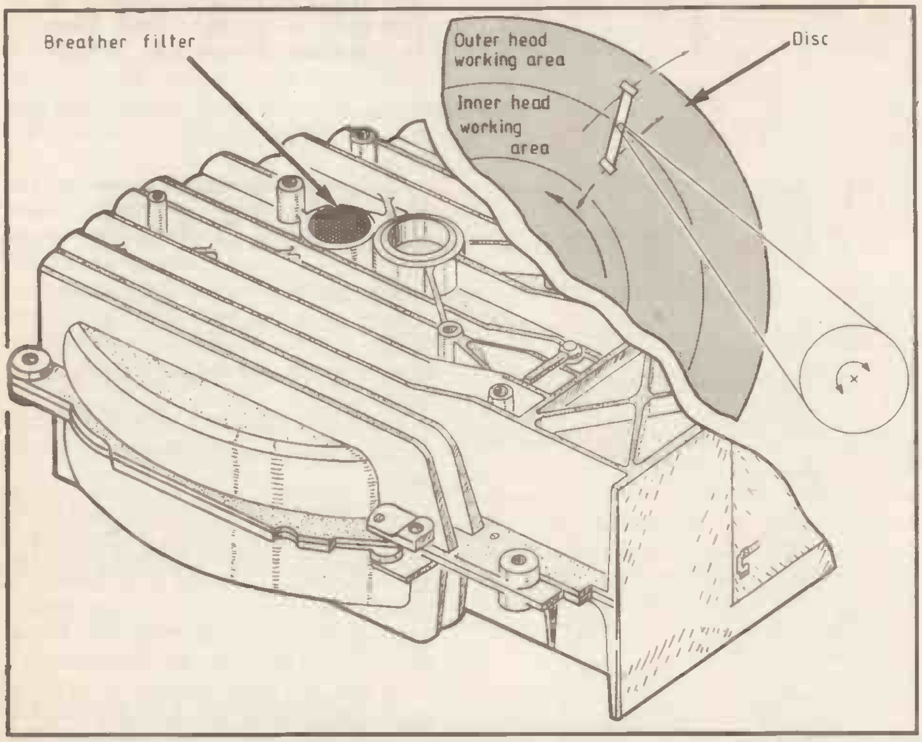



*Fig. 9. A Mini-Winchester disc drive having a capacity of nearly 10 megabytes shown with a rotary positioner having two heads per surface. The tolerances involved in the spacing between the heads and the axis of rotation means that each arm records data in a unique position. That data can only be read back by the same heads, which rules out the use of a rotary positioner in exchangeable pack drives. In a head disc assembly the problem of compatibility does not arise.*

carriageway is unnecessary. Figure 10 shows an h.d.a. with a rotary positioner, which functions in the same way as a moving-coil ammeter. Other aspects of the associated circuits are almost identical to those required by a linear positioner, with the exception that rotary positioners suffer from windage due to the spinning disc having a component which tries to turn the positioner inwards. In linear positioners, windage is almost at right angles to the positioner axis, and can be neglected. Windage is overcome in rotary positioners by feeding the current cylinder address to a r.o.m. which sends a word to a d-to-a converter for inserting an offset voltage into the track-following circuit.

As has been stated, it is possible to make a Winchester-type disc drive with an operator exchangeable h.d.a. The h.d.a. is ejected by a motorized mechanism, and a system of levers disengages the drive belt from the stack pulley and removes electrical connections. The machinery involved adds to the unit cost, and to avoid this, many drives have fixed h.d.as, only replacable by an engineer. Head/disc assemblies, like all human artefacts, can fail, but unlike a conventional disc pack, which can often be put in another drive, a failure can take place in electronic circuitry inside the h.d.a., which means that the data is essentially lost. This places added emphasis on the necessity to back up data stored on disc. Back-up is however made more difficult by a fixed h.d.a. and it is necessary to use high-speed magnetic tapes or conventional disc drives to perform the necessary copying. One useful technique is known as 'journaling', where a permanently mounted magnetic tape records all of the changes made to the disc since it was last backed up. In the case of a failure, the tape and the backup disc can be merged to create an up to date working disc. Contact start/stop technology offers extremely low cost per bit, rapid access and high transfer rate with the inherent reliability of the sealed medium. It is these desirable features which override the above problems in many cases.

*Fig. 10. A head disc assembly with a rotary positioner. The adoption of this technique allows a very compact structure.*

Last month's article showed that the introduction of the servo surface permitted a great reduction in the cylinder spacing, but that each read/write head was assumed to be at the same temperature as the servo head. At extremely small cylinder spacings, small differences in head temperature become significant, and it is necessary to combine the principle of the servo surface with that of the embedded servo. In this approach, the servo head generates velocity feedback and coarse positioning information for the carriage, but when in the vicinity of the desired track, the selected head adjusts itself perfectly to the embedded servo information on each surface. This permits several thousand tracks to be accommodated on one surface.

At the small end of the capacity scale, the mechanical simplicity of contact start/stop yields a low cost product. The nature of the market rules out advanced positioners such as have been described, on grounds of cost. Current 'Mini-Winchester' have simple open-loop stepping positioners, in conjunction with moderate track spacing. Despite this, the price-to-performance ratio of these drives is still impressive. Figure 9 shows a typical Mini-Winchester disc drive with a capacity of almost 10 megabytes. The disc diameter is about five inches.

**Previous articles in this series.**
**Introduction, the drive's role in a computer system, March 1982.**
**Read/write head assemblies, April 1982.**
**Read/write head positioning systems, May 1982.**

**Motors, mountings, bearings and cooling/filtration, July 1982.**
**Servo-surface and embedded-servo disc drives, August 1982.**
**Subsequent articles planned cover floppy-disc drives, disc control logic and data integrity.**

# SIMPLE DIGITAL FILTERS FOR SOUND REPRODUCTION

*Filters for disc recording equalization, tone control, channel dividing and notch filtering, as well as graphic equalization can be obtained by combining first-order digital filters*

**by Yoshimutsu Hirata**

Many methods of designing digital filters have been proposed, but most from the point of computer-based filtering for speech-signal processing. In audio, digital techniques have entered the field of recording and p.c.m. recorders are being developed, and it is expected that digital processing such as filtering will be incorporated. For this purpose, digital filters using second-order digital filters as the basic building block have been described by McNally[1], but the realization requires a large table for storing filter coefficients and a large filter word length, i.e. more than 30 bits for the arithmetic operation of digitized audio input signals to avoid errors occasioned by overflow and coefficient truncation. What is needed is a digital filter of least filter word length and the minimum number of coefficients to obtain the desired spectrum shaping of input signals[2].

## Basic filter

The design of digital filters is simplified by the z transfer function which can be realized using adders, coefficient multipliers and delay elements. The z transform operator, which corresponds to a unit delay in the discrete time sequence, is related to a frequenty f by

$$z^{-1} = e^{-j2\pi f/F}$$

where $j = \sqrt{-1}$ and F is the sampling frequency. As usual, suppose in the following discussion that the frequency response of the digital filter is considered in the region $f<F/2$ and that the frequency of an input signal is limited to half the sampling frequency.

Figure 1 (a) shows the structure of a basic digital filter for low-frequency shelving, which consists of a non-recursive filter with a coefficient A and a first-order recursive filter which comprises a coefficient B. The transfer function is

$$\frac{1-Az^{-1}}{1-Bz^{-1}}$$

in which the numerator corresponds to the non-recursive filter and the denominator to the recursive filter.

The processing required to implement the basic digital filter is two adders, two multipliers and one unit display element. But to avoid overflow, the digital filter structure shown in Fig. 1 is preferable, with impulse and frequency response of the filter shown in (b) and (c). The maximum slope of the frequency response is + 6 dB/octave when B = 1 and the minimum slope is − 6 dB/octave when A = 1.

Figure 2(a) shows the structure of another basic digital filter for high-frequency shelving. This consists of a non-recursive filter which comprises a coefficient G, a first-order recursive filter which comprises a coefficient H, and two multipliers which multiply the input signal by (1 − H) and 1/(1 − G). The transfer function is

$$\frac{1-H}{1-G}\cdot\frac{1-Gz^{-1}}{1-Hz^{-1}}.$$

Impulse and frequency responses of the filter are shown in (b) and (c). The maximum level is given by H = 0 and the minimum by G = 0, provided that a turnover frequency $f_2$ is kept constant.

## Tone controller

A tone controller can be obtained by the serial combination of the first and second basic digital filter shown in Figs 1 & 2. The transfer function of the tone controller is

$$D(z)=\frac{1-Az^{-1}}{1-Bz^{-1}}\cdot\frac{1-Gz^{-1}}{1-Hz^{-1}}\cdot\frac{1-H}{1-G} \quad (1)$$

with the low-frequency shelving characteristic defined by two coefficients A and B, and the high-frequency shelving by two coefficients G and H. For example, when the sampling frequency is 44kHz and the turnover frequency $f_1$ is chosen as 500Hz,

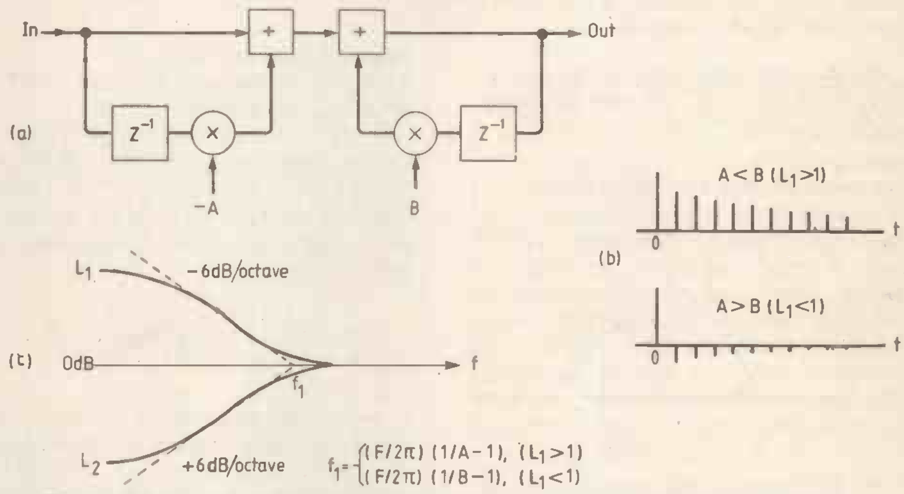



*Fig. 1. Basic digital filter for low-frequency shelving comprises two adders, two multipliers and two unit delay elements (a), impulse response (b), and amplitude response (c).*

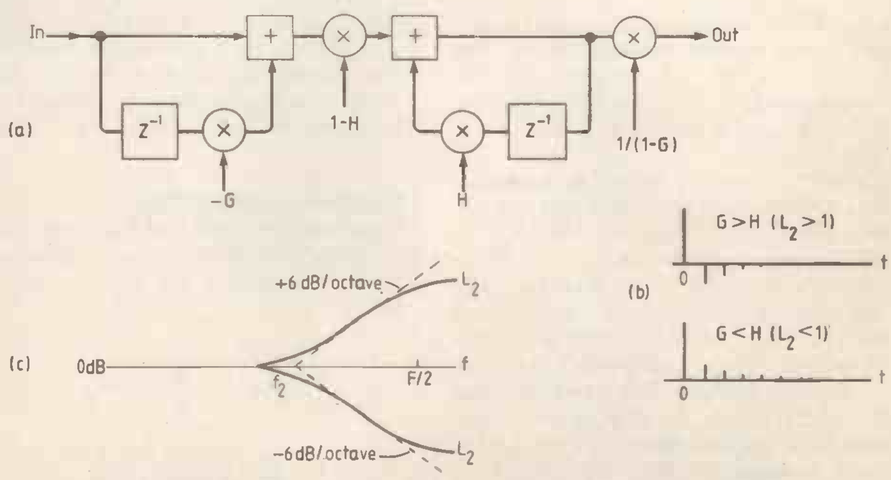



*Fig. 2. Basic digital filter for high-frequency shelving comprises two adders, four multipliers and two unit delay elements (a), impulse response (b), and amplitude response (c).*

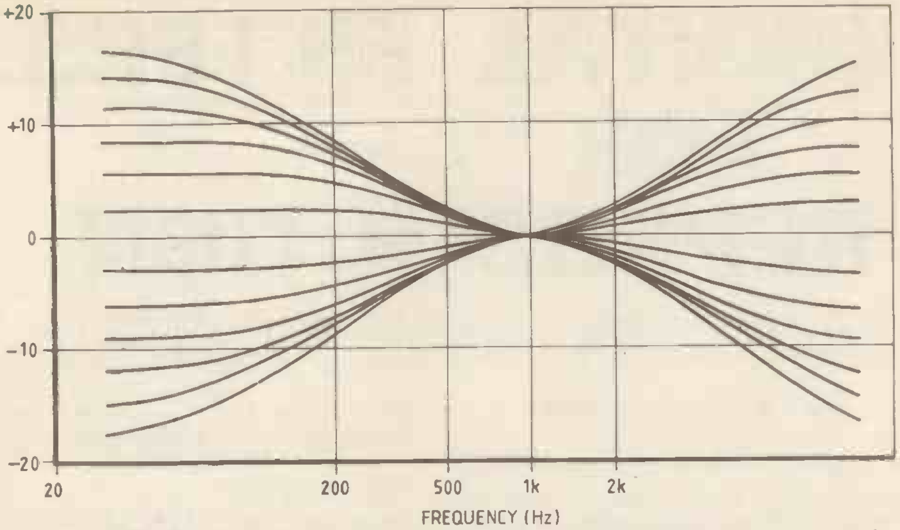


*Fig. 3. Family of measured curves obtained by tone controller implemented as hardware.*

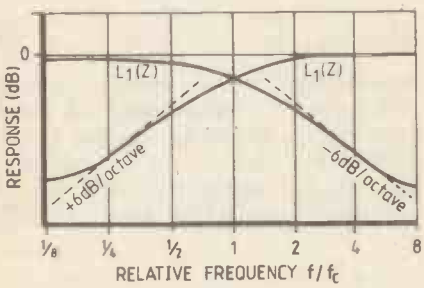


*Fig. 4. Amplitude response of complementary low and high-pass filters expressed by equations 1.*

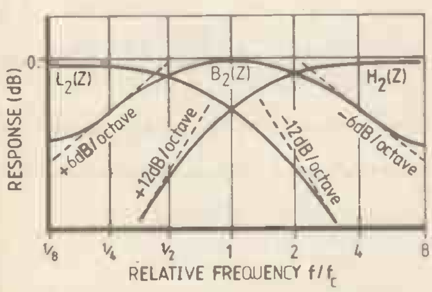


*Fig.5. Frequency response of complementary low, band and high-pass filters expressed by equations 3.*

a low-frequency boost is obtained by putting $A=0.93$ and selecting B so that $L_1=0.07/(1-B)>1$. Similarly, a low-frequency attenuation is obtained by putting $B=0.93$ and selecting A so that $L_1=(1-A)/0.07<1$.

Figure 3 shows a family of measured curves obtained by the digital tone controller. When $f_1 \approx 500$Hz, $f_2 \approx 2$kHz, $F = 44$kHz, and $-18\text{dB}<L_1, L_2<+18\text{dB}$, the addition of four bits (experimentally three bits) in the arithmetic operation of the tone controller can prevent overflow. In practice, selecting the level steps $L_1$ and $L_2$ and the turnover frequencies suitable for binary values, the additional ten bits, four for headroom and six for the coefficient word-length (filter word-length is given by ten bits plus the input signal bits), will be sufficient to avoid overflow and coefficient truncation.

The digital tone controller discussed above is well suited for a digital audio system based on microprogramming where minimum instruction steps and a maximum dynamic range for a given word length are required. The filter of equation 1 has been accomplished by hardware controlled by the microprogram of six instructions using about 1 μs[3].

## Record equalization

The recording characteristic is specified by three time constants $T_1 = 3180$, $T_2 = 318$ and $T_3 = 75$ μs which correspond to turnover frequencies 50.05, 500.5 and 2122Hz. For example, when $F = 44$kHz, applying 88kHz as the sampling frequency of the high-frequency shelving process, the RIAA coefficients are

$$A = FT_1/(1+FT_1) = 0.993$$
$$B = FT_2/(1+FT_2) = 0.933$$
$$G = 2FT_3/(1+2FT_3) = 0.868$$
$$H = 0.$$

In practice the quantization error of coefficients will cause certain deviations from the ideal curve. For $F = 44.056$kHz (88.112kHz for the high-frequency shelving), we have $A = 0.9921875$ (binary 0.1111111), $B = 0.9296875$ (0.1110111), $G = 0.875$ (0.111) and $H = 0$. In this case, the deviation from the ideal curve is within ± 0.5dB and the additional ten bits (three bits for headroom and seven bits for coefficient word-length) are sufficient to avoid both overflow and coefficient truncation.

## Channel dividing filter

Complementary low and high-pass filters in a parallel combination have a linear response in amplitude and phase, expressed by

$$L_1(z) = \frac{1-B}{2-B} \cdot \frac{1}{1-Bz^{-1}}$$
$$H_1(z) = \frac{1}{2-B} \cdot \frac{1-Az^{-1}}{1-Bz^{-1}} \qquad (2)$$
$$(1>A>B>0 \text{ and } A = 2B-B^2)$$

respectively. $L_1(z)$ and $H_1(z)$ satisfy the identity

$$L_1(z) + H_1(z) = 1.$$

Figure 4 shows the frequency response of $L_1(z)$ and $H_1(z)$, whose crossover is

$$f_c \approx (F/2\mu)(1-B).$$

These complementary digital filters can be used for a digital two-way limiter analogous to the conventional analogue two-way limiter. Incidentally, a digital limiter can be realized by either a variable coefficient multiplier, where a digital input signal is multiplied by a coefficient whose magnitude varies with an appropriate time constant according to the amplitude of an input signal, or an s-type non-linearity which can be realized by a simple arithmetic operation of the input signal[4].

Squaring the identity $L_1(z) + H_1(z) = 1$, we have complementary low, band and high-pass filters

$$L_2(z) = L_1^2(z)$$
$$B_2(z) = 2L_1(z)H_1(z) \qquad (3)$$
$$H_2(z) = H_1^2(z)$$

respectively. They satisfy the identity

$$L_2(z) + B_2(z) + H_2(z) = 1.$$

Figure 5 shows the amplitude response of these three filters, while the phase response of $L_1(z)$, $H_1(z)$, . . . and $H_2(z)$ is shows in Fig. 6.

## Notch filter

The z transfer function of the simplest notch filter is

$$N(z) = 1 - \frac{N(1-z^{-1})}{(1-Bz^{-1})^2}, \quad N \simeq 2(1-B)$$

which is realized by the digital structure shown in Fig. 7. If $B \approx 1$, the response of this equation is approximately

$$N(f) \simeq 1 - \frac{1}{1+(j/2)(f_d/f - f/f_d)} \qquad (4)$$
$$\text{where } f_d \simeq (F/2\pi)(1/B - 1)$$

## Graphic equalizer

The z transfer function of the simplest filter which can control a mid-band level is expressed by

$$M(z) = 1 + \frac{K(1-B)(1-Az^{-1})}{(1-Bz^{-1})^2}, \qquad (5)$$
$$(1>A>B>0)$$

where K is a variable coefficient. If $A = 1$, a peak-level occurs at

$$f_p \approx (F/2\pi)(1/\sqrt{B} - \sqrt{B}), (K>0)$$

and a dip-level occurs at the frequency $f_p$ of equation 4 when $0>K>-4$. The dip-

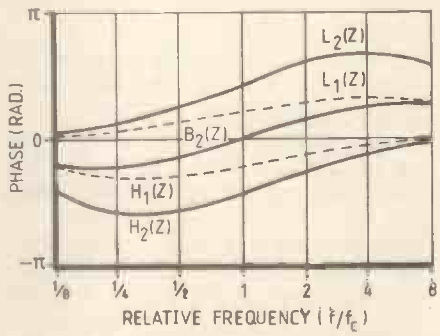


*Fig. 6. Phase response of $L_1(z)$, $H_1(z)$, . . . and $H_2(z)$.*

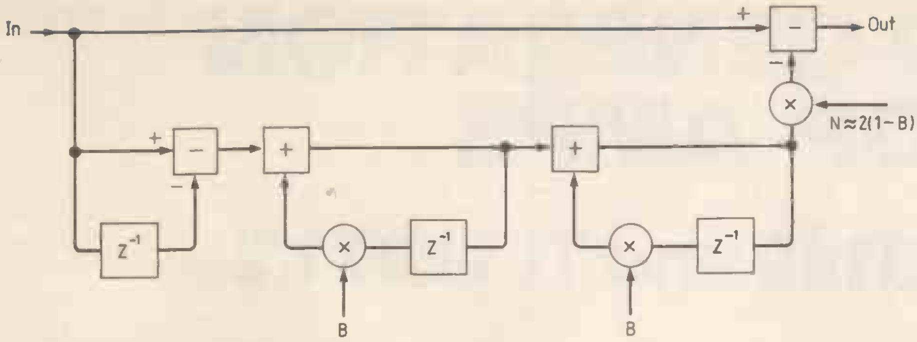



*Fig. 7. Digital filter structure of N(z).*

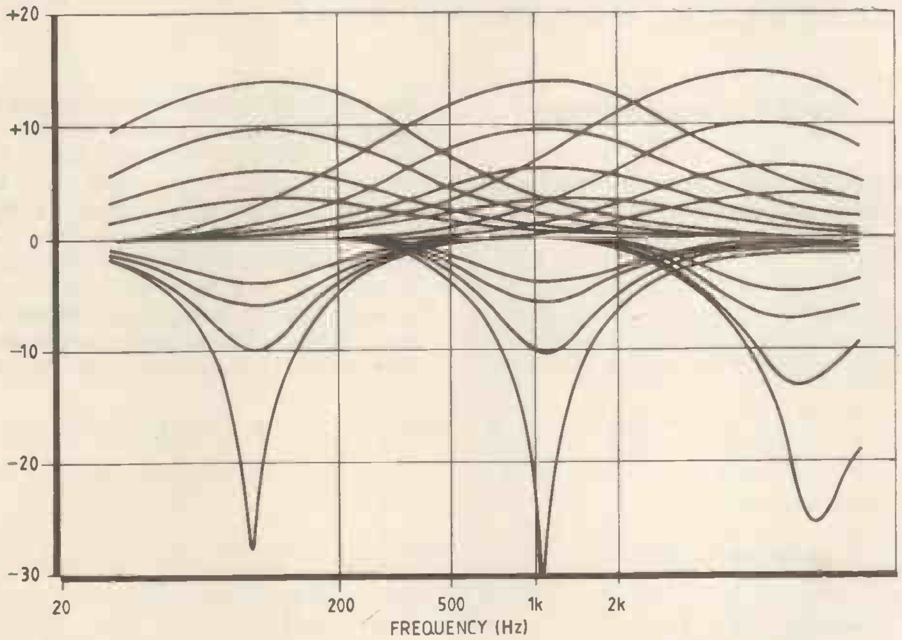



*Fig. 8. Measured curves obtained by the simple graphic equalizer whose transfer function is given by equation 5.*

level becomes minimum at $K \approx -2$ (notch filter). When $B \approx 1$ and $\approx -4$, the amplitude of M(z) is approximately equal to 1 (all-pass filter). Adjusting $A = 2B/(1 + B^2)$, gives

$$f_p = f_d = (F/2\mu)\cos^{-1}(A + 1/A - B/2 - 1/2B).$$

The mid-band level is controlled by the single variable coefficient K.

A family of measured curves of equation 5 obtained by a hardware filter is shown in Fig. 8, where F = 44.056kHz and A = 1. The difference between $f_p$ and $f_d$ at $f_d$ = 10kHz is theoretically given by 3.58kHz. If the maximum level is limited to 15dB, for example, the additional two bits (theoretically and experimentally) can prevent overflow.

The z transfer function capable of control for a narrow-band level using a single variable coefficient can be obtained also by the combination of first-order digital filters. This allows implementation of the filter as hardware with a relatively small word-length, i.e. the additional bits are less than eight.

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2. Hirata, Y. Digitalization of conventional analogue filters for recording use, *J. Audio Eng. Soc.*, vol.29, no.5, 1981, p.333-7.
   Ishida, S., Nagatani, S., Hirata, Y. & Itow, T. Digital filter for tone control and spectrum shaping, Acoust. Soc. Japan Convention Report, May 1981, p.577-8.
3. Sekiguchi, K., Ishizaka, K., Matsudaira, T. K. & Nakajima, H. New approach to high-speed digital signal processing based on microprogramming, Audio Eng. Soc., 70th Convention Report, 1841(A-1), 1981.
4. Hirata, Y. Digital limiter, IECE Japan, Technical Report EA79-67, Dec. 1979.

# EVENTS

**September 6-12**
**SBAC Show** – 25th air show and exhibition, society of British Aerospace Companies Ltd, 29 Kings Street, St Janes, London SW1Y 6RD.

**September 8-10**
**Auditorium Acoustics and Electro Acoustics Conference** at the David Hume Tower, Edinburgh University. Details from Institute of Acoustics, 25 Chambers Street, Edinburgh EH1 1HV.

**September 13-17**
**12th European Micro Wave Conference** in Helsinki. Details from LPL, Convex House, 43 Dudley Road, Tunbridge Wells, Kent TN1 1LE.

**September 14**
**Power Control Seminar.** A one-day event on Motorola solid-state power control. Cavendish Conference Centre. Details from Motorola Ltd, York House, Wembley, Middlesex HA9 0PL.

**September 21-23**
**International Conference on Electromagnetic Compatibility.** IERE Conference at University of Surrey, Guildford, on radio interference problems. Details from Conference Department, IERE, 99 Gower Street, London WC1E 6AZ.

**September 28**
**7th Sound Broadcasting Show.** Albany Hotel, Birmingham. Details from Audio and Design Recording, North Street, Reading, Berkshire RG1 4DA.

**September 19-24**
**Human Aspects of Computer Systems.** Course on Ergonomics and Computers Systems in commercial organizations, at Loughborough University. Details from Rachel Shattock on Loughborough (0509) 212041.

**October 5-6-7**
**Electronic Displays '82.** Conference and exhibition on displays at Kensington Exhibition Centre, London. Details from Network Exhibitions Ltd, Printers Mews, Market Hill, Buckingham MK18 1JX.

**October 6**
**Radio and TV interference.** IEEIE. At Royal Star Hotel, High Street, Maidstone, at 7.30pm. Details from IEEIE, 2 Savoy Hill, London WC2R 0BS.

**October 7**
**Auto Electronics.** IEEIE meeting at Conference Centre, Friargate Hill, Preston, at 6.30pm. Details from IEEIE, 2 Savoy Hill, London WC2R 0BS.

**Publication delays**

Production problems have meant the late publication of *Wireless World* in July and August. We apologise for the delays and expect to be on time in September with the October issue.

*Continued from page 72*

The theorem is useful not only quantitatively, but also qualitatively. For example it predicts that a second-order delay corrector should have a loss maximum in the neighbourhood of its resonant frequency, which is true.

The corresponding subroutine is called up by GOTO DISS, which in the listing starts at line 2100.

## References

3 J. K. Skwirzynski, Design theory and data for electrical filters. Van Nostrand, 1965.
4 J. W. Head, Mathematical techniques in electronics and engineering analysis. Iliffe, 1964.
5 H. F. Mayer, Über die Dämpfung von Siebketten im Durchlässigkeitsbereich. *E.N.T.*, vol.10, no.2, pp.335-8.

# THIRD-GENERATION OP-AMPS

## RCA CA3140 and TI TL071/2

*John Linsley continues his series of articles on i.c. design with a look at the operational amplifiers which succeeded the versatile 741. The TL072 is the type used in the modular preamplifier, to be described in the next three issues.*

by J. L. Linsley Hood

I made the comment in the first article of this series, last October, that I felt the advent of the 741 integrated-circuit operational amplifier was the turning point in the conversion of many linear circuit engineers to the use of i.cs. However, useful though the 741 and other similar contemporary i.c. op-amps were, they were relatively slow and their input impedance was low enough to make it necessary to consider the likely effects of the flow of the input bias current in the input circuitry.

### CA3140

It is understandable, therefore, that the advent of the RCA 'mosfet-input' op-amp, the CA3140, with an input impedance of more than $10^{12}\Omega$ and a slew-rate of some 9V/µs in comparison with that of the 0.5V/µs typical of the 741 in the mid-1970s, should have been greeted with great enthusiasm by the industrial electronic-engineering fraternity, for whom a lot of rather awkward jobs now became very much easier to accomplish. Examination of the circuit, drawn in simplified form in Fig. 1, shows a very great similarity in general structure to that of the 741, except that the complementary-pair output stage emitter followers have been replaced by a single emitter-follower Darlington pair ($Tr_{17,18}$) with an active emitter load built up from $Tr_{15,16}$ and $Tr_{21}$.

The input stage is conventional, consisting of an input long-tailed pair of p-channel mosfets driving a current mirror ($Tr_{11,12}$) and a single class-A amplifier ($Tr_{13}$) with a constant-current source as its collector load. High-frequency compensation is again conventional in form, with a collector-base capacitor ($C_c$) connected across $Tr_{13}$ to impose a dominant-lag type reduction in h.f. gain.

The major advantage of this circuit arrangement stems from the replacement of the relatively poor 'lateral' p-n-p transistors which would have to be used in a conventional, bipolar only type of i.c., with p.m.o.s. devices, which have an exceedingly high input impedance and very good h.f. characteristics. Unfortunately, in this circuit, there is an inevitable load mismatch so that, in spite of the current-mirror load, the gain of this input stage is only about 10×. Also, the need to protect the input gates from inadvertent breakdown due to electrostatic charges forces the use of internal Zener diodes, whose leakage currents effectively limit the input impedance to some $1.5\times10^{12}$ ohms at 25°C.

In order, therefore, to get the gain up to the 100,000 mark expected from his type of device, some ingenuity has been applied to the design of the second class-A gain stage and the output circuitry, shown in full in Fig. 2. In this, the most obvious feature, apart from the four p.m.o.s. devices ($Tr_{8,9,10,21}$), is the most elaborate biassing circuitry, with its ladder of current-mirrors built up from $D_1$, $Tr_1$, $Tr_6$ and $Tr_7$, all fed from $Tr_8$, whose geometry is organized to make it act as a current source. This ladder of current-mirrors is used to control the cascade-connected current sources ($Tr_2$ and $Tr_5$) in the 'tail' of

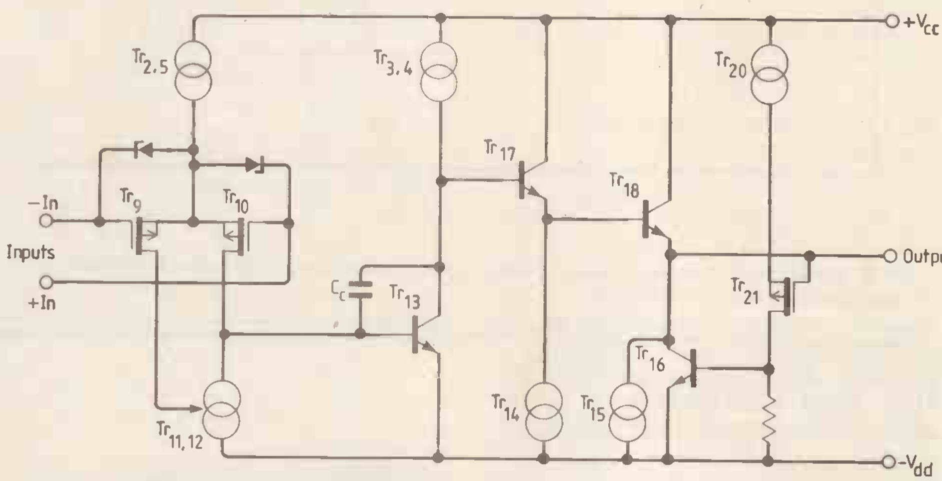



*Fig. 1. Simplified CA3140 circuit, showing general similarity to 741 structure.*

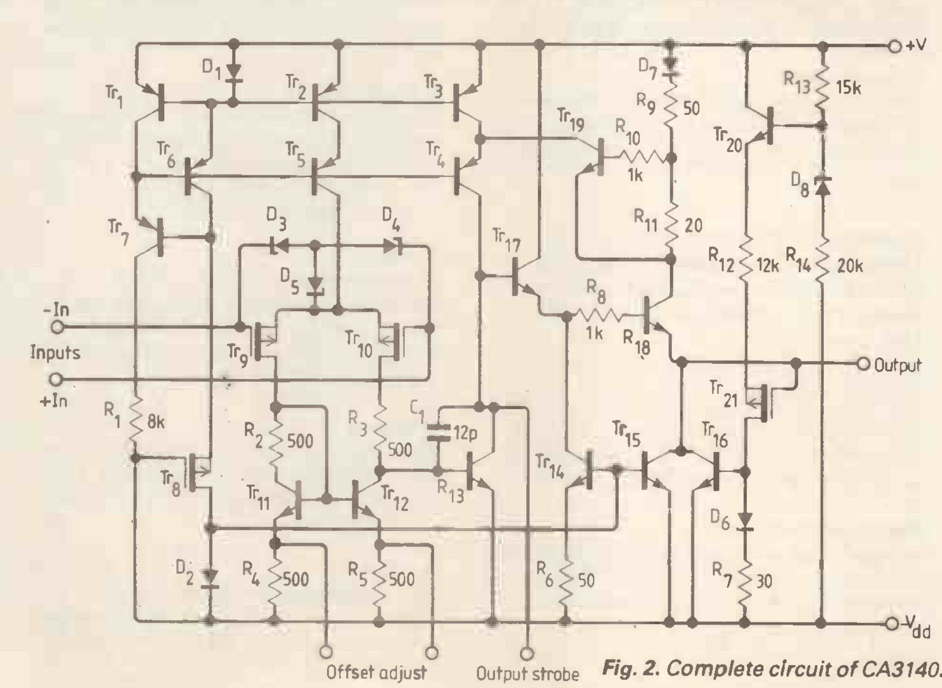



*Fig. 2. Complete circuit of CA3140.*

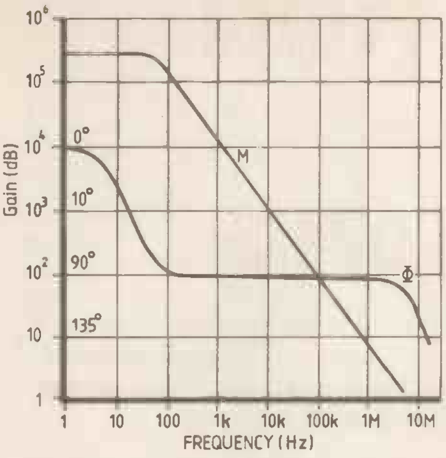



*Fig. 3. Gain/frequency plot for CA3140.*

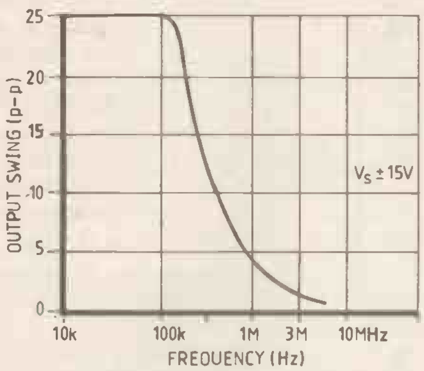



*Fig. 4. Output swing plotted against frequency for CA3140.*

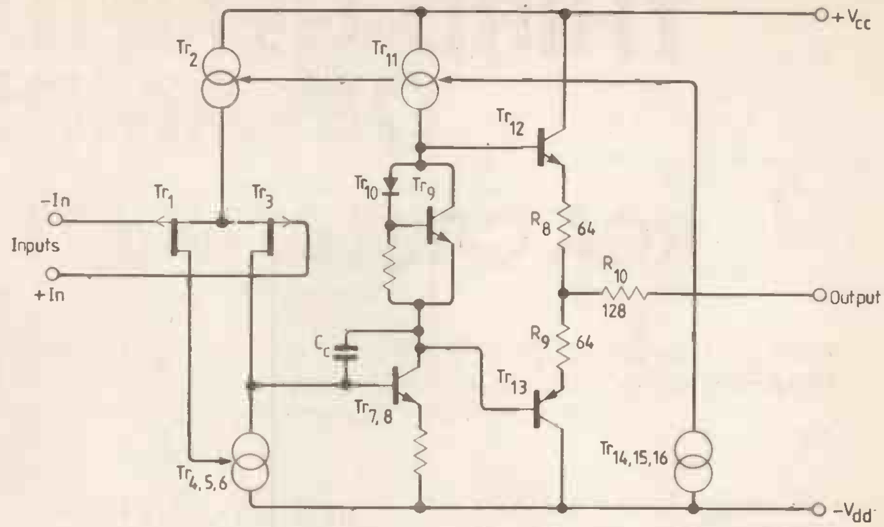



*Fig. 5. TL071 in simplified form, showing return to complementary-pair output and apparently rudimentary short-circuit protection.*

the input long-tailed pair ($Tr_9$ and $Tr_{10}$) and in the load circuit ($Tr_3$ and $Tr_4$) of the class-A amplifier transistor ($Tr_{13}$). This second pair of cascade-connected current sources is used as an ingenious output overload protection device, in that if the current through the output transistor ($Tr_{18}$) exceeds some 30mA at 25°C (or less at higher temperatures), $Tr_{19}$ will be turned on, and will steal the current from the driver stage.

The maximum current available from the lower half of the output stage ($Tr_{16,15}$) is already limited by the current fed into the two output current-mirrors ($Tr_{15}+D_2$, $Tr_{16}+D_6$ and $R_7$) from $Tr_8$ and $R_{12}$, which is itself fed from a semi-fixed voltage source arranged around the zener diode $D_8$ and $Tr_{20}$.

All in all, it is a rather elaborate circuit arrangement, which has always been somewhat expensive to produce and has demanded a relatively large chip size. Nevertheless, the performance of the i.c. is very satisfactory, and it has retained its place in instrumentation use, where its good high-frequency performance, its high input impedance, and its ability to operate over the supply voltage range ±2V – ±18V has made it a useful circuit component. Characteristic gain/frequency and output swing/frequency graphs are shown in Figs. 3 and 4.

## TL071

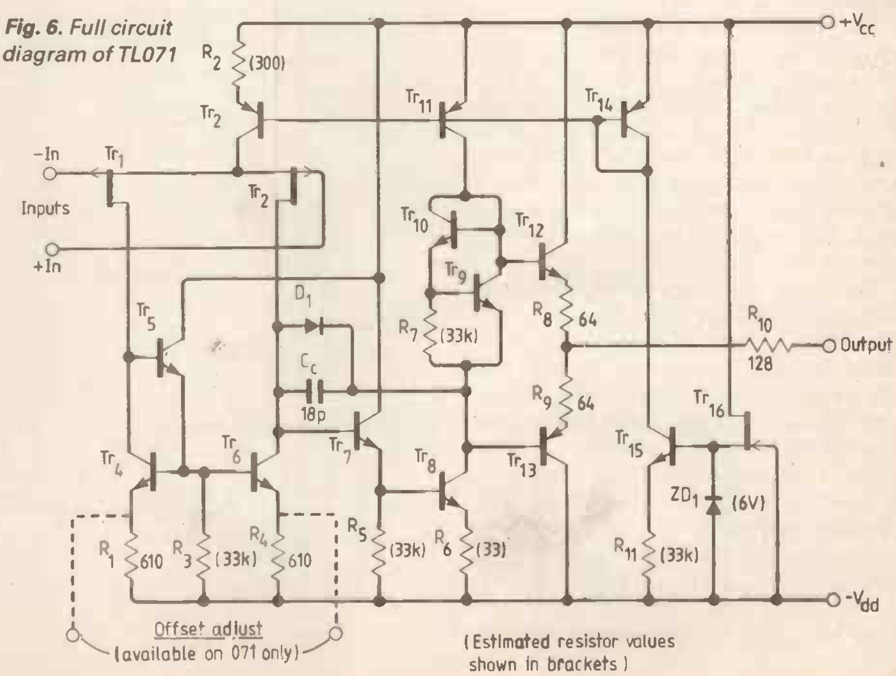
From the point of view of the audio circuit engineer, the remaining requirements which remained to be satisfied in the field of i.c. operational amplifiers were guaranteed low noise and low distortion parameters. These residual requirements were amply met in mid-1977 when Texas Instruments introduced their TL0** series of 'BiFET' devices, based on a combination of bipolar and junction fet technologies, which were now capable of fabrication on the same chip.

Of these, for reasons of personal interests, the one which was most immediately attractive was the TL071, 072, 074 series of single, dual and quad op-amps which are characterized for use in audio circuitry, with a noise specification of $18nV/\sqrt{Hz}$ and a total harmonic distortion, just below clipping, of typically less than 0.01%. In addition, the typical input impedance was still of the order of $10^{12}$ ohms, and the unity-gain slew rate was typically 13V/μs. The use of junction fet input devices has also allowed a somewhat simpler circuit configuration, shown in its basic form in Fig. 5.

Once again, the circuit architecture is of familiar form, with an input long-tailed pair of p-channel junction fets driving a current mirror to add the signal components of both halves, a single class A amplifier stage (actually a Darlington-pair connected stage), and a complementary pair of n-p-n and p-n-p output transistors biased into class AB1 operation. The only curious feature to the professional op-amp watcher is the apparently complete absence of any formal positive-excursion output short-circuit protection, other than the use of an output resistor, $R_{10}$, and the adoption of relatively high-value emitter resistors for the output emitter-follower pair. However, the makers claim that such an output short-circuit can be sustained indefinitely.

I have shown the full circuit of the TL071 in Fig. 6, in which there are a few further details not apparent from the simplified diagram. It will be seen that the input circuit load is formed from a more highly developed form of current-mirror $Tr_{4,5,6}$ and $R_{1,3,4}$) than the simple, two-

*Fig. 6. Full circuit diagram of TL071*



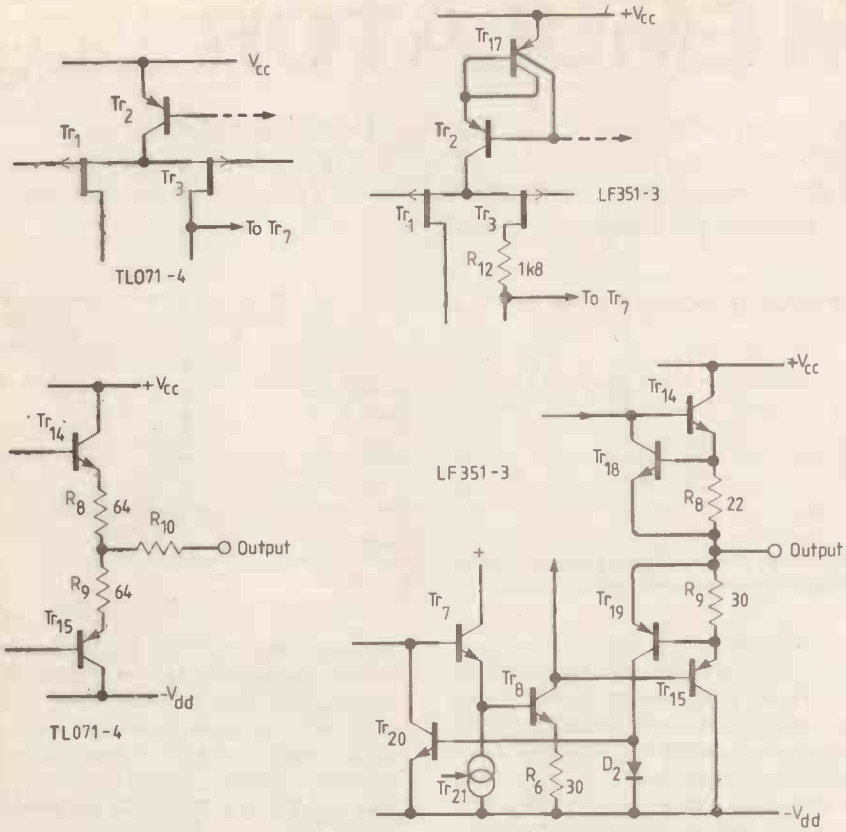



*Fig. 7. Comparison between TL071 and LF351 from National Semiconductor, showing variations in input stage and overload protection.*

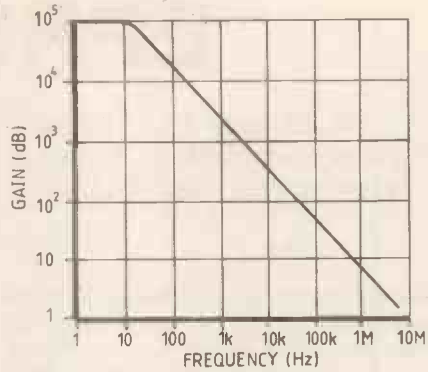



*Fig. 8. Open-loop gain and phase characteristics of TL071-4.*

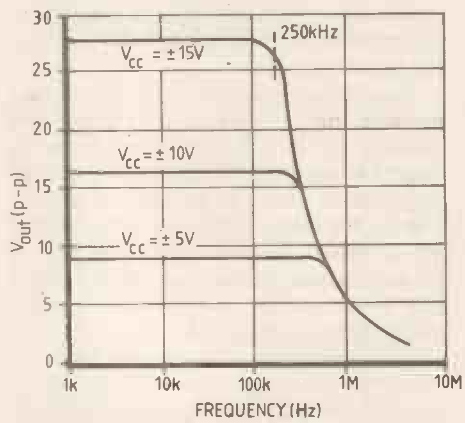



*Fig. 9. Output voltage swing as function of supply voltage and frequency in TL071.*

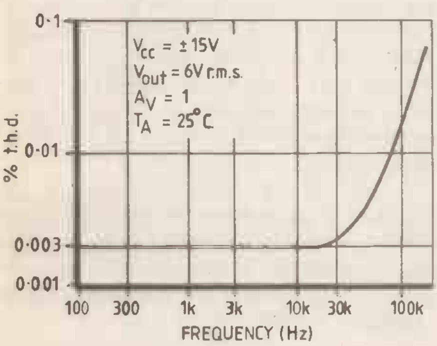



*Fig. 10. Harmonic distortion plotted against frequency.*

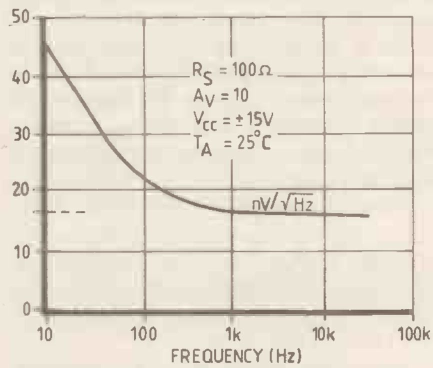



*Fig. 11. Equivalent input noise voltage.*

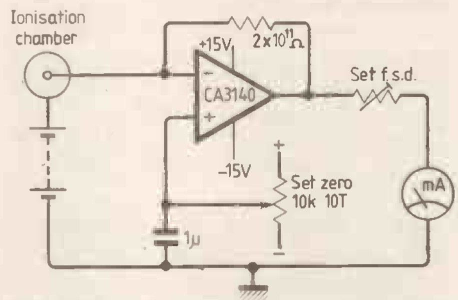



*Fig. 12. Typical application of CA3140 is as ionization chamber amplifier at high impedance.*

transistor circuit employed in the 3140, and a catch-diode is connected across the compensation capacitor ($D_1$) to bypass the amplifier stages $Tr_7$ and $Tr_8$ if $Tr_{13}$ is driven into saturation. This assists in output overload protection, and also speeds up recovery from any swing which drives the circuit into negative line clipping.

Transistors $Tr_{2,11,14}$ form a current-mirror group fed from the constant current source $Tr_{16,15}$,$R_{11}$, with transistors 2 and 11 acting as the input 'tail' and the class 'A' stage load, respectively. The transistor pair $Tr_{10}$ and $Tr_9$, are merely a passive biassing network for the output emitter followers, in which $Tr_{10}$ acts simply as a forward-biassed diode. Because of the relatively large proportion of the total (1.5-2mA) quiescent current consumption

*Continued on page 87*

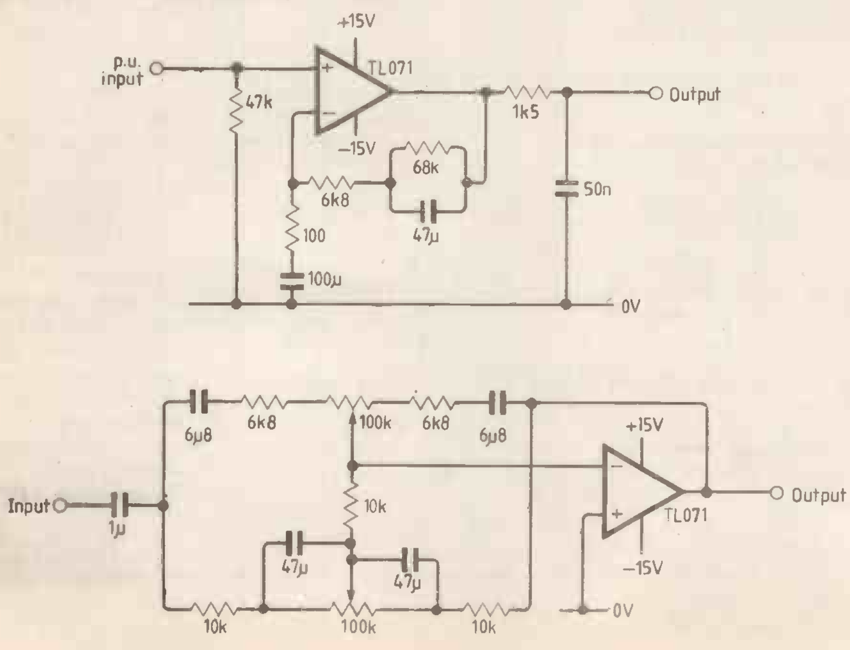



*Fig. 13. Low noise and low distortion of TL071 make it very useful in small-signal audio circuitry.*

# EPROM EMULATOR

*A 2K-byte 2516/2716 emulator to aid software development. Designed for use in a secondary school, the unit is simple yet provides eight control funtions, including two for storing and recalling data on cassette. A directly compatible eprom programmer is to be described in a subsequent article.*

**by Peter Nicholls, M.A.**

Microprocessor system design requires some facility for transfering software from paper to semiconductor memory. Often, an eprom programmer is used, but it is extremely useful to be able to evolve and test a piece of software without having to repeatedly erase and reprogram an eprom – a process required even if only one byte needs altering.

An emulator provides the facility to load software into ram using a keyboard and display, and then to use that software to control an external microprocessor system. Any byte in ram may be changed at will, making for easy testing and correction of the software and breakpoint insertion. A 24-way jumper and 'header' plug connects the emulator to the external system through its eprom socket.

This article describes an emulator for 2516/2716 eproms, designed for use in secondary schools with cheapness and simplicity in mind. At the same time a range of useful facilities are provided making the emulator suitable for the 'serious' system designer. Manual input to the emulator is through eight control keys and a hexadecimal keypad. A description of the control key functions should help one understand how the circuit operates, Table 1.

The eighth control key is spare and may be used to add another function, such as a print command, which might allow the emulator ram's contents to be recorded on a printer. At present, the unmodified monitor program, to be shown, causes a jump to the start when the eighth key is pressed, resulting in a display of 'a', 000, XX.

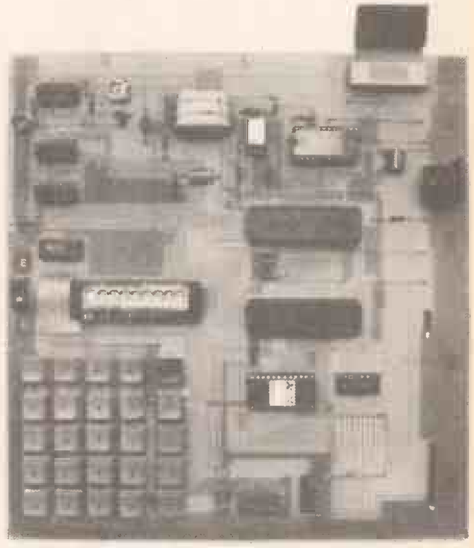
To make the unit easier to use, the following features have been added to supplement the single-character prompts for constantly monitoring the emulator's operating mode.

– If ↑ is pressed at addresses 7FF or 000, resulting in an attempt by the system to go to an illegal address, an error message is displayed for one second, after which the monitor jumps to the start.

– When recording of the memory contents on tape is finished, the display 'sent' is given until the 'a' key is pressed.

– The cassette-recorder interface used is not RS232, but a software interface called Transwift. With this, a check-byte is included at the end of each transmission and checked when the data is read back. If the received parity is correct, the display will show 'read', and if incorrect, will give an error message. This display is held until the 'a' key is pressed.

– When eprom programming is com-



plete, the display shows 'burnt'.

If the software to be programmed does not fill an eprom, further data bytes sent by the emulator must be FF if remaining eprom locations are to be left free. Without software this is a tedious business but it was felt that a separate function key for filling superfluous locations would lead to students loosing their software by accidentally pressing the wrong key.

So, to overcome this, the software is designed so that if the 'e' key is pressed within one second of a first depression, the prompt will show 'f' and all ram displayed from the address when 'e' was pressed will be filled with FF.


*Fig. 1. A typical display. The 8060 processor has only 12 address lines, hence the hexadecimal address display consists of only three digits.*

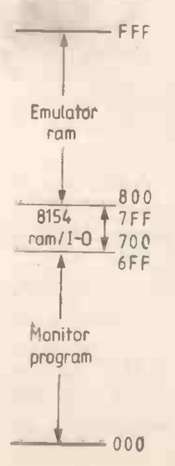



*Fig. 2. The emulator's memory map in load mode. Additional logic is used to rearrange the memory map so that an external system addresses the emulator between 000 and 7FF.*

**Table 1.** Control-key functions and prompts

| Control key | Prompt | Function |
|---|---|---|
| A | a | Address entry. When display shows this character, an address may be entered on the keypad. This address is displayed together with ram contents at the address. |
| D | d | Data entry. This function allows data to be entered at the displayed address. |
| ↑ | | Increment address. With this function, the system remains in data-entry mode. |
| ↓ | | Decrement address. Here, again the system remains in data-entry mode. |
| T | t | Transmit to tape. On display of this character, ram contents are transmitted to cassette recorder through a 'software interface'. |
| R | r | Receive from tape. Reads data recorded using previous function. |
| E | e | Eprom program. This function programs a 2716 with the emulator contents using a small external board. |

**Table 2.** The 24-way jumper lead that plugs into the external system's eprom socket should be connected to the emulator board by a transition socket to provide strain relief. A 26-way socket was used with the following pin assignments.

| Point on board | Pin number | Pin name (2716) |
|---|---|---|
| 1 | 24 | +5V |
| 2 | 1 | A7 |
| 3 | 23 | A8 |
| 4 | 2 | A6 |
| 5 | 22 | A9 |
| 6 | 3 | A5 |
| 7 | 21 | Vpp (+5V) |
| 8 | 4 | A4 |
| 9 | 20 | ($\overline{OE}$ to $\overline{CS}$ on emulator) |
| 10 | 5 | A3 |
| 11 | 19 | A10 |
| 12 | 6 | A2 |
| 13 | 18 | $\overline{CE}$ (0V) |
| 14 | 7 | A1 |
| 15 | 17 | D7 |
| 16 | 8 | A0 |
| 17 | 16 | D6 |
| 18 | 9 | D0 |
| 19 | 15 | D5 |
| 20 | 10 | D1 |
| 21 | 14 | D4 |
| 22 | 11 | D2 |
| 23 | 13 | D3 |
| 24 | 12 | GND |
| 25 not used | | |
| 26 not used | | |

The reset button functions in the usual way and can be useful when, for example, a badly corrupted data transfer from tape occurs, the error message will not be displayed until 16K-bits of data of some sort have been received. A Schmitt trigger inverter is used to provide a clean pulse for 8060's reset input.

Operation of the load/emulate switch should be self explanatory.

## Use of the emulator

Normally, the emulator is operated as follows.

– With the header plug disconnected from the external system and the load/emulate switch in the load position, the required software is loaded into the emulator.

– After loading, the system is switched to emulate mode.

– Now the header is connected to the external microprocessor system, which may need resetting so that it fetches from the emulator's first location.

Care must be taken with power supplies. For example, if the system connected to the emulator has to be powered by the emulator, it is not advisable to use the 24-way connecting cable for this purpose. Generally, if the external circuit has its own supply, it may be connected to the emulator's supply, provided that both are regulated and nominally 5V.

If the system under development has a microprocessor that will relinquish its buses in response to a control command, this facility may be used so that the two systems may remain connected together while the emulator is in load mode. An appropriate control command could be derived from the load/emulate switch and connected through a separate lead to the microprocessor of the system under development.

## Circuit description

As stated, the prime considerations for a piece of school equipment are complexity and cost, so an attempt was made to eliminate the need for buffers on the buses. This influenced the choice of processor for the emulator; the 6502, for example cannot be switched to a high-impedance state on all its buses. The INS-8060 can, and also has the following features that make it suitable for this application.

– no external clock is required
– the device may be rendered static for 50ms in the eprom-programming cycle
– control lines are available that simplify implementation of the emulator's 't, r, e' and 'p' functions:

Referring to the main circuit diagram, Fig. 4, the processor is linked to an 8154 parallel-interface adapter – which provides 128 bytes of 'scratch-pad' ram and two sets of 8-bit input/output lines for display and keypad control – to a 2716 eprom containing the monitor program, and to a 2K by 8-bit cmos ram. This static ram, the HM6116, is more compact than the slightly cheaper equivalent of four 4114s, simplifying p.c.b. design, and it consumes only 20µA in standby mode. A p.c.b.-mounting nickel-cadmium battery will power the 6116 in standby mode for some 200 days. This makes the emulator more reliable and allows one to develop a piece of software over extended periods with minimal use of the cassette-storage facility.

When the main-power supply is used, $Tr_1$ conducts, allowing the ram's chip-select input to be controlled by the NAND gate. When the main supply is removed, $R_{13}$ holds the input high without excessive battery drain. Provided that the board is used on average for about a half an hour each day, the back-up batteries will be sufficiently trickle charged through $R_{12}$.

Figure 2 shows the memory map, which is implemented by most of the low-power Schottky gates. When the ram is addressed by the outside world though the header, data appears in memory between addresses 000 and 7FF. Since the processor only has 12 address lines, which is adequate addressing capability for this application, a fourth hexadecimal digit is not found in either the display or the memory map.

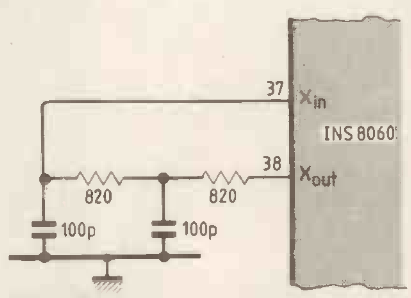



*Fig. 3. To keep costs to a minimum, the crystal section controlling the 8060's clock may be replaced by an RC circuit as shown.*

Peter Nicholls studied natural sciences at Trinity College, Cambridge in the middle of a "thick sandwich" apprenticeship with AEI Telecommunications. In 1967, after a brief period engaged in quality control on a production line for early electronic telephone exchanges, he left to set up an electronics department at Oundle School in Northants. Then, in 1973, Peter moved to Belper High School to establish electronics at all levels in the new school's curriculum, subsequently becoming head of the sixth form. Recently, he left to work for the Microelectronics Education Programme in the East Midlands.

A further small economy may be made when the crystal used for the 8060 clock is replaced by an RC circuit as shown in Fig. 3. The only section of the emulator likely to be affected by the small reduction in timing accuracy caused by this modification is the cassette interface.

Switch $S_1$ on the main circuit diagram, the load/emulate switch, applies either or logic 1 or a logic 0 to the processor's NENIN input. At this input a logic 1 disables the processor, setting all the address and data lines and control lines NRDS and NWDS to their high-impedance state. In this condition, the external system may control the emulator buses without impediment. The signal at NENIN is also used to rearrange the memory map so that the 6116 appears at the bottom of the map as far as the external system is concerned.

**Tape interface** Data is sent to the tape by the processor as a series of 16K bits preceded by a header and ended by a parity-check byte. The value of each bit is conveyed as the time interval between two successive changes in magnitude of the output signal. When reading, the signal from the tape is squared using two Schmitt trigger inverters, and the data is then recovered by software.

Transwift, the name given to this interface by its designer, Barry Savage, requires very few components, yet it is relatively insensitive to changes in tape speed and output level and is fast, taking about nine seconds to load the emulator's 2K ram contents.

**Keyboard/display.** Functioning of the display and keyboard is straightforward, as the second circuit diagram shows. A 7445 decodes three bits of part B and provides sufficient current to drive the multiplexed-display cathodes. Seven bits of port A control the display anodes through a darlington driver i.c., $IC_3$. This technique is slightly wasteful of current, but it is a practical solution as p-n-p - driver i.cs are difficult to obtain.

The keypad is connected to port B in such a way that no software decoding is necessary. Lines $B_3$ to $B_0$ carry the hexadecimal value of the key pressed. Depression of a control key results in a low transition on $B_7$, which is easily detected by the software using a jump if positive command.

Diodes one to seven may be replaced by wire links if the emulator is to be kept basic, but they were included in my design to allow printer heads to be driven by $IC_3$.

## Construction and testing

Wire wrapping was used for the prototype, resulting in a compact unit, and later, a single-sided board was made measuring 233 by 220mm. A 26-way transition connector was used to join the 24-way rib-

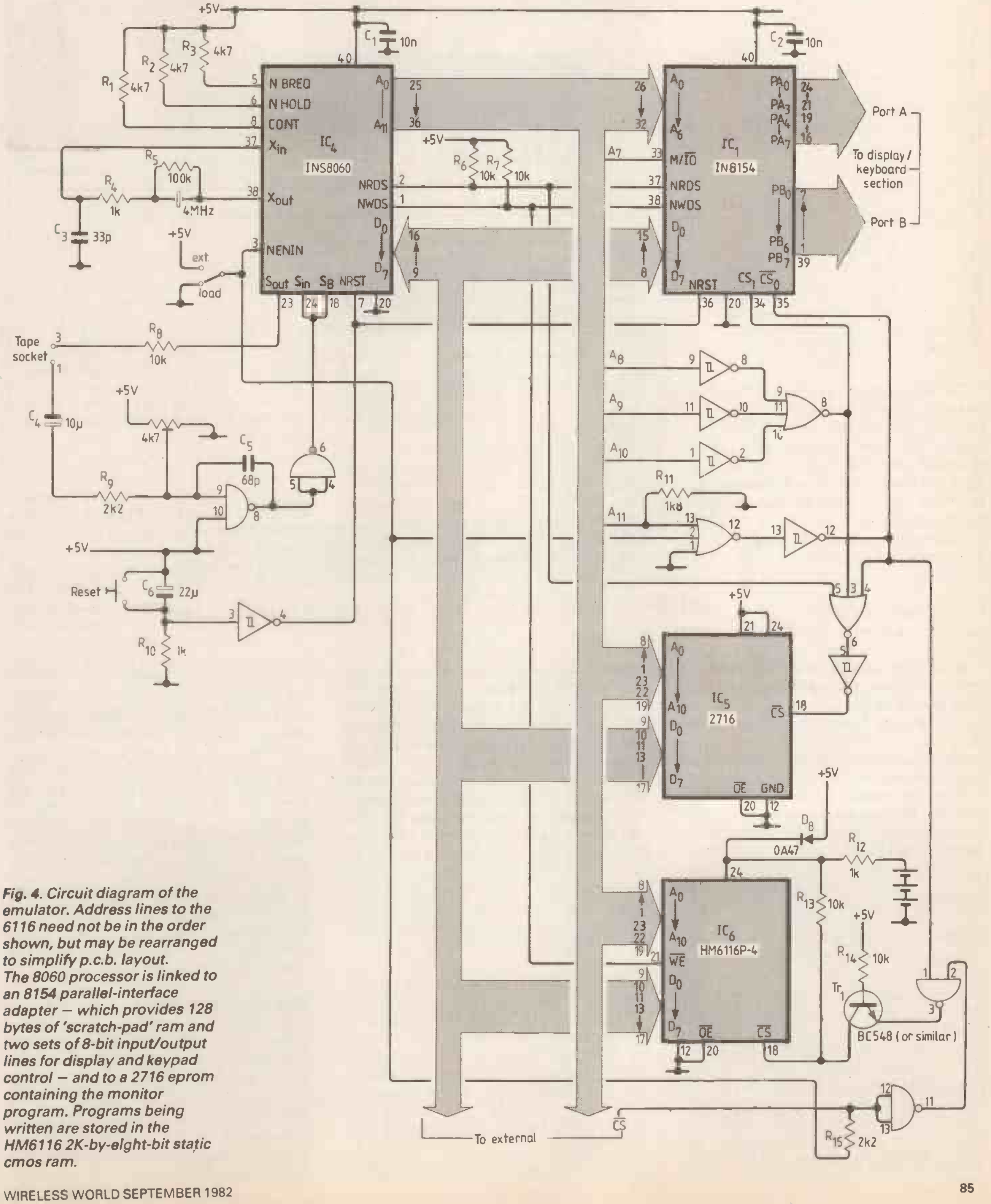
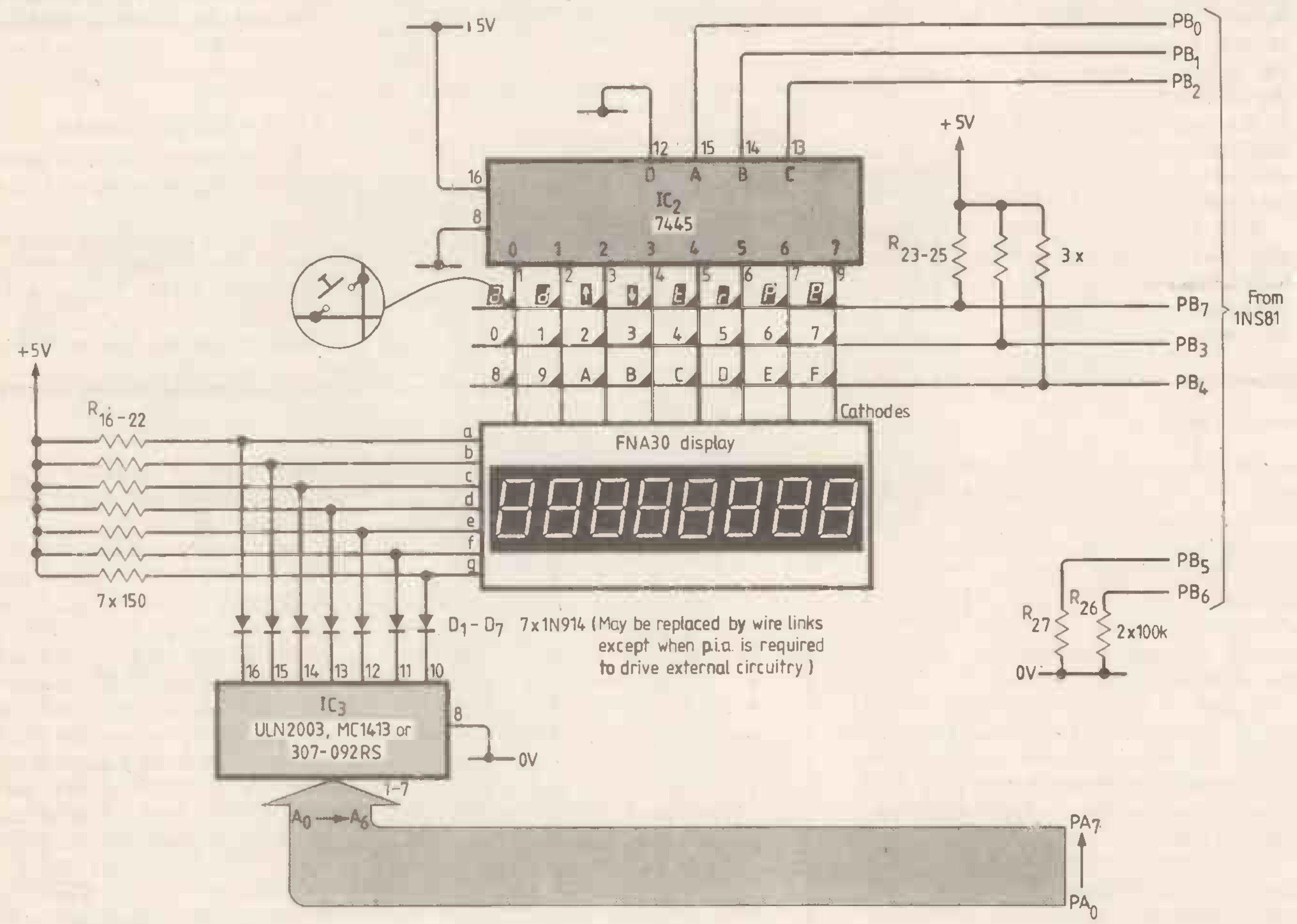



*Fig. 4. Circuit diagram of the emulator. Address lines to the 6116 need not be in the order shown, but may be rearranged to simplify p.c.b. layout. The 8060 processor is linked to an 8154 parallel-interface adapter – which provides 128 bytes of 'scratch-pad' ram and two sets of 8-bit input/output lines for display and keypad control – and to a 2716 eprom containing the monitor program. Programs being written are stored in the HM6116 2K-by-eight-bit static cmos ram.*

*Fig. 5. Diagram of display/keyboard section. Port B and the keyboard are connected such that no software decoding is necessary and the hexadecimal value appears on lines B3 to B0. A logic 0 on B7 indicates to the software that a control key is pressed.*




bon cable to the board. This method is preferred since the transition connector provides strain relief.

When construction is complete, the load/emulate switch should be set to the load position and the power applied. If the display is blank, pressing reset should result in a display of 'a', 000, XX. If this does not happen, a fault must be assumed as there are no adjustment points on the board. Should a close visual inspection fail to reveal the fault, checking the circuit from i.c. pin to i.c. pin with an analogue multimeter which uses a 1.5V battery for its resistance range will usually locate the fault, without risking the semiconductors.

Operation of the address and data entry and address increment and decrement functions may easily be checked by referring to the previous description of functions. Next, connect a cassette recorder to the interface, set the displayed address to 000 and press the 'e' key twice (if an eprom programmer board is to be used with the emulator it should not be connected for this test). This should fill the whole of the ram with FF and after a few seconds, the display will show 'burnt'. Now, when 'a' is pressed, the usual display will be restored.

Set up the cassette recorder for recording, then press 't'. When the display shows 'sent' the recording is complete, and should consist of a steady tone of about 1.3kHz for a few seconds after a short leader. This recording can be used to set up the tape interface using an oscilloscope. First, connect the oscilloscope to pin 18 of the 8060 and start replaying the tape. Play back the recorded data and adjust the 4.7kΩ variable resistor on the main circuit diagram to give a 1:1 mark-to-space ratio. After pressing the 'r' function key, a further replay of the recorded data should result in the acceptance message 'recd' being displayed.

Should 'error' appear, or the display continue to show the 'r' prompt, it should first be checked that the whole message has been sent and received, and that part of it has not been lost on the cassette's leader. Minor adjustments to the cassette recorder volume control and to the setting of the variable resistor may be made to ensure that the signal at pin 18 of the 8060 is 5V peak-to-peak.

Without an oscilloscope, the voltage at pin 18 of the 8060 may be set to 2.5V using an analogue meter, provided that the cassette recorder input is grounded and that one is certain that noise is not falsifying the reading.

As a final test of the cassette interface, switch off the emulator-power supply and touch pin 24 of $IC_6$ to ground. This will fill the 6116 with random data which can then be recorded on tape and played back again, the display confirming accurate reception and transmission.

Single-sided printed-circuit boards (233 by 220mm) and monitor eproms for the emulator, at £8 and £5 respectively, will be available from PKG Electronics, Oak Lodge, Tansley, Derbyshire.

**Acknowledgements**
The Transwift interface, designed by Barry Savage and incorporated in Softy I and Softy II, is used by kind permission and is the subject of a patent. Acknowledgments also go to the Microelectronics Education Program, without whose financial support this project would not have been possible, and to Denys Gaskell for his patience and skill.

*continued from p.50*

the vertical signal from the Y amplifier and triggers the sawtooth oscillator if the switch on pin 2 of the 4070 is in the 'Trig' position (closed). In the 'Free Run' position, the sawtooth oscillator runs continuously.

Two exclusive-Or gates form the clipper circuit, the 2.2 MΩ feedback resistor across the two gates preventing the trigger waveform having multiple edges due to noise on the vertical signal. The polarity of the trigger waveform may be inverted by the following ex-Or gate when the switch is in the negative position. The first of the two Nand gates in the feedback path of the sawtooth oscillator is used to inhibit the oscillator when $\overline{Q}$ of the 4013 is logic 0.

With the circuit waiting for a trigger edge, and the switch in the 'Trig' position, logic levels are:

4011 pin 8 – logic 1
4011 pin 9 – logic 0
4011 pin 1 and 2 – logic 1
4011 pin 12 and 13 – logic 1
4070 pin 3 – logic 1
4013 pin 4 – logic 0 (reset is off)
4013 pin 8 – logic 0 (set if off)

When a positive-going trigger edge clocks pin 11 of the 4013, the Q output pin goes to logic 0, the 4011 pin 3 goes to logic 1 and resets the 4013, $\overline{Q}$ pin 2 to a logic 1; this allows the sawtooth oscillator to run. Further trigger waveform edges cannot now inhibit the oscillator until it has reset and the positive-going edge following flyback clocks the 4013 at pin 3. The circuit is then ready to accept a further trigger pulse.

Note that when the sawtooth generator is waiting for a trigger edge, the CA3130, pin 6, is at +12 V (the fet is therefore off) and the 4011 pin 4 is logic 0, so that the current transistor is off. The timing capacitor therefore floats from a starting voltage of +4 V and, depending on the leakage, would gradually drift over a period of tens of seconds. However, this drift has no effect when the circuit is operating normally.

### Flyback suppression

This is a.c. coupled to simplify the coupling to the tube grid, which is at about −200V. The pulse amplitude is about 35V negative-going at the collector of the 2N2369. A.c. coupling results in a spot at the left-hand side of the trace when the circuit is waiting to trigger.

### Calibration oscillator

The squarewave oscillator generates an accurate 1 kHz squarewave at 1 volt p-p.

*Cathode-ray tubes for this design can be obtained from: Colomor (Electronics) Ltd, 170 Goldhawk Road, London W12; Langrex Supplies Ltd, Climax House, Fallsbrook Road, Streatham, London SW16 6ED.*

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*continued from p.82*

which is routed through the last class 'A' stage ($Tr_8$-$Tr_{11}$), a very high slewing rate (13V/μs) is attained in spite of the relatively large value of $C_c$. An offset nulling adjustment, for the output d.c. level, is provided on the TL071 only, by which an adjustment may be made with a centre-tapped trimmer potentiometer between the 'offset adjust' pins and the $-V_{dd}$ line.

In spite of the relatively simple circuit layout (for an i.c.) the performance of this device is excellent, and is becoming adopted as the industry standard for low-noise, low-distortion, high-input-impedance amplifiers of this type.

As is fairly typical, the National Semiconductors design engineers have 'second-sourced' this device with their own version (known as the LF351 and LF353 for the single and dual units) incorporating a few design improvements, which I have shown in side-by-side comparison in Fig. 7. Although these design changes allow a somewhat improved published specification, my own tests suggest that the performance differences between the TI and NS units are less than the small random variations between one device and the next, so the performance characteristics for the TL07* devices shown in Figs. 8-11 can be taken as representative of the LF351-353 as well. The basic differences in the circuitry concern the 'tail' of the input stage, and in the output stage overload protection, which is done much more formally in the NS design by the addition of the protection transistors $Tr_{18}$ and $Tr_{19}$. Because $Tr_{19}$ is a low gain 'lateral' type of device, it is used to rob base current from $Tr_7$ by way of an additional amplifier transistor $Tr_{20}$. Other circuit differences between these two types of i.c. are trivial.

As examples of the types of circuit which can be built very satisfactorily using these types of op-amp i.c., I have shown two typical applications in Figs. 12 and 13. In particular, the low noise and very low distortion of the TL07* family makes its use in high quality audio preamplifier systems a very natural development. It is unlikely that developments of such i.cs., in this type of TO99 or DIL package, will rest at this level of performance, and straws in the wind are the Mullard/Signetics NE5532-5534 series and the Precision Monolithics OP-27, which have noise figures in the range 3-5nV/√Hz, though as yet, only with relatively low input impedance characteristics. WW

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# Next month

**Modular preamplifier.** John Linsley Hood begins his description of a new, modular preamplifier, designed for use with the 100W power amplifier recently featured. Among its features are a noise-blanker stage to minimize scratch 'clicks', a push-button, eight-octave tone-control, a four-input mixer, a rumble filter with a 22dB/octave cut and a signal-strength meter.

**Electronic compass.** This is a 'no-moving part' design, by Neil Pollock which uses a flux-gate sensor, the construction of which is described. The output of the sensor can be processed by a microprocessor to provide a numerical display, or the hard-wired circuit shown in the article can be used.

**Low-frequency oscillator.** A sine-plus-square oscillator, working in the 10-Hz to 250KHz range, which provides a tone-burst output for loudspeaker testing. There is octave switching and a RIAA pre-emphasis network, and the instrument is built in the modular manner.

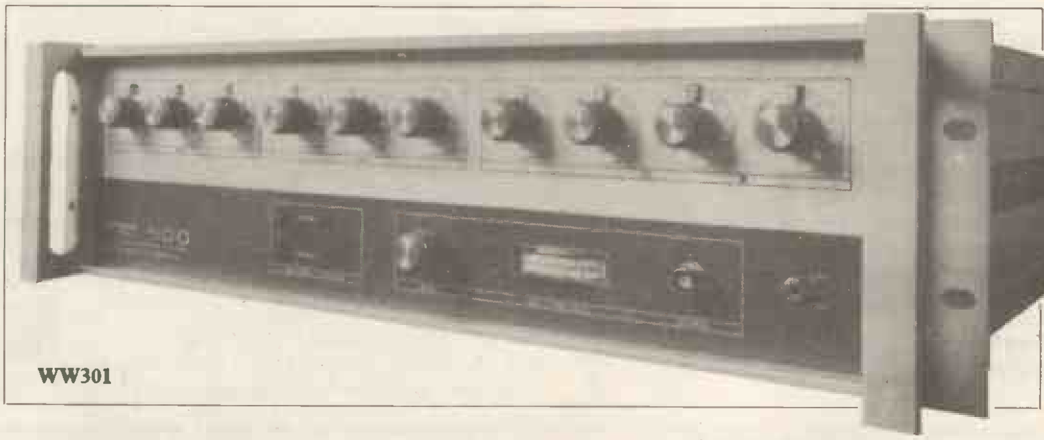
## On sale Sept 15.

# NEW PRODUCTS

## 500MHZ FREQUENCY SYNTHESIZER

Internal or external references may be used to determine output frequencies from 1 to 500MHz in steps of 0.1Hz on the PTS500 synthesized-signal generator. All functions may be programmed using either binary-coded decimal signals or the IEEE488 bus. Switching between frequencies takes from 5 to 20μs, output levels are between +3 and +13dBm, and resolution may be selected. Wessex Electronics, the manufacturer's representatives, say that the instrument introduces little phase noise (−63dBc from 0.5Hz to 15kHz) and that the simple synthesizing method used involves fewer components than competitive instruments do, resulting in a reduction in power consumption of up to 50%. A wideband-h.f. linear amplifier from RF Power Labs is since recently also available from Wessex Electronics. This 150W instrument may be used at frequencies from 1 to 30MHz with an average gain of 50dB, within ±1.5dB. Comprehensive circuit protection is incorporated in the design. Wessex Electronics Ltd, 114-116 North Street, Downend, Bristol BS16 5SE.

**WW301**

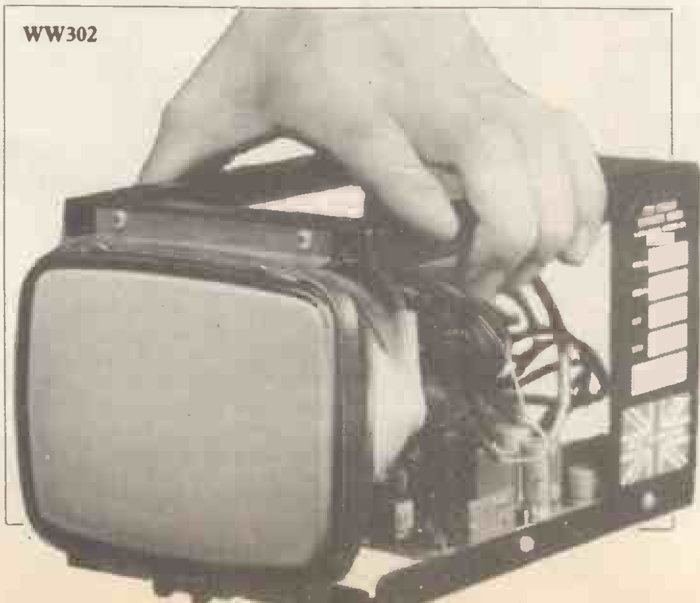


WW301

## MONITORS FOR PORTABLE USE

An uncased 5in monitor from Kent Modular Electronics has 25MHz bandwidth and is claimed to be suitable for displaying up to 80 columns by 36 lines. Designated the MC500, this monitor is suitable for displaying characters, in point-of-sale terminals and computers for instance, or for use in picture-display applications including surveillance and closed-circuit tv. It requires a 12V d.c. supply, may be driven by either composite video or separate t.t.l.-level signals, and has line and field-scan rates of 15.6kHz and 50 or 60Hz respectively. Resolution is 700 lines at screen centre and 500 lines at the corners. Different phosphors can be obtained. Kent Modular Electronics Ltd, Maidstone Road, Rochester, Kent ME1 3QL.

**WW302**



WW302

## 12-by-12-BIT MULTIPLIER

What is claimed to be the fastest unsigned-magnitude 12-by-12-bit multiplier, the MPY112K from TRW LSI Products, multiplies in under 50ns. This 48-pin device, available through MCP Electronics, has dual-input registers, a multiplier array and a 16-bit output-product register with three-state t.t.l.-compatible output buffers. Applications include real-time video-signal processing, digital filtering, FFT calculations and geometric transformations. MCP Electronics Ltd, 38 Rosemont Road, Alperton, Wembley, Middx HA0 4PE.

**WW303**

## BYTE-ERASABLE EEPROM

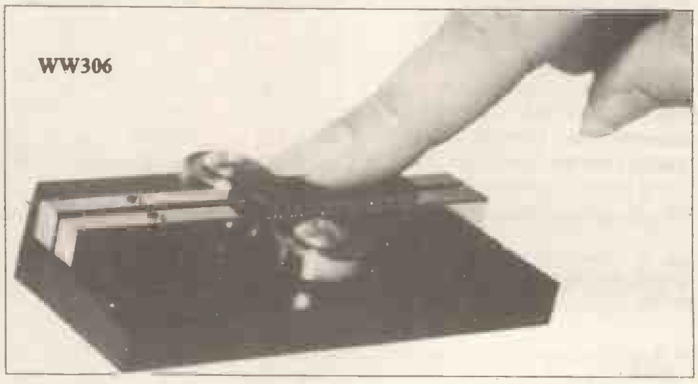
Limited samples of National Semiconductor's 2K-by-eight electrically-erasable prom can be obtained for evaluation purposes. Two versions are available, the NMC2816 and the NMC9716, the difference being that the latter device may be erased or written using a t.t.l. pulse on the chip-enable input while the programming-pulse input is held at 21V. The erase/write cycle is similar to that of the industry-standard 2716 eprom. To erase or write a byte takes 10ms, or alternatively the whole device may be erased at once in 10ms. Apart from the difference mentioned, the devices are pin and function compatible with each other. Prices for 250ns and 450ns versions are between £30 and £40 for small quantities. National Semiconductor (UK) Ltd, 301 Harpur Centre, Horne Lane, Bedford MK40 1TR.

**WW304**

## MICROWAVE TRIMMERS

Four microwave trimming capacitors from Waycom cover 0.3 to 1.2, 0.4, to 2.5, 0.6 to 4.5 and 0.8 to 8pF ranges respectively and have minimum-Q values of between 1000 and 5000 at 250MHz. Self-resonant frequencies are between 5 and 13GHz. The MTRX2X series can directly replace the company's MTMX0X trimmers. Waycom Ltd, Wokingham Road, Bracknell, Berkshire RG12 1ND.

**WW305**



WW306

## DIL PREFORMING TOOL

As many readers will be aware, integrated-circuit pins are intentionally splayed so that the device stays in place when mounted on a board by an automatic-insertion machine or tool. If manual insertion is preferred, the pins must be preformed in some way. Kam Circuits sell two small preforming fixtures, one for 0.3in-wide devices and one for 0.6in-wide types, which can quickly preform i.c. pins. One-off prices are £15 for the DHPT3 and £18 for the DHPT6, excluding vat. Kam Circuits Ltd, Porte Marsh Road, Calne, Wilts SN11 9BW.

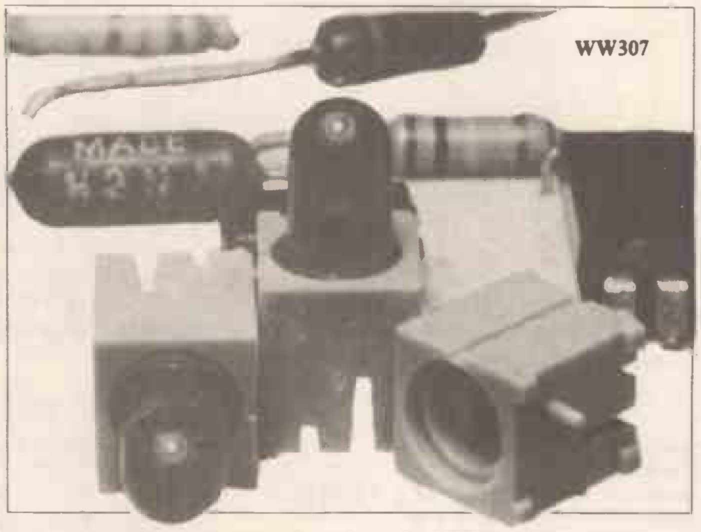
**WW306**

## LED MOUNTINGS

Glass-filled polycarbonate holders for mounting 5mm leds either horizontally or vertically on a p.c.b. are available from Zaerix Electronics Ltd. These holders may be end or stack mounted on a 3mm pitch, used between −50 and +125°C and serve as a guide for led lead forming. Zaerix Electronics Ltd, Electron House, Cray Avenue, St Mary Cray, Orpington, Kent BR5 3QJ.
**WW307**

## CONTROL COMPUTER

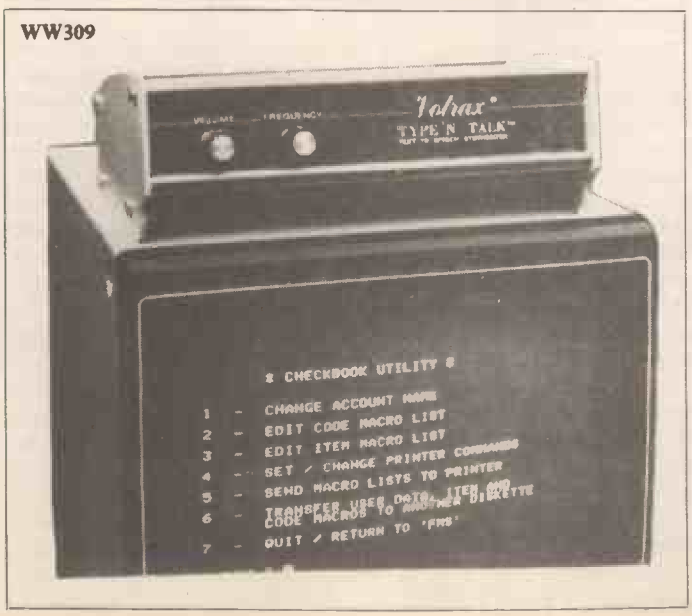
This single-board microcomputer which, it is claimed, can function as its own development system, uses the Zilog Z8671 'single-chip microcomputer' – a microprocessor with a Basic interpreter, two timers, a uart, four i/o ports, vectored interrupts and 144 bytes of ram. The Arc computer, designed for control applications, can be set to initiate itself on power up so that it may be used as a stand-alone controller. Built on a Eurocard, by Arcom Control Systems, the computer has a real-time clock/calender with battery back-up, 4Kbytes of ram and a 2Kbyte eprom containing demonstration programs written in Basic, and an RS232 interface, rate selectable from 110 to 19200 bit/s. Space is available on the board to extend the memory capacity to 20K. Excluding vat, the Arc's price is £135. Arcom Control Systems Ltd, 38 Grantchester Road, Newnham, Cambridge CB3 9ED.
**WW308**



WW307

## COMPUTER SPEECH

Keyboard entries may be converted into speech on most computers using the Votrax Type-and-Talk, claim Intelligent Artefacts (a company name). Typewritten words are translated into electronic speech by the unit's microprocessor-based text-to-speech algorithm. Suggested applications include education for, say, spelling tests, and in aiding blind and dumb persons. Communication with the computer is through an RS232 link and the device gives its verbal response according to the English language, but possibly with an American accent since it originated in the US. It can be obtained for £275 excluding vat. Intelligent Artefacts, Cambridge Road, Orwell, Royston, Herts SG8 5QD.
**WW309**




WW309

WW310

## LARGE G.T.O. THYRISTOR

A gate turn-off thyristor capable of handling 50 to 150kW in uninterruptible power supplies, inverters, variable-speed a.c. motor drive circuits etc., is manufactured by International Rectifier. The 160PFT is a 250A r.m.s., 600A peak device with a 1200V-maximum repetitive peak off-state rating and a turn-off time of 8us. International Rectifier Co. (GB) Ltd, Hurst Green, Oxted, Surrey RH8 9BB.
**WW310**

## CONTINUITY TESTER

Some find it difficult to imagine what a continuity tester costing £54.40 might feature. The Buzzbox, from Kelvin Electronics, can locate p.c.b. short circuits since, claim its makers Kelvin Electronics, it is possible to resolve resistances lower than 10mΩ with the aid of the unit's ten-turn potentiometer and audible-signal generator. A similar method using a medium-resistance range of 0.5 to 30Ω can be used to identify and check multiple cables. Here, a built-in intercom may be of use should the cable ends be far apart. The instrument is also claimed to give consistently more reliable indications than most multimeters where general continuity testing is concerned. Internal calibration resistors are included, and the unit may be used to check capacitor leakage current, as a simple signal generator for audio-amplifier testing, and for alternating and direct voltage checks. In short-circuit location mode, current through the circuit under test is about 20μA and the alternating test voltage too low to turn on a silicon junction. Kelvin Electronics, 18 Exeter Close, Tilgate, Crawley, Sussex RH10 5HW.
**WW311**

## POLYPHONIC-SOUND GENERATOR

An integrated circuit for simplifying the construction of polyphonic keyboard instruments, the M112, is manufactured by SGS. The device contains a microprocessor interface, eight sound-generating channels and output-control logic. Each generator consists of gating logic to select required tones and harmonics, and an a.d.s.r.-envelope shaper to determine the sound's dynamics. Twelve-bit words are sent to the i.c. through a six-bit data bus to determine pitch, a.d.s.r. and output options such as 'hold' and 'pedal'. The device has fifteen outputs in all and includes an input to provide a percussion effect. Cascading of the M112 is possible. Sample quantities of the device should be available in September. SGS recently introduced a 28-pin version of the M3870 microprocessor, the M2870, which will sell in large quantities at 'significantly' under $3. The device is identical to the 3870, except in the number of i/o lines. Both have a 2K rom, 64 bytes of ram, a counter/timer, programmable i/o, external-interrupt facility, internal clock, and require a single 5V supply. SGS-ATES (UK) Ltd, Walton Street, Aylesbury, Bucks.
**WW312**

*Professional readers are invited to request further details on items featured here by entering the appropriate WW reference number(s) on the mauve reply-paid card.*

# RANDOM ECHOES

By Chirp

## THREE DIMENSIONS

There is an advertisement in my paper for one of those new Sony television outfits made up from a set of separate units. It has a separate picture monitor, a separate receiver/demodulator, teletext unit, video cassette unit, etc. It's the logical video extension of the audio hi-fi philosophy, and I'm sure it will be a winner with the "video" enthusiast. It makes good sense in terms of flexibility and must have considerable prestige value.

It is clear from the advertisement picture that Sony intends the tv sound to be handled by the hi-fi stereo system, a small loudspeaker being shown placed at each side of the picture monitor. Of course, British tv sound does not come in stereo, so the system would have to operate in mono for broadcast entertainment. Perhaps some video cassettes have two-track sound, and broadcast television with stereo sound is being developed in Germany.

Personally I have my doubts about the advantages of stereo sound on television. Even with a very large picture tube, I find it hard to believe that the stereophonic illusion can pinpoint the sound source image to coincide with the visual image accurately enough to improve the realism. But I'm probably wrong. Even with real sound sources I find it difficult to locate them aurally. I have very little aural sense of direction, and I am usually unable to tell whether a two-speaker system is providing stereo sound or just doubling up on the monophonic.

Had I not made this admission, however, I am sure I could pursue the argument on the futility of the combination of television and stereo sound and convince a significant following. But there is bound to be a large number of viewer/listeners who can locate the direction of a sound source within a tenth of a second of arc or even less. Indeed, I'm probably the only person who can't do it.

I made the mistake some years ago after a demonstration 3D film at the local cinema. It was based on the use of a different colour filter for the left and the right eye, with appropriately coloured images on the screen.

I found that the stereoscopic effect was far greater than I was accustomed to in real life, and I was easily able to persuade a large number of my colleagues that we were only able to detect the three dimensions visually to a range of about 10 feet. I frequently heard my opinion voiced by others, and each occasion reinforced my conviction of the truth of the statements.

Then I got some new spectacles. The moment I put them on out-of-doors my whole flat world leapt into 3D, and I realized that my disciples were preaching a false doctrine. I was not too penitent, for some were, presumably, normally sighted and should have known that the 10-foot limit was nonsense, even if the film's stereoscopic effect was somewhat exaggerated.

The moral of this story is that, if you believe what you are saying, you can probably fool some of the people most of the time, even in contradiction to the evidence of their eyes.

## MARKING TIME

Quite recently a kind lady gave me an electronic ball-point-pen – all-solid-state with quartz-crystal frequency control – a high-technology writing instrument if ever there was one.

Actually it was not really intended as a gift so much as a prize for ordering more stationery than one really needs. It is what our supplier calls a "promotion"; and there are, I know, folk who regard the acceptance of such gifts as not quite proper, especially as they are nearly always received by somebody else. Anyway I'm quite pleased with mine. It is not everyone who has an electronic ball-point pen.

It's just the same as any other ball-point pen really, except that it has a tiny digital clock built into its upper half, with an l.c.d. readout on the side giving the time in hours and mminutes. It has been quite well engineered – in Hong Kong – and it has some attractive features; e.g., it takes Parker refills, which are readily available outside Hong Kong, and it is fat enough to hold comfortably when writing.

I'm not too fond of digital timepieces in general. I find it easier to relate time intervals to distance round the circumference of my wrist watch than to do the arithmetic with digital information. This is particularly true first thing in the morning, when it comes to the nice assessment of time for a final doze before crawling out of bed. Although the digital characters on our clock radio are large and bright, the concentration needed to subtract 6:33 from a quarter to seven is such that I find I'm wide awake and the pleasure is lost; so I still squint bleary-eyed at my old fashioned watch.

Of course, my analogue mind lasts all day and, in common with the rest of the human race, I find it easier to absorb diagrammatic information than to interpret characters. But that little digital timepiece in the stem of my ball-point has one important advantage over the wrist watch. It is easy to read when holding the pen in the normal writing position.

This means that, when I get involved in one of those boring office meetings, I am able to keep track of the time without the more obvious frequent reference to my wrist watch. It is perfectly natural to look in the direction of one's pen when taking notes, and I can look as often as I like without upsetting anyone.

Terry Wogan has just announced that it is coming up to eighteen minutes to ten. Is that later than 9:41?

## STRANGER THAN FICTION

So it's arrived at last. There it is on the front page of the *Financial Times* complete with a full-size photograph – the world's first wristwatch television. Needless to say, it's Japanese; and i must admit it upstages my electronic ball point pen. It must have impressed the *FT*, because I cannot recall ever having seen a new-product photograph on the front page before.

According to the paper it is all made possible by the development of a liquid-crystal display with a matrix of 32,000 dots covering a 1.2-in screen. It says, "the tv is part of a slightly oversized electronic wristwatch with digital time display, calendar, stop-watch and alarm."

Fantastic; but how do they manage to pack the receiver circuit and all the video signal processing etc. into the wristwatch case? Well, actually, they don't. The watch tv is connected by a thin cable to a pocket-sized receiver unit, weighing just under half a pound, complete with batteries and all the normal controls. An earphone is also attached by a lightweight cable; so it seems that the wearer of the wristwatch tv must be wired for vision and sound.

The manufacturer expects to start mass production in Japan in six months' time, and perhaps we shall see them here in time for Wimbledon 1982. It should be fairly easy to spot the wristwatch television viewer out of doors watching the tennis. With a viewing screen about half the size of a 35mm negative, it will be necessary to hold it about eight inches from one's eyes to keep an eye on the ball; and, no doubt, an aerial will be needed for all but the highest field-strength areas, suggesting some interesting headgear.

So if, next July, you should see a man in the park with a deaf-aid and an antenna on his hat, staring intently at his wristwatch, you'll know what he's doing, won't you? You could be wrong, of course. If he talks to his wristwatch and then slowly fades away to nothing, it could mean that he's been "beamed up" to a 25th century space ship.

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3A/147J 7.50
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3A3A 3.00
3A4 1.10
3AL5 0.95
3AT2 1.75
3AW2 3.35
3B2 3.00
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6AG7 1.20
6AH6 1.00
6AJ4 2.00
6AJ7 2.00
6AK5 0.60
6AK6 2.00
6AL5 0.52
6AM4 2.50
6AM5 6.00
6AM6 1.20
6AN5 2.00
6AN8A 2.15
6AQ5 0.82
6AR5 2.00
6AR8 2.00
6AS5 1.50
6AS6 2.50
6AS7G 6.00
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6AU6 0.55
6AV6 0.72
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6B8G 0.75
6BA6 0.50
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6BA7 3.75
6BA8A 3.50
6BC8 1.00
6BD4 1.50
6BD6 1.00
6BE6 0.72
6BF5 1.10
6BG6G 1.25
6BF5 1.60
6BH6 1.60
6BH8 1.00
6BJ6 1.05
6BK4 2.75
6BK7A 1.50
6BM8 0.58
6BN4 1.25
6BN6 1.30
6BN7 3.50
6BN8 2.00
6BQ5 0.60
6BQ7A 0.72
6BL8 0.65
6BR5 0.70
6BR7 3.75
6BR8 1.20
6BR8A 1.20
6BS7 3.75
6BS8 1.88

6BW4 1.30
6BW6 4.50
6BW7 0.75
6BW8 4.00
6BX6 0.48
6BX7GT 2.00
6BZ6 2.00
6BZ7 2.50
6BZ8 0.95
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6C6 0.50
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6F17 3.00
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6F23 0.48
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6F25 1.25
6F28 1.25
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12K7GT 0.60
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12Q7GT 0.50
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12U7 1.50
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20P3 0.60
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30C15 0.40
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30C18 2.00
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30FL13 1.10
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|---|---|---|
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| | 2K2-6K8 | 0.18 |
| | 10K | 0.24 |
| 7 Watt | R47-4K7 | 0.18 |
| | 5K6-12K | 0.19 |
| | 15K-22K | 0.20 |
| 11 Watt | 1R-10K | 0.20 |
| | 15K-22K | 0.24 |
| 17 Watt | 1R-10K | 0.26 |
| | 15K-22K | 0.28 |

WW-2

## BASES ETC.

B7G 0.15
B7G Skirted 0.30
B8G 0.70
B9A 0.20
B9A Skirted 0.30
B10B 0.16
B13B 0.50
8 Pin DIL 0.10
14 Pin DIL 0.12
14 Pin DIL/Q 0.30
16 Pin DIL 0.15
OCTAL 0.35
CANS 0.27
B9A PCB 0.15
B5 0.75
B9G 0.75

## ZENER DIODES

**BZX61 0.15**
6V2 7V5 8V2 9V1 10V 11V 12V 13V 15V 16V 18V 20V 22V 24V 27V 30V 33V 36V 39V 47V 51V 56V 68V 75V

**BZY88 0.07**
2V7 3V 3V3 3V6 3V9 4V3 4V7 5V1 5V6 6V2 6V8 7V5 8V2 9V1 10V 11V 12V 13V 15V 18V 20V 24V 27V 30V

## THERMISTORS

VA1040 0.23
VA1056S 0.23
VA1104 0.70
VA8650 0.45
VA1097 0.25

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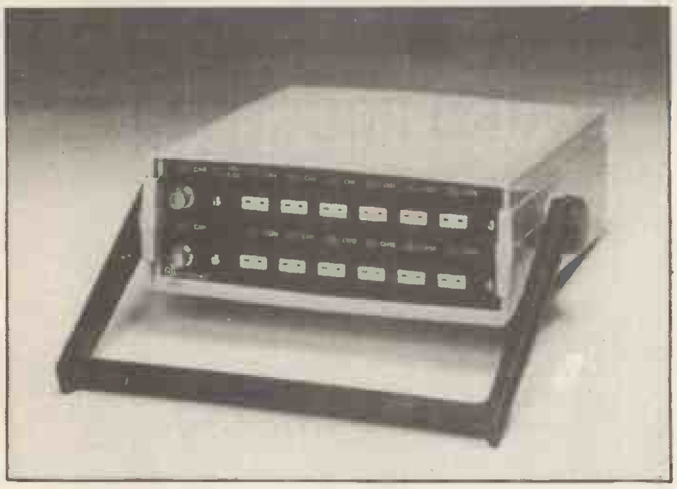
# PCI 1002 IEEE THERMOCOUPLE CONVERTER



The PCI 1002 is a 12 Channel IEEE compatible thermocouple converter having two input ranges of ± 10mV or ±100mV F.S.D. selected by an internal switch. It has 12 Bit resolution of the A to D converter giving a resolution of 0.06 deg.C on 10mV range and covers all common thermocouple types.

Cold Junction Compensation is provided giving a resolution of 0.2°C on 100mV range and 0.02°C on 10mV range.

Linearising software in Basic using optimised coefficients for ranges and thermocouple types.

Two other channels are provided via BNC input sockets on the front panel. Input ranges are I/V for 10 mV range and ±10V for 100mV range.

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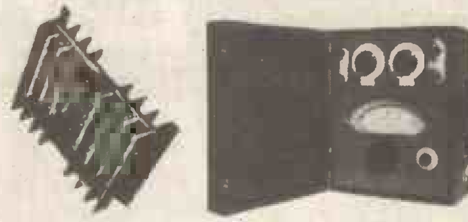

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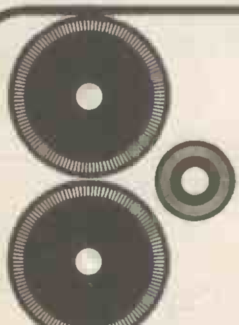

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Veco Electroforming Photo-etching Limited, one of the largest European suppliers of custom-designed electroformed and photo-etched components is now offering a range of "off the shelf" encoder discs.

These will enable small users to purchase at highly competitive prices and larger users to carry out initial development work and prototype manufacture prior to purchase of production quantities. In addition, these "off the shelf" designs can also be supplied in larger quantities for production with a relatively short delivery time.

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**Mark Space ratio** 1 to 1.
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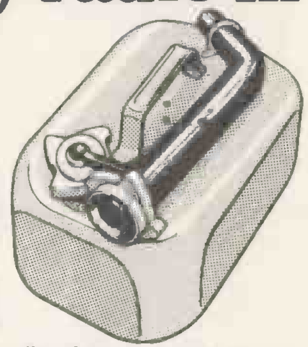

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A tough professional instrument you can trust – at a price you can afford! ★ Max. sensitivity 2mV/cm. ★ Stepped and continuously variable attenuator and timebase controls. ★ D.C. coupled triggering and "active" T.V. sync separator. ★ 'Add' and 'Invert' for differential measurements. ★ X-Y facility.
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GRAHAM BELL HOUSE, ROPER CLOSE, CANTERBURY CT2 7EP
Telephone Sales (0227) 54778 **Technical Only** (0227) 64723 Telex 965780

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**FOR YOUR FREE I.L.P. CATALOGUE AND OPEN UP TO A NEW WORLD OF QUALITY & VALUE**

To: I.L.P. ELECTRONICS LTD.
PLEASE SEND ME I.L.P. CATALOGUE, POST PAID BY RETURN

I HAVE/HAVE NOT PREVIOUSLY BUILT WITH I.L.P. MODULES

Name: ______________________

Address: ______________________

______________________

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*I.L.P. products are available also from Henry's, Marshall's, Technomatic & Watford.*

WW – 019 FOR FURTHER DETAILS

# HF ANTENNAS

★ MODE; Full half wave operation.

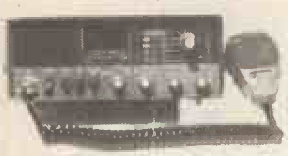
★ BANDS; Up to 4 spot frequencies.

★ POWER; Receive to 800W (PEP).

★ SWR; Better than 1.5:1 on channel.


### THE SMC TRAPPED DIPOLE ANTENNA

has been developed to satisfy the needs of commerical and military users. It is capable of operation between 2 and 30 MHz on as many as four spot frequencies – each capable of accommodating many channels. Excellent matching and efficiency with a single coaxial feed is offered by the use of SMC H1Q traps and the incorporation of a ferrite balun in a full half wave design. NB: Power absorbing terminating resistors are not employed. The antenna may be deployed using one or two support masts, installation (incorporating SMC light duty portable masts) can be easily effected by two people in half an hour.



**FT180 "PIONEER" HF SSB TRANSCEIVER.** 1.8-18MHz, 6 channels 100 watts RF output measuring only 95(H) x 240(W) x 310(D) mm and weighing 6kg. May be operated as a base or mobile transceiver, complementing our trap dipole and HW4 mobile aerials. **Prices start at £500**, making this unit not only very attractive but highly competitive.

**SOUTH MIDLANDS COMMUNICATIONS LTD.**

OSBORNE ROAD, TOTTON
SOUTHAMPTON SO4 4DN

Telex: 477351 SMCOMM G
Tel: Totton (0703) 867333

**WW – 094 FOR FURTHER DETAILS**

**Dwight Cavendish**

# So why do we put a protection circuit indicator on our amplifiers?


Well you see, the amplifier is inherently so robust that you might never know that it was operating into an adverse load, in fact it copes with anything in between a dead short and open circuit. And once you have corrected the load the amplifier automatically reverts to "normal" working.

This is just one of many features on our new range of 19" rack mounted or stand alone audio power amplifiers. The system comes complete in powers up to 500W with a variety of options and at a price which won't shock you.

For further details about our new range of f.e.t. amplifiers, drop us a line or phone 0480-215778.

Dwight Cavendish Company Limited,
Paxton Hall, Gt. North Rd, Lt Paxton, Huntingdon, Cambs PE19 4EL.
Tel 0480 215778 215753 Telex 32744 DWICAV G

Designers and manufacturers of electronic equipment, control systems and devices.

**WW – 082 FOR FURTHER DETAILS**

**TECHNOMATIC TECHNOMATIC TECHNOMATIC**

## CONNECTOR SYSTEMS

### I.D. CONNECTORS
(Speedblock Type)

| No. of Ways | Header Plug | Receptacle | Edge Conn. |
|---|---|---|---|
| 10 . . . | 90p | 90p | 200p |
| 20 . . . | 145p | 125p | 240p |
| 26 . . . | 175p | 150p | 300p |
| 34 . . . | 200p | 160p | 380p |
| 40 . . . | 220p | 190p | 550p |
| 50 . . . | 235p | 200p | 600p |

### D CONNECTORS

| | 9 way | 15way | 25way | 37way |
|---|---|---|---|---|
| MALE | | | | |
| Solder | 95p | 135p | 170p | 275p |
| Angled | 160p | 180p | 210p | 425g |
| FEMALE | | | | |
| Solder | 125p | 200p | 230p | 400p |
| Angled | 175p | 240p | 275p | 500p |
| Hood | 100p | 100p | 100p | 125p |

IDC Type 25 way M £4.50. P £5.00

### DIP PLUGS

| | Solder Type | IDC Type |
|---|---|---|
| 14 pin | 40p | 90p |
| 16 pin | 50p | 100p |
| 24 pin | 100p | 175p |
| 40 pin | 200p | 225p |

### FLAT CABLE
(Grey)

| | |
|---|---|
| 10 way | 60p |
| 14 way | 80p |
| 18 way | 90p |
| 20 way | 105p |
| 26 way | 140p |
| 34 way | 220p |
| 40 way | 265p |
| 50 way | 300p |
| 64 way | 370p |

### JUMPER LEADS
24" Cable with DIP Headers

| | 14 pin | 16 pin | 24 pin | 40 pin |
|---|---|---|---|---|
| 1 End | 145p | 165p | 240p | 380p |
| 2 Ends | 210p | 230p | 345p | 540p |

Cable with Sockets

| No. of Ways | 20 | 26 | 34 | 40 |
|---|---|---|---|---|
| 1 End | 160p | 210p | 270p | 300p |

Cable with D Connectors
24" Single End Male £5.50 Female £6
36" Double End Male £11 Female £11.50
36" Male/Female £11.00

### EDGE CONNECTORS

| | 0.1" | 0.156" |
|---|---|---|
| 2 × 18 way | – | 140p |
| 2 × 22 way | 200p | 170p |
| 2 × 23 way | 210p | – |
| 2 × 25 way | 225p | 220p |
| 1 × 43 way | 260p | – |
| 2 × 43 way | 395p | – |
| 1 × 77 way | 700p | – |

S-100 £6.00

### EURO CONNECTORS

| | Plug | Skt |
|---|---|---|
| DIN41612 2 × 32 | 260p | 330p |
| 2 × 32 Angled Pins | 330p | 400p |
| (pse specify a+b/a+c) | | |
| 3 × 32 way | 295p | 400p |
| IDC 2 × 32 way | a+b 475p | a+c 525p |
| DIN 41617 31 way | 180p | 180p |
| 21 way | 170p | 170p |

## ★ SPECIAL OFFER ★

| | 1–24 | 25–99 |
|---|---|---|
| 2114L-200nS | 100p | 90p |
| 2114L-450nS | 85p | 80p |
| 2716 (+5v) | 250p | 225p |
| 2532 | 375p | 350p |
| 2732 | 375p | 350p |
| 6116P-3 | 410p | 375p |

**OFFICIAL BBC STOCKIST**

**UPGRADE KIT MODEL A → MODEL B £65**

MEMORY PACK
8 x 4816AP-100nS
£21.60

PRINTER & USER PORTS
IC69,70 PL9, 10 £9.50
36" Printer Lead Complete £13.50

ANALOGUE PORT
IC73, SK6 £7.30

ALL BBC CONNECTORS AVAILABLE IN STOCK
SEND FOR OUR LEAFLET
Telephone for availability of Models A & B

## PRINTERS

SEIKOSHA GP100A Dot Matrix Printer, Full Graphics, double-width characters, up to 10" wide paper, self-testing parallel interface. £189+£6 Carr.

EPSON MX80 F/TIII. This is an upgrade of F/T2 featuring improved graphics, auto underline, super and subscripts. £340+£8 carr.

NEC PC 8023 BE-C 80 Cols. 100 CPS bi-directional, Logic seeking printer with forward reverse line feed, Hi-Res & Block Graphics, International and Greek charc. Auto-underline. £375+£8 carr.

FULL DETAILS ON REQUEST

## FLOPPY DISC DRIVES

Single TEAC FD 50A in cabinet with PSU £190+£6 Carr.
Two TEAC FD-50A in cabinet with PSU £360+£8 Carr.

**Single Drive for Apple II**

Siemens FDD 100-5 Drive housed in attractive case. Drive complete with track zero micro switch, motor control pcb, read, write and control electronics + cable £270+£6 carr.

## MONITORS

BMC 12" Green Screen 18MHz Bandwidth £99+£6 Carr.
BMC 14" Colour Monitor (25 x 40 chars.) £240+£6 Carr.

## SOFTY II EPROM PROGRAMMER

The complete microprocessor development system for both Engineers and Hobbyists. You can develop programs, debug, verify and commit them to EPROMs. Will accept most +5V EPROMs. Can also be used as a ROMULATOR. Full review in September, 1981 P.E. Built unit complete with PSU and TV lead £169.

## MENTA

A sophisticated Z80 development system and trainer. Direct interface to TV & cassette recorder. Powerful keyboard assembler and program debugging facility – ideal for both engineers and students. Audible feedback on keyboard input. Menta + PSU + TV Lead £115.

## UV ERASERS

UV1B up to 6 Eproms £47.50 UV1T with Timer £60
UV140 up to 14 Eproms £61.50 UV141 with Timer £78
(Carr. £2/eraser)
All erasers are fitted with mains switches and safety interlocks.

**TECHNOMATIC TECHNOMATIC TECHNOMATIC**

# COMPUTER COMPONENTS

## 74 SERIES

| | |
|---|---|
| 7400 | 11p |
| 7401 | 11p |
| 7402 | 12p |
| 7403 | 12p |
| 7404 | 12p |
| 7405 | 15p |
| 7406 | 20p |
| 7407 | 20p |
| 7408 | 14p |
| 7409 | 14p |
| 7410 | 14p |
| 7411 | 18p |
| 7412 | 18p |
| 7413 | 18p |
| 7414 | 20p |
| 7416 | 20p |
| 7417 | 20p |
| 7420 | 15p |
| 7421 | 20p |
| 7422 | 20p |
| 7423 | 20p |
| 7425 | 24p |
| 7426 | 28p |
| 7427 | 22p |
| 7428 | 26p |
| 7430 | 14p |
| 7432 | 22p |
| 7433 | 22p |
| 7437 | 25p |
| 7438 | 25p |
| 7439 | 25p |
| 7440 | 15p |
| 7441 | 70p |
| 7442A | 32p |
| 7443 | 90p |
| 7444 | 90p |
| 7445 | 50p |
| 7446A | 60p |
| 7447A | 36p |
| 7448 | 45p |
| 7450 | 15p |
| 7451 | 15p |
| 7453 | 15p |
| 7454 | 15p |
| 7460 | 15p |
| 7470 | 35p |
| 7472 | 25p |
| 7473 | 25p |
| 7474 | 20p |
| 7475 | 25p |
| 7476 | 30p |
| 7480 | 50p |
| 7482 | 70p |
| 7483A | 38p |
| 7484 | 65p |
| 7485 | 60p |
| 7486 | 20p |
| 7489 | 210p |
| 7490A | 20p |
| 7491 | 35p |
| 7492A | 25p |
| 7493A | 24p |
| 7494 | 35p |
| 7495A | 35p |
| 7496 | 40p |
| 7497 | 90p |
| 74100 | 80p |
| 74107 | 22p |
| 74109 | 25p |
| 74110 | 35p |
| 74111 | 55p |
| 74116 | 50p |
| 74118 | 60p |
| 74119 | 80p |
| 74120 | 60p |
| 74121 | 25p |
| 74122 | 40p |
| 74123 | 40p |
| 74125 | 34p |
| 74126 | 34p |
| 74128 | 35p |
| 74132 | 30p |
| 74136 | 28p |
| 74141 | 55p |
| 74142 | 200p |
| 74145 | 50p |
| 74147 | 90p |
| 74148 | 70p |
| 74150 | 50p |
| 74151A | 40p |
| 74153 | 40p |
| 74154 | 50p |
| 74155 | 40p |
| 74156 | 40p |
| 74157 | 30p |
| 74159 | 75p |
| 74160 | 60p |
| 74161 | 48p |
| 74162 | 48p |
| 74163 | 48p |
| 74164 | 48p |
| 74165 | 48p |
| 74166 | 48p |
| 74170 | 120p |
| 74172 | 275p |
| 74173 | 60p |
| 74174 | 55p |
| 74175 | 50p |
| 74176 | 40p |
| 74177 | 45p |
| 74178 | 80p |
| 74179 | 80p |
| 74180 | 40p |
| 74181 | 115p |
| 74182A | 60p |
| 74184A | 90p |
| 74185 | 90p |
| 74186 | 500p |
| 74188 | 250p |
| 74190 | 48p |
| 74191 | 48p |
| 74192 | 48p |
| 74193 | 48p |
| 74194 | 48p |
| 74195 | 48p |
| 74196 | 48p |
| 74197 | 48p |
| 74198 | 85p |
| 74199 | 85p |
| 74221 | 55p |
| 74251 | 70p |
| 74259 | 140p |
| 74265 | 55p |
| 74273 | 140p |
| 74276 | 110p |
| 74278 | 100p |
| 74279 | 50p |
| 74283 | 55p |
| 74284 | 175p |
| 74285 | 175p |
| 74290 | 100p |
| 74293 | 100p |
| 74298 | 100p |
| 74365 | 40p |
| 74366 | 40p |
| 74367 | 40p |
| 74368 | 50p |
| 74390 | 75p |
| 74393 | 100p |
| 74490 | 95p |

## 74LS SERIES

| | |
|---|---|
| 74LS00 | 11p |
| 74LS01 | 11p |
| 74LS02 | 12p |
| 74LS03 | 12p |
| 74LS04 | 12p |
| 74LS05 | 12p |
| 74LS08 | 12p |
| 74LS09 | 12p |
| 74LS10 | 12p |
| 74LS11 | 13p |
| 74LS12 | 13p |
| 74LS13 | 20p |
| 74LS14 | 34p |
| 74LS15 | 12p |
| 74LS20 | 12p |
| 74LS21 | 12p |
| 74LS22 | 12p |
| 74LS26 | 12p |
| 74LS27 | 14p |
| 74LS28 | 15p |
| 74LS30 | 12p |
| 74LS32 | 14p |
| 74LS33 | 15p |
| 74LS37 | 15p |
| 74LS38 | 15p |
| 74LS42 | 30p |
| 74LS47 | 36p |
| 74LS48 | 45p |
| 74LS51 | 14p |
| 74LS54 | 22p |
| 74LS55 | 15p |
| 74LS63 | 120p |
| 74LS73 | 18p |
| 74LS74 | 16p |
| 74LS75 | 18p |
| 74LS76 | 18p |
| 74LS83 | 38p |
| 74LS85 | 50p |
| 74LS86 | 18p |
| 74LS90 | 24p |
| 74LS91 | 70p |
| 74LS92 | 32p |
| 74LS93 | 24p |
| 74LS95 | 40p |
| 74LS96 | 50p |
| 74LS107 | 40p |
| 74LS109 | 27p |
| 74LS112 | 22p |
| 74LS113 | 22p |
| 74LS114 | 22p |
| 74LS122 | 36p |
| 74LS123 | 34p |
| 74LS124 | 90p |
| 74LS125 | 24p |
| 74LS126 | 25p |
| 74LS132 | 40p |
| 74LS133 | 30p |
| 74LS136 | 25p |
| 74LS138 | 30p |
| 74LS139 | 30p |
| 74LS145 | 70p |
| 74LS147 | 160p |
| 74LS148 | 75p |
| 74LS151 | 40p |
| 74LS153 | 40p |
| 74LS154 | 90p |
| 74LS155 | 32p |
| 74LS156 | 36p |
| 74LS157 | 27p |
| 74LS158 | 30p |
| 74LS160 | 36p |
| 74LS161 | 36p |
| 74LS162 | 36p |
| 74LS163 | 36p |
| 74LS164 | 40p |
| 74LS165 | 60p |
| 74LS166 | 65p |
| 74LS168 | 85p |
| 74LS169 | 85p |
| 74LS170 | 75p |
| 74LS173 | 60p |
| 74LS174 | 40p |
| 74LS175 | 40p |
| 74LS181 | 100p |
| 74LS183 | 180p |
| 74LS190 | 40p |
| 74LS191 | 40p |
| 74LS192 | 40p |
| 74LS193 | 40p |
| 74LS194 | 35p |
| 74LS195 | 35p |
| 74LS196 | 48p |
| 74LS197 | 80p |
| 74LS221 | 50p |
| 74LS240 | 55p |
| 74LS241 | 55p |
| 74LS242 | 55p |
| 74LS243 | 55p |
| 74LS244 | 60p |
| 74LS245 | 75p |
| 74LS247 | 50p |
| 74LS248 | 55p |
| 74LS249 | 55p |
| 74LS251 | 35p |
| 74LS253 | 35p |
| 74LS257 | 35p |
| 74LS258 | 35p |
| 74LS259 | 60p |
| 74LS260 | 20p |
| 74LS266 | 20p |
| 74LS273 | 60p |
| 74LS275 | 225p |
| 74LS279 | 35p |
| 74LS280 | 160p |
| 74LS283 | 40p |
| 74LS290 | 45p |
| 74LS293 | 40p |
| 74LS295 | 90p |
| 74LS297 | 500p |
| 74LS298 | 90p |
| 74LS299 | 250p |
| 74LS323 | 175p |
| 74LS324 | 150p |
| 74LS348 | 120p |
| 74LS352 | 80p |
| 74LS353 | 80p |
| 74LS356 | 250p |
| 74LS363 | 140p |
| 74LS364 | 140p |
| 74LS365 | 30p |
| 74LS367 | 30p |
| 74LS368 | 30p |
| 74LS373 | 60p |
| 74LS374 | 60p |
| 74LS375 | 45p |
| 74LS377 | 60p |
| 74LS378 | 60p |
| 74LS390 | 50p |
| 74LS393 | 45p |
| 74LS395 | 90p |
| 74LS399 | 160p |
| 74LS445 | 100p |
| 74LS490 | 200p |
| 74LS540 | 75p |
| 74LS541 | 100p |
| 74LS624 | 150p |
| 74LS629 | 180p |
| 74LS640 | 160p |
| 74LS641 | 170p |
| 74LS643 | 200p |
| 74LS644 | 250p |
| 74LS645 | 160p |
| 74LS668 | 120p |
| 74LS669 | 120p |
| 74LS670 | 140p |
| 74LS678 | 550p |
| 74LS682 | 400p |
| 74LS684 | 400p |

## 74S SERIES

| | |
|---|---|
| 74S00 | 40p |
| 74S02 | 40p |
| 74S04 | 40p |
| 74S05 | 75p |
| 74S08 | 75p |
| 74S10 | 80p |
| 74S11 | 60p |
| 74S20 | 60p |
| 74S30 | 60p |
| 74S32 | 90p |
| 74S37 | 60p |
| 74S74 | 90p |
| 74S85 | 300p |
| 74S86 | 180p |
| 74S112 | 90p |
| 74S113 | 90p |
| 74S114 | 90p |
| 74S124 | 300p |
| 74S132 | 160p |
| 74S133 | 75p |
| 74S138 | 175p |
| 74S139 | 225p |
| 74S157 | 250p |
| 74S163 | 300p |
| 74S174 | 250p |
| 74S175 | 320p |
| 74S188 | 250p |
| 74S189 | 350p |
| 74S194 | 350p |
| 74S200 | 450p |
| 74S201 | 400p |
| 74S225 | 550p |
| 74S241 | 400p |
| 74S260 | 70p |
| 74S261 | 300p |
| 74S262 | £10 |
| 74S287 | 300p |
| 74S288 | 225p |
| 74S373 | 400p |
| 74S374 | 400p |
| 74S471 | 650p |
| 74S474 | 400p |
| 74S571 | 900p |
| 74S573 | 900p |

## 4000 CMOS

| | |
|---|---|
| 4000 | 10p |
| 4001 | 10p |
| 4002 | 12p |
| 4006 | 50p |
| 4007 | 15p |
| 4008 | 40p |
| 4009 | 24p |
| 4010 | 24p |
| 4011 | 11p |
| 4012 | 16p |
| 4013 | 23p |
| 4014 | 48p |
| 4015 | 45p |
| 4016 | 20p |
| 4017 | 36p |
| 4018 | 45p |
| 4019 | 25p |
| 4020 | 48p |
| 4021 | 48p |
| 4022 | 45p |
| 4023 | 15p |
| 4024 | 32p |
| 4025 | 15p |
| 4026 | 80p |
| 4027 | 22p |
| 4028 | 45p |
| 4029 | 50p |
| 4030 | 20p |
| 4031 | 125p |
| 4032 | 80p |
| 4033 | 125p |
| 4034 | 140p |
| 4035 | 60p |
| 4036 | 275p |
| 4038 | 110p |
| 4040 | 48p |
| 4041 | 50p |
| 4042 | 44p |
| 4043 | 50p |
| 4044 | 45p |
| 4045 | 105p |
| 4046 | 50p |
| 4047 | 45p |
| 4048 | 50p |
| 4049 | 24p |
| 4050 | 24p |
| 4051 | 45p |
| 4052 | 60p |
| 4053 | 50p |
| 4054 | 90p |
| 4055 | 90p |
| 4056 | 90p |
| 4059 | 450p |
| 4060 | 55p |
| 4063 | 100p |
| 4066 | 27p |
| 4067 | 250p |
| 4068 | 14p |
| 4069 | 14p |
| 4070 | 14p |
| 4071 | 14p |
| 4072 | 14p |
| 4073 | 14p |
| 4075 | 14p |
| 4076 | 48p |
| 4077 | 16p |
| 4078 | 16p |
| 4081 | 14p |
| 4082 | 15p |
| 4086 | 55p |
| 4089 | 150p |
| 4093 | 24p |
| 4094 | 90p |
| 4095 | 75p |
| 4096 | 70p |
| 4097 | 290p |
| 4098 | 90p |
| 4099 | 100p |
| 4501 | 28p |
| 4502 | 60p |
| 4503 | 40p |
| 4504 | 75p |
| 4506 | 35p |
| 4507 | 35p |
| 4508 | 140p |
| 4510 | 30p |
| 4511 | 48p |
| 4512 | 48p |
| 4514 | 120p |
| 4515 | 120p |
| 4516 | 60p |
| 4518 | 40p |
| 4520 | 60p |
| 4521 | 120p |
| 4526 | 60p |
| 4527 | 60p |
| 4528 | 50p |
| 4532 | 70p |
| 4534 | 470p |
| 4536 | 300p |
| 4538 | 90p |
| 4539 | 90p |
| 4543 | 75p |
| 4553 | 270p |
| 4555 | 35p |
| 4556 | 35p |
| 4560 | 170p |
| 4566 | 170p |
| 4568 | 300p |
| 4569 | 180p |
| 4572 | 30p |
| 4583 | 90p |
| 4584 | 40p |
| 4585 | 100p |
| 40014 | 90p |
| 40085 | 90p |
| 40097 | 50p |
| 40102 | 150p |
| 40103 | 180p |
| 40105 | 120p |
| 40106 | 40p |
| 40109 | 100p |
| 40110 | 280p |
| 40163 | 75p |
| 40174 | 75p |
| 40175 | 75p |
| 40193 | 75p |
| 40244 | 180p |
| 40245 | 250p |
| 40373 | 180p |
| 40374 | 180p |
| 4495 | 300p |
| 14500 | 700p |
| 14568 | 200p |
| 14569 | 250p |
| 14599 | 290p |

## ECLs

| | |
|---|---|
| MC4024 | 325p |
| MC4044 | 325p |
| MC10116 | 70p |
| MC10231 | 350p |

## COUNTERS

| | |
|---|---|
| 74C925 | £4 |
| 74C928 | £6 |
| 7216B | £16 |
| 2N1040 | 670p |

## LINEAR ICs

| | |
|---|---|
| ADC0808 | 990p |
| AN103 | 200p |
| AY1-0212 | 600p |
| AY1-1313 | 668p |
| AY1-1320 | 320p |
| AY1 5050 | 140p |
| AY3-1270 | 825p |
| AY3-1350 | 400p |
| AY3-8910 | 550p |
| AY3-8912 | 650p |
| AY5-3600 | 600p |
| AY5-4007D | 520p |
| CA3028 | 120p |
| CA3019 | 80p |
| CA3046 | 70p |
| CA3048 | 225p |
| CA3059 | 300p |
| CA3060 | 350p |
| CA3080E | 72p |
| CA3086 | 48p |
| CA3089E | 200p |
| CA3090AQ | 375p |
| CA3130E | 90p |
| CA3130T | 130p |
| CA3140E | 50p |
| CA3160E | 100p |
| CA3161E | 175p |
| CA3162E | 450p |
| CA3189E | 300p |
| CA3240E | 120p |
| CA3280G | 200p |
| D7002 | 480p |
| DAC1408-8 | 200p |
| HA1366 | 195p |
| HA1388 | 270p |
| ICL7106 | 850p |
| ICL7660 | 200p |
| ICL8038 | 300p |
| ICM7216B | £16 |
| ICM7217 | 750p |
| ICM7555 | 80p |
| ICL7611 | 90p |
| LC7120 | 325p |
| LC7130 | 325p |
| LF347 | 100p |
| LF351 | 48p |
| LF353 | 100p |
| LF356P | 95p |
| LF357 | 120p |
| LF13331 | 150p |
| LM10C | 425p |
| LM301A | 27p |
| LM310 | 120p |
| LM311 | 75p |
| LM318 | 150p |
| LM319 | 225p |
| LM324 | 30p |
| LM334Z | 100p |
| LM335Z | 140p |
| LM339 | 50p |
| LM348 | 75p |
| LM358P | 60p |
| LM377 | 175p |
| LM380 | 75p |
| LM381AN | 180p |
| LM382 | 120p |
| LM386 | 90p |
| LM387 | 120p |
| LM389 | 95p |
| LM391 | 150p |
| LM392N | 60p |
| LM393 | 100p |
| LM394CH | 300p |
| LM709 | 36p |
| LM710 | 50p |
| LM711 | 70p |
| LM725 | 400p |
| LM733 | 70p |
| LM741 | 18p |
| LM747 | 70p |
| LM748 | 35p |
| LM1014 | 150p |
| LM1801 | 300p |
| LM1830 | 250p |
| LM1871 | 450p |
| LM1872 | 450p |
| LM1886 | 700p |
| LM1889 | 350p |
| LM2917 | 200p |
| LM3302 | 90p |
| LM3900 | 50p |
| LM3909 | 95p |
| LM3911 | 130p |
| LM3914 | 210p |
| LM3915 | 225p |
| LM3916 | 225p |
| LM13600 | 110p |
| M51513L | 300p |
| M51516L | 500p |
| MB3712 | 200p |
| MB3730 | 400p |
| MC1310P | 150p |
| MC1445 | 250p |
| MC1458 | 40p |
| MC1493 | 100p |
| MC1495L | 350p |
| MC1496 | 70p |
| MC3340P | 120p |
| MC3401 | 90p |
| MC3403 | 75p |
| MC3480 | 600p |
| MK50938 | 750p |
| ML920 | 800p |
| MM57160 | 620p |
| MN6221A | 600p |
| NE531 | 150p |
| NE555 | 18p |
| NE556 | 50p |
| NE564 | 420p |
| NE565 | 130p |
| NE566 | 155p |
| NE567 | 140p |
| NE570 | 375p |
| NE571 | 375p |
| NE5534A | 150p |
| PLL02A | 500p |
| RC4136 | 60p |
| RC4151 | 200p |
| S566B | 260p |
| SAA1900 | 1600p |
| SAD1024A | 850p |
| SFF96364 | 800p |
| SL490 | 350p |
| SN76477 | 480p |
| SN76488 | 450p |
| SN87489 | 400p |
| SN76495 | 400p |
| SP8515 | 750p |
| TA7120 | 160p |
| TA7204 | 200p |
| TA7205 | 90p |
| TA7222 | 160p |
| TA7310 | 160p |
| TBA641AX1 | 275p |
| TBA641BX1 | 300p |
| TBA651 | 200p |
| TBA800 | 90p |
| TBA810 | 100p |
| TBA820 | 90p |
| TBA920 | 200p |
| TBA950 | 225p |
| TC9109 | 900p |
| TCA210 | 350p |
| TCA220 | 350p |
| TCA940 | 175p |
| TDA1004A | 300p |
| TDA1008 | 320p |
| TDA1010 | 225p |
| TDA1022 | 520p |
| TDA1024 | 120p |
| TDA1034B | 250p |
| TDA1170 | 300p |
| TDA2002V | 325p |
| TDA2006 | 350p |
| TDA2020 | 320p |
| TLO64 | 100p |
| TL071/81 | 25p |
| TL072/82 | 45p |
| TL074 | 100p |
| TL083 | 75p |
| TL084 | 90p |
| TL094 | 200p |
| TL170 | 50p |
| TL430C | 70p |
| UA1003-3 | 950p |
| UA2240 | 150p |
| UAA170 | 170p |
| ULN2003 | 100p |
| ULN2004 | 75p |
| ULN2068 | 290p |
| ULN2802 | 200p |
| UPC575 | 275p |
| UPC592H | 200p |
| UPC1156H | 275p |
| XR2206 | 300p |
| XR2207 | 400p |
| XR2211 | 600p |
| XR2216 | 675p |
| ZN414 | 90p |
| ZN419C | 225p |
| ZN423E | 150p |
| ZN424E | 135p |
| ZN425E | 350p |
| ZN426E | 350p |
| ZN427E | 625p |
| ZN428E | 500p |
| ZN1034E | 200p |
| ZN1040E | 670p |
| ZNA234 | 850p |

## CPUs

| | |
|---|---|
| 1802CE | 700p |
| 2650A | £12 |
| 6502 | 400p |
| 6502A | 500p |
| 6800 | 300p |
| 6802 | 350p |
| 68B02 | 790p |
| 6809 | 850p |
| 68B09 | £14 |
| 6809E | £15 |
| 8035 | 350p |
| 8039 | 300p |
| 8080A | 280p |
| 8085A | 350p |
| 1NS8060 | £11 |
| TMS9980 | £20 |
| Z8 | £24 |
| Z80 | 320p |
| Z80A | 360p |
| Z80B | £15 |
| 8088 | £18 |
| Z80P10 | 280p |
| Z80AP10 | 300p |
| Z80CTC | 280p |
| Z80ACTC | 300p |
| Z80ADART | 800p |
| Z80ADMA | £10 |
| Z80S10/1/2 | £9 |

## SUPPORT DEVICES

| | |
|---|---|
| 3242 | 800p |
| 3245 | 450p |
| 6520 | 280p |
| 6522 | 350p |
| 6522A | 650p |
| 6532 | 600p |
| 6551 | 650p |
| 6821 | 120p |
| 68B21 | 220p |
| 6840 | 400p |
| 68B40 | 600p |
| 6850 | 140p |
| 68B50 | 220p |
| 6852 | 370p |
| 6854 | 700p |
| 68B54 | 800p |
| 6875 | 600p |
| 8154 | 950p |
| 8155 | 350p |
| 8156 | 350p |
| 8205 | 225p |
| 8212 | 110p |
| 8216 | 100p |
| 8224 | 110p |
| 8226 | 250p |
| 8228 | 220p |
| 8243 | 280p |
| 8250 | 850p |
| 8251 | 250p |
| 8253 | 350p |
| 8255 | 250p |
| 8256 | £36 |
| 8257 | 400p |
| 8259 | 400p |
| 8279 | 440p |
| 8284 | 350p |
| 8288 | £11 |
| 3755 | £16 |
| IMS9918 | £60 |

## MEMORIES

| | |
|---|---|
| 21014A | 400p |
| 2102-3L | 120p |
| 2107B | 500p |
| 2111A | 300p |
| 2112-A | 300p |
| 2114-2L | 100p |
| 2147 | 450p |
| 4027-3 | 300p |
| 4044-45 | 450p |
| 4116-15 | 100p |
| 4116-20 | 90p |
| 4118-3 | 500p |
| 4164-2 | 600p |
| 4816AP-3 | 280p |
| 5101 | 300p |
| 5516 | 900p |
| 6116P-3 | 500p |
| 6116LP-3 | 750p |
| 6514-45 | 300p |
| 6810 | 120p |
| 7489 | 210p |
| 74S189 | 325p |
| 74S201 | 350p |
| 74S289 | 325p |
| 93415 | 600p |
| 93425 | 600p |

## ROMs/PROMs

| | |
|---|---|
| 74S188 | 225p |
| 74S287 | 308p |
| 74S288 | 225p |
| 74S387 | 325p |
| 74S471 | 650p |
| 74S473 | 850p |
| 74S474 | 650p |
| 74S570 | 650p |
| 74S571 | 650p |
| 74S573 | 950p |

## EPROMs

| | |
|---|---|
| 2516(+5v) | 255p |
| 2532 | 450p |
| 2564 | £25 |
| 2708 | 250p |
| 2716(+5v) | 250p |
| 2732 | 450p |
| 2716(350ns) | 500p |
| 2732(350ns) | 750p |
| TMS2716 | 750p |

## CRT CONTROLLER

| | |
|---|---|
| CRT6545 | 950p |
| CRT5027 | £18 |
| CRT5037 | £18 |
| EF9365 | £60 |
| MC6845 | 700p |
| MC6847 | 825p |
| SFF96364 | £8 |
| TMS9918 | £60 |
| TMS9927 | £18 |

## INTERFACE ICs

| | |
|---|---|
| AD558CJ | 775p |
| AD561J | £14 |
| AM25S10 | 350p |
| AM25LS2521 | £2 |
| AM26LS31 | 125p |
| AM26LS32 | 125p |
| COM8116 | 800p |
| D7002 | 480p |
| DAC80 | £20 |
| DM8131 | 375p |
| DP8304 | 460p |
| DS3691 | 400p |
| DS8830 | 140p |
| DS8831 | 140p |
| DS8832 | 250p |
| DS8833 | 225p |
| DS8836 | 150p |
| DS8838 | 225p |
| LF13201 | 450p |
| MC1488 | 55p |
| MC1489 | 55p |
| MC3418 | 950p |
| MC3446 | 300p |
| MC3480 | 850p |
| MC3486 | 500p |
| MC3487 | 300p |
| MC4024 | 325p |
| MC4044 | 325p |
| MC14411 | 675p |
| MC14412 | 900p |
| ULN2003A | 100p |
| ULN2004A | 100p |
| 75107 | 160p |
| 75110/12 | 160p |
| 75114/15 | 160p |
| 75121/22 | 140p |
| 75150P | 140p |
| 75154 | 140p |
| 75182 | 230p |
| 75324 | 375p |
| 75361 | 150p |
| 75363 | 150p |
| 75365 | 150p |
| 75451/2 | 72p |
| 75453/4 | 72p |
| 75491/2 | 70p |
| 8T26 | 120p |
| 8T28 | 120p |
| 8T95/96 | 90p |
| 8T97/98 | 90p |
| 81LS95/96 | 90p |
| 81LS97/98 | 90p |
| 81LS95 | 90p |
| 81LS96 | 90p |
| 81LS97 | 90p |
| 81LS98 | 90p |
| 9602 | 220p |
| 9637AP | 160p |
| ZN425E-8 | 350p |
| ZN426E-8 | 350p |
| ZN427E-8 | 650p |
| ZN428E-8 | 500p |

## DISC CONTROL ICs

| | |
|---|---|
| FD1771 | £20 |
| FD1791 | £30 |
| FD1793 | £32 |
| FD1795 | £35 |
| FD1797 | £37 |
| WD1691 | £15 |
| WD2143 | 550p |

## CHARACTER GENERATORS

| | |
|---|---|
| RO-3-2513UC | 750p |
| RO-3-2513LC | 700p |
| SN74S262AN | £10 |

## KEYBOARD ENCODER

| | |
|---|---|
| AY5-2376 | 700p |
| 74C922 | 500p |

## BAUD RATE GENERATORS

| | |
|---|---|
| MC14411 | 700p |
| COM8116 | 800p |
| 4702B | 750p |

## UARTs

| | |
|---|---|
| AY-3-1015P | 300p |
| AY-5-1013P | 300p |
| COM8017 | 300p |
| IM6402 | 450p |
| TR1602 | 300p |

## ZIF SKTS

(TEX TOOL)

| | |
|---|---|
| 24 pin | 600p |
| 28 pin | 800p |
| 40 pin | £10 |

## MODULATORS

| | |
|---|---|
| 6MHz UHF | 375p |
| 8MHz UHF | 450p |

## CRYSTALS

| | |
|---|---|
| 32.768KHz | 100p |
| 100KHz | 250p |
| 200KHz | 280p |
| Freq in MHz | |
| 1.0 | 290p |
| 1.008 | 275p |
| 1.5 | 450p |
| 1.8432 | 210p |
| 2.00 | 225p |
| 2.45760 | 210p |
| 2.5 | 250p |
| 2.662 | 250p |
| 3.276 | 150p |
| 3.5795 | 100p |
| 3.686 | 300p |
| 4.00 | 150p |
| 4.194 | 200p |
| 4.43 | 110p |
| 4.608 | 250p |
| 4.915 | 250p |
| 5.0 | 175p |
| 6.0 | 150p |
| 6.144 | 150p |
| 7.0 | 150p |
| 7.168 | 175p |
| 8.00 | 175p |
| 8.86 | 175p |
| 10.00 | 175p |
| 10.5 | 250p |
| 10.7 | 150p |
| 12.00 | 150p |
| 14.318 | 175p |
| 14.756 | 250p |
| 15.00 | 200p |
| 16.00 | 200p |
| 18.00 | 200p |
| 18.432 | 150p |
| 19.968 | 150p |
| 20.00 | 200p |
| 26.690 | 150p |
| 27.145 | 200p |
| 38.6667 | 175p |
| 48.0 | 175p |
| 55.5 | 400p |
| 116 | 300p |
| 145.80 | 250p |

## DIL SWITCHES

| | |
|---|---|
| 4 way | 70p |
| 6 way | 85p |
| 8 way | 90p |
| 10 way | 145p |

## TELETEXT DECODER

| | |
|---|---|
| SAA5020 | 600p |
| SAA5030 | 900p |
| SAA5041 | £16 |
| SAA5050 | 900p |

## VOLTAGE REGULATORS

FIXED PLASTIC

| 1A | +ve | | -ve | |
|---|---|---|---|---|
| 5V | 7805 | 45p | 7905 | 50p |
| 6V | 7806 | 50p | 7906 | 60p |
| 8V | 7808 | 50p | 7908 | 60p |
| 12V | 7812 | 50p | 7912 | 50p |
| 15V | 7815 | 50p | 7915 | 50p |
| 18V | 7818 | 50p | 7918 | 60p |
| 24V | 7824 | 50p | 7924 | 60p |
| 5V 100mA | 78L05 | 30p | 79L05 | 60p |
| 6V 100mA | 78L06 | 30p | | |
| 8V 100mA | 78L08 | 30p | | |
| 12V 100mA | 78L12 | 30p | 79L12 | 60p |
| 15V 100mA | 78L15 | 30p | 79L15 | 60p |

## OTHER REGULATORS

| | | | |
|---|---|---|---|
| LM309K 1A 5V | 140p | 78HGKC | 600p |
| LM317K T03 | 325p | 78HO5KC | 550p |
| LM317T | 200p | 78GUIC | 200p |
| LM337T | 225p | 79GUIC | 225p |
| LM323K 3A 5V | 500p | 79HGKC | 700p |
| LM723 150mA Adj | 37p | ICL 7660 | 200p |
| | | TL497 | 300p |
| TL494 | 400p | LM305AH | 250p |
| 78S40 | 225p | 78H12 | 600p |
| 78P05 | 900p | SG3524 | 300p |

## OPTO-ELECTRONICS

| | | | |
|---|---|---|---|
| 2N5777 | 45p | ORP60 | 120p |
| OCP71 | 180p | ORP61 | 120p |
| ORP12 | 120p | TIL78 | 55p |
| | | TIL31A | 120p |
| | | TIL81 | 90p |
| | | TIL100 | 75p |

## OPTO ISOLATORS

| | | | |
|---|---|---|---|
| ILD74 | 130p | TIL111 | 90p |
| MCT26 | 100p | TIL112 | 90p |
| MCS2400 | 190p | TIL113 | 90p |
| ILQ74 | 240p | TIL116 | 90p |

## LEDS

| | | | |
|---|---|---|---|
| 0.125" | | 0.2" | |
| TIL32 | 55p | TIL220 Red | 12p |
| TIL209 Red | 11p | TIL222 Gr | 15p |
| TIL211 Gr | 16p | TIL228 Ye | 22p |
| TIL212 Ye | 18p | Rectangular LEDs(R,G,Y) | 30p |
| TIL216 R | 18p | | |

## DISPLAYS

| | | | |
|---|---|---|---|
| DL704 | 140p | NSB5881 | 570p |
| DL707 Red | 140p | TIL311 | 600p |
| FND357 | 120p | TIL312/3 | 110p |
| FND500 | 90p | TIL321/3 | 130p |
| FND507 | 90p | TIL330 | 140p |
| MAN3640 | | 7750/60 | 200p |
| MAN4640 | 200p | | |

## DRIVERS

| | |
|---|---|
| 9368 | 250p |
| 9370 | 300p |

## LOW PROFILE SOCKETS BY TI

| | | | | | |
|---|---|---|---|---|---|
| 8 pin | 9p | 18 pin | 16p | 24 pin | 24p |
| 14 pin | 10p | 20 pin | 18p | 28 pin | 26p |
| 16 pin | 11p | 22 pin | 22p | 40 pin | 30p |

## WIRE WRAP SOCKETS BY TEXAS

| | | | | | |
|---|---|---|---|---|---|
| 8 pin | 25p | 18 pin | 50p | 24 pin | 70p |
| 14 pin | 35p | 20 pin | 60p | 28 pin | 80p |
| 16 pin | 40p | 22 pin | 65p | 40 pin | 100p |

## TRANSISTORS

| | |
|---|---|
| AD161/2 | 45p |
| BC107/8 | 13p |
| BC109C | 14p |
| BC117 | 20p |
| BC147/8 | 9p |
| BC149 | 10p |
| BC157/8 | 10p |
| BC159 | 11p |
| BC169C | 12p |
| BC172 | 12p |
| BC177/8 | 17p |
| BC179 | 18p |
| BC182/3 | 10p |
| BC184 | 11p |
| BC187 | 30p |
| BC212/3 | 11p |
| BC214 | 12p |
| BC237 | 15p |
| BC327 | 16p |
| BC337 | 16p |
| BC338 | 16p |
| BC461 | 25p |
| BC477/8 | 30p |
| BC516/7 | 40p |
| BC547B | 14p |
| BC548C | 12p |
| BC549C | 16p |
| BC557B | 14p |
| BC559C | 16p |
| BCY70 | 18p |
| BCY71 | 22p |
| BD131 | 75p |
| BD132 | 50p |
| BD135/6 | 40p |
| BD139 | 40p |
| BD140 | 40p |
| BD189 | 60p |
| BD232 | 60p |
| BD233 | 75p |
| BD235 | 85p |
| BD241 | 60p |
| BD242 | 60p |
| BD379 | 60p |
| BD380 | 60p |
| BD677 | 40p |
| BF244B | 35p |
| BF256B | 50p |
| BF257/8 | 32p |
| BF337 | 30p |
| BFR39 | 25p |
| BFR40/1 | 25p |
| BFR79 | 25p |
| BFR80/1 | 25p |
| BFR96 | 180p |
| BFX29 | 40p |
| BFX30 | 27p |
| BFX84/5 | 40p |
| BFX86/7 | 27p |
| BFX88 | 27p |
| BFX89 | 180p |
| BFY50 | 24p |
| BFY51/2 | 24p |
| BFY56 | 33p |
| BFY90 | 80p |
| BRY39 | 45p |
| BSX19/20 | 24p |
| BU104 | 225p |
| BU105 | 190p |
| BU108 | 250p |
| BU109 | 225p |
| BU126 | 150p |
| BU180A | 120p |
| BU205 | 200p |
| BU208 | 200p |
| BU406 | 145p |
| BUX80 | 600p |
| BUY69C | 350p |
| E310 | 50p |
| MJ802 | 400p |
| MJ2501 | 225p |
| MJ2955 | 90p |
| MJ3001 | 225p |
| MJ4502 | 400p |
| MJE340 | 60p |
| MJE2955 | 100p |
| MJE3055 | 70p |
| MPF102 | 40p |
| MPF103/4 | 30p |
| MPF105 | 30p |
| MPSA06 | 30p |
| MPSA12 | 50p |
| MPSA13 | 50p |
| MPSA20 | 50p |
| MPSA42 | 50p |
| MPSA43 | 50p |
| MPSA56 | 32p |
| MPSA70 | 50p |
| MPSA93 | 40p |
| MPSU06 | 63p |
| MPSU07 | 60p |
| MPSU45 | 90p |
| MPSU65 | 78p |
| TIP29A | 35p |
| TIP29C | 40p |
| TIP30A | 35p |
| TIP30C | 40p |
| TIP31A | 40p |
| TIP31C | 45p |
| TIP32A | 45p |
| TIP32C | 40p |
| TIP33A | 75p |
| TIP33C | 80p |
| TIP34A | 90p |
| TIP34C | 120p |
| TIP35A | 120p |
| TIP35C | 140p |
| TIP36A | 140p |
| TIP36C | 150p |
| TIP41A | 50p |
| TIP41C | 55p |
| TIP42A | 60p |
| TIP42C | 65p |
| TIP54 | 160p |
| TIP120 | 75p |
| TIP121 | 75p |
| TIP122 | 80p |
| TIP142 | 120p |
| TIP147 | 120p |
| TIP2955 | 78p |
| TIP4055 | 70p |
| TIS93 | 30p |
| ZTX108 | 12p |
| ZTX300 | 13p |
| ZTX452 | 45p |
| ZTX500 | 15p |
| ZTX502 | 16p |
| ZTX504 | 18p |
| ZTX552 | 55p |
| ZTX652 | 60p |
| ZTX752 | 70p |
| VN66AF | 70p |
| VN10KM | 60p |
| VN66 | 80p |
| 2N697 | 25p |
| 2N698 | 45p |
| 2N706A | 30p |
| 2N708 | 30p |
| 2N918 | 45p |
| 2N930 | 18p |
| 2N1131/2 | 36p |
| 2N1613 | 25p |
| 2N1711 | 25p |
| 2N2102 | 70p |
| 2N2160 | 350p |
| 2N2219A | 25p |
| 2N2222A | 25p |
| 2N2369A | 25p |
| 2N2484 | 30p |
| 2N2646 | 45p |
| 2N2904/5 | 25p |
| 2N2906A | 25p |
| 2N2907A | 25p |
| 2N2926 | 9p |
| 2N3053 | 30p |
| 2N3054 | 65p |
| 2N3055 | 48p |
| 2N3442 | 140p |
| 2N3553 | 240p |
| 2N3584 | 250p |
| 2N3643/4 | 48p |
| 2N3702/3 | 12p |
| 2N3704/5 | 12p |
| 2N3706/7 | 14p |
| 2N3708/9 | 12p |
| 2N3773 | 225p |
| 2N3819 | 25p |
| 2N3820 | 40p |
| 2N3823 | 50p |
| 2N3866 | 90p |
| 2N3902 | 700p |
| 2N3903/4 | 16p |
| 2N3905/6 | 16p |
| 2N4037 | 65p |
| 2N4123/4 | 27p |
| 2N4125/6 | 27p |
| 2N4401/3 | 27p |
| 2N4427 | 90p |
| 2N4871 | 60p |
| 2N5087 | 27p |
| 2N5089 | 27p |
| 2N5172 | 27p |
| 2N5191 | 90p |
| 2N5194 | 90p |
| 2N5245 | 40p |
| 2N5296 | 65p |
| 2N5401 | 60p |
| 2N5457/8 | 40p |
| 2N5459 | 40p |
| 2N5460 | 60p |
| 2N5485 | 44p |
| 2N5875 | 250p |
| 2N6027 | 48p |
| 2N6052 | 300p |
| 2N6059 | 325p |
| 2N6107 | 65p |
| 2N6247 | 190p |
| 2N6254 | 130p |
| 2N6290 | 65p |
| 2SC1172 | 150p |
| 2SC1306 | 100p |
| 2SC1307 | 150p |
| 2SC1957 | 90p |
| 2SC1969 | 150p |
| 2SC2028 | 95p |
| 2SC2029 | 250p |
| 2SC2078 | 200p |
| 2SC2335 | 250p |
| 2SC2612 | 250p |
| 3N128 | 120p |
| 3N140 | 120p |
| 3N141 | 110p |
| 3N201 | 110p |
| 3N204 | 120p |
| 40290 | 260p |
| 40361/2 | 75p |
| 40408 | 90p |
| 40409 | 100p |
| 40410 | 100p |
| 40411 | 300p |
| 40594 | 120p |
| 40595 | 120p |
| 40673 | 75p |
| 40871/2 | 100p |

## DIODES

| | |
|---|---|
| BY127 | 12p |
| BYX36300 | 20p |
| OA47 | 8p |
| OA90/91 | 9p |
| OA95 | 9p |
| OA200 | 9p |
| OA202 | 10p |
| 1N914 | 4p |
| 1N916 | 7p |
| 1N4148 | 4p |
| 1N4001/2 | 5p |
| 1N4003/4 | 6p |
| 1N4005 | 6p |
| 1N4006/7 | 7p |
| 1N5404/5 | 14p |
| 1N5404/7 | 19p |
| IS920 | 9p |

## BRIDGE RECTIFIERS

| | |
|---|---|
| 1A 50V | 19p |
| 1A 100V | 20p |
| 1A 400V | 25p |
| 1A 600V | 30p |
| 2A 50V | 30p |
| 2A 100V | 35p |
| 2A 400V | 45p |
| 3A 200V | 60p |
| 3A 600V | 72p |
| 4A 100V | 95p |
| 4A 400V | 100p |
| 6A 50V | 80p |
| 6A 100V | 100p |
| 6A 400V | 120p |
| 10A 400V | 200p |
| 25A 400V | 400p |

## ZENERS

| | |
|---|---|
| 2.7V-33V | |
| 400mW | 9p |
| 1W | 15p |

## TRIACS PLASTIC

| | |
|---|---|
| 3A 400V | 60p |
| 6A 400V | 70p |
| 6A 500V | 88p |
| 8A 400V | 75p |
| 8A 500V | 95p |
| 12A 400V | 85p |
| 12A 500V | 105p |
| 16A 400V | 110p |
| 16A 500V | 130p |
| T2800D | 130p |

## THYRISTORS

| | |
|---|---|
| 3A 400V | 100p |
| 8A 600V | 140p |
| 12A 400V | 160p |
| 16A 100V | 180p |
| 16A 400V | 180p |
| C106D | 45p |
| MCR101 | 36p |
| TIC44 | 27p |
| 2N3525 | 130p |
| 2N4444 | 180p |
| 2N5060 | 30p |
| 2N5064 | 35p |

## PCB MOUNTING RELAYS

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| 6 or 12V DC Coil SPDT 2A 24V DC | 160p |
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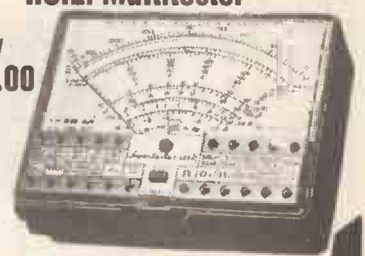

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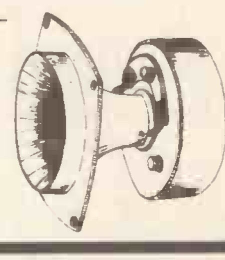

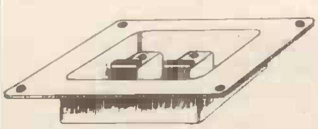

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AT-50H/S – 30 Watts ( – 2 dB), 25 Watts ( – 6 dB), 15 Watts ( – 12 dB)
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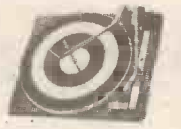

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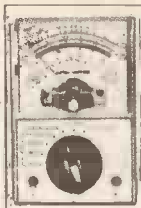

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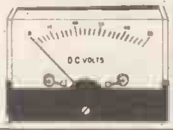



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| 3 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 | £12.50 | £2 |
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| 6V. ½ amp. | £2.00 | £1 | 20V 1 amp | £3.00 | £1 |
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| 12V 3 amps | £3.50 | £1 | TOROIDAL30-0 30V 4a and | | |
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**TEAK VENEERED CABINET**
11×8½×7in, 15 watts
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500mF 12V 15p; 25V 20p; 50V 30p. 1200mF 76V 86p.
1000mF 12V 20p; 25V 35p; 50V 50p; 100V 70p.
2000mF 6V 25p; 25V 42p; 40V 60p; 1200mF 76V 80p.
2200mF 63V 90p. 2500mF 50V 70p; 3000mF 50V 65p;
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.22MF 350V 12p. 600V 20p. 1000V 30p. 1750V 50p.
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**SOLID DIELECTRIC** 100pf £1.50, 500pf £1.50

**HEATING ELEMENTS, WAFER THIN**
Size 11×9×⅛in. Operating voltage 240V, 250W approx. Suitable for Heating Pads, Food Warmers, Convector Heaters, Propagation, etc. Must be clamped between two sheets of metal or ceramic, etc.
ONLY 60p EACH (FOUR FOR £2) ALL POST PAID.

## NEW baker Star sound

high power full range quality loudspeakers produced to give exceptional reproduction. Ideal for Hi-Fi, music P.A. or discotheques. These loudspeakers are recommended where high power handling is required with quality results. The high flux ceramic magnet ensures clear response.

| MODEL | INCHES | OHMS | WATTS | TYPE | PRICE | POST |
|---|---|---|---|---|---|---|
| MAJOR | 12 | 4-8-16 | 30 | HI-FI | £14 | £2 |
| DELUXE MK II | 12 | 8 | 15 | HI-FI | £14 | £2 |
| SUPERB | 12 | 8-16 | 30 | HI-FI | £24 | £2 |
| AUDITORIUM | 12 | 8-16 | 45 | HI-FI | £22 | £2 |
| AUDITORIUM | 15 | 8-16 | 60 | HI-FI | £34 | £2 |
| GROUP 45 | 12 | 4-8-16 | 45 | PA | £14 | £2 |
| GROUP 75 | 12 | 4-8-16 | 75 | PA | £18 | £2 |
| GROUP 100 | 12 | 8-16 | 100 | Guitar | £24 | £2 |
| DISCO 100 | 12 | 8-16 | 100 | Disco | £24 | £2 |
| GROUP 100 | 15 | 8-16 | 100 | Guitar | £32 | £2 |
| DISCO 100 | 15 | 8-16 | 100 | Disco | £32 | £2 |



## BAKER 150 WATT MIXER/POWER AMPLIFIER £89 Post £2

For Discotheque, Vocal, Public Address. Three speaker outlets for 4, 8 or 16 ohms. Four high gain inputs, 20 mv, 50K ohm. Individual volume controls "Four channel" mixing. 150 watts 8 ohms R.M.S. Music Power. Slave output 500 M.V. 25K.ohm. Response 25 Hz – 20kHz ± 3dB. Integral Hi-Fi preamp separate Bass & Treble. Size – 16" x 8" x 5½". Wt – 14lb. Master volume control. British made. 12 months' guarantee. 240v A.C. mains or 120V to order. All transistor and solid state.
**MONO SLAVE VERSION £75.** 100 Volt Line Model £104.
**New Stereo Slave Model 150 + 150 watt £125. Post £4.**
**BAKER'S NEW PA150 MICROPHONE PA AMPLIFIER £129.** PP £3.
4 channel 8 inputs, dual impedance, 50K-600 ohm 4 channel mixing, volume, treble, bass. Presence controls, Master volume control, echo/send/return socket. Slave input/output sockets.

## BAKER £69 Post £2 50 WATT AMPLIFIER

Ideal for PA systems, Discos and Groups. Two inputs, Mixer, Volume, Controls, Master Bass, Treble Gain.

**RCS offers MOBILE PA AMPLIFIERS. Outputs 4-8-16 ohms**
20-watt RMS 12v DC, AC 240v, 3 inputs. 50K £46 PP £2.
40-watt RMS 12v DC, AC 240v, 4 inputs. 50K £75 PP £2
Mic 1; Mic 2; Phono; aux. outputs 4 or 8 or 16 and 100v line
60-watt RMS, Mobile 24 volt DC & 240-volt AC mains. inputs 50K.
3 mics + 1 music. Outputs 4-8-16 ohm + 100 volts line £95 PP £2

**Battery only Shoulder PA Amplifier** 10w max. Includes mike and speaker, OK for meetings, crowd control, stalls, fetes, traders, etc. Batteries included (6 of U2) £27.50 post £1.50.

## FAMOUS LOUDSPEAKERS "SPECIAL PRICES"

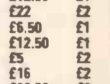
| MAKE | MODEL | SIZE | WATTS | OHMS | PRICE | POST |
|---|---|---|---|---|---|---|
| SEAS | TWEETER | 4in | 50 | 8 | £9.50 | £1 |
| GOODMANS | TWEETER | 3½in | 25 | 8 | £4 | £1 |
| AUDAX | TWEETER | 4in | 30 | 8 | £6.50 | £1 |
| SEAS | MID-RANGE | 4in | 50 | 8 | £7.50 | £1 |
| SEAS | MID-RANGE | 5in | 80 | 8 | £12 | £1 |
| SEAS | MID-RANGE | 4½in | 100 | 8 | £12.50 | £1 |
| GOODMANS | HIFAX | 7½×4¼ | 100 | 4/8/16 | £22 | £2 |
| GOODMANS | WOOFER | 8in | 25 | 4/8 | £6.50 | £1 |
| GOODMANS | HB | 8in | 60 | 8 | £12.50 | £1 |
| RIGONDA | GENERAL | 10in | 15 | 8 | £5 | £2 |
| SEAS | WOOFER | 10in | 50 | 8 | £16 | £2 |
| GOODMANS | HPG | 12in | 120 | 8/15 | £29.50 | £2 |
| GOODMANS | GR12 | 12in | 90 | 8/15 | £27.50 | £2 |
| GOODMANS | HPD | 12in | 120 | 8/15 | £29.50 | £2 |

**SPEAKER COVERING MATERIALS.** Samples Large S.A.E.
**B.A.F. LOUDSPEAKER CABINET WADDING** 18in wide 35p ft.

**MOTOROLA PIEZO ELECTRIC HORN TWEETER,** 3¾in. square £5
100 watts. No crossover required. 4-8-16 ohm, 7⅜x3⅛in. £10

**CROSSOVERS. TWO-WAY** 3000 c/s 30 watt 8 or 15 ohm £3.
3-way 950 cps/3000 cps. 40 watt rating. £4. 3 way 60 watt £6.
**LOUDSPEAKER BARGAINS**
3 ohm, 5in, 7×4in, £2.50; 6½in, 8×5in, £3; 8in, £3.50. 10in, £5.
8 ohm, 2⅝in, 3in, £2; 5in, £2.50; 6½in, £3; 8in, £4.50; 10in, £5; 12in, £6.
15 ohm, 3½in, 5×3in, 6×4in, £2.50.
25 ohm, 3in, £2; 5×3in, 7×4in, £2.50. 120 ohm, 3¼in dia. £1.
**CASSETTE MONO REPLAY.** Complete working £12.50
**CAR CASSETTE MECHANISM.** 12V Stereo Head £5

**THE "INSTANT" BULK TAPE ERASER** £9.50 Post 95p



Suitable for cassettes and all sizes of tape reels. AC mains 200/250V. Hand held size with switch and lead (120 volt to order).
Will also demagnetise small tools.
**Head Demagnetiser only £5.**

**R.C.S. LOW VOLTAGE STABILISED POWER PACK KITS** £3.95. Post 65p.
All parts and instructions with Zener diode printed circuit, mains transformer 240V a.c. Output 6 or 7½ or 9 or 12V d.c. up to 100mA or less. Please state voltage required.

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WW-7

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## SEMICONDUCTORS

| | |
|---|---|
| AA119 | 0.12 |
| AAY30 | 0.20 |
| AAY32 | 0.48 |
| AAZ13 | 0.17 |
| AAZ15 | 0.17 |
| AAZ17 | 0.17 |
| AC107 | 0.63 |
| AC125 | 0.29 |
| AC126 | 0.29 |
| AC127 | 0.29 |
| AC128 | 0.35 |
| AC141 | 0.32 |
| AC141K | 0.40 |
| AC142 | 0.32 |
| AC142K | 0.40 |
| AC176 | 0.35 |
| AC187 | 0.32 |
| AC188 | 0.32 |
| ACY17 | 1.50 |
| ACY18 | 1.32 |
| ACY19 | 1.27 |
| ACY20 | 1.27 |
| ACY21 | 1.32 |
| ACY39 | 2.88 |
| AD149 | 0.86 |
| AD161 | 0.40 |
| AD162 | 0.40 |
| AF106 | 0.40 |
| AF114 | 0.86 |
| AF115 | 0.86 |
| AF116 | 0.86 |
| AF117 | 0.86 |
| AF139 | 0.38 |
| AF186 | 1.15 |
| AF239 | 0.45 |
| AFZ11 | 4.60 |
| AFZ12 | 4.60 |
| ASY26 | 1.61 |
| ASY27 | 1.04 |

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|---|---|
| ASZ15 | 1.38 |
| ASZ16 | 1.27 |
| ASZ17 | 1.15 |
| ASZ20 | 2.64 |
| ASZ21 | 2.88 |
| AU113 | 2.88 |
| AUY10 | 3.45 |
| AU110 | 2.88 |
| BA145 | 0.15 |
| BA148 | 0.17 |
| BA154 | 0.12 |
| BA155 | 0.13 |
| BA156 | 0.12 |
| BAW62 | 0.06 |
| BAX13 | 0.07 |
| BAX16 | 0.07 |
| BC107 | 0.18 |
| BC108 | 0.18 |
| BC109 | 0.18 |
| BC113 | 0.17 |
| BC114 | 0.17 |
| BC115 | 0.21 |
| BC116 | 0.22 |
| BC117 | 0.26 |
| BC118 | 0.21 |
| BC125 | 0.21 |
| BC126 | 0.21 |
| BC135 | 0.17 |
| BC136 | 0.22 |
| BC137 | 0.22 |
| BC147 | 0.14 |
| BC148 | 0.14 |
| BC149 | 0.15 |
| BC157 | 0.15 |
| BC158 | 0.15 |
| BC159 | 0.15 |
| BC167 | 0.13 |
| BC170 | 0.13 |
| BC171 | 0.12 |

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|---|---|
| BC172 | 0.13 |
| BC173 | 0.13 |
| BC177 | 0.32 |
| BC178 | 0.16 |
| BC179 | 0.32 |
| BC182 | 0.13 |
| BC183 | 0.13 |
| BC184 | 0.13 |
| BC212 | 0.13 |
| BC213 | 0.13 |
| BC214 | 0.13 |
| BC237 | 0.13 |
| BC238 | 0.13 |
| BC301 | 0.38 |
| BC303 | 0.39 |
| BC307 | 0.13 |
| BC308 | 0.13 |
| BC327 | 0.14 |
| BC328 | 0.14 |
| BC337 | 0.14 |
| BC338 | 0.14 |
| BCY30 | 1.44 |
| BCY31 | 1.73 |
| BCY32 | 1.73 |
| BCY33 | 1.27 |
| BCY34 | 1.15 |
| BCY39 | 3.91 |
| BCY40 | 3.22 |
| BCY42 | 0.35 |
| BCY43 | 0.35 |
| BCY58 | 0.22 |
| BCY70 | 0.20 |
| BCY71 | 0.21 |
| BCY72 | 0.20 |
| BCZ11 | 2.01 |
| BD115 | 0.48 |
| BD121 | 1.96 |
| BD123 | 3.22 |
| BD124 | 2.30 |

| | |
|---|---|
| BD131 | 0.51 |
| BD132 | 0.55 |
| BD135 | 0.46 |
| BD136 | 0.46 |
| BD137 | 0.46 |
| BD138 | 0.55 |
| BD139 | 0.55 |
| BD140 | 0.58 |
| BD144 | 2.30 |
| BD181 | 1.38 |
| BD182 | 1.36 |
| BD237 | 0.62 |
| BD238 | 0.62 |
| BDX10 | 1.05 |
| BDX32 | 2.30 |
| BDY20 | 1.73 |
| BDY60 | 3.16 |
| BF115 | 0.40 |
| BF152 | 0.18 |
| BF153 | 0.18 |
| BF154 | 0.20 |
| BF159 | 0.20 |
| BF160 | 0.20 |
| BF167 | 0.28 |
| BF173 | 0.35 |
| BF177 | 0.40 |
| BF178 | 0.40 |
| BF179 | 0.40 |
| BF180 | 0.32 |
| BF181 | 0.32 |
| BF182 | 0.35 |
| BF183 | 0.32 |
| BF184 | 0.32 |
| BF185 | 0.35 |
| BF194 | 0.16 |
| BF195 | 0.14 |
| BF196 | 0.15 |
| BF197 | 0.16 |
| BF200 | 0.46 |
| BF224 | 0.29 |
| BF244 | 0.32 |

| | |
|---|---|
| BF257 | 0.31 |
| BF258 | 0.31 |
| BF259 | 0.32 |
| BF336 | 0.39 |
| BF337 | 0.38 |
| BF338 | 0.41 |
| BFS21 | 4.60 |
| BFS28 | 2.58 |
| BFS61 | 0.23 |
| BFS98 | 0.23 |
| BFW10 | 1.12 |
| BFW11 | 1.10 |
| BFX84 | 0.35 |
| BFX85 | 0.35 |
| BFX87 | 0.35 |
| BFX88 | 0.35 |
| BFY50 | 0.29 |
| BFY51 | 0.29 |
| BFY52 | 0.29 |
| BFY64 | 0.35 |
| BFY90 | 1.09 |
| BSX19 | 0.31 |
| BSX20 | 0.31 |
| BSX21 | 0.33 |
| BT106 | 1.38 |
| BTY79/400R | 2.30 |
| BU205 | 1.50 |
| BU206 | 1.73 |
| BU208 | 2.30 |
| BY100 | 0.46 |
| BY126 | 0.15 |
| BY127 | 0.16 |
| BZX61 Series | 0.20 |
| BZY88 Series | 0.12 |
| CRS1/40 | 0.69 |
| CRS3/40 | 0.86 |
| CRS3 60 | 1.04 |
| GEX66 | 3.45 |

| | |
|---|---|
| GEX541 | 5.75 |
| GJ3M | 1.73 |
| GM0378A | 2.02 |
| KS100A | 0.52 |
| MJE340 | 0.69 |
| MJE370 | 0.84 |
| MJE371 | 0.82 |
| MJE520 | 0.54 |
| MJE521 | 0.84 |
| MJE2955 | 1.50 |
| MJE3055 | 1.27 |
| MPF102 | 0.40 |
| MPF103 | 0.40 |
| MPF104 | 0.40 |
| MPF105 | 0.40 |
| MPSA06 | 0.30 |
| MPSA56 | 0.32 |
| MPSU01 | 0.61 |
| MPSU06 | 0.75 |
| MPSU56 | 0.79 |
| NE555 | 0.52 |
| NKT401 | 4.03 |
| NKT403 | 2.88 |
| NKT404 | 2.53 |
| OA5 | 1.38 |
| OA7 | 0.69 |
| OA10 | 0.63 |
| OA47 | 0.14 |
| OA70 | 0.29 |
| OA79 | 0.14 |
| OA81 | 0.20 |
| OA85 | 0.20 |
| OA90 | 0.09 |
| OA91 | 0.09 |
| OA95 | 0.09 |
| OA200 | 0.17 |
| OA202 | 0.17 |
| OA211 | 1.73 |
| OAZ200 | 1.73 |
| OAZ201 | 1.73 |
| OAZ206 | 1.73 |

| | |
|---|---|
| OAZ207 | 1.73 |
| OC16 | 2.88 |
| OC20 | 2.88 |
| OC22 | 2.88 |
| OC23 | 4.60 |
| OC24 | 3.45 |
| OC25 | 1.15 |
| OC26 | 1.73 |
| OC28 | 2.30 |
| OC29 | 2.30 |
| OC35 | 1.73 |
| OC36 | 1.73 |
| OC41 | 1.04 |
| OC42 | 1.04 |
| OC43 | 1.73 |
| OC44 | 0.98 |
| OC45 | 0.75 |
| OC71 | 0.63 |
| OC72 | 1.15 |
| OC73 | 1.15 |
| OC74 | 0.81 |
| OC75 | 0.75 |
| OC76 | 1.15 |
| OC77 | 1.15 |
| OC81 | 0.75 |
| OC81Z | 1.38 |
| OC82 | 1.04 |
| OC83 | 0.92 |
| OC84 | 0.92 |
| OC122 | 3.16 |
| OC123 | 2.30 |
| OC139 | 3.45 |
| OC140 | 4.60 |
| OC141 | 4.93 |
| OC170 | 1.44 |
| OC171 | 1.44 |
| OC200 | 1.73 |
| OC201 | 2.88 |
| OC202 | 3.16 |
| OC203 | 3.45 |
| OC204 | 3.45 |

| | |
|---|---|
| OC205 | 3.16 |
| OC206 | 3.16 |
| OC207 | 2.88 |
| OCP71 | 2.30 |
| ORP12 | 1.15 |
| R2008B | 2.30 |
| R2009 | 2.59 |
| R2010B | 2.30 |
| T1C44 | 0.31 |
| T1C226D | 1.38 |
| T1L209 | 0.18 |
| T1P29A | 0.49 |
| T1P30A | 0.52 |
| T1P31A | 0.38 |
| T1P32A | 0.41 |
| T1P33A | 0.62 |
| T1P34A | 0.77 |
| T1P41A | 0.51 |
| T1P42A | 0.48 |
| T1P2955 | 0.81 |
| T1P3055 | 0.64 |
| T1S43 | 0.49 |
| ZS140 | 0.29 |
| ZS170 | 0.24 |
| ZS178 | 0.62 |
| ZS271 | 0.26 |
| ZS278 | 0.65 |
| ZTX107 | 0.14 |
| ZTX108 | 0.14 |
| ZTX109 | 0.14 |
| ZTX300 | 0.15 |
| ZTX301 | 0.16 |
| ZTX302 | 0.21 |
| ZTX303 | 0.21 |
| ZTX304 | 0.23 |
| ZTX311 | 0.15 |
| ZTX314 | 0.29 |
| ZTX500 | 0.16 |
| ZTX501 | 0.16 |
| ZTX502 | 0.21 |
| ZTX503 | 0.22 |

| | |
|---|---|
| ZTX504 | 0.24 |
| ZTX531 | 0.28 |
| ZTX550 | 0.29 |
| 1N914 | 0.06 |
| 1N916 | 0.10 |
| 1N4001 | 0.07 |
| 1N4002 | 0.07 |
| 1N4003 | 0.07 |
| 1N4004 | 0.08 |
| 1N4005 | 0.10 |
| 1N4006 | 0.13 |
| 1N4007 | 0.14 |
| 1N4009 | 0.08 |
| 1N4148 | 0.05 |
| 1N5400 | 0.15 |
| 1N5401 | 0.15 |
| 1S44 | 0.05 |
| 1S920 | 0.09 |
| 1S921 | 0.10 |
| 2G301 | 1.15 |
| 2G302 | 1.15 |
| 2G306 | 1.15 |
| 2N404 | 1.50 |
| 2N696 | 0.37 |
| 2N697 | 0.37 |
| 2N698 | 0.37 |
| 2N705 | 1.44 |
| 2N706 | 0.29 |
| 2N708 | 0.29 |
| 2N930 | 0.29 |
| 2N1131 | 0.35 |
| 2N1132 | 0.35 |
| 2N1302 | 1.38 |
| 2N1303 | 0.92 |
| 2N1304 | 1.38 |
| 2N1305 | 1.15 |
| 2N1306 | 1.73 |
| 2N1307 | 1.27 |
| 2N1308 | 2.01 |
| 2N1309 | 1.38 |
| 2N1613 | 0.37 |

| | |
|---|---|
| 2N1671 | 5.75 |
| 2N1893 | 0.37 |
| 2N2147 | 4.60 |
| 2N2148 | 4.31 |
| 2N2218 | 0.37 |
| 2N2219 | 0.37 |
| 2N2220 | 0.23 |
| 2N2221 | 0.23 |
| 2N2222 | 0.23 |
| 2N2223 | 4.89 |
| 2N2368 | 0.29 |
| 2N2369A | 0.29 |
| 2N2484 | 0.29 |
| 2N2646 | 0.58 |
| 2N2904 | 0.37 |
| 2N2905 | 0.37 |
| 2N2906 | 0.24 |
| 2N2907 | 0.24 |
| 2N2924 | 0.30 |
| 2N2925 | 0.25 |
| 2N2926 | 0.17 |
| 2N3053 | 0.30 |
| 2N3054 | 0.63 |
| 2N3055 | 0.75 |
| 2N3440 | 0.81 |
| 2N3441 | 0.98 |
| 2N3442 | 1.44 |
| 2N3614 | 2.53 |
| 2N3702 | 0.13 |
| 2N3703 | 0.13 |
| 2N3704 | 0.13 |
| 2N3705 | 0.13 |
| 2N3706 | 0.13 |
| 2N3707 | 0.13 |
| 2N3708 | 0.12 |
| 2N3709 | 0.13 |
| 2N3710 | 0.12 |
| 2N3711 | 0.12 |
| 2N3771 | 1.61 |
| 2N3772 | 1.84 |
| 2N3773 | 2.07 |

| | |
|---|---|
| 2N3819 | 0.35 |
| 2N3820 | 0.45 |
| 2N3823 | 0.69 |
| 2N3866 | 1.15 |
| 2N3904 | 0.20 |
| 2N3905 | 0.20 |
| 2N3906 | 0.20 |
| 2N4058 | 0.23 |
| 2N4059 | 0.23 |
| 2N4060 | 0.18 |
| 2N4061 | 0.18 |
| 2N4062 | 0.18 |
| 2N4124 | 0.18 |
| 2N4126 | 0.18 |
| 2N4286 | 0.17 |
| 2N4288 | 0.21 |
| 2N4289 | 0.21 |
| 2N5457 | 0.37 |
| 2N5458 | 0.37 |
| 2N5459 | 0.37 |
| 2S017 | 11.50 |
| 2S019 | 13.80 |
| 2S026 | 28.75 |
| 2S103 | 1.73 |
| 2S302 | 2.30 |
| 2S303 | 4.03 |
| 2S322 | 4.03 |
| 2S324 | 4.03 |
| 2S701 | 2.30 |
| 2S745A | 1.09 |
| 2S746A | 1.09 |

## VALVES

| | |
|---|---|
| A1834 | 10.35 |
| A2087 | 13.58 |
| A2134 | 20.13 |
| A2293 | 8.62 |
| A2426 | 17.63 |
| A2521 | 24.38 |
| A2900 | 14.43 |
| A3343 | 51.75 |
| AZ31 | 1.26 |
| AZ41 | 1.32 |
| BK448 | 110.27 |
| BK484 | 149.09 |
| BS90 | 52.27 |
| BS810 | 86.25 |
| BT5 | 58.13 |
| BT17 | 106.89 |
| BT19 | 36.17 |
| BT29 | 327.69 |
| BT69 | 333.50 |
| BT75 | 102.46 |
| BT95 | 127.02 |
| CBL31 | 2.30 |
| CL33 | 2.30 |
| CY31 | 1.15 |
| C1K | 21.30 |
| C3A | 11.50 |
| C3JA | 23.23 |
| DA41 | 28.75 |
| DA42 | 21.51 |
| DA100 | 97.93 |
| DAF91 | 0.46 |
| DAF96 | 1.15 |
| DET22 | 32.78 |
| DET24 | 52.90 |
| DF91 | 0.46 |
| DF96 | 1.15 |
| DK91 | 1.21 |
| DK92 | 1.44 |
| DK96 | 1.26 |
| DL92 | 1.26 |
| DL94 | 1.38 |
| DL96 | 1.26 |
| DLS10 | 9.48 |
| DLS15 | 12.37 |
| DLS16 | 12.37 |
| DLS19 | 12.37 |
| DM70 | 1.44 |
| DM71 | 1.44 |
| DM160 | 3.96 |
| DY87 | 0.74 |
| DY802 | 0.96 |
| E55L | 25.17 |
| E80CC | 11.27 |
| E80CF | 12.96 |
| E80F | 14.19 |
| E80L | 13.98 |
| E81CC | 6.62 |
| E81L | 14.06 |
| E82CC | 7.03 |
| E83CC | 7.16 |
| E86C | 13.23 |
| E88C | 7.12 |
| E88CC | 3.86 |
| E90CC | 9.94 |
| E90F | 11.39 |
| E91H | 5.34 |
| E92CC | 9.40 |
| E99F | 10.16 |

| | |
|---|---|
| E130L | 19.39 |
| E180CC | 11.39 |
| E180F | 7.83 |
| E182CC | 13.80 |
| E186F | 12.58 |
| E188CC | 9.40 |
| E280F | 25.88 |
| E283CC | 9.02 |
| E288CC | 18.54 |
| EA52 | 28.18 |
| EA76 | 2.30 |
| EABC80 | 1.38 |
| EAC91 | 0.92 |
| EAF42 | 1.44 |
| EAF801 | 2.02 |
| EB41 | 2.30 |
| EB91 | 1.01 |
| EBC33 | 2.02 |
| EBC41 | 1.44 |
| EBC81 | 1.26 |
| EBC90 | 0.97 |
| EBF80 | 0.58 |
| EBF83 | 1.44 |
| EBF89 | 0.97 |
| EBL31 | 5.75 |
| EC90 | 1.28 |
| EC91 | 9.33 |
| EC92 | 1.44 |
| EC157 | 349.26 |
| ECC33 | 4.02 |
| ECC35 | 4.02 |
| ECC40 | 2.30 |
| ECC81 | 1.01 |
| ECC82 | 0.82 |
| ECC83 | 1.01 |
| ECC84 | 1.36 |
| ECC85 | 1.38 |
| ECC86 | 2.30 |
| ECC88 | 2.07 |
| ECC89 | 1.88 |
| ECC91 | 10.27 |
| ECC189 | 1.90 |
| ECC807 | 2.02 |
| ECC808 | 2.59 |
| ECF80 | 1.24 |
| ECF82 | 1.38 |
| ECF86 | 1.73 |
| ECH35 | 2.30 |
| ECH42 | 1.32 |
| ECH81 | 1.38 |
| ECH83 | 1.44 |
| ECH84 | 1.47 |
| ECL80 | 1.15 |
| ECL81 | 1.73 |
| ECL82 | 1.15 |
| ECL83 | 1.73 |
| ECL84 | 1.61 |
| ECL85 | 1.28 |
| ECL86 | 1.38 |
| EF37A | 4.02 |
| EF39 | 3.16 |
| EF40 | 3.45 |
| EF41 | 2.30 |
| EF42 | 2.30 |
| EF50 | 1.73 |
| EF54 | 5.75 |
| EF55 | 2.88 |
| EF80 | 0.92 |
| EF83 | 4.03 |
| EF85 | 0.92 |

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|---|---|
| EF86 | 1.74 |
| EF89 | 1.84 |
| EF91 | 2.07 |
| EF92 | 6.68 |
| EF93 | 1.15 |
| EF94 | 1.24 |
| EF95 | 6.27 |
| EF98 | 1.44 |
| EF183 | 0.92 |
| EF184 | 0.96 |
| EF804S | 12.65 |
| EF805S | 12.65 |
| EH90 | 1.61 |
| EK90 | 1.24 |
| EL32 | 1.73 |
| EL33 | 4.02 |
| EL34TH | 2.53 |
| EL34MUI | 3.16 |
| EL36 | 1.84 |
| EL41 | 1.44 |
| EL42 | 2.02 |
| EL81 | 4.03 |
| EL83 | 4.03 |
| EL84 | 1.15 |
| EL86 | 2.88 |
| EL90 | 1.10 |
| EL91 | 8.21 |
| EL95 | 1.51 |
| EL156 | 27.60 |
| EL360 | 9.77 |
| EL500/504 | 2.16 |
| EL509 | 3.63 |
| EL821 | 11.96 |
| EL822 | 12.55 |
| EM34 | 5.75 |
| EM80 | 1.26 |
| EM81 | 1.15 |
| EM84 | 1.73 |
| EM85 | 1.44 |
| EM87 | 1.73 |
| EN32 | 13.66 |
| EN91 | 2.94 |
| EN92 | 5.23 |
| EY51 | 2.02 |
| EY81 | 1.89 |
| EY83 | 2.02 |
| EY84 | 10.57 |
| EY86 | 0.96 |
| EY88 | 2.02 |
| EY500A | 2.23 |
| EY802 | 94 |
| EZ35 | 97 |
| EZ40 | 1.44 |
| EZ41 | 1.44 |
| EZ80 | 0.96 |
| EZ81 | 0.96 |
| EZ90 | 1.38 |
| FW4-500 | 2.88 |
| FW4-800 | 2.88 |
| G1.371K | 41.40 |
| G551K | 12.65 |
| G180.2M | 18.42 |
| G240.2D | 12.85 |
| G400.1K | 19.28 |
| GN4 | 8.62 |
| GN4A | 8.62 |
| GS16 | 10.35 |
| GT1C | 14.38 |
| GU50 | 14.31 |
| GU51 | 13.62 |

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|---|---|
| GXU1 | 16.10 |
| GXU2 | 28.43 |
| GXU3 | 30.49 |
| GXU4 | 32.77 |
| GXU50 | 17.25 |
| GY501 | 3.16 |
| GZ32 | 1.44 |
| GZ33 | 4.60 |
| GZ34 | 2.88 |
| GZ37 | 4.60 |
| KT61 | 4.02 |
| KT66 | 11.50 |
| KT88 | 13.80 |
| KTW61 | 2.02 |
| KTW62 | 2.02 |
| KTW63 | 2.02 |
| M8079 | 12.29 |
| M8080 | 9.49 |
| M8081 | 11.30 |
| M8082 | 9.87 |
| M8083 | 8.54 |
| M8091 | 11.99 |
| M8096 | 4.31 |
| M8097 | 4.09 |
| M8098 | 5.50 |
| M8099 | 5.98 |
| M8100 | 9.49 |
| M8136 | 9.98 |
| M8137 | 9.73 |
| M8140 | 5.17 |
| M8141 | 5.52 |
| M8142 | 7.77 |
| M8144 | 4.31 |
| M8149 | 5.86 |
| M8161 | 9.11 |
| M8162 | 10.36 |
| M8163 | 5.17 |
| M8190 | 5.29 |
| M8195 | 4.25 |
| M8196 | 7.47 |
| M8204 | 6.57 |
| M8212 | 12.47 |
| M8223 | 3.80 |
| M8224 | 4.66 |
| M8225 | 2.99 |
| M8248 | 13.32 |
| MU14 | 1.73 |
| MX119 | 58.65 |
| MX123 | 67.85 |
| MX145 | 62.10 |
| MX151 | 17.25 |
| MX152 | 143.75 |
| MX161 | 166.75 |
| MX163 | 23.11 |
| MX164 | 27.95 |
| MX166 | 161.00 |
| MX168 | 48.30 |
| N78 | 20.13 |
| OA2 | 2.30 |
| OA3 | 5.69 |
| OA4 | 4.02 |
| OB2 | 1.44 |
| OB3 | 2.20 |
| OC2 | 3.04 |
| OC3 | 2.20 |
| OD3 | 2.20 |
| OZ4 | 1.84 |
| PC86 | 1.61 |
| PC88 | 1.61 |
| PC95 | 1.49 |

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|---|---|
| PC97 | 1.38 |
| PC900 | 1.38 |
| PCC84 | 1.15 |
| PCC85 | 1.38 |
| PCC88 | 1.38 |
| PCC89 | 1.56 |
| PCC189 | 1.61 |
| PCC805 | 1.51 |
| PCC806 | 2.07 |
| PCE82 | 2.07 |
| PCF80 | 1.15 |
| PCF82 | 1.15 |
| PCF86 | 1.84 |
| PCF87 | 1.84 |
| PCF200 | 3.74 |
| PCF201 | 2.45 |
| PCF801 | 1.84 |
| PCF802 | 2.19 |
| PCF805 | 1.84 |
| PCF806 | 1.84 |
| PCF808 | 1.84 |
| PCL82 | 1.15 |
| PCL83 | 2.30 |
| PCL84 | 1.15 |
| PCL85 | 1.24 |
| PCL86 | 1.24 |
| PCL805/85 | 1.24 |
| PD500 | 4.14 |
| PE06-40N | 31.40 |
| PFL200 | 2.07 |
| PL36 | 1.38 |
| PL81 | 1.38 |
| PL81A | 1.38 |
| PL82 | 1.38 |
| PL83 | 2.55 |
| PL84 | 1.24 |
| PL504/5 | 1.61 |
| PL508 | 2.07 |
| PL509 | 5.75 |
| PL519 | 5.75 |
| PL801 | 1.27 |
| PL802 | 3.40 |
| PY33 | 1.27 |
| PY81 | 0.97 |
| PY82 | 0.92 |
| PY83 | 0.81 |
| PY88 | 1.01 |
| PY500A | 2.07 |
| PY800 | 0.97 |
| PY801 | 0.97 |
| QQV02-6 | 16.17 |
| QQV03-20A | 20.13 |
| QQV06-40A | 47.15 |
| QQV07-50 | 60.66 |
| QQZ03-20A | 59.80 |
| QQZ06-40A | 63.37 |
| QU37 | 14.38 |
| QV03-12 | 5.62 |
| QV04-7 | 2.88 |
| QV08-100 | 137.08 |
| QY3-65 | 57.06 |
| QY3-125 | 62.40 |
| QY4-250 | 77.05 |
| QY4-400 | 80.44 |
| QY5-500 | 168.83 |

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|---|---|
| QY5-3000A | 356.66 |
| QZ06-20 | 34.16 |
| R10 | 5.75 |
| R17 | 1.89 |
| R18 | 4.89 |
| R19 | 1.38 |
| R20 | 1.66 |
| RG3-250 | 35.77 |
| RG3-250A | 37.49 |
| RG3-1250 | 63.94 |
| RG4-1250 | 43.13 |
| RR3-250 | 53.54 |
| RR3-1250 | 94.83 |
| S11E12 | 55.20 |
| S130 | 3.45 |
| S130P | 4.03 |
| STV280-40 | 11.50 |
| STV280-80 | 24.15 |
| SU41 | 2.88 |
| SU42 | 10.35 |
| TD03-10 | 32.78 |
| TD03-10E | 32.78 |
| TD03-29F | 33.93 |
| TT15 | 34.50 |
| TT21 | 16.98 |
| TT22 | 16.98 |
| TT100 | 59.51 |
| TY2-125 | 69.01 |
| TW4-400 | 74.07 |
| TY4-500 | 105.97 |
| TY5-500 | 187.45 |
| TY6-800 | 193.20 |
| TY6-5000A | 356.50 |
| TY6-5000B | 264.50 |
| TY6-5000W | 316.25 |
| TY7-6000A | 368.80 |
| TY7-6000W | 322.00 |
| TZ40 | 28.75 |
| U18-20 | 2.88 |
| U19 | 15.81 |
| U25 | 1.33 |
| U26 | 1.66 |
| U37 | 10.35 |
| UABC80 | 1.44 |
| UAF42 | 1.44 |
| UB41 | 1.44 |
| UBC41 | 1.73 |
| UBF89 | 1.38 |
| UCC84 | 1.26 |
| UCC85 | 1.38 |
| UCF80 | 1.32 |
| UCH42 | 1.38 |
| UCH81 | 2.67 |
| UCL82 | 1.20 |
| UCL83 | 1.66 |
| UF41 | 1.15 |
| UF42 | 1.44 |
| UF80 | 1.66 |
| UF85 | 1.66 |
| UF89 | 1.66 |
| UL41 | 2.88 |

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|---|---|
| UL84 | 1.38 |
| UM80 | 1.15 |
| UY41 | 1.44 |
| UY85 | 1.20 |
| VLS631 | 15.24 |
| XG1-2500 | 58.02 |
| XG2-6400 | 113.50 |
| XG5-500 | 28.23 |
| XG2-6400 | 155.42 |
| XR1-1600A | 58.88 |
| XR1-3200 | 87.15 |
| XR1-3200A | 93.15 |
| XR1-6400 | 108.30 |
| XR1-6400A | 164.23 |
| YD1120 | 264.50 |
| YD1240 | 366.62 |
| Z759 | 19.32 |
| ZM1000 | 6.03 |
| ZM1001 | 6.19 |
| ZM1020 | 10.83 |
| ZM1021 | 10.17 |
| ZM1022 | 10.60 |
| ZM1023 | 8.81 |
| ZM1040 | 22.26 |
| ZM1041 | 19.16 |
| ZM1042 | 20.44 |
| ZM1051 | 100.05 |
| 1B3GT | 2.58 |
| 1B24 | 11.50 |
| 1B35A | 28.75 |
| 1B63 | 57.50 |
| 1R5 | 1.21 |
| 1S5 | 0.46 |
| 1T4 | 0.46 |
| 2AS15 | 11.50 |
| 2C39A | 21.85 |
| 2C43 | 20.70 |
| 2D21 | 2.94 |
| 2E26 | 17.86 |
| 2J42 | 109.25 |
| 2J55 | 239.97 |
| 2J70A | 442.75 |
| 2J70B | 418.34 |
| 2K25 | 40.25 |
| 3-400Z | 57.50 |
| 3-500Z | 63.25 |
| 3A5 | 2.70 |
| 3B24 | 9.20 |
| 3B28 | 16.50 |
| 3B29 | 11.50 |
| 3B240M | 17.25 |
| 3B241M | 17.25 |
| 3C23 | 26.83 |
| 3C45 | 28.18 |
| 3CX100A5 | 40.25 |
| 3E29 | 29.67 |
| 3S4 | 1.26 |
| 3V4 | 1.38 |
| 465A | 29.15 |
| 4-125A | 41.99 |
| 4-250A | 41.99 |
| 4-400A | 52.05 |

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|---|---|
| 4B32 | 29.16 |
| 4C35 | 74.75 |
| 4CX250B | 51.75 |
| 4CX350A | 80.50 |
| 4X150A | 24.41 |
| 4X150D | 28.75 |
| 5B254M | 23.12 |
| 5B255M | 23.12 |
| 5C22 | 74.75 |
| 5J180E | 1380.00 |
| 5R4GY | 4.03 |
| 5U4G | 1.75 |
| 5U4GB | 2.90 |
| 5V4G | 1.75 |
| 5Y3GT | 0.98 |
| 5Z3 | 1.73 |
| 5Z4G | 1.75 |
| 5Z4GT | 1.75 |
| 6-30L2 | 1.79 |
| 6AB4 | 1.44 |
| 6AB7 | 1.73 |
| 6AC7 | 1.61 |
| 6AF4A | 1.84 |
| 6AG7 | 2.30 |
| 6AH6 | 5.52 |
| 6AK5 | 4.15 |
| 6AK6 | 2.81 |
| 6AL5 | 1.01 |
| 6AM4 | 2.65 |
| 6AM5 | 8.21 |
| 6AM6 | 2.07 |
| 6AN5 | 4.45 |
| 6AN8A | 3.97 |
| 6AQ5 | 1.10 |
| 6AS6 | 5.73 |
| 6AS7G | 9.49 |
| 6AT6 | 0.98 |
| 6AU5GT | 4.97 |
| 6AU6 | 1.24 |
| 6AV5GA | 4.52 |
| 6AV6 | 0.98 |
| 6AX5GT | 3.57 |
| 6B7 | 1.73 |
| 6B8 | 2.02 |
| 6BA6 | 1.15 |
| 6BA7 | 5.89 |
| 6BA8A | 4.31 |
| 6BC4 | 4.27 |
| 6BE6 | 1.24 |
| 6BH6 | 1.75 |
| 6BJ6 | 1.24 |
| 6BK4 | 4.84 |
| 6BL6 | 97.75 |
| 6BL7GT | 4.44 |
| 6BM6 | 97.75 |
| 6BN6 | 1.89 |
| 6BQ7A | 4.28 |
| 6BR7 | 4.60 |
| 6BR8 | 2.02 |
| 6BS7 | 4.60 |
| 6BW6 | 4.60 |
| 6BW7 | 1.75 |
| 6BX7GT | 5.70 |
| 6BZ6 | 2.73 |
| 6C4 | 1.01 |
| CB6A | 2.86 |
| 6CD6GA | 5.83 |
| 6CG7 | 2.62 |
| 6CH6 | 11.96 |
| 6CL6 | 4.12 |

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|---|---|
| 6CW4 | 8.83 |
| 6D2 | 1.01 |
| 6DK6 | 3.00 |
| 6DQ6B | 4.69 |
| 6EA8 | 3.38 |
| 6EB8 | 2.44 |
| 6EW6 | 1.73 |
| 6F6 | 2.02 |
| 6F23 | 1.84 |
| 6F28 | 1.33 |
| 6F33 | 34.50 |
| 6H1 | 14.38 |
| 6H2N | 1.21 |
| 6H3N | 1.21 |
| 6H6 | 1.73 |
| 6J4 | 6.10 |
| 6J6 | 6.21 |
| 6J7 | 2.88 |
| 6K4N | 1.44 |
| 6K6GT | 1.50 |
| 6K7 | 1.73 |
| 6K8 | 2.02 |
| 6KD6 | 7.31 |
| 6L6G | 2.88 |
| 6L6GA | 1.73 |
| 6L6GT | 2.24 |
| 6L6GC | 2.88 |
| 6L7 | 2.30 |
| 6N2P | 1.21 |
| 6N3P | 1.21 |
| 6N7 | 1.73 |
| 6P25 | 4.14 |
| 6Q7 | 2.53 |
| 6R7 | 2.07 |
| 6SA7 | 1.67 |
| 6SC7 | 1.73 |
| 6SF7 | 1.84 |
| 6SH7 | 1.73 |
| 6SJ7 | 1.84 |
| 6SK7 | 1.50 |
| 6SK7GT | 3.08 |
| 6SN7GT | 1.84 |
| 6SQ7 | 1.50 |
| 6SR7 | 1.73 |
| 6SS7 | 2.07 |
| 6U5G | 2.30 |
| 6U8 | 0.92 |
| 6U8A | 3.38 |
| 6V6GT | 1.84 |
| 6X4 | 1.38 |
| 6X5GT | 0.97 |
| 7B7 | 1.96 |
| 7C5 | 3.40 |
| 7C6 | 2.60 |
| 7H7 | 2.30 |
| 7R7 | 1.73 |
| 7S7 | 2.59 |
| 7Y4 | 1.84 |
| 7Z4 | 2.13 |
| 11E3 | 60.82 |
| 12AT6 | 1.38 |
| 12AT7 | 1.01 |
| 12AU6 | 2.97 |
| 12AU7 | 0.83 |
| 12AV6 | 2.55 |
| 12AV7 | 4.00 |
| 12AX7 | 1.01 |
| 12AY7 | 4.69 |
| 12B4A | 3.62 |
| 12BA6 | 2.52 |

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|---|---|
| 12BE6 | 2.79 |
| 12BH7 | 1.29 |
| 12BY7 | 3.11 |
| 12E1 | 19.67 |
| 12E11TT | 19.26 |
| 12E14 | 34.50 |
| 13E1 | 123.05 |
| 19H4 | 28.75 |
| 19H5 | 40.25 |
| 24B9 | 55.20 |
| 30C15 | 1.84 |
| 30C17 | 1.84 |
| 30C18 | 1.84 |
| 30F5 | 1.93 |
| 30FL1/2 | 1.28 |
| 30FL12 | 2.07 |
| 30FL14 | 1.84 |
| 30L1 | 1.15 |
| 30L15 | 2.07 |
| 30L17 | 2.07 |
| 30P4 | 1.06 |
| 30P19 | 1.38 |
| 30PL1 | 2.88 |
| 30PL14 | 1.93 |
| 30PL15 | 2.07 |
| 35W4 | 0.69 |
| 50C5 | 0.81 |
| 75B1 | 5.38 |
| 75C1 | 2.70 |
| 85A1 | 8.63 |
| 85A2 | 2.75 |
| 90AG | 14.90 |
| 90AV | 14.90 |
| 90C1 | 3.35 |
| 90CG | 16.72 |
| 90CV | 17.50 |
| 92AG | 14.90 |
| 92AV | 14.90 |
| 95A1 | 7.48 |
| 150B2 | 3.47 |
| 150B3 | 6.39 |
| 150C2 | 2.21 |
| 150C4 | 2.75 |
| 211 | 21.85 |
| 723AB | 40.25 |
| 803 | 11.50 |
| 805 | 23.00 |
| 807 | 4.31 |
| 811A | 21.08 |
| 812A | 21.08 |
| 813 | 91.15 |
| 833A | 153.57 |
| 866A | 17.56 |
| 872A | 24.69 |
| 922 | 5.01 |
| 931A | 18.15 |
| 1624 | 2.59 |
| 1625 | 1.96 |
| 2050 | 8.00 |
| 4212E | 304.75 |
| 4212H | 304.75 |
| 5544 | 62.10 |
| 5545 | 67.85 |
| 5551A | 123.51 |
| 5552A | 166.98 |
| 5553A | 259.10 |
| 5642 | 6.45 |
| 5654 | 3.93 |
| 5651 | 4.66 |

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|---|---|
| 5670 | 5.18 |
| 5675 | 21.47 |
| 5687 | 6.31 |
| 5696 | 4.35 |
| 5718 | 7.87 |
| 5725 | 5.62 |
| 5726 | 3.62 |
| 5727 | 6.47 |
| 5749 | 5.14 |
| 5751 | 4.80 |
| 5763 | 4.66 |
| 5814A | 4.28 |
| 5840 | 5.06 |
| 5842 | 13.90 |
| 5876A | 19.55 |
| 5879 | 5.38 |
| 5886 | 12.08 |
| 5963 | 3.38 |
| 5965 | 4.00 |
| 6005 | 5.62 |
| 6021 | 5.13 |
| 6057 | 4.02 |
| 6058 | 12.47 |
| 6059 | 4.60 |
| 6061 | 4.89 |
| 6062 | 4.31 |
| 6063 | 4.20 |
| 6064 | 8.54 |
| 6067 | 4.02 |
| 6072 | 5.80 |
| 6080 | 7.88 |
| 6097AxBxC | 166.75 |
| 6146A | 12.24 |
| 6146B | 9.34 |
| 6159B | 19.91 |
| 6189 | 10.03 |
| 6201 | 10.92 |
| 6442 | 17.25 |
| 6883B | 14.64 |
| 6973 | 4.38 |
| 7025 | 2.73 |
| 7551 | 6.45 |
| 7586 | 11.66 |
| 7587 | 20.11 |
| 7609 | 36.57 |
| 7868 | 5.04 |
| 7895 | 13.25 |
| 8005 | 86.40 |
| 8068 | 6.33 |
| 8122 | 60.11 |
| 8136 | 2.48 |
| 8417 | 6.76 |
| 18042 | 8.63 |
| 18045 | 12.06 |

Tested Ex-Equipment

| | |
|---|---|
| 4CX250B | 5.75 |

## BASES

| | |
|---|---|
| B7G unskirted | 0.25 |
| B7G skirted | 0.35 |
| B9A unskirted | 0.25 |
| B9A skirted | 0.35 |
| Int Octal | 0.40 |
| Loctal | 0.63 |
| Nuvistor base | 0.86 |
| 8 pin DIL | 0.17 |
| 14 pin DIL | 0.17 |
| 16 pin DIL | 0.20 |
| Valve screening cans all sizes | 0.35 |

## CRTs

| | |
|---|---|
| 2AP1 | 9.78 |
| 2BP1 | 10.35 |
| 3BP1 | 11.50 |
| 3DP1 | 5.75 |
| 3EG1 | 11.50 |
| 3FP7 | 6.90 |
| 3GP1 | 6.90 |
| 3JP1 | 9.20 |
| 3JP2 | 9.20 |
| 3JP7 | 11.50 |
| 3KP1 | 17.25 |
| 3RP1 | 40.25 |
| 3WP1 | 23.00 |

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|---|---|
| 5ADP1 | 40.25 |
| 5BP1 | 11.50 |
| 5CP1 | 11.50 |
| 5CP1A | 46.00 |
| 5FP15A | 17.25 |
| 5UP7 | 28.75 |
| DG7-5 | 72.82 |
| DG7-31 | 66.78 |
| DG7-32 | 66.78 |
| DH3-91 | 67.65 |
| DH7-11 | 130.09 |
| VCR97 | 13.80 |
| VCR138 | 11.50 |

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|---|---|
| VCR138A | 14.38 |
| VCR139A | 9.20 |
| VCR517A | 11.50 |
| VCR517B | 11.50 |
| VCR517C | 11.50 |

Tube Bases Prices on application

## INTEGRATED CIRCUITS

| | |
|---|---|
| 7400 | 0.18 |
| 7401 | 0.20 |
| 7402 | 0.20 |
| 7403 | 0.20 |
| 7404 | 0.21 |
| 7405 | 0.21 |
| 7406 | 0.49 |
| 7407 | 0.49 |
| 7408 | 0.23 |
| 7409 | 0.23 |
| 7410 | 0.20 |
| 7412 | 0.33 |
| 7413 | 0.37 |
| 7416 | 0.37 |
| 7417 | 0.37 |
| 7420 | 0.21 |
| 7422 | 0.23 |

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|---|---|
| 7423 | 0.38 |
| 7425 | 0.35 |
| 7427 | 0.35 |
| 7428 | 0.50 |
| 7430 | 0.20 |
| 7432 | 0.35 |
| 7433 | 0.46 |
| 7437 | 0.37 |
| 7438 | 0.37 |
| 7440 | 0.37 |
| 7441 | 1.04 |
| 7442 | 0.83 |
| 7447AN | 1.35 |
| 7450 | 0.21 |
| 7451 | 0.21 |
| 7453 | 0.21 |
| 7454 | 0.21 |

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|---|---|
| 7460 | 0.21 |
| 7470 | 0.44 |
| 7472 | 0.38 |
| 7473 | 0.44 |
| 7474 | 0.44 |
| 7475 | 0.62 |
| 7476 | 0.48 |
| 7480 | 0.64 |
| 7482 | 0.86 |
| 7483 | 1.15 |
| 7484 | 1.21 |
| 7486 | 0.45 |
| 7490 | 0.69 |
| 7491 | 0.94 |
| 7492 | 0.69 |
| 7493 | 0.69 |
| 7494 | 0.94 |

| | |
|---|---|
| 7495 | 0.84 |
| 7496 | 0.94 |
| 7497 | 3.62 |
| 74100 | 1.77 |
| 74107 | 0.52 |
| 74109 | 0.84 |
| 74110 | 0.59 |
| 74111 | 0.82 |
| 74116 | 2.13 |
| 74118 | 1.15 |
| 74119 | 1.77 |
| 74120 | 0.95 |
| 74121 | 0.49 |
| 74122 | 0.71 |
| 74123 | 1.36 |
| 74125 | 0.67 |
| 74126 | 0.67 |
| 74128 | 0.72 |
| 74132 | 0.83 |

| | |
|---|---|
| 74136 | 0.59 |
| 74141 | 1.02 |
| 74142 | 2.64 |
| 74143 | 2.99 |
| 74144 | 2.99 |
| 74145 | 1.15 |
| 74147 | 2.30 |
| 74148 | 2.02 |
| 74150 | 2.07 |
| 74151 | 1.08 |
| 74154 | 2.07 |
| 74155 | 1.04 |
| 74156 | 1.04 |
| 74157 | 0.86 |
| 74159 | 2.53 |
| 74170 | 2.76 |
| 74172 | 5.06 |
| 74173 | 1.63 |
| 74174 | 1.84 |

| | |
|---|---|
| 74175 | 1.17 |
| 74176 | 1.33 |
| 74178 | 1.56 |
| 74179 | 1.56 |
| 74180 | 1.38 |
| 74190 | 2.19 |
| 74191 | 2.19 |
| 74192 | 2.19 |
| 74193 | 2.19 |
| 74194 | 1.44 |
| 74195 | 1.38 |
| 74196 | 1.55 |
| 74197 | 1.55 |
| 74198 | 3.11 |
| 74199 | 2.64 |
| 76013N | 2.02 |
| TAA570 | 2.65 |
| TAA630S | 4.02 |
| TAA700 | 4.50 |

| | |
|---|---|
| TBA480Q | 2.12 |
| TBA520Q | 2.65 |
| TBA530 | 2.28 |
| TBA540Q | 2.65 |
| TBA550Q | 3.70 |
| TBA560CQ | 3.70 |
| TBA673 | 2.52 |
| TBA700 | 1.75 |
| TBA720Q | 2.65 |
| TBA750Q | 2.38 |
| TBA800 | 1.38 |
| TBA920 | 3.34 |
| TBA920Q | 3.34 |
| TBA990Q | 3.34 |
| TCA270Q | 3.34 |
| TCA760A | 1.59 |

Terms of business: CWO. Postage and packing valves and semiconductors 58p per order. CRTs £1.73. All prices include VAT. Price ruling at time of despatch.
In some cases prices of Mullard and USA valves will higher than those advertised. Prices correct when going to press.
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WW – 057 FOR FURTHER DETAILS

# MULTIPURPOSE DIGITAL THERMOMETER

## £59 EX-WORKS

Sensors are £5 to £14 for Air, Liquid Immersion, Surface and Penetration measurements.

Total range −50 to 1100°C with 1.0°C resolution. Type K Ni-Cr/Ni-Al Thermocouple input. Suitable for applications from the workshop to the laboratory. Solder Baths, Soldering Irons, Ovens, Components are only a few of the many temperatures needing to be measured. Send for Product Details. Calibration Certificates can be supplied, details on request.

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**PROLAB INSTRUMENT COMPANY**
GREENSIDE HOUSE, LISLE WAY
EMSWORTH, HAMPSHIRE, ENGLAND
Telephone: 02434-77743
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**WW – 079 FOR FURTHER DETAILS**

# Happy Memories

| Part type | 1 off | 25-99 | 100 up |
|---|---|---|---|
| 4116 200ns | .83 | .72 | .66 |
| 4116 250ns | .75 | .65 | .60 |
| 4816 100ns for BBC comp | 2.95 | 2.70 | 2.50 |
| 4164 200ns | 6.15 | 5.25 | 4.65 |
| 2114 200ns Low Power | 1.15 | 1.00 | .90 |
| 2114 450ns Low Power | .95 | .85 | .80 |
| 4118 250ns | 3.25 | 2.85 | 2.65 |
| 6116 150ns CMOS | 4.25 | 3.65 | 3.35 |
| 2708 450ns | 2.60 | 2.25 | 2.10 |
| 2716 450ns 5 volt | 2.60 | 2.25 | 2.10 |
| 2716 450ns three rail | 5.75 | 5.00 | 4.65 |
| 2732 450ns Intel type | 3.95 | 3.45 | 3.25 |
| 2532 450ns Texas type | 3.95 | 3.45 | 3.25 |

Z80A-CPU £4.35 Z80A-PI0 £3.25 Z80A-CTC £3.25
6522 PIA £3.98 7805 reg .50 7812 reg .50

| Low profile IC sockets: | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Pins | 8 | 14 | 16 | 18 | 20 | 22 | 24 | 28 | 40 |
| Pence | 9 | 10 | 11 | 14 | 15 | 18 | 19 | 25 | 33 |

Soft-sectored floppy discs per 10 in plastic library case:
5-inch SSSD £17.00 5-inch SSDD £19.25 5-inch DSDD £21.00
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74LS series TTL: Large stocks at low prices with D.I.Y. discounts starting at a mix of just 25 pieces. Write or phone for list.

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# TRANSFORMERS

CONTINUOUS RATINGS — Despatch by return

### MAINS ISOLATORS

Pri 0-120; 0-100-120V. Sec 0-CT-115V×2.

| Ref. | VA (Watts) | £ | P&P |
|---|---|---|---|
| 07★ | 20 | 5.32 | 1.50 |
| 149 | 60 | 8.84 | 1.60 |
| 150 | 100 | 10.06 | 1.84 |
| 151 | 200 | 13.69 | 2.12 |
| 152 | 250 | 16.31 | 2.64 |
| 153 | 350 | 20.34 | 2.12 |
| 154 | 500 | 25.02 | 2.90 |
| 155 | 750 | 35.91 | OA |
| 156 | 1000 | 45.89 | OA |
| 157 | 1500 | 60.52 | OA |
| 158 | 2000 | 72.43 | OA |
| 159 | 3000 | 101.12 | OA |
| 161 | 6000 | 203.65 | OA |

★115 or 240v sec only. State volts required. Pri 0-220-240V.

### 12 or 24-VOLT RANGE

Separate 12V windings Pri 220-240V

| Ref. | 12v Amps | 24v | £ | P&P |
|---|---|---|---|---|
| 242 | 300mA | 150mA | 2.41 | .90 |
| 213 | 1 | 0.5 | 3.19 | 1.20 |
| 71 | 2 | 1.0 | 4.25 | 1.20 |
| 18 | 4 | 2.0 | 4.91 | 1.60 |
| 85 | 5 | 2.5 | 6.78 | 1.50 |
| 70 | 6 | 3.0 | 7.69 | 1.40 |
| 108 | 8 | 4.0 | 8.98 | 1.64 |
| 72 | 10 | 5.0 | 9.82 | 1.80 |
| 116 | 12 | 6.0 | 10.89 | 1.90 |
| 17 | 16 | 8.0 | 12.97 | 2.12 |
| 115 | 20 | 10.0 | 17.46 | 2.44 |
| 187 | 30 | 15.0 | 21.69 | 2.64 |
| 226 | 60 | 30.0 | 44.45 | OA |

### 50 VOLT RANGE

2×25V tapped secs. Volts available 5, 7, 8, 10, 13, 15, 17, 20, 25, 30, 33, 40 or 20V-0-20V or 25V-0-25V

| Ref. | Amps 50v | 25v | £ | P&P |
|---|---|---|---|---|
| 102 | 0.5 | 1 | 4.13 | 1.40 |
| 103 | 1 | 2 | 5.03 | 1.40 |
| 104 | 2 | 4 | 8.69 | 1.84 |
| 105 | 3 | 6 | 10.36 | 1.90 |
| 106 | 4 | 8 | 14.10 | 2.12 |
| 107 | 6 | 12 | 18.01 | 1.84 |
| 118 | 8 | 16 | 24.52 | 2.70 |
| 119 | 10 | 20 | 30.23 | OA |
| 109 | 12 | 24 | 36.18 | OA |

### 30 VOLT RANGE

Sec. Volts available 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 20, 24, 30V or 12V-0-12V or 15V-0-15V

| Ref. | Amps 30v | 15v | £ | P&P |
|---|---|---|---|---|
| 112 | 0.5 | 1 | 3.19 | 1.20 |
| 79 | 1 | 2 | 4.32 | 1.40 |
| 3 | 2 | 4 | 6.99 | 1.60 |
| 20 | 3 | 6 | 8.10 | 1.85 |
| 21 | 4 | 8 | 9.67 | 1.90 |
| 51 | 5 | 10 | 11.95 | 2.00 |
| 117 | 6 | 12 | 13.52 | 2.02 |
| 88 | 8 | 16 | 18.10 | 2.26 |
| 89 | 10 | 20 | 20.88 | 2.24 |
| 90 | 12 | 24 | 23.20 | OA |
| 91 | 15 | 30 | 26.60 | 3.00 |
| 92 | 20 | 40 | 35.64 | 4.83 |

### 60 VOLT RANGE

Pri 0-120V×2
2×30V tapped secs volts available 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60V, or 24V-0-24V or 30V-0-30V

| Ref. | Amps 60v | 30v | £ | P&P |
|---|---|---|---|---|
| 124 | 0.5 | 1 | 4.70 | 1.50 |
| 126 | 1 | 2 | 7.15 | 1.50 |
| 127 | 2 | 4 | 9.20 | 1.90 |
| 125 | 3 | 6 | 13.31 | 2.02 |
| 123 | 4 | 8 | 15.15 | 2.26 |
| 40 | 5 | 10 | 19.16 | 2.24 |
| 120 | 6 | 12 | 21.86 | 2.64 |
| 121 | 8 | 16 | 30.72 | OA |
| 122 | 10 | 20 | 35.76 | OA |
| 189 | 12 | 24 | 41.22 | OA |

### SCREENED MINIATURES Pri 240V

| Ref. | mA | Sec Volts | £ | P&P |
|---|---|---|---|---|
| 238 | 200 | 3-0-3 | 3.11 | .90 |
| 212 | 1A, 1A | 0-6, 0-6 | 3.45 | 1.20 |
| 13 | 100 | 9-0-9 | 2.59 | .80 |
| 235 | 330, 330 | 0-9, 0-9 | 2.41 | .90 |
| 207 | 500, 500 | 0-8-9, 0-8-9 | 3.36 | 1.20 |
| 208 | 1A, 1A | 0-8-9, 0-8-9 | 4.27 | 1.40 |
| 236 | 200, 200 | 0-15, 0-15 | 2.41 | .90 |
| 239 | 50MA | 12-0-12 | 3.11 | .90 |
| 214 | 300, 300 | 0-20, 0-20 | 3.39 | 1.20 |
| 221 | 700 (DC) | 20-12-0-12-20 | 4.13 | 1.20 |
| 206 | 1A, 1A | 0-15-20, 0-15-20 | 5.60 | 1.60 |
| 203 | 500, 500 | 0-15-27, 0-15-27 | 4.83 | 1.50 |
| 204 | 1A, 1A | 0-15-27, 0-15-27 | 7.30 | 1.60 |

### 400/440V ISOLATORS

400/440 to 200/240V

| VA | Ref. | £ | P&P |
|---|---|---|---|
| 60 | 243 | 8.11 | 1.50 |
| 250 | 246 | 16.07 | OA |
| 350 | 247 | 19.88 | OA |
| 500 | 248 | 24.77 | OA |
| 1000 | 250 | 50.53 | OA |
| 2000 | 252 | 74.79 | OA |
| 3000 | 253 | 104.86 | OA |
| 6000 | 254 | 207.92 | OA |

### AUTO TRANSFORMERS

Voltages available 105, 115, 190, 200, 210, 220, 230, 240. For step up or step down.

| Ref. | VA (Watts) | TAPS | £ | P&P |
|---|---|---|---|---|
| 113 | 15 | 0-10-115-210-240V | 2.39 | 1.20 |
| 64 | 80 | 0-10-115-210-240V | 4.84 | 1.40 |
| 4 | 150 | 0-10-115-200-220-240V | 6.48 | 1.60 |
| 67 | 500 | 0-10-115-200-220-240V | 13.30 | 2.24 |
| 84 | 1000 | 0-10-115-200-220-240V | 22.70 | 2.80 |
| 93 | 1500 | 0-10-115-200-220-240V | 28.17 | OA |
| 95 | 2000 | 0-10-115-200-220-240V | 42.14 | OA |
| 73 | 3000 | 0-10-115-200-220-240V | 71.64 | OA |
| 80 | 4000 | 0-10-115-200-220-240V | 93.01 | OA |
| 57 | 5000 | 0-10-115-200-220-240V | 108.30 | OA |

### CASED AUTOS

240V cable input USA 115V outlets

| VA | Price | P&P | Ref |
|---|---|---|---|
| 20 | £7.21 | 1.25 | 56W |
| 80 | £9.35 | 1.50 | 64W |
| 150 | £12.10 | 1.84 | 4W |
| 250 | £14.73 | 1.60 | 69W |
| 500 | £22.14 | 2.24 | 67W |
| 1000 | £33.74 | 2.80 | 84W |
| 2000 | £60.47 | OA | 95W |

### CONSTANT VOLTAGE TRANSFORMERS

For 'clean' mains to computers, peripherals.
250VA £137.36
500VA £159.43 } + p&p
1kVA £213.12 } + VAT

Tap Changing Type. Cased. 400VA, £97.50 + £2 p&p + VAT.

### INVERTERS

Cased 12V input 240V a.c., 13 amp socket outlet. Continuous 100W.
£46 + p&p £2 + VAT 15%. (Tool rating 150W.)

### COTSWOLD TOROIDALS OFF THE SHELF

30VA, 60VA, 100VA, 160VA, 230VA, 330VA, 530VA
**Send for list**

PLEASE ADD 15% VAT AFTER P&P
Overseas post extra

## OTHER PRODUCTS

### AVO TEST METERS

| | |
|---|---|
| 8 Mk. 5 Latest Model | £122.10 |
| 71 (Electronics & | £49.30 |
| 73 TV Service) | £68.90 |
| MM5 Minor | £43.60 |
| DA211 LCD Digital | £58.50 |
| DA212 LCD Digital | £81.90 |
| DA116 LCD Digital | £131.30 |
| Megger 70143 500v | £101.50 |
| Megger Battery BM7 | £71.60 |
| DA117 Autorange LCD | £157.00 |

Avo Cases and Accessories
P&P £1.60 + VAT 15%

### MAINS BATTERY ELIMINATORS

No wiring, ready to plug into 13A socket. 3, 4.5V, 6, 7.5V 9, 12V DC @ 300mA £5.10 + £1.20 p&p + VAT 15%

**ANTEX SOLDERING IRONS** 15W CCN240 or C £5.
Safety stand............£1.75 25W X25 ............£5.30
12V 25W car soldering kit............................£5.30
P&P 50p + VAT

**PANEL METERS £6.70 ea + 76p P/P + VAT**
43 × 43mm or 82 × 78mm — V.U. Indicator
50µA, 500µA, 1mA, 30V d.c. etc. £1.95+30p P&P+VAT
Educational Meter 10A8 30V £4.50+VAT

Precision De-Solder Pumps — Spring loaded quick action button release for one hand working. Large £5.86 P&P 35p+VAT. Small £5.17 P&P 30p+VAT. Replacement tips: Small 65p-VAT. Large 86p+VAT.

### BRIDGE RECTIFIERS

| | | |
|---|---|---|
| 200v | 2A | 45p |
| 400v | 2A | 55p |
| 100v | 25A+ | £2.10 |
| 100v | 35A | £2.60 |
| 200v | 4A | 65p |
| 400v | 4A | 85p |
| 400v | 6A | £1.40 |
| 500v | 12A | £2.85 |

P&P 20p. VAT 15%

Telephones: Trimphone £28 + £1.20 p&p + VAT.
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**WW – 045 FOR FURTHER DETAILS**

| Item No. | | Price |
|---|---|---|
| 1 | HEWLETT PACKARD RMS VOLTMETER type 3400A 1mV-300V; 10HZ-10MHZ | £150 |
| 2 | BOONTON SIGNAL GEN POWER AMPLIFIER type 230A 10-500MHZ | £50 |
| 3 | HEWLETT PACKARD AUDIO SIGNAL GENERATOR type 205AG | £25 |
| 4 | CLAUDE LYONS AUTOMATIC VOLTAGE STABILISER 2.88KVA. Compact | £60 |
| 5 | TEKTRONIX AMPLIFIER type 1121 | £40 |
| 6 | SES ABSORPTION WATTMETER type TG2600 2-1000MHZ; 100 Watts 50 ohm | £100 |
| 7 | TEKTRONIX PLUG-IN type D Single Trace High Gain DC Differential | £20 |
| 8 | TEKTRONIX PLUG-IN type E Single Trace Low Level AC Differential | £20 |
| 9 | TEKTRONIX PLUG-IN type G Single Trace Wide Band DC Differential | £25 |
| 10 | TEKTRONIX PLUG-IN type L Single Trace 30MHZ High Gain | £25 |
| 11 | TEKTRONIX PLUG-IN type M 4 Trace DC-20MHZ | £125 |
| 12 | TEKTRONIX PLUG-IN type O Operational Amplifier | £95 |
| 13 | TEKTRONIX PLUG-IN type Q Transducer & Strain Gauge | £75 |
| 14 | TEKTRONIX PLUG-IN type R Transistor Rise Time | £75 |
| 15 | TEKTRONIX PLUG-IN type W Differential Comparator | £125 |
| 16 | TEKTRONIX PLUG-IN type Z Differential Comparator | £75 |
| 17 | HEWLETT PACKARD LCR BRIDGE type 4261A | £795 |
| 18 | HEWLETT PACKARD AMPLIFIER type 462A | £35 |
| 19 | HEWLETT PACKARD DC CURRENT SOURCE type 6181B 0-100V; 0-250MA | £125 |
| 20 | FAST RESPONSE RECORDER type H3020-3 (3 channel) Brand new | £50 |
| 21 | HEWLETT PACKARD AUDIO OSCILLATOR type 200J | £35 |
| 22 | HEWLETT PACKARD PULSE GENERATOR Model 212A | £25 |
| 23 | HEWLETT PACKARD DC MICRO VOLT AMMETER type 425A | £40 |
| 24 | HEWLETT PACKARD OSCILLOSCOPE 182A with 1808A and 1825A. 75MHZ Dual Trace Delayed Sweep | £750 |
| 25 | AVO VALVE TESTER type CT160. (22 valve bases) | £20 |
| 26 | AVO TRANSISTOR ANALYSER type CT446 | £20 |
| 27 | MARCONI UNIVERSAL BRIDGE type TF868A | £50 |
| 28 | GENERAL RADIO DIGITAL TIME & FREQUENCY METER type 1151-A | £45 |
| 29 | MARCONI (SANDERS) MICROWAVE POWER METER type 6598 | £150 |
| 30 | MARCONI UHF SIGNAL GENERATOR type TF1060 | £95 |
| 31 | MARCONI FM SIGNAL GENERATOR type TF1077/1 19.7-102.5MHZ | £30 |
| 32 | MARCONI SUPPRESSED ZERO VOLTMETER type TF1377 | £15 |
| 33 | MARCONI VARIABLE ATTENTUATOR type TF1073A/2S (CT421) | £30 |
| 34 | ERNST TURNER 20KV ELECTROSTATIC VOLTMETER 6 inch | £20 |
| 35 | MARCONI AM/FM SIGNAL GENERATOR TF995A/3/S (CT402) 1.5-220MHZ | £160 |
| 36 | MARCONI AC MILLIVOLTMETER type TF2600 10HZ-5MHZ; 1mV-300V | £95 |
| 37 | B & K ACCELEROMETER PREAMPLIFIER type 2620 | £30 |
| 38 | B & K DEVIATION BRIDGE type 1503 | £50 |
| 39 | B & K DEVIATION BRIDGE type 1504 | £65 |
| 40 | B & K MICROPHONE AMPLIFIER type 2602 | £55 |
| 41 | B & K MICROPHONE AMPLIFIER type 2605 | £30 |
| 42 | B & K BEAT FREQUENCY OSCILLATOR type 1013 | £95 |
| 43 | B & K BEAT AUTOMATIC VIBRATION EXCITER CONTROL type 1018 | £50 |
| 44 | B & K EXCITER CONTROL PRE AMPLIFIER type 1608 | £20 |
| 45 | B & K FREQUENCY RESPONSE TRACER type 4707 | £200 |
| 46 | SOLARTRON/SCHLUMBERGER SYNTH. SSB GENERATOR type SSB30 with MODULATOR MA30 10HZ-32MHZ | £950 |
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| 48 | BRADLEY MULTIMETER type CT471C | £35 |
| 49 | MOSELEY WAVEFORM TRANSLATOR type 101 | £50 |
| 50 | HOUSTON INSTRUMENTS LOG VOLTMETER-CONVERTOR Model HLVC150 | £60 |
| 51 | POLARAD FIELD STRENGTH METER type FIM-B2 with RF Tuning Unit FIM-X2 7360-10,000MHZ | £95 |
| 52 | HEWLETT PACKARD DIGITAL VOLTMETER type 3460B with AC CONVERTER type 3461A. +/– 0.004% | £100 |
| 53 | SANDERS OSCILLATOR type CLC2-4 | £75 |
| 54 | B & K ELECTRONIC VOLTMETER type 2409 2HZ-200KHZ | £95 |
| 55 | GENERAL RADIO MICROWAVE OSCILLATOR type 1360B 1.7-4.1GHZ | £225 |
| 56 | GENERAL RADIO FREQUENCY/DISCRIMINATOR METER type 1142A. 0-1.5MHZ | £95 |
| 57 | HEWLETT PACKARD MEMORY DISPLAY type 5480A with CONTROL type 5486B and Two Channel Input type 5485A | £225 |
| 58 | GENERAL RADIO DECADE CAPACITOR 1413 with ANALOG LIMIT COMPARATOR 1782 and IMPEDANCE COMPARATOR 1654 | £150 |
| 59 | STOODART RADIO INTERFERENCE & FIELD INTENSITY METER type N-M 52A | £195 |
| 60 | KEITHLEY REGULATED HIGH VOLTAGE SUPPLY type 241 | £145 |
| 61 | BRANDENBURGH HIGH VOLTAGE GENERATOR type MR50 | £75 |
| 62 | BRANDENBURGH HIGH VOLTAGE P.U. Model 705 Metered 0-15KV. +/– | £100 |
| 63 | BELIX POWER UNIT type CMT3001. +/– | £40 |
| 64 | PLESSEY TELEGRAPH SIGNAL GENERATOR TSG10 with TDMS type 70. Speed 50-75-100 (2 units) | £60 |
| 65 | As Above but SPEED 45.5 -50 -75 | £80 |
| 66 | RACAL H.F. SELECTIVE ANALYSER type 9056 | £235 |
| 67 | RACAL UHF FREQUENCY METER type 9839 10-560MHZ | £225 |
| 68 | RACAL 600MHZ DECADE DIVIDER type 9010 | £40 |
| 69 | RACAL AUTO FREQUENCY CONVERTOR type 803R 500MHZ | £20 |
| 70 | RHODE & SCHWARZ NOISE GENERATOR SKTU BN4151/2/60 3-1000MHZ | £75 |
| 71 | R & S UHF TEST RECEIVER BN1523 280-940MHZ | £50 |
| 72 | R & S FREQUENCY METER VHF-UHF 30-300MHZ type W1D BN442 | £40 |
| 73 | R & S ATTENUATOR type DPR BN18042/50 | £25 |
| 74 | R & S RESONANCE FREQUENCY METER 30-500MHZ WAM BN4312/2 | £50 |
| 75 | R & S WIDE BAND SIG GEN type SBF BN40861 10HZ-10MHZ | £60 |
| 76 | R & S SIGNAL GENERATOR type SMAR BN4123 30HZ-30MHZ | £50 |
| 77 | R & S CAPACITANCE METER BN5201 | £50 |
| 78 | ISOLATING TRANSFORMER 240V Input 240V Output 1300 Watts | £15 |
| 79 | AUTO TRANSFORMER 1.4 KVA Pri Volts 90/240 Sec Volts 115 | £15 |
| 80 | DC SERVO MOTOR 110V 2.5A Cont. Double Shaft 4 wire 4 brush. New | £15 |
| 81 | JLT TRANSISTOR A.C. VOLTAGE REGULATOR MODEL LT-T1000-2S Rating 1000V | £40 |
| 82 | WAYNE KERR AUTOBALANCE CAPACITANCE BRIDGE type B541 | £75 |
| 83 | PHILIPS VIDEO COLOUR TEST GENERATOR type PM5522. No case | £145 |
| 84 | PHILIPS FM STEREO GENERATOR type PM6456. Separate L & R Signals Carrier Freq 100MHZ +/– 1% RF O/P 3mV pk-pk | £125 |
| 85 | PHILIPS COMPARATOR 278KHZ | £30 |
| 86 | PHILIPS AUTOMATIC ELECTRONIC VOLT OHM METER type PM2405 | £20 |
| 87 | B & K AUTOMATIC VIBRATION EXCITER CONTROL type 1016 | £50 |
| 88 | HEWLETT PACKARD DC POWER SUPPLY type 6448B. 0-600 Volts 0-1.5 Amps | £295 |
| 89 | BRANDENBURG REGULATED HIGH VOLTAGE. P.U. type 928R. 0-1000KV; 0-1MA | £150 |
| 90 | ADVANCE PULSE GENERATOR type PG5002D | £20 |
| 91 | GAUMONT-KALEE FLUTTER METER type 1740 | £30 |
| 92 | ADVANCE SIGNAL GENERATOR L.F. type 81A 15HZ-200KHZ | £25 |
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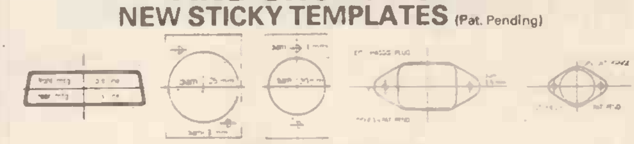

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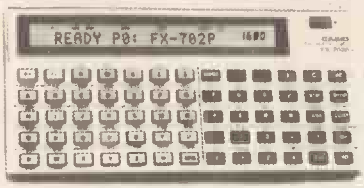


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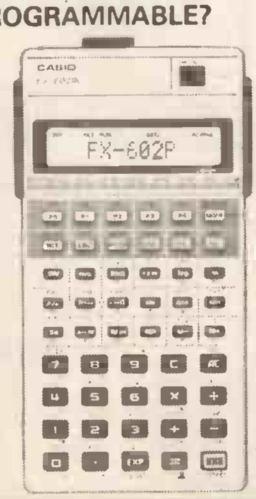


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| Regulation | 1x013 | 15+15 | 1.00 | TOTAL £7 08 |
| 18% | 1x014 | 18+18 | 0.83 | |
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| Regulation | 2x013 | 15+15 | 1.66 | TOTAL £8 05 |
| 13% | 2x014 | 18+18 | 1.38 | |
| | 2x015 | 22+22 | 1.13 | |
| | 2x016 | 25+25 | 1.00 | |
| | 2x017 | 30+30 | 0.83 | |
| | 2x028 | 110 | 0.45 | |
| | 2x029 | 220 | 0.22 | |
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| 160 VA | 5x011 | 9+9 | 8.89 | £7.91 |
| 110×40mm | 5x012 | 12+12 | 6.66 | +p/p £1 67 |
| 1.8 Kg | 5x013 | 15+15 | 5.33 | +VAT £1 44 |
| Regulation | 5x014 | 18+18 | 4.44 | TOTAL £11 02 |
| 8% | 5x015 | 22+22 | 3 63 | |
| | 5x016 | 25+25 | 3.20 | |
| | 5x017 | 30+30 | 2.66 | |
| | 5x018 | 35+35 | 2.28 | |
| | 5x026 | 40+40 | 2.00 | |
| | 5x028 | 110 | 1.45 | |
| | 5x029 | 220 | 0.72 | |
| | 5x030 | 240 | 0.66 | |

| TYPE | SERIES No. | SECONDARY Volts | RMS Current | PRICE |
|---|---|---|---|---|
| 225 VA | 6x012 | 12+12 | 9 38 | £9.20 |
| 110×45mm | 6x013 | 15+15 | 7 50 | +p/p £2 00 |
| 2.2 Kg | 6x014 | 18+18 | 6 25 | +VAT £1 68 |
| Regulation | 6x015 | 22+22 | 5 11 | TOTAL £12 88 |
| 7% | 6x016 | 25+25 | 4.50 | |
| | 6x017 | 30+30 | 3.75 | |
| | 6x018 | 35+35 | 3 21 | |
| | 6x026 | 40+40 | 2 81 | |
| | 6x025 | 45+45 | 2.50 | |
| | 6x033 | 50+50 | 2.25 | |
| | 6x028 | 110 | 2.04 | |
| | 6x029 | 220 | 1.02 | |
| | 6x030 | 240 | 0 93 | |
| 300 VA | 7x013 | 15+15 | 10 00 | £10.17 |
| 110×50mm | 7x014 | 18+18 | 8 33 | +p/p £2 00 |
| 2.6 Kg | 7x015 | 22+22 | 6.82 | +VAT £1 83 |
| Regulation | 7x016 | 25+25 | 6.00 | TOTAL £14 00 |
| 6% | 7x017 | 30+30 | 5.00 | |
| | 7x018 | 35+35 | 4 28 | |
| | 7x026 | 40+40 | 3 75 | |
| | 7x025 | 45+45 | 3 33 | |
| | 7x033 | 50+50 | 3 00 | |
| | 7x028 | 110 | 2.72 | |
| | 7x029 | 220 | 1 36 | |
| | 7x030 | 240 | 1.25 | |
| 500 VA | 8x016 | 25+25 | 10 00 | £13.53 |
| 140×60mm | 8x017 | 30+30 | 8 33 | +p/p £2 35 |
| 4 Kg | 8x018 | 35+35 | 7 14 | +VAT £2 38 |
| Regulation | 8x026 | 40+40 | 6.25 | TOTAL £18 26 |
| 4% | 8x025 | 45+45 | 5.55 | |
| | 8x033 | 50+50 | 5.00 | |
| | 8x042 | 55+55 | 4 54 | |
| | 8x028 | 110 | 4 54 | |
| | 8x029 | 220 | 2 27 | |
| | 8x030 | 240 | 2 08 | |
| 625 VA | 9x017 | 30+30 | 10.41 | £16.13 |
| 140×75mm | 9x018 | 35+35 | 8 92 | +p/p £2 50 |
| 5 Kg | 9x026 | 40+40 | 7 81 | +VAT £2 79 |
| Regulation | 9x025 | 45+45 | 6 94 | TOTAL £21 42 |
| 4% | 9x033 | 50+50 | 6 25 | |
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| | 9x029 | 220 | 2 84 | |
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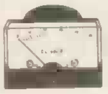

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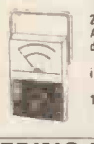

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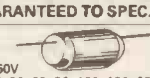

**POLYSTYRENE, SIEMENS** 5% Tolerance. 160V
5, 7, 10, 12, 15, 18, 22, 27, 33, 39pF **12p**; 47, 56, 68, 82, 100, 120, 150, 180, 220, 270, 330, 390, 470, 560, 680, 820pF; 1n, 1n2, 1n5, 1n8, 2n2, 2n7, 3n3, 3n9, 4n7 **8p**; 5n6, 6n8, 8n2, 10n **9p**.

**CERAMIC** Very small. 1.8, 2.2, 2.7, etc. up to 1n 5p each. 1n5, 2n2, 3n3, 4n7, 6n8 **5p**; 10n, 22n **6p**. 33n, 47n **7p**; 100n **8p**.

**POLYESTER, SIEMENS LAYER-TYPE** *7.5mm lead spacing 100V*
1n, 1n5, 2n2, 3n3, **6p**; 4n7, 6n8, 8n2. 10n, 12n, 15n, 18n, 22n, 27n, 33n, 39n, 47n **7p**; 56n. 68n **8p**; 82n, 100n **9p**; 120n, 150n, **11p**; 180n, 220n, **12p**; 270n, 330n, 15p; 390n, 470n **17p**; 560n, 680n **24p**; *100mm spacing* 1μF **26p**; *15mm spacing* 2μ2 **35p**; *22.5mm spacing* 1μF 400V **47p**; 3.3μF 100V **50p**; In-depth stocks.

**ELECTROLYTICS NON-polar** (for LS X-overs) 50V peak 2μF **26p**; 4μF **28p**; 6, 8, 10, 16μF **32p**; 25μF **37p**; 40, 60μF **59p**; 100μF **69p**.
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(μF/V) 10/40, 22/25, 47/10 **11p**; 47/25 **12p**; 100/10 **13p**; 10/63, 22/40, 100/16 **14p**; 22/63, 47/40, 100/25, 100/40 **15p**; 220/10, 220/16 **16p**; 220/25 **18p**; 220/40 **20p**; 470/10, 470/16, 470/25, 100/10 **19p**; 470/40, 1000/16 **27p**; 1000/25 36p; 1000/40, 2200/16 **44p**; 1000/63 76p; 2200/40, 4700/16 **73p**.

**PLUGGABLE SIEMENS** single ended
1/63, 2.2/63, 4.7/63 **10p**; 10/63, 22/63 **12p**; 22/40, 47/16 **10p**; 47/40 **12p**; 47/63 **15p**; 100/16, 100/25 **12p**; 100/40 **15p**; 100/63 **20p**; 220/10 **13p**; 220/16, 220/25 **13p**; 470/6.3 **15p**; 470/10 **16p**; 470/16 **18p**; 470/25 **22p**; 470/40 25p; 1000/10 **22p**; 1000/16 23p.

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**TANTALUM**
0.1/35, 0.22/35, 0.47/35, 1/35, 2.2/16 **13p**; 2.2/35, 4.7/16 **18p**; 10/6.3 **18p**; 4.7/35, 10/16, 22/6.3, 10/25 **18p**; 22/16, 22/25, 33/10, 47/6.3, 100/3 **30p**.

**LOW LEAKAGE** All single ended
0.1/50, 0.22/50, 0.47/50, 4.7/35 **10p**; 1/50, 2.2/50, 4.7/50 **12p**; 10/16, 22/6, **10p**; 10/35, 22/10, 22/16, 22/35, 47/6, 47/10 **12p**; 47/16, 100/6 **12p**.

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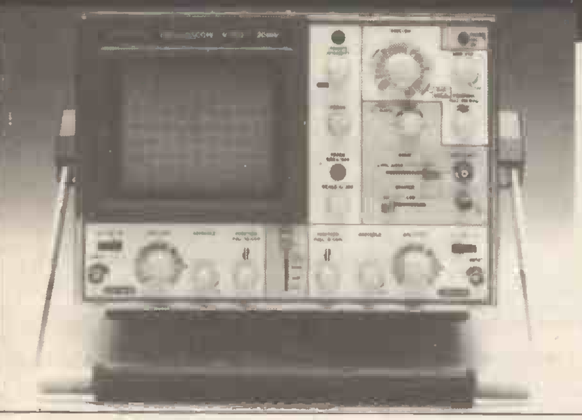

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**Audio Support Engineer (RF/Analogue Products)**

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*If you are interested please write, giving brief details of experience and current salary, to Mike Jones, Senior Personnel Officer, Sony Broadcast Limited, City Wall House, Basing View, Basingstoke, Hants RG21 2LA. Tel: 55011.*

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**Department of Electronic and Communications Engineering**

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**Further details and application form from Mr. E. W. Bowman, Departmental Superintendent, Department of Electronic and Communications Engineering, The Polytechnic of North London, Holloway Road, London N7 8DB.**

(1641)

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Completed forms should be received within fourteen days of publication date.

BBC

1638

The Polytechnic of North London

**Department of Electronic and Communications Engineering**

# LABORATORY TECHNICIAN (Grade 4)

Applications are invited for the above post. The duties involve assistance in our Teaching Laboratories.

Applicants will be required to construct, modify and maintain experiments and electronic equipment. Greater consideration will be given to those with experience in servicing equipment to component level.

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(1531)

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(1635)

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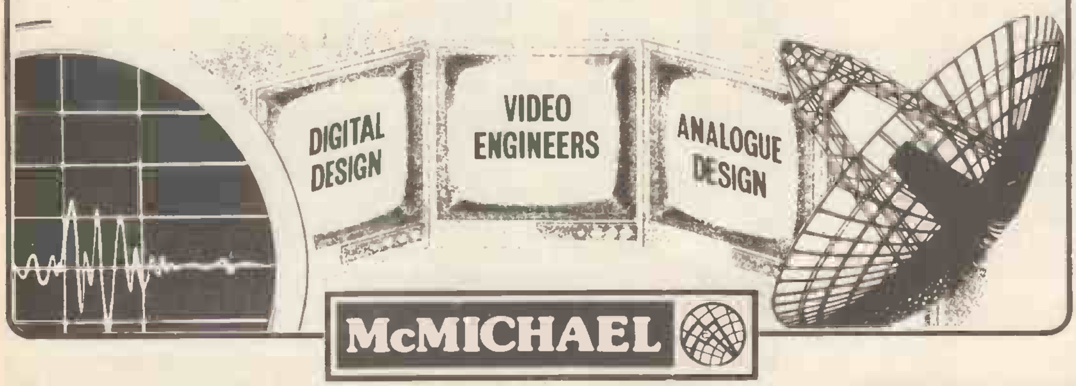


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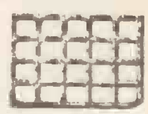

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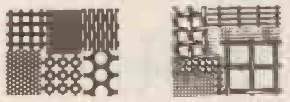

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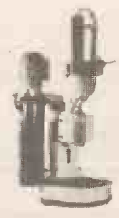

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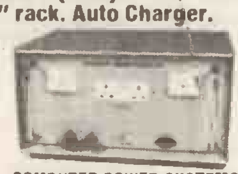

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Printed in Great Britain by QB Ltd., Sheepen Place, Colchester, and Published by the Proprietors IPC ELECTRICAL-ELECTRONIC PRESS LTD., Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS, telephone 01-661 3500. *Wireless World* can be obtained abroad from the following: AUSTRALIA and NEW ZEALAND: Gordon & Gotch Ltd. INDIA: A. H. Wheeler & Co, CANADA: The Wm. Dawson Subscription Service Ltd, Gordon & Gotch Ltd. SOUTH AFRICA: Central News Agency Ltd: William Dawson & Sons (S.A.) Ltd. UNITED STATES: Eastern News Distribution Inc., 14th floor, 111 Eighth Avenue, New York, N.Y. 10011.

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