

# wireless world

MARCH 1982 70p

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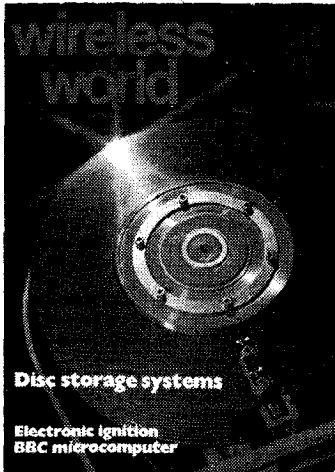
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# wireless world

ELECTRONICS  
TELEVISION  
RADIO  
AUDIO

MARCH 1982 Vol 88 No 1554



Front cover picture is a prototype DEC disc drive, photographed by John Watkinson for the new series starting this month.

## NEXT MONTH

Heating-fuel saver by David Ryder delays switch-on to an extent determined by ambient temperature. It is used with normal time switch.

Stage lighting system linearizes light output/fader position relationship, making system suitable for microprocessor control.

32W D mosfet amplifier is a simple, general-purpose audio amplifier. Complete design and construction details are given.

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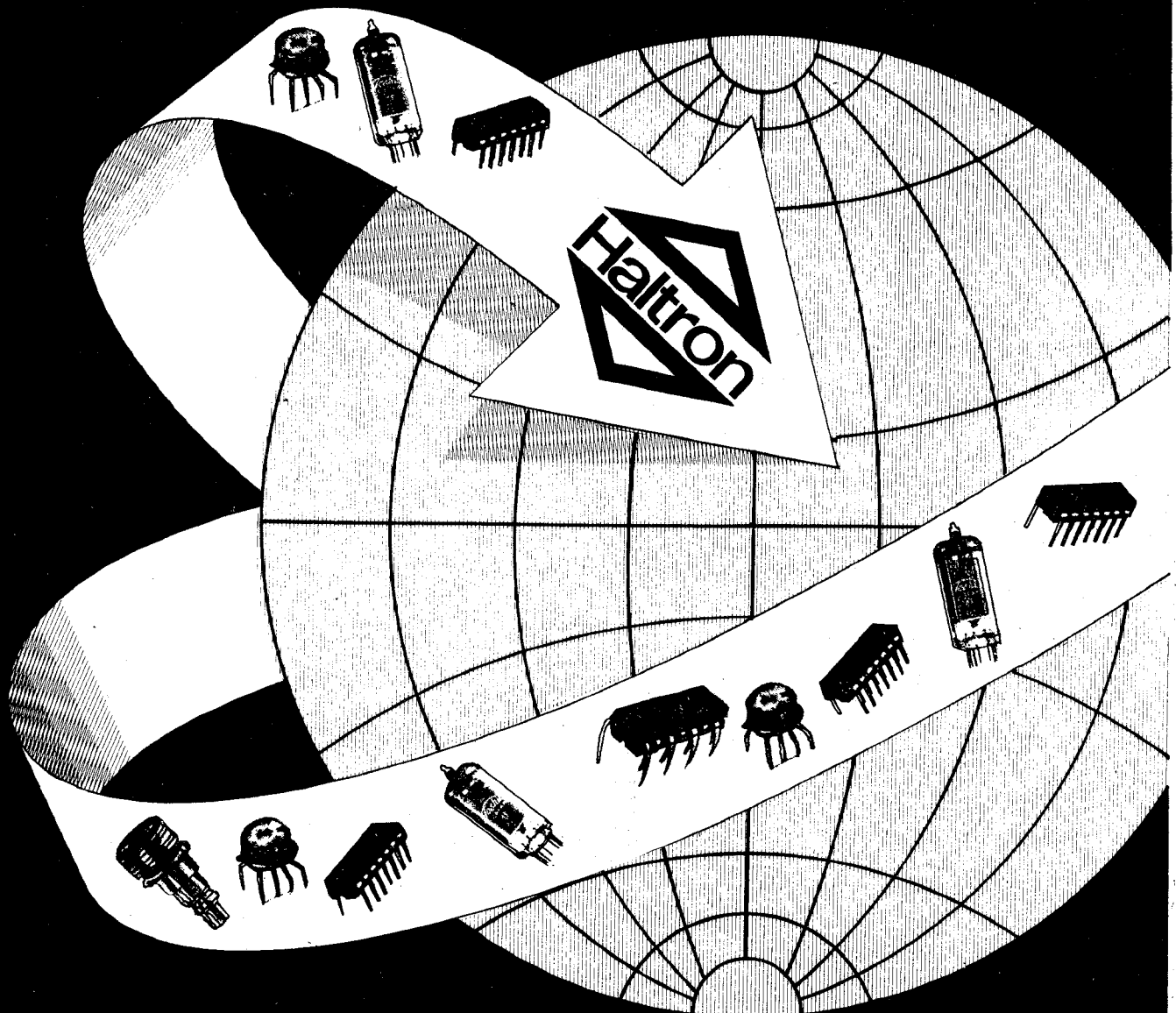
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## Alien intelligence

We are becoming accustomed to seeing our industries savaged by the industrious, ambitious and commercially ferocious Japanese. Consumer electronics, cars, motorcycles, cameras and many more have been attacked and, in some cases, subdued by the Eastern invasion. The British press directs its comment, in the main, towards the effect of the inundation on British industry and tends to leave the impression that the Japanese have singled the UK out for treatment. We are, however, not alone in facing an assault on our livelihood, for even IBM is to be overtaken by 1990, if the Japan Information Processing Development Centre is to be believed – and experience indicates that it would be a serious mistake not to.

Not only are the Japanese absolutely open in declaring that their goal is world domination in computing in the next decade but are, with apparently straight faces, inviting representatives from the countries they are planning to overwhelm to help them achieve their object.

The means whereby they intend to carry out their plan is the 'fifth generation' of computers, a term which is certain to be the buzz word of the '80s. Equally magnetic expressions such as logic programming, data flow, expert systems and artificial intelligence will also be on well-informed lips, since these concepts are to be examined by the Japanese with a view to constructing a machine that will be capable of conversing (the word is used in a literal sense) in everyday language, of processing data at immensely high speeds, of learning and of making inferences and associations from apparently unconnected sets of data. In other words, it will think in human terms in that it will possess a base of knowledge (provided by an 'expert') from which it will be able to make decisions and judgements without reference to a precise set of instructions. Its intelligence will approach that of humans.

For at least two years, the Japanese have been trying to encourage workers in the field – mainly American and some British – to join them in this work, and invited 50 to a meeting in Tokyo last October, at which the hosts were to "give the results so

far" of the fifth generation project, according to Yuji Yamaduri, the project's research manager. Significantly, he also said that the guests would be expected to provide information on their own work. From this, one might imagine the programme to be international in nature, but a report from JIPDEC states categorically that it is not. Japan will decide how to run it, since one of its objects is to provide Japan with bargaining power.

Not surprisingly, the Western scientists invited to hand over their work are wary, to say the least. In Britain, they await action from Ray Atkinson, who went to the Tokyo meeting. He intends to meet British workers to coordinate the activity and to come up with some kind of intelligent response to the new project. No government body has yet delivered itself of any reasoned statement on a course of action, or has taken any decision on the financial backing of computer research in this country in direct response to that in Japan. At present, therefore, the situation is absolutely normal – no decisions, no action and no clear idea of what to do next.

Why, though, does a response to the Eastern stimulus have to come from a government body? The first part of such a programme ought not to be too costly for industry which, it is devoutly to be hoped, will still be in business when the present Government is but a bad memory. The defence of industry is an industrial matter and industrialists should now be taking concerted action to forestall the Japanese, who are evidently intent on the destruction of all Western industry. A later administration may be disposed to allocate public funds when the going becomes too expensive for the private purse, but until then, the first steps could at least be taken.

In Europe, the EEC intends to spend nearly a thousand million pounds on computer research – part of that on work in response to Japan's £200m initiative – and presumably British firms are to be involved. But here, again, a good deal of the money will come from taxpayers, a source which has been known to dry up rather suddenly.

# Disc drives

*The drive's role in a computer system*

*— part one of an explanatory series*

by J. R. Watkinson, B.Sc., M.Sc.,  
Digital Equipment Co.



Almost all modern mainframe and mini computers rely on disc drives for rapid-access, non-volatile data storage, but surprisingly few people have more than a vague idea of how such memories function. Their design is fascinating, involving a combination of mechanical and electronic engineering technologies, and despite their obvious drawbacks in terms of mechanical reliability they will continue to be used well into the future. How long they remain viable is of course determined by the introduction date of a competitive storage medium. No such date is yet in sight and as the uncertainty continues, demands on potential alternatives will increase proportionally with subsequent improvements in disc technology. With the aforementioned in mind, we present this series of articles to fully explain present disc-drive technology and give an idea of what is to come. This particular article, on the disc-drive's role in a computer system, provides the background information necessary to understand why features to be discussed in subsequent articles are necessary.

Digital computers are logical machines working under the control of a stored program, that is to say the central processing unit (c.p.u.) processes data according to instructions from the memory. In the past, most computer memories consisted of many tiny iron toroids, often called core stores, in which binary information was stored as one of two directions of magnetic flux. More recently, semiconductor memories in the form of bipolar latches or

m.o.s. cells have taken over from core stores mainly because of their relatively low cost per bit. Bubble memories, although quite amazing in theoretical terms of cost per bit and physical size, have yet to have a significant influence on the memory market.

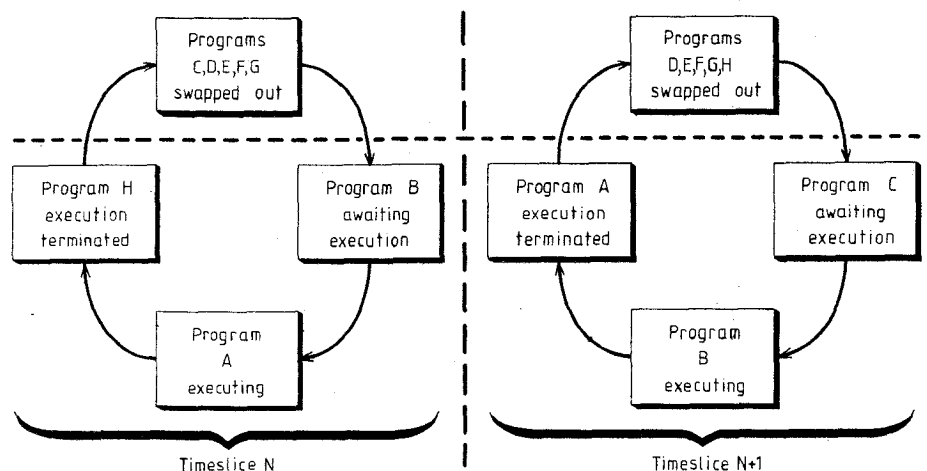
A computer is expected to execute thousands of different programs; if all these programs were stored in the computer's immediate memory, the memory size, and hence its cost, would be enormous — not to mention other difficulties. So some means of storing programs other than those required for immediate use is necessary outside the main computer. This need arose before the development of the disc drive and many external storage media were used including punch cards, paper tape and magnetic tape. These media are cheap but transferring programs to and

from them is very slow. Computing time is expensive so the speed aspect is important.

As c.p.us developed, instruction execution time fell proportionally with the increase in speed of logic elements to such an extent that one c.p.u. could jump between programs so fast that it seemed as if all the programs were being run simultaneously. This phenomenon is called multi-programming (or time-sharing if the programs belong to different users).

Normally, the size of a program to be executed is limited by the address range of the c.p.u., i.e. a 16-bit computer can only address 32K different memory locations (1K = 1024 bits). But in true time-sharing, it would appear as if 32K of memory were available to each user.

There is a two-stage solution to this problem, currently the most effective approach to time-sharing. A 'memory man-



**Fig. 1.** Multi-programming using the swapping technique. In this simplification, programs A to H are time-sharing the c.p.u. Only one program is executed at any one time and the computer's main memory only needs to hold three of the eight programs.

agement' unit is interposed between the c.p.u. and the memory. One purpose of this unit is to expand the memory addressing range of the system. In a typical application, the 16-bit c.p.u. address known as the virtual address, can be converted to a 22-bit memory address known as the physical address, by adding relocation constants. This allows addressing of up to 2M of memory (1M = 1024K). The operating-system software can change the relocation constants so that

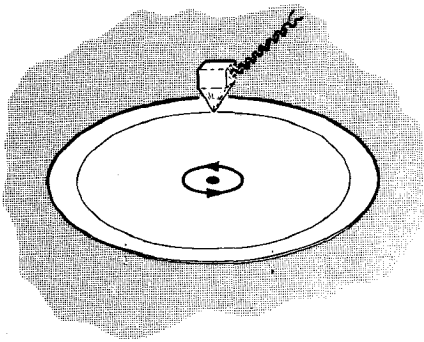


Fig. 2. The rotating data-store concept. Data on the rotating circular track is repeatedly presented to the head.

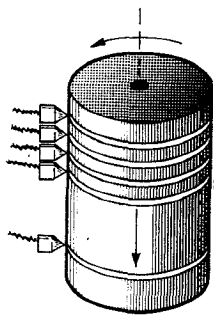
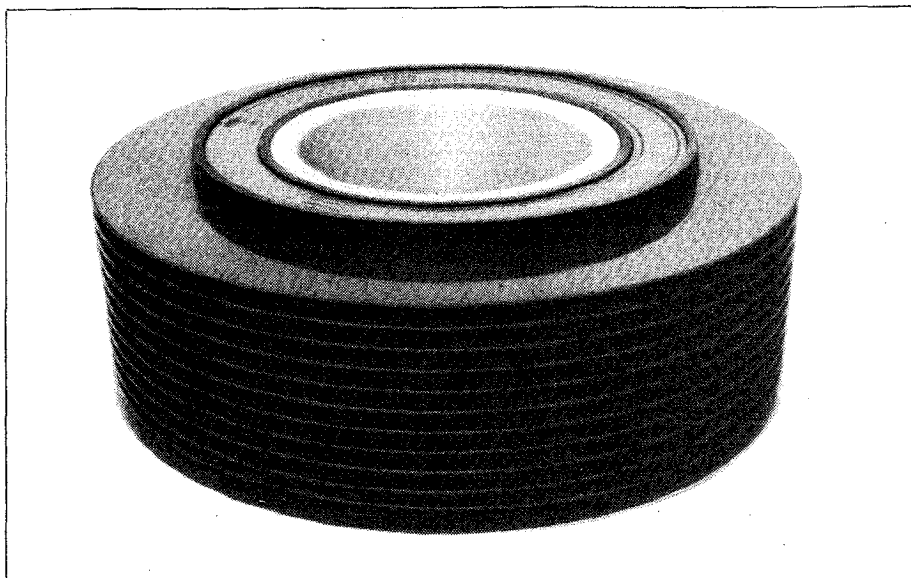


Fig. 3. The first rotating stores were in the form of drums, with one head per track.



A multi-platter disc pack with 20 working surfaces, removed from its protection cover. Note the well in the centre.

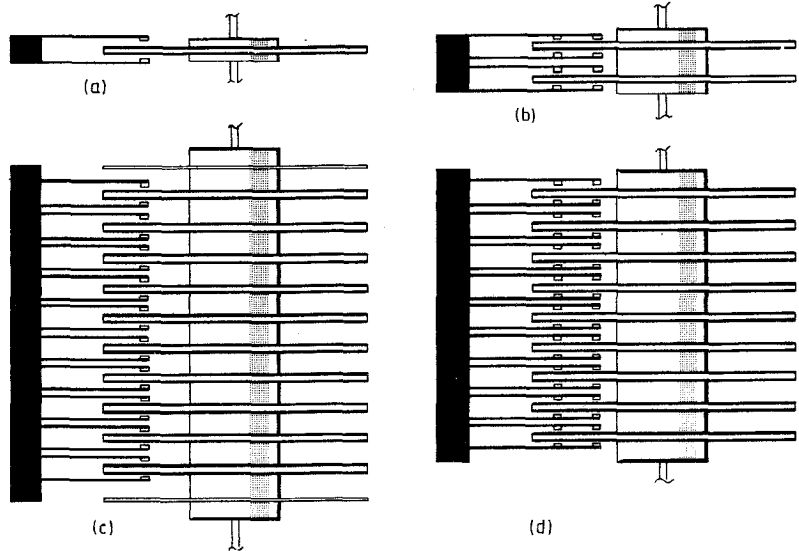


Fig. 4. Moving-head disc configurations (a) and (b) are single and dual-platter drives often found in cartridge form. (c), the ten-disc pack shown is removable but is not in cartridge form, hence the two protection discs. (d), here the disc pack is fixed and two heads per surface are used. The greater the number of heads, the greater the amount of data that can be transferred before the positioner has to move. This reduces the effect of seek time on overall access time.

the c.p.u. addresses a different 32K of instructions belonging to a different user. In practice, the full memory capacity is not necessary, because only a few different programs need to be in the memory at any one time. The remainder are stored on a rapid-access disc drive.

As the time-sharing process proceeds, a program which has used its time slice is discontinued, and a second program begins. The first program can now be written back to the disc to make room in the memory for a third program, which is read in from the disc. This process is called swapping, and the disc involved is called the swapping disc, Fig. 1. The process is enhanced if the disc drive can access the memory without using the c.p.u., a technique known as direct memory access (d.m.a.). The swapping principle used in timesharing is analogous to juggling,

where one hand is the memory management unit and the other is the disc. The hands must be well coordinated or the illusion is destroyed. The most successful multi-programming machines are those where both hardware and software dovetailing of the disc and memory management systems is best. For this reason even 32-bit machines, which have an address range beyond anyone's wildest dreams (4.3 billion locations), retain the principle of relocation in conjunction with disc drives.

The above principle will only work if the access time of the disc drive is short and

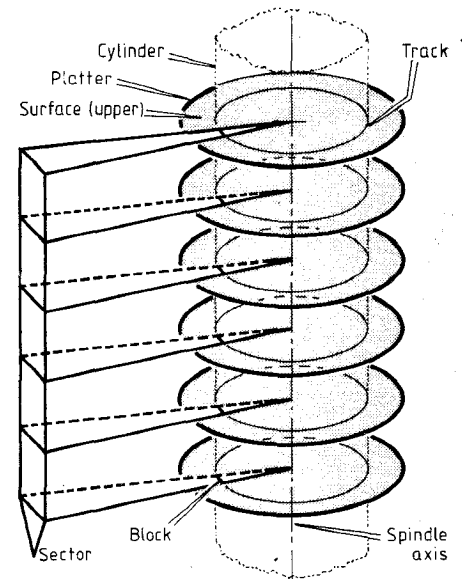
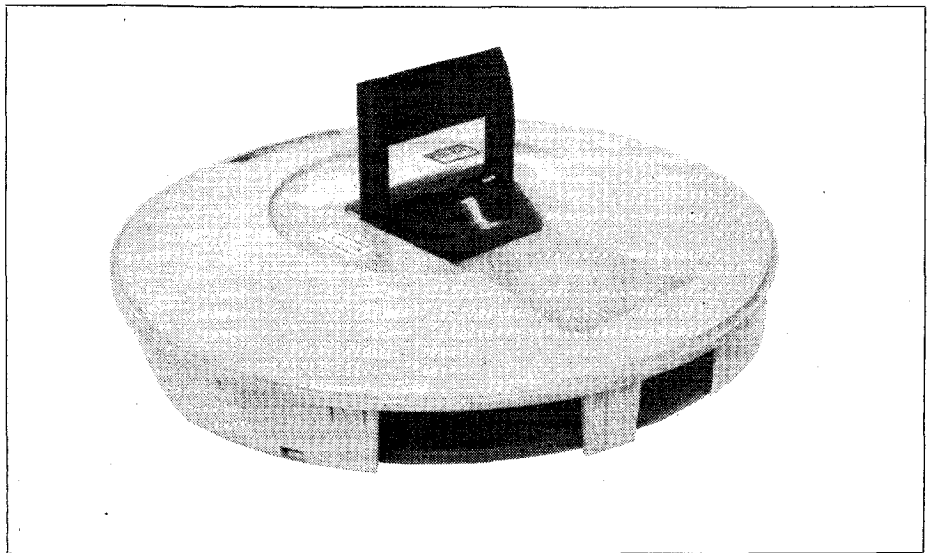


Fig. 5. Disc terminology. A surface is one side of a platter and a track is a path described on the surface by a stationary head. Cylinder is the term used to describe an imaginary form which intersects all surfaces at tracks of the same radius, and sector describes an angular subdivision of a track. A block is part of the track within the sector. Each block has its own cylinder, head and sector address.

the data transfer rate rapid. Let us now examine how this is achieved. Referring to Fig 2, data is stored on a magnetic coating, similar to that on tape, in the form of a circular track. The disc revolves at several thousand rev/min, and as a result, the maximum time it is necessary to wait in order to access a particular part of the track is of the order of milliseconds. This time is referred to as rotational latency. The data transfer rate is also high, as the relative speed of the head to the medium is of the order of 100 mile/h. At this speed, no physical contact between the head and the disc can be tolerated, so the head is designed to float on the layer of air rotating with the disc at a height measured in micro-inches.

In the first rotating stores, the medium was in the form of a drum, and many parallel tracks could be accommodated, with one head per track, Fig. 3. Track switching was electronic, and therefore instantaneous, so access time was still only governed by rotational latency. Some of



A dual-platter cartridge with the bottom cover removed revealing the apertures in the cartridge where the drive gains access to the disc.

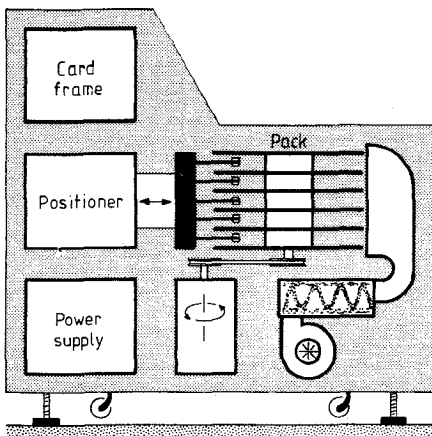


Fig. 6. Major subsystems of a typical disc drive. Analogue and digital circuits are contained in the card frame. The malfunction detection section and safety interlock are not shown here but are nevertheless important.

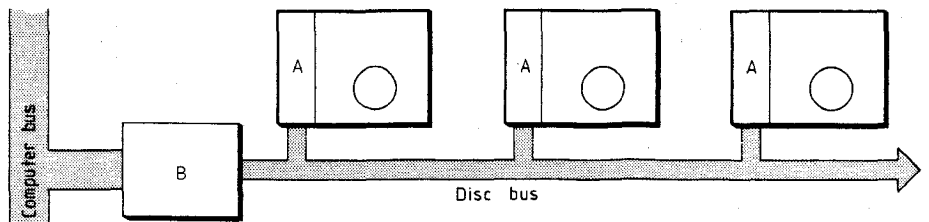


Fig. 7. Block diagram of a disc system using multiple drive units. For cost reasons, the circuitry is split into two parts, A and B.

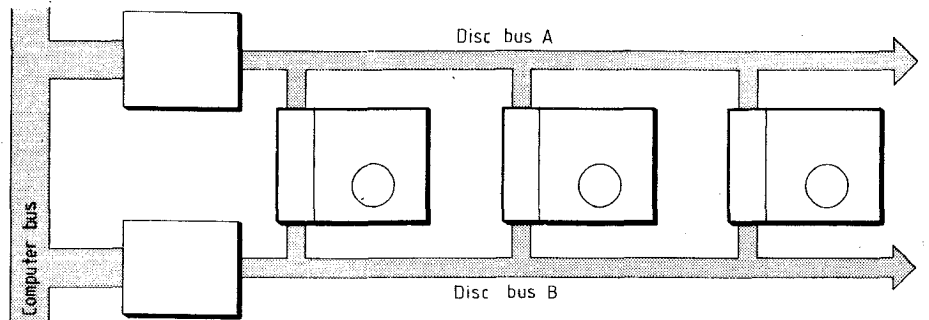


Fig. 8. Dual-controller, dual-port system. This method is more efficient but obviously more costly than that shown in Fig. 7.

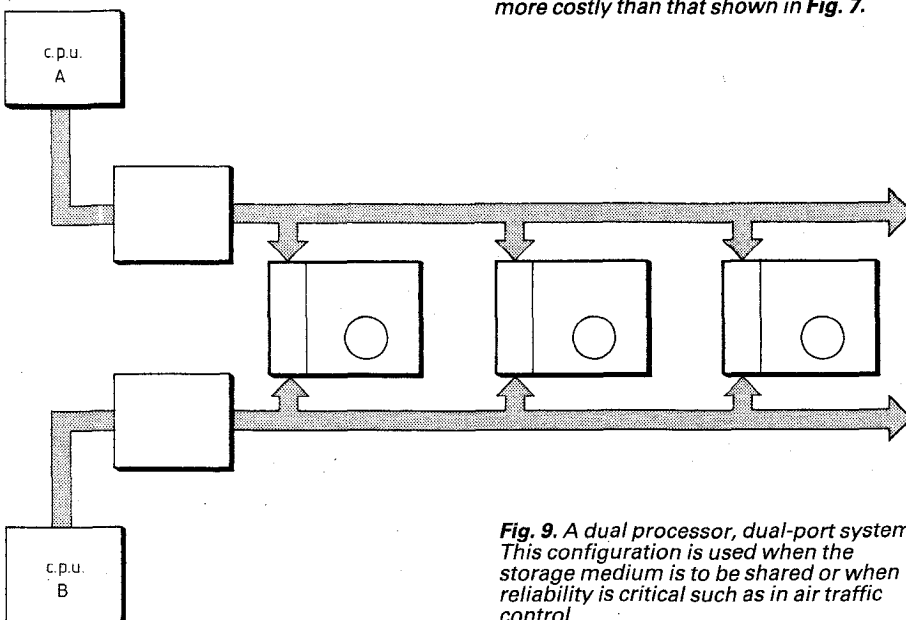


Fig. 9. A dual processor, dual-port system. This configuration is used when the storage medium is to be shared or when reliability is critical such as in air traffic control.

these drum stores were quite large and heavy, and it could take a day for the drum to stop after power was removed. A bearing seizure would unleash the kinetic energy of the drum and cause extensive damage to the computer room.

It was soon realized that many parallel tracks could be accommodated on the surfaces of a flat disc, with consequent weight saving. When one head per track was used, the device was termed a fixed-head disc drive. As the advancing technology permitted a greater number of tracks to be accommodated on a given disc, it became more cost effective to use a single head per surface, and use some kind of radial positioner to mechanically place the head over the desired track. When this approach is used, the resulting device is called a

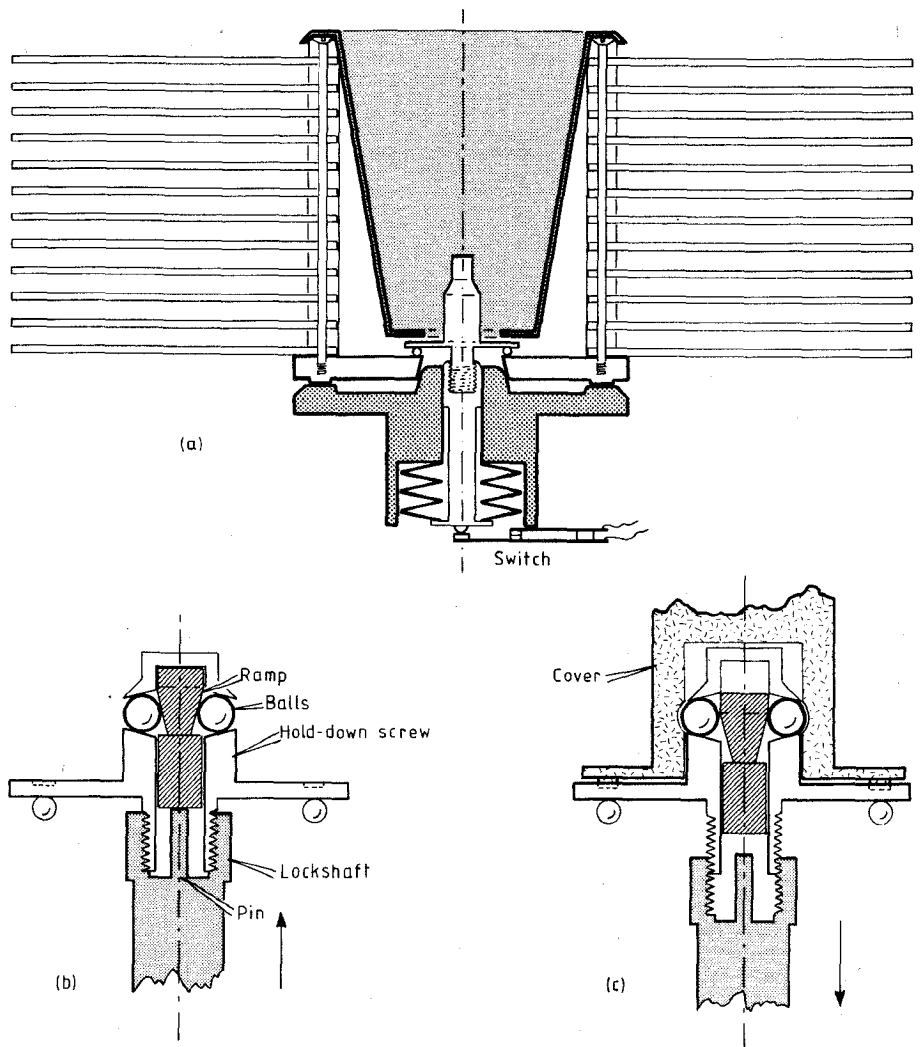


moving-head disc drive. The positioner could retract the head(s) away from the disc altogether, making replacement of the disc easy. This was not possible with fixed-head disc drives or drums. Exchangeable-pack moving-head disc drives thus became the standard for mainframe installations, and subsequently for minicomputers. It is normal to have at least two such devices per c.p.u. A copy of the system data can then be made on the second drive, which can then be removed and kept in a safe place so that the valuable data is not lost in the event of a failure. This process is called "backing up" and its importance can not be over estimated.

A penalty of using moving heads is that the access time is extended. The process of moving the heads is referred to as a seek, and the access time becomes the sum of the seek time plus the rotational latency. In order to reduce the number of seeks required for a given data transfer, the amount of data stored at any one setting of the positioner is often increased. This is done by mounting several discs on a common spindle, and fixing all of the heads to one positioner so that they move together. On some drives this is taken a stage further by having a number of heads per surface.

Figure 4 shows some typical head and disc configurations. Which configuration is chosen for a given situation depends on the performance required and the cost of the unit. A drive's capacity is usually expressed in megabytes (M-byte) per spindle, where one byte is eight bits. Drive units are available with from 2M-byte to 1000M-byte capacity and range in price from £10<sup>3</sup> to £10<sup>5</sup> each. A major factor in the competitiveness of a disc product is the cost per bit stored. As a given disc drive needs only one positioner, one spindle and one set of drive circuits, the more data that can be packed into one unit, the lower the cost per bit of storage.

The problems encountered in the ceaseless quest for lower cost per bit, and the ingenious solutions, will form a major



**Fig. 10.** Typical construction of a multi-platter interchangeable pack. The pack weighs about 9kg and rotates at about 3600 rev/min. The pack securing mechanism must be very reliable, capable of resisting the forces involved and must centre the pack precisely to ensure proper track alignment and balancing. In (b), the hold-down screw is fully screwed into the lockshaft so the pin lifts the ramp, thus retracting the balls. In (c), the lockshaft is screwed off the hold-down screw and the ramp pushes the balls outwards thus locking the assembly to the cover. The lockshaft operates a switch, shown in (a), to indicate to the logic that the pack is fitted.

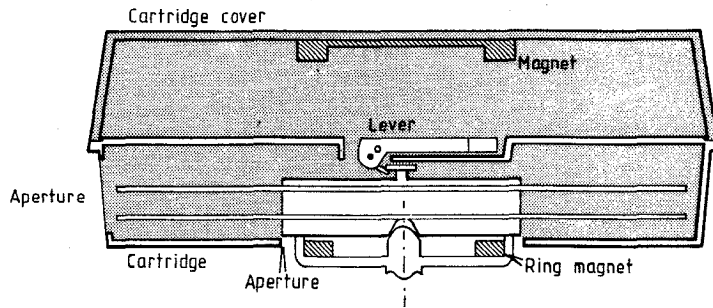


A cartridge being loaded into a drive. The cartridge base cover is stored on top of the cartridge to keep it clean.

part of this series. It will be appreciated that many of the solutions were the result of millions of dollars of research, and are often subject to patents.

As with any technology, there is a whole terminology associated with disc drives. Some of the terms have already surfaced and, with the basics explained, now is a good time to introduce some more important ones. Figure 5 shows a typical multi-platter disc pack in conceptual form, and introduces terms which will be used throughout this series. The reader should be aware that some variation on these definitions can be expected from one manufacturer to the next.

A set of coordinates for cylinder, head and sector, known as a disc address or pack address, defines each particular data block. A common capacity for a block is 512 bytes. The subdivision of tracks into sectors is sometimes omitted in mainframes, owing to the larger quantities of data involved, in which case the whole track becomes a block.



**Fig. 11.** A dual-platter disc cartridge. Unlike the disc pack, the medium is permanently enclosed by the cartridge. Apertures are provided for the spindle and positioner, the disc hub being retained by a ring magnet in the spindle. The cartridge cover, which seals the apertures when the disc is not in use, goes upside down on top of the cartridge when it is in the drive (as shown). The magnet in the cover attaches to the disc's hub when the cover is fitted.

Figure 6 shows the major subsystems of a typical disc drive, and introduces topics which will be discussed as the series progresses.

Figure 7 outlines a typical multi-drive installation. For reasons of cost effectiveness, the circuitry involved is often split into two parts; that which is required by each spindle, and that which is common to all spindles. A penalty of this approach is that only one drive can transfer data at a time although positioners for other drives may be moving simultaneously, a situation known as overlapped seeking. Often though, the transfer rate of the drive (in bytes/s) is of the same order as the bandwidth of the computer bus, so that only one transfer can be supported at a time. Where the computer bus can tolerate higher rates, it is possible to use two controllers in parallel. A disc drive which can operate with more than one controller is called a multi-port drive, and dual port drives are relatively common. Figure 8 shows a dual-controller, dual-port system, from which it will be evident that this installation possesses a degree of redun-

dancy in that the system could continue to run in the event of a controller failure. As an alternative, it is possible to use multi-port drives to provide a common data base for two or more CPUs. Figure 9 shows such a configuration, which could be used to provide total redundancy for critical applications, such as air traffic control, or to allow a minicomputer front end to communicate with a host mainframe.

### The medium

A disc platter consists of an aluminium-alloy substrate coated with magnetic-oxide particles in a binder. The standard of surface finish must be extremely high, owing to the small operating clearance between the disc and the head. Characteristics of the oxide coating, although similar to those of audio magnetic tape, have different effects. In order to increase storage density, the tracks are made narrower, which in turn calls for a higher-output medium to restore the signal-to-noise ratio while reading. In audio recording, the tape format remains fixed so a high-output medium

results in improved signal-to-noise ratio. In digital recording, harmonic distortion is of little consequence. Lastly the effect of surface defects in digital recording is to corrupt data, whereas a defect of the same magnitude on an audio tape might be inaudible. The hardware and software required to ensure data integrity is a major part of a disc system.

Figure 10 shows a cross section of a multi-platter disc pack. As the head-to-disc speed and data density are functions of the track radius, the data is confined to the outer parts of the platters. The pack is centred by the conical spindle nose, and is held down by a screw thread and spring. To remove the pack, a cover is placed over it, the edge of which operates a parking brake to lock the spindle. A handle free to rotate in the cover engages dogs in the fixing screw so it can be turned. As the pressure spring retracts, a tapered rod within the screw descends, forcing a set of ball bearings outwards to enter a groove in the handle. The pack is now secured to the cover, and can be lifted away by the handle. A separate base is then clipped onto the bottom of the pack to exclude contaminants.

Figure 11 shows a typical disc cartridge used on smaller drives. As the name would suggest, the disc stays inside the plastic casing, which has several apertures for the spindle, positioner and various other purposes. The disc is held to the spindle by a permanent magnet, and the cartridge may incorporate a lever to assist removal from the drive. The cartridge cover, which seals the assembly when not in use, is often stored in the drive during use to ensure cleanliness. This is an asset of the smaller drives, which may be expected to operate in an office environment, but the multi-platter units invariably require air conditioning.

# IN OUR NEXT ISSUE

## The heating-fuel saver

Designed by David Ryder, automatically delays the switch-on of a domestic heating system, according to ambient temperatures. The low-cost unit is used in conjunction with the normal time switch and can continuously display the measured temperature.

## 32W f.e.t. amplifier

Comprehensive design and constructional details are included in an article describing a 32 watt amplifier. Simplicity is achieved by use of complementary d.m.o.s. output transistors and output power can be increased to 60 watts with a four ohm load.

## Microprocessor-controlled lighting system

These stage-lighting control circuits for interfacing with a microprocessor are the fruits of a final-year electronics course at Keele University. The article illustrates how complex 'behind the scenes' tasks, such as linear fading and sequence co-ordination can be simplified using a microprocessor.

# On Sale March 17.

# LM109 three-terminal voltage regulator

*A look at the design of one of the classic i.c. regulators*

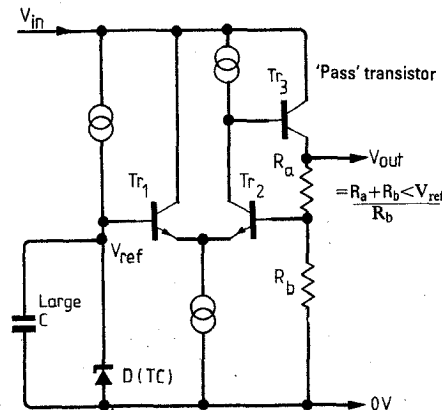
by John L. Linsley Hood

**A description is given of the circuit techniques employed to produce a monolithic three-terminal voltage-regulator i.c., having a very good stability output voltage, and also an internal protection against both output short circuits and thermal overload. The theoretical basis of the energy-band gap voltage reference circuit is examined in an appendix.**

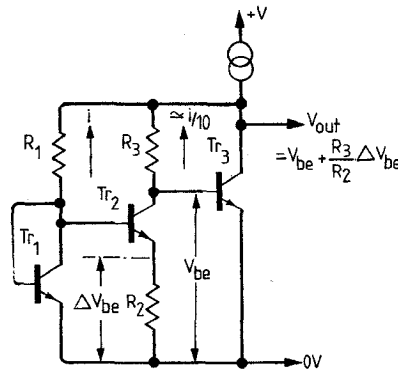
In the first article of this series, it was suggested that a closer look at the internal circuitry of some of the common 'building block' integrated circuits could be instructive on two counts — that a better knowledge of the way in which the circuit functioned could be helpful in employing it to its best advantage, and that, for anyone with an inclination to try their hand at circuit design, such circuits were a treasure trove of elegant and innovative design techniques.

However, while there are — literally — thousands of different integrated-circuit designs in common use, there are a lesser number whose availability has had a major impact on the way in which 'linear' circuit designers implement their thoughts, and, of these circuits, next to the ubiquitous operational amplifier, must stand the three-terminal i.c. voltage regulators, of which the LM 109 was one of the earliest, and remains a classic design.

I am restricting my field of view, in this context, to linear or analogue electronics, in that this is still a field which is largely dominated by circuitry assembled from



**Fig. 1.** Simplified arrangement of conventional discrete-component voltage regulator



**Fig. 2.** Temperature-compensated 'band-gap' voltage reference.

discrete components, and in which the appearance of separate i.c.s. is a departure from previous practice, whereas in the area of digital electronics the presence of anything other than an i.c. — with the possible exception of the odd supply line decoupling capacitor — would be unusual and noteworthy.

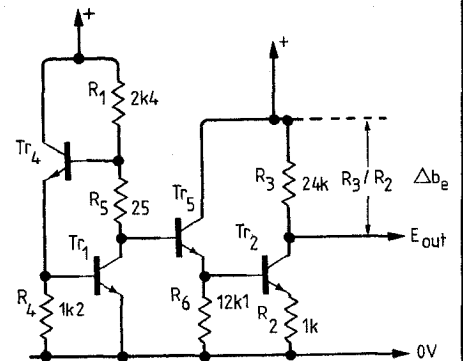
In the light of this restriction, it is, perhaps, a little ironic that the i.c. voltage regulator mainly came into existence to meet the need of the t.t.l. logic elements (which were used in vast numbers in the early digital computer circuits, and which were both extravagant in their use of supply current and critical in the magnitude of the supply voltage) for a local 'on-board' voltage regulator circuit which would simplify the provision of an accurate +5 supply in spite of predictable voltage drops along the incoming power supply lines.

The existing 5 volt standard for the supply voltage to t.t.l. digital i.c.s. coupled with the relatively heavy current demand imposed by the accumulation of fifty or so on one board, gave rise to some design thinking which has had a lasting effect on the internal circuitry of these voltage regulator units. In particular, the low output-voltage specification made it inconvenient to employ the circuit structure of the typical discrete component voltage regulator of the type shown in Fig. 1, since it is impracticable to make a temperature compensated Zener diode which operates at much less than 6 or 7 volts. Also, Zener diodes have a significant noise component in their operating voltage, which would be difficult to eliminate without the use of

substantial values of capacitance, not readily available on a silicon chip.

For these reasons, the voltage against which the voltage output of the circuit is compared is normally derived from a 'band-gap' voltage reference. This takes its name from the energy-band gap of the semiconductor material at 0° Kelvin, \$V\_{go}\$, which, for silicon, is 1.205V. If, as in the circuit of Fig. 2, two identical transistors, \$Tr\_1\$ and \$Tr\_2\$ are operated at substantially different collector currents, so that the current through \$Tr\_1\$ is, for example, ten times greater than that through \$Tr\_2\$, there will be a potential developed across \$R\_2\$ in the emitter circuit of \$Tr\_2\$ (\$\Delta V\_{be}\$), which is equal to the difference between these two base-emitter voltages. Since this potential has a positive coefficient of voltage against temperature, it provides an elegant means of generating a voltage reference with a near zero temperature coefficient. Referring again to Fig. 2, if the current gain of \$Tr\_2\$ is sufficiently high, the voltage developed across its load resistor \$R\_3\$ will be \$R\_3 \Delta V\_{be} / R\_2\$. The total voltage across the circuit, from the positive end of \$R\_3\$ to the 0V line, will then be \$V\_{be} + R\_3 \Delta V\_{be} / R\_2\$, and if these two component voltages, one with a positive temperature coefficient and one with a negative, add up to the 'band-gap' potential of 1.205 volts, the output voltage will have a zero temperature coefficient. This result is analysed in Appendix 1.

Because integrated-circuit voltage stabilizers contain the 'pass' transistor within the package, and are therefore likely to become hot in use, this temperature stability of output voltage is a very important



**Fig. 3.** Elaborated band-gap voltage reference circuit.



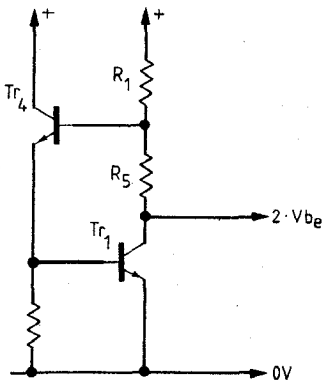


Fig. 4. Rearrangement of circuit of  $Tr_1$  to give lower output impedance.

consideration. Moreover, since the operating junctions are all forward biased, they have a low noise component of output voltage, which eliminates the need for smoothing. Also, the characteristics of forward junctions are much more predictable and controllable in a production environment than highly doped, reverse-breakdown Zener diodes. For these reasons, this type of 'band-gap' stabilizer has been widely adopted as the voltage reference in i.c. voltage regulators, although the transmutation of the circuit layout often makes it difficult to recognize as such.

In the case of the LM 109, the band-gap reference circuit is elaborated into the form shown in Fig. 3, which bears little superficial resemblance to that of Fig. 2. However, it can be disentangled. For example, the original forward-biased diode-connected transistor,  $Tr_1$  in Fig. 2, has become the two-transistor buffered version of Fig. 4, with an output voltage of twice  $V_{be}$ . This is buffered through  $Tr_5$ , an emitter follower, to  $Tr_2$  as before. As in the first example, the values of  $R_1$  and  $R_3$

Fig. 5. Control loop amplifier and voltage reference chain of LM 109.

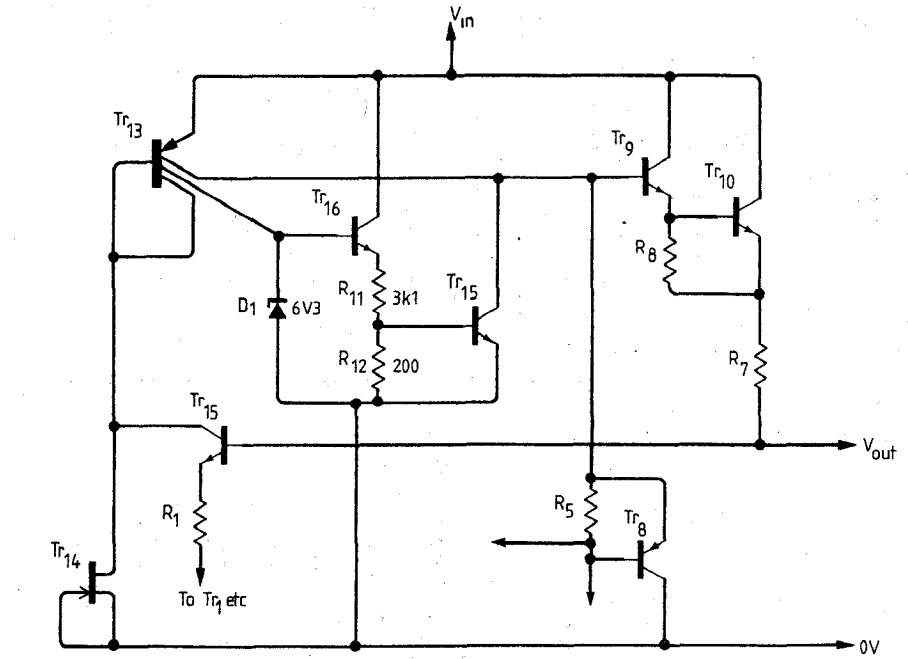
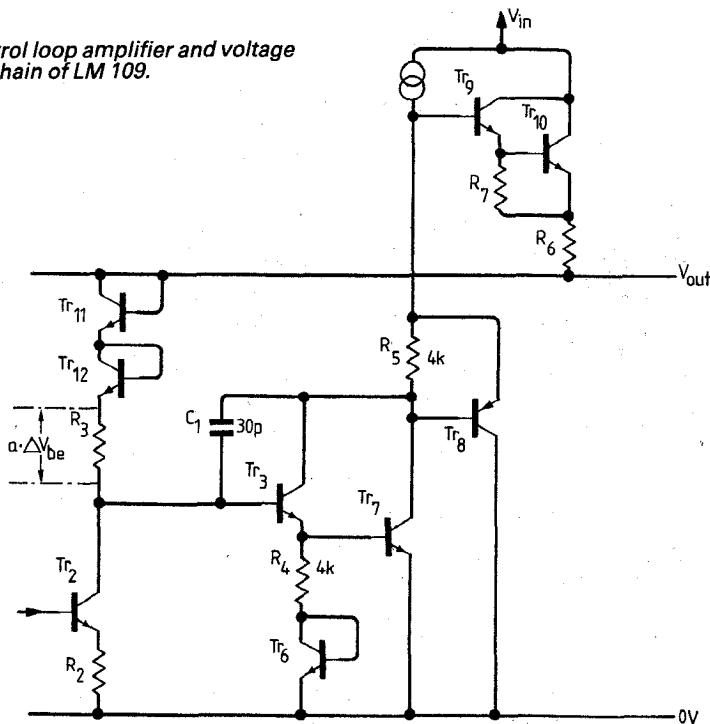


Fig. 6. Thermal-overload shutdown circuitry of LM 109.

are chosen so that the current through  $Tr_1$  is some ten times greater than that through  $Tr_3$ . The small resistor  $R_5$  in the collector circuit of  $Tr_1$  is added to compensate for changes in the transconductance of  $Tr_1$  and make the performance of the circuit less dependent on supply voltage and the absolute values of the resistors fabricated on the chip.

In the final circuit of the voltage reference and control loop of the regulator, shown in Fig. 5, the simple band-gap reference system of Fig. 2 has been modified yet again so that the positive temperature coefficient, magnified base-emitter differential potential developed across  $R_3(a \cdot \Delta V_{be})$  now appears in series with the

four base-emitter junctions ( $Tr_{11}$ ,  $Tr_{12}$ ,  $Tr_3$  and  $Tr_7$ ) forming the reference potential divider chain. Transistors  $Tr_3$ ,  $Tr_7$  and the 'd.c.-bootstrap' transistor  $Tr_8$  form a very-high-gain inverting amplifier driving the Darlington-connected output pass-transistor pair  $Tr_9$  and  $Tr_{10}$ . Transistor  $Tr_6$  compensates for the base-emitter potential differential between  $Tr_3$  and  $Tr_7$ , and  $Tr_8$  increases the load impedance seen at the collector of  $Tr_7$  and increases the amplifier stage gain.

Because of the high loop gain of the system, some form of h.f. stabilization is necessary to ensure loop stability on an open circuit load. This is achieved by the 'dominant lag' capacitor,  $C_1$ , of 30pF value, connected between collector and base of  $Tr_3$ . Although the emitter load of the emitter follower  $Tr_8$  is shown simply as a constant-current source, it does, in reality, employ a circuit artifice much beloved of i.c. designers, the multiple-collector 'current mirror', ( $Tr_{13}$ ) shown in Fig. 6.

Part of the current which is fed to the base and collector of this transistor, connected in parallel, is derived from the common-base connected device ( $Tr_{15}$ ) whose emitter feeds the  $Tr_1/Tr_4$  compound diode shown in Fig. 4, and described earlier. Since this is a resistor-diode chain connec-

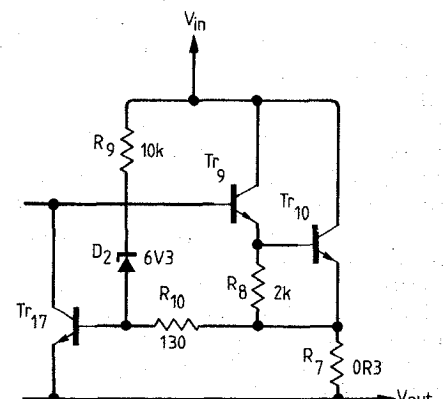


Fig. 7. Output over-current protection.

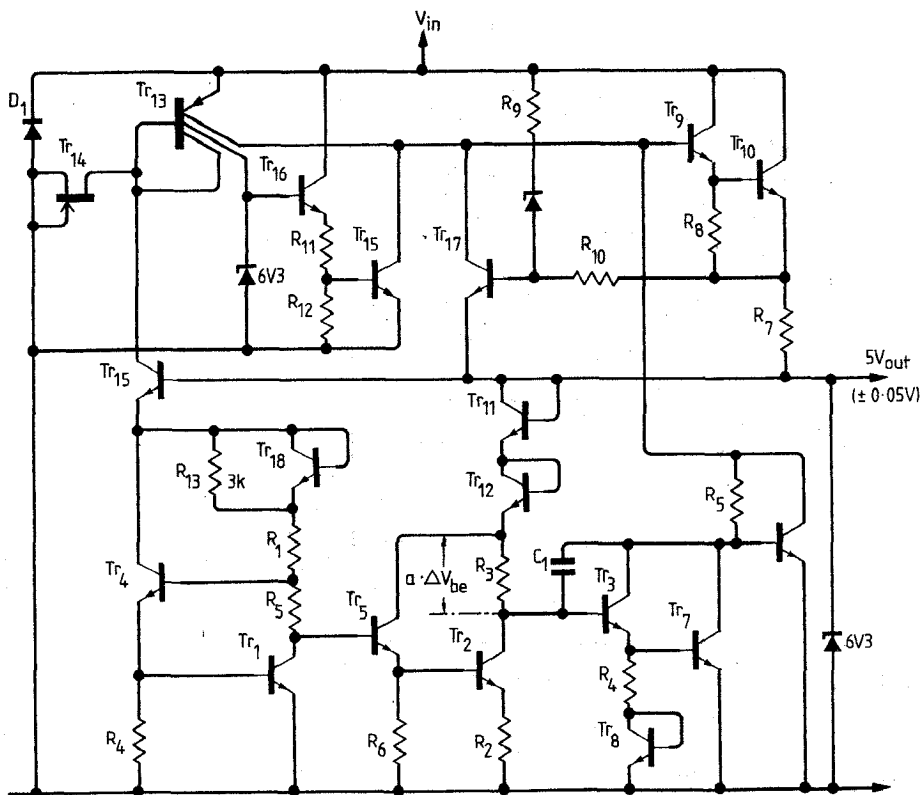


Fig. 8. LM 109 three-terminal voltage regulator.

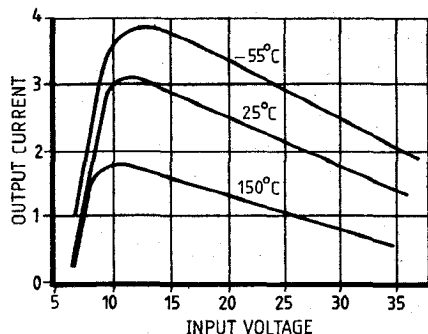


Fig. 9. Output current characteristics.

ted across a constant voltage source (the stabilized output voltage of the regulator circuit), it will serve quite well as a constant-current input to the current mirror transistor  $Tr_{13}$ . Unfortunately, this would not be self starting on switch-on, so a simple f.e.t. current source,  $Tr_{14}$ , is connected in parallel with it.

In the earliest designs of integrated circuit voltage regulator, the pass transistor was kept as an external component to the regulator, in order to minimize the heat dissipated in the regulator chip. With the advent of predictable, well compensated, band-gap voltage reference sources, this problem became less acute, and the way was opened to build onto the chip a temperature-sensitive overload shut-down circuit, so that any combination of inadequate heat sinking, excessive input voltage, or prolonged output current drain which caused the chip to approach its maximum permitted operating temperature, would cause the regulator to shut down. This function is neatly accomplished by the combination of  $ZD_1$ ,  $Tr_{15}$

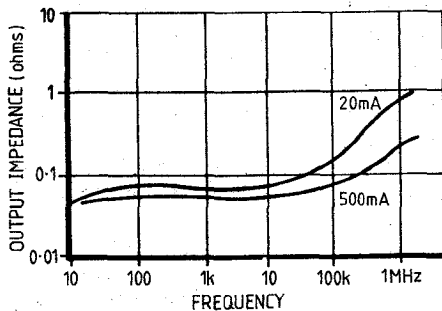


Fig. 10. Output impedance characteristics.

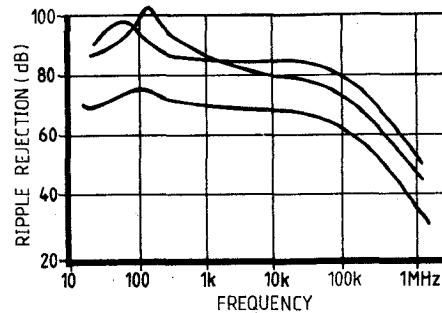


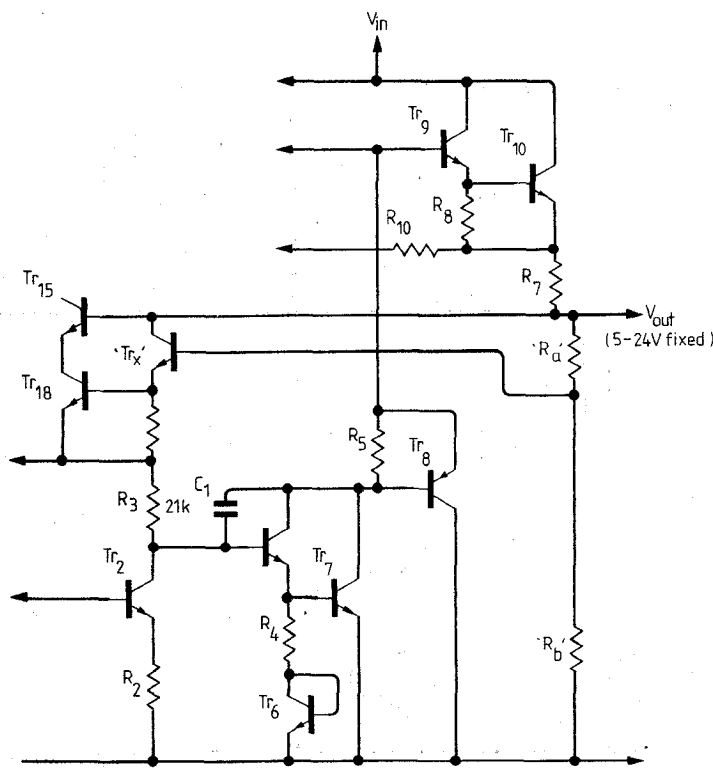
Fig. 11. Ripple rejection of regulator i.c.

and  $Tr_{16}$  shown also in Fig. 6. This applies a d.c. forward potential of some 0.33 volts to the base of  $Tr_{15}$ . When the chip temperature reaches about 180°C, this transistor conducts, and clamps the output Darlington pair to the 0 volt line.

While this will prevent the regulator chip from being damaged by thermal overload, it would be of little value against a condition of instantaneous excess output current, due to an output short-circuit. This function is provided by a series resistor in the output circuit,  $R_7$ , in combination with a transistor  $Tr_{17}$ , arranged as shown in Fig. 7. When the output current drawn through  $R_7$  exceeds about 2 amperes,  $Tr_{17}$  conducts, and causes the regulator to operate in a constant-current mode. Further, if the voltage difference between input and output exceeds some 7 volts, the Zener diode  $ZD_2$  will conduct, and progressively reduce the permitted maximum output current.

The circuit of the complete regulator is shown in Fig. 8. The only two features not already covered are the output Zener diode,  $ZD_3$ , also 6.3 volts for convenience

Fig. 12. Modification to LM 109 circuit to permit range of fixed voltage regulators, as in 78xx series.



in fabrication, included to prevent the regulator from being embarrassed by voltage transients fed into the regulator through its output line, and the on-chip diode,  $D_1$ , included to prevent damage through a reverse polarity input supply voltage.

Although the number and variety of three-terminal fixed, and variable, voltage regulator i.c.s has multiplied since the introduction of the National Semiconductors LM 109 in the early 1970s, the general circuit techniques and performance characteristics of these newer types have a lot in common with their forerunners. Because of the relatively low cost and convenient packaging of many of these i.c.s, it is now a practical proposition to include these devices in analogue circuitry wherever supply line isolation is desirable, and where, in the past, large value smoothing or decoupling capacitors would have been obligatory, permitting not only a reduction in cost and bulk of the equipment, but also, in many cases, an improvement in circuit performance.

The claimed output current, output impedance and ripple rejection characteristics of this i.c. are shown in Figs. 9, 10 and 11.

## Appendix 1

The voltage which will appear across a forward biased base-emitter junction in a transistor can be defined by the equation

$$V_{be} = V_{go} \left( 1 - \frac{T}{T_0} \right) + V_{be0} \cdot \frac{T}{T_0} + \frac{nkT}{q} \log_e \frac{T_0}{T} + \frac{kT}{q} \log_e \frac{I_c}{I_{c0}} \quad (1)$$

where  $V_{go}$  is the energy-band-gap voltage of the semiconductor material at 0°K,  $k$  is Boltzmann's constant,  $q$  is the charge on the electron,  $n$  is the operational constant determined by the method of construction of the device (about 1.5 for a double diffused n-p-n structure),  $V_{be0}$  is the extrapolated base-emitter voltage at zero forward junction current and  $T_0$ , and  $I_c$  is the collector current.

The difference in the forward base-emitter voltage between two identical transistors operated at different collector currents could be derived from two such equations, by subtraction. Since it is only the last term in the equation (1), above, which is dependent on collector current, all the other terms cancel leaving only the equation

$$\Delta V_{be} = \frac{kT}{q} \log_e \frac{J_1}{J_2} \quad (2)$$

where  $J_1$  and  $J_2$  are the current densities through the base-emitter junctions of  $Tr_1$  and  $Tr_2$ . If the transistors are of identical area, the terms  $J_1$  and  $J_2$  can be replaced by  $I_{c1}$  and  $I_{c2}$ . Restating the equation, therefore,

$$\Delta V_{be} = \frac{kT}{q} (\log_e I_{c1} - \log_e I_{c2}) \quad (3)$$

This has a positive temperature coefficient so long as the collector current of  $Tr_1$  is greater than that of  $Tr_2$ , which is the only practical possibility in the operation of Fig. 2.

Because  $kT/q$  is only of the order of 0.025, the last two terms of equation (1) can be neglected in the practical determination of the total voltage produced by the negative temperature coefficient term  $V_{be}$  and the positive temperature coefficient term  $\Delta V_{be}$  which will be

$$V_{out} = V_{go} \left( 1 - \frac{T}{T_0} \right) + V_{be0} \frac{T}{T_0} + a \frac{kT}{q} \log_e \frac{I_{c1}}{I_{c2}} \quad (4)$$

in which 'a' is a circuit magnification factor.

Differentiating this with respect to temperature yields

$$\frac{\delta V_{out}}{\delta T} = -\frac{V_{go}}{T_0} + \frac{V_{be0}}{T_0} + a \frac{kT_0}{q} \log_e \frac{I_{c1}}{I_{c2}} \quad (5)$$

for zero change in output voltage as a function of temperature, the right hand side of this equation should equal zero, from which

$$V_{be0} + a \frac{kT_0}{q} \log_e \frac{I_{c1}}{I_{c2}} = V_{go} = 1.205 \text{ volts,} \quad (6)$$

so that for some predetermined ratio of collector currents in  $Tr_1$  and  $Tr_2$ , it should be possible to find a circuit magnification factor ('a'), usually in the range 15-30 if  $I_{c1} = 10I_{c2}$ , which will make the sum of these two potentials add up to the energy-band-gap potential of 1.205 volts, at which the condition for a zero temperature coefficient will be met.

## Appendix 2

Although, as mentioned above, the LM 109 was specifically designed to meet the problems inherent in the need for good temperature stability in a regulator circuit having a low output voltage, which is to say at voltage levels below those for which temperature-compensated Zener diodes would be available, the success of this design was such that it was extended to cover higher-output fixed voltage units, such as the 78\*\* and 78M\*\* series, covering the voltage range 5-24 volts, by the simple expedient of replacing the upper two diodes in the voltage reference chain ( $Tr_{11}$  and  $Tr_{12}$  in Fig. 5), by a conventional voltage divider, as in Fig. 1 ( $R_a$  and  $R_b$ ), and an emitter follower output, ( $Tr_x$ ).

This small modification is shown in Fig. 12. Clearly, by an appropriate choice of  $R_a$ ,  $R_b$  and the temperature compensating resistor  $R_3$ , this will allow the manufacturer to choose the required output voltage at will. Inevitably, there is a small penalty to be paid in a slightly lower precision of voltage control as the ratio of output voltage to reference voltage is increased. However, the other excellent performance characteristics of the circuit remain unimpaired.

# Literature Received

A wallchart from Ferranti gives brief specifications of their products in **data conversion**. It includes fixed and trimmable voltage references, monolithic digital voltmeters, and A-to-D and D-to-A converters. A glossary of the terms used is included. Copies of the wallchart may be obtained from: The Publicity Department, Ferranti Electronics Ltd, Fields New Road, Chadderton, Oldham, Lancs OL9 8NP.

WW401

**Chart recorders** that can cope with Z-fold paper as well as rolls are described in a leaflet published by Allen Datagraph and available from Techmation Ltd, 58 Edgware Way, Middlesex HA8 3JP. The recorders, from the 2100 series are available in one- or two-pen models with 13 calibrated spans and ten chart speeds.

WW402

The first five parts of a new Standard, BS 6160: **Methods of measurement for radio equipment used in mobile services**, has been published by BSI. The first part is concerned with general definitions and standard conditions of measurement, the others relate to specific equipment: A3 or F3 transmitters, A3 or F3 receivers, s.s.b. transmitters (A3A, A3H or A3J) and s.s.b. receivers for the same bands. The Standard is identical with IEC Publication 498-1 to 5. British Standards Institution, 101 Pentonville Road, London N1 9ND.

WW403

The KEF Constructor series of leaflets (CSI to 5) give designs for the construction of five **loud-speaker** enclosures using KEF drive units. Details are given of the construction and the circuit diagram for suitable crossover networks are provided. The designs cover a range of sizes from a miniature bookshelf loudspeaker to a large three-way system. KEF Electronics Ltd, Tovil, Maidstone, Kent ME15 6QP.

WW404

**D.c.-d.c. converters** in the Avel C101 range provide 12 or 24V outputs from supply voltages between 12 and 220V d.c. They are described in a leaflet available from Avel-Lindberg, South Ockendon, Essex RM15 5TD.

WW405

113 pages are needed by Harting to describe their ranges of **multi-pole electrical connectors**. The plugs and sockets range from low current/low voltage applications up to 35A and 750V requirements. Included are a variety of accessories and a users' guide. The manual is available free from Harting Electronik Ltd, Airport Estate, Biggin Hill, Kent.

WW406

C & K have produced so many new **switches** that they have issued a new product supplement to their catalogue. It includes solid state push buttons, d.i.p. slide and toggle, rotary and rocker switches. Copies are available from Roxburgh Switches Ltd, 22 Winchelsea Road, Rye, E. Sussex TN31 7BR.

WW407



# Microprocessor tutor

Z80-based unit helps to teach micro-centred circuit design

by **S. O. Newstead** and **P. Jackson, B.Sc.(Hons.), F.I.E.E., F.I.E.R.E.**  
Both authors are at the Mid-Kent College of Higher and Further Education

The number of engineers and technicians engaged in developing microprocessor-controlled systems is increasing daily. Whilst programming courses are readily available, there seem as yet to be few establishments offering courses in circuit design. The lack of suitable equipment around which to build such courses is a contributory factor to their scarcity. The equipment described in this article is intended to be a central core around which design courses can be structured.

The central processor unit chosen is the Z80, some of the facilities of which have not been used in this tutor unit. Access to these facilities is, however, easily obtained by making minor modifications to the printed-circuit artwork and to the front panel. Five printed-circuit boards contain circuit components associated with the keyboard, the memory, the central processor unit, ports and with the bus-bar indicators. Designs for the boards will be made available later.

## Keyboard circuit

In Fig. 1, a matrix keyboard is connected via a keyboard encoder 74C922 to sixteen 74LS75 data latches, in groups of four, each group being enabled in turn by the output from a shift register. Instructions loaded into memory locations are therefore entered on the keyboard as address followed by data.

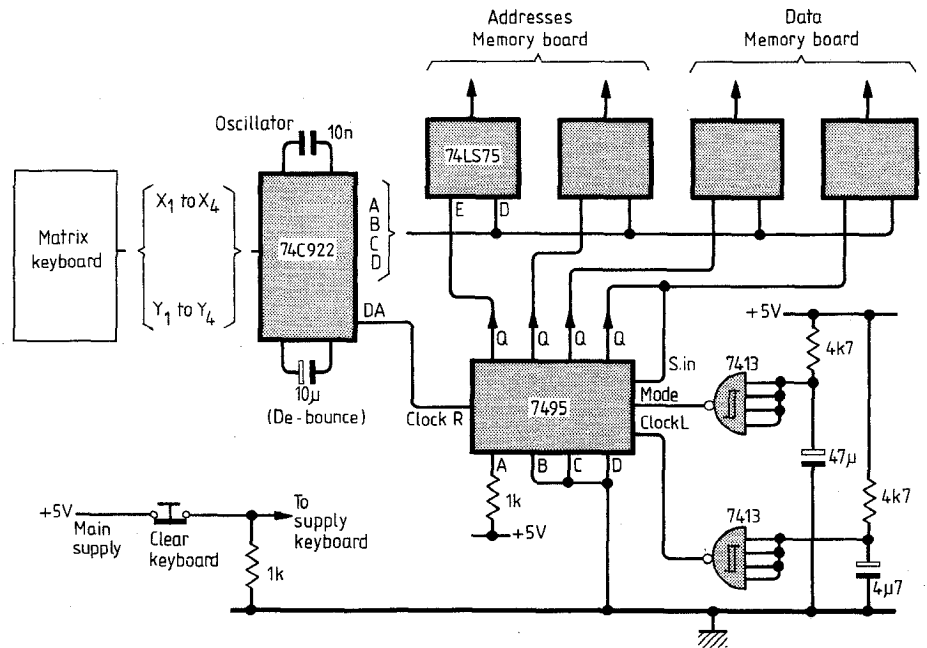


Fig. 1. Keyboard circuit.

When the "clear keyboard" button is pressed, the supply to the keyboard is interrupted, and the two tantalum capacitors discharge to below the logic 0 level. When the push-button is released, "mode control" is at logic 1 and "clock left" goes low when the 4µF capacitor has charged to

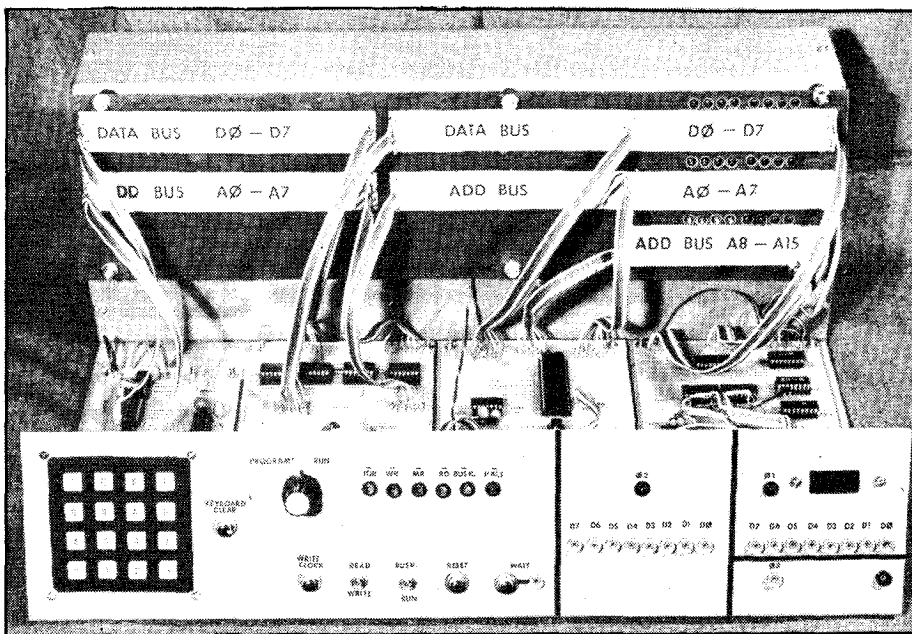
logic 1. This causes the shift register to parallel load A=1, B=C=D=0. The "mode control" then goes low when the 47µF capacitor has charged to logic 1 and control of the shift register is by "right clock".

Each group of four latches is enabled in turn by a signal from the DA pin on the 74C922.

## Memory board

In Fig. 2, two switches mounted on the front panel and connected to the memory board are marked Read/Write and Program/Run. The first switch enables the operator to examine the contents of any memory location by entering the address of the location required on the keyboard, with the program/run switch in program mode: the memory content will then be displayed in binary on the l.e.d.s connected to the data bus-bars. The 4066 c.m.o.s. switches, which can couple the keyboard data lines to the main data bus-bars, will be open, whilst those which couple the keyboard address lines to the main address bus-bar will be closed.

In "Run" mode, the "write clock" is disconnected and the Read/Write function of the memory is controlled by the "Write" signal from the c.p.u. The "chip enable" is now controlled by "Memory Request" from the c.p.u.



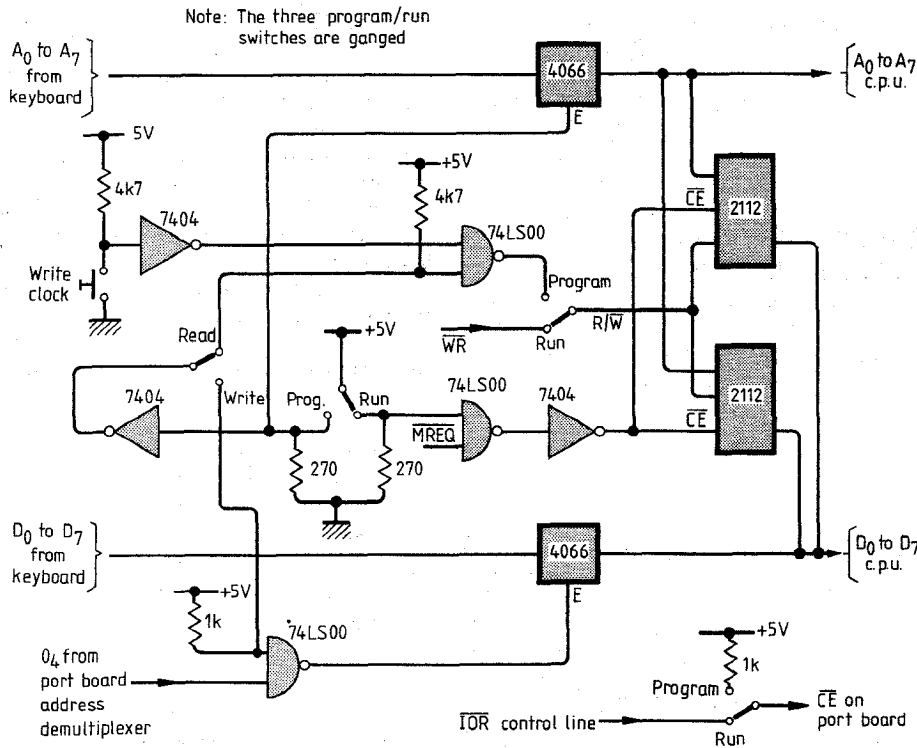


Fig. 2. Memory board.

### Central processor

A very slow clock, shown in Fig. 3, enables the operator to follow the flow of signals round the system. The "Wait" control can be used to hold the c.p.u. at any step in the program so that the address, data and control lines can be inspected. For example, an instruction to output the contents of the accumulator to port 01 can be held at the state where

- (a) the lowest significant 8 address bus-bars show 01
- (b) the highest significant 8 address bus-bars, which carry data out to ports from the Z80, show the contents of the accumulator and
- (c) l.e.d.s are illuminated at  $\overline{\text{IOREQ}}$ ,  $\overline{\text{WR}}$  and at the port address decoder output 01.

If it is desired to bring out other control lines from the Z80 to the front panel, this can easily be done and the l.e.d.s associated with them can be buffered as shown.

### Ports

C.m.o.s. buffers minimize the loading effects on the bus-bars and data lines. The 74LS245 bidirectional tristate buffer has been used in preference to the 74LS241 because the printed circuit art-work is easier to make. The 8-bit output from port 01 can be used to drive a 2-digit hexadecimal display to good effect.

### Analogue-to-digital convertor

Mention has been made in the instruction book of an a-to-d convertor, and the use of the  $\overline{\text{WAIT}}$  feedback signal to the c.p.u. is demonstrated thereby. One alternative to the hard-wired  $\overline{\text{WAIT}}$  command is obtained by using the input port to test the state of the status bit obtained from the a-

to-d convertor. Constructing a convertor round the ZN425E with a slow clock and l.e.d. displays on the count and status outputs has proved very successful in illustrating the above effects.

### Instruction register

As each instruction is fetched from memory, it is placed in the instruction register and decoded. The control section performs this function and then generates and supplies all the control signals required.

### Z80 Pins

**A<sub>0</sub> - A<sub>15</sub> address bus.** These have tristate outputs, are active high (i.e. logic 1) and the tristates are disenabled when the  $\overline{\text{BUSRQ}}$  pin is made low. A<sub>0</sub> to A<sub>15</sub> address

memory locations, A<sub>0</sub> to A<sub>7</sub> also address ports. With an output port in use, A<sub>0</sub> to A<sub>7</sub> hold the address and A<sub>8</sub> to A<sub>15</sub> hold the data. With an input port in use, A<sub>0</sub> to A<sub>7</sub> hold the address and D<sub>0</sub> - D<sub>7</sub> receive the data.

**D<sub>0</sub> - D<sub>7</sub> Data Bus.** Tristate output, active high.

**MI, RFSH, INT, NMI.** These control signals which indicate the first part of the current machine cycle ( $\overline{\text{MI}}$ ), refresh dynamic memory ( $\overline{\text{RFSH}}$ ), interrupt provided that an interrupt enable signal has been put into c.p.u. by software ( $\overline{\text{INT}}$ ) or interrupt and then restart the program at location 0066 ( $\overline{\text{NMI}}$ ) are not used in the College tutor.

**MREQ memory request** output active low. Indicates that the address bus holds a valid address for a memory read or write operation.

**IORQ input/output request** output active low. Indicates that the lower half, A<sub>0</sub> to A<sub>7</sub>, of the address bus holds a valid address for an input or an output port.

**RD read data** output active low. Indicates that the c.p.u. is ready to read data.

**WR write** output active low. Indicates that the data bus holds valid data to be written in memory or A<sub>8</sub> - A<sub>15</sub> holds data which can be written into an output port.

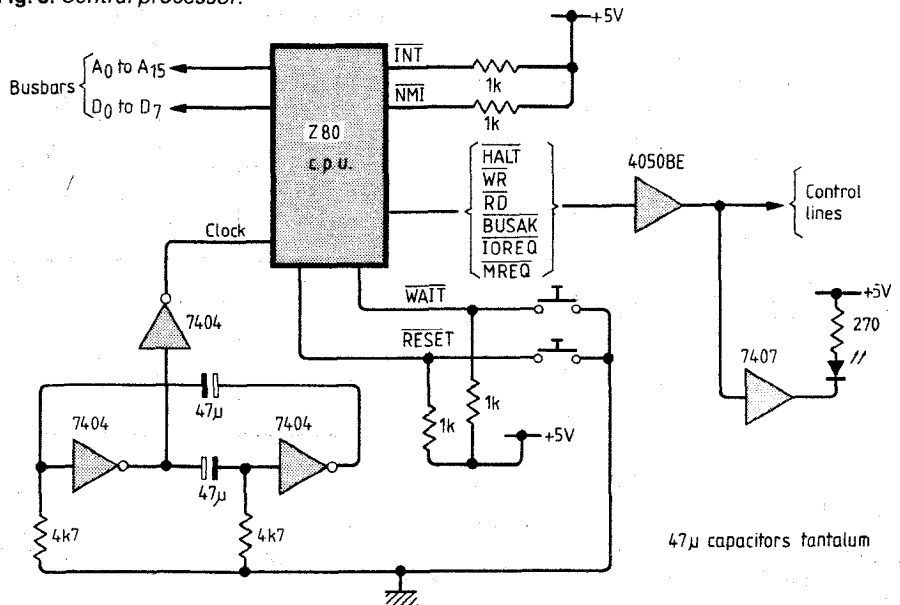
**HALT** output active low. Indicates that the c.p.u. has responded to a software halt instruction. (instruction 76).

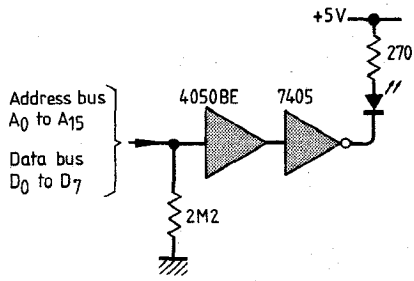
**WAIT** input active low. This signal, supplied by external devices, will hold the c.p.u. until the external device has completed the instruction it has been given via an output port. When the signal goes high, the c.p.u. will continue with the programme from the point at which it was put into a waiting state.

**RESET** input active low. This forces the programme counter to zero, clears the registers and during the time in which the signal is active the address bus, data bus and control signal tristates are disenabled.

**BUSRQ** bus request, input active low.

Fig. 3. Central processor.





This circuit is repeated 24 times. The 2M2 resistors ensure that the indicators are out when the c.p.u. bus-bar tristates are disenabled by BUSREQUEST

Fig. 4. Bus-bar indicator.

This disables the address bus, data bus and control signal tristates so that other devices can use the busbars.

**BUSAK** bus acknowledge, output active low. This indicates that the tristates have been disabled by a **BUSRQ** signal.

### Writing into and reading from memory

Two identical integrated circuits are used, each storing four bits of information in each of 256 separate locations. The circuits are connected to the address bus bars A<sub>0</sub> to A<sub>7</sub> and the demultiplexing of this 8 to 256 lines takes place on chip. The chip-enable pin on each i.c. is active when low. When the read/write pin on the i.c. is high, the contents of the memory location addressed are put on the data bus bars. When the read/write pins are low, the data on the bus bars is written into the memory location addressed.

**Writing** Set the controls to Program, **BUSR**, Write. Clear the keyboard to set the keyboard counter to zero. Type in the address of the memory location as a two-bit hexadecimal number between 00 and FF. Follow this with the data. Press the "write clock" button. This makes the read/write pin go low. When the button is released, this pin goes high and the address and data can be seen on the appropriate bus bars. (For fuller instructions refer to section 5).

**Reading.** Set controls to Program, Read, **BUSRQ**, clear the keyboard. Type in a memory address as a two-bit hexadecimal number between 00 and FF. The contents of that memory location will appear on the data bus bars. Clear the keyboard and repeat the process for any desired memory location.

### Address decoding for ports

The first eight addresses (00 to 07) can be used as ports. In this model tutor, only 01, 02 and 03 have been brought out to the front panel. (Using demultiplexer circuits and gating **IOREQ** with **RD** and **W** it is possible to have 256 input ports and 256 output ports as the full capability of the Z80 c.p.u.) Address lines A<sub>0</sub>, A<sub>1</sub>, A<sub>2</sub> are connected to a 3 line to 8 line decoder/demultiplexer (74LS138) which is enabled by **IOREQ**. A port is enabled therefore when

its address has been put onto the address busbars and when **IOREQ** has also appeared on the control lines, the port enable pin being connected to 01, 02 or 03 on the 74LS138 as appropriate. The other outputs 00, 05, 06 and 07 have been left unconnected, ready for future developments.

### Loading and running programmes on the tutor

The output port has address 01. The input port has address 02. The address line 03, brought out to the front panel, will go low for a short time in response to the instruc-

tion pair D3 03  
The port addresses available are 0000 to 00FF, but only the two lower significant bits are required in the program.  
**How to load a program.** Set the controls to Program, Write, **BUSR**. Clear the keyboard. Enter on the keyboard address, 00, followed by the first instruction. These four hexadecimal digits will be stored in latches on the printed circuit connected to the keyboard. To enter the data in the memory address, press the "write clock" button. Now enter address 01 followed by its data and press "write clock" again.

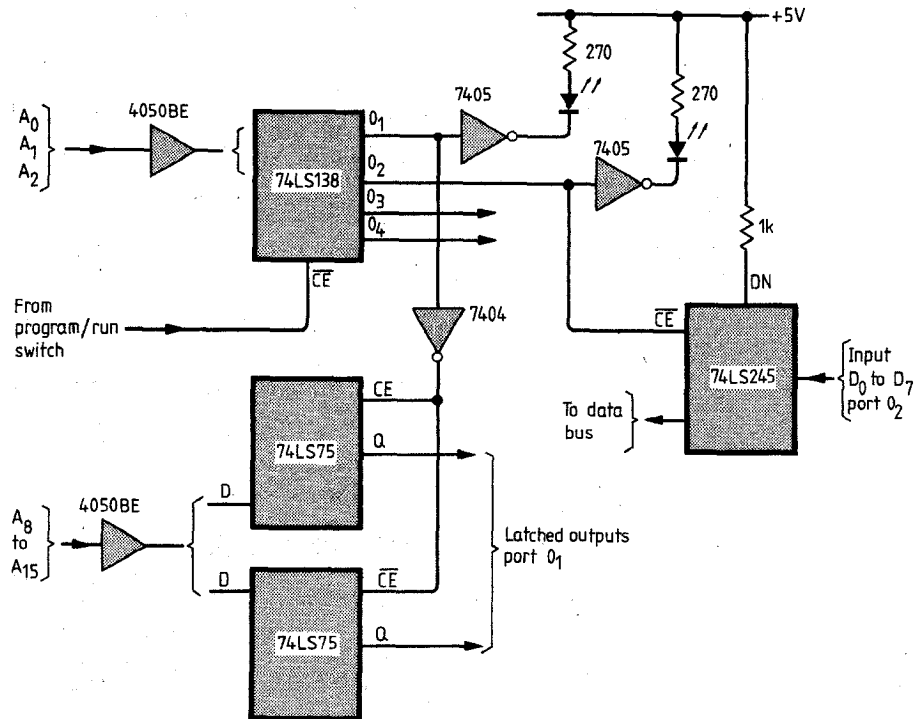


Fig. 5. Ports.

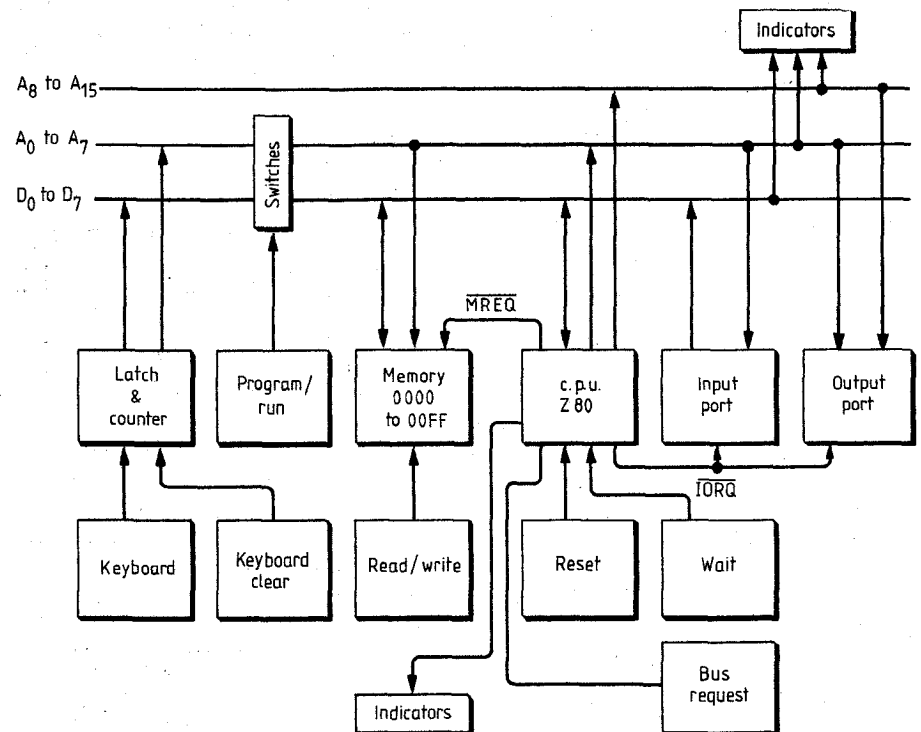


Fig. 6. Interconnexion of controls and circuit boards.



Repeat to the end of the program.

Note: The c.p.u. calls addresses in full, i.e. 4 digits, but the keyboard is designed to call them in the two least significant digits because a small memory has been fitted.

**How to run a program.** Reset the c.p.u., set the "PROGRAM" switch to "RUN" then set the "BUSR" switch to "RUN". The c.p.u. will step through the program starting at address 0000. During the running of the programme, the WAIT button may be held pressed and the c.p.u. will wait until the button is released, thus allowing the operator to observe the current state of the bus bars and signals.

**Abbreviated instruction set for Z80**

In this instruction set, four-digit hexadecimal addresses are referred to as abcd where ab are the two highest significant bits and cd the two lowest. A two-digit hexadecimal number is referred to as xy. When reading this section, refer to the next section, which contains some simple programs.

The most important register is the accumulator.

**To load the accumulator from**

Register	B	78
"	C	79
"	D	7A
"	E	7B
"	H	7C
"	L	7D

Memory location	abcd	3A
		cd
		ab

**To load a register from the accumulator**

Register	B	47
"	C	4F
"	D	57
"	E	5F
"	H	67
"	L	6F

**To load a register with a number xy**

Register	B	06
"	C	xy
"	D	OE
"	E	xy
"	H	1E
"	L	xy
		26
		xy
		2E
		xy

**To load a number xy into the accumulator**  
3E  
xy

**To write the contents of the accumulator in memory address abcd.**  
32  
cd  
ab

**Arithmetic operations which leave the answer in the accumulator.**

Function	Source							A number xy
	B	C	D	E	H	L		
Add	80	81	82	83	84	85	C6 xy	
Add with CARRY	88	89	8A	8B	8C	8D	CE xy	
SUBTRACT	90	91	92	93	94	95	D6 xy	
SUBTRACT with CARRY	98	99	9A	9B	9C	9D	DE xy	
INCREMENT	04	0C	14	1C	24	2C		
DECREMENT	05	0D	15	1D	25	2D		

Increment accumulator	3C
Decrement accumulator	3D
Rotate left with carry	07
Rotate right with carry	0F
Rotate left	17
Rotate right	1F
Halt	76
Restart at 0000	C7
Restart at 0008	CF
Restart at 0020	E7
No operation	00

Output data from accumulator to port cd	D3	cd
Input data to accumulator from port cd	DB	cd

Memory address	Data	Meaning
00	00	do nothing
01	00	
02	00	
03	00	
04	00	load accumulator from memory location 0066.
05	3A	
06	66	output contents of accumulator to port 01.
07	00	
08	D3	
09	01	add 03 to contents of accumulator.
0A	C6	
0B	03	write contents of accumulator in memory location 0066.
0C	32	
0D	66	
0E	00	restart at address 00. start 0066 at 02.
0F	C7	
66	02	

**To Load a number into the accumulator and then to output it to a port**

Memory address	Data	Meaning
00	00	do nothing
01	00	
02	3E	load 23 into accumulator
03	23	
04	D3	output accumulator to port 01
05	01	
06	76	halt

Load and run this program. Observe 23 appearing on the output port hexadecimal display. Overwrite the data in memory location 03 and run again. Ignore all the indicator lights except BUSAK and HALT.

**To observe the sequence of operation when data is transferred between the accumulator and memory locations**

This program writes data into memory, loads the accumulator with data from memory, outputs data to a port and then restarts.

**Note:** Each address is preceded by 00 but the keyboard does not use this as the memory "on board" is 00 to FF). Instructions in 00 to 04 are *no operation* instructions.

The c.p.u. will be seen to count through these memory locations, operating MREQ and RD control signals, which will enable the memory chips but the data in each case will be 00.

After the c.p.u. has read instruction 07 it will output 0066 on the address lines followed by MREQ and RD. The data held in location 0066 will then appear on the data lines. Press the WAIT button at this stage and observe all the displays. (If you miss it the first time round, there are plenty of opportunities although the data will increase by 3 each time the programme is run through.) Use the WAIT facility after instruction 09 and after 0E. Note what you see.

**The use of conditional jumps**  
Jump, Call and Return instructions are conditional upon the state of flags in the flag register.

	Flags							
	Uncond. carry		Non Carry	Zero	Non Zero	Sign Neg	Sign Pos	
Jump to abcd	C3	DA	D2	CA	C2	FA	F2	
	cd	cd	cd	cd	cd	cd	cd	
	ab	ab	ab	ab	ab	ab	ab	
Call abcd	CD	DC	D4	CC	C4	FC	F4	
	cd	cd	cd	cd	cd	cd	cd	
	ab	ab	ab	ab	ab	ab	ab	
Return	C9	D8	D0	C8	C0	F8	F0	

A "call" instruction will cause the program to jump into a sub-routine which starts at abcd and it will return to the main program from whence it came when it reaches the return instruction in the sub-routine.

To convert an analogue voltage into an 8-bit digital signal, read it into the microprocessor and then output the result on port 01 as a hexadecimal number between 00 and FF.

Connect "Convert" on the a-to-d convertor to port 03 on the m.p.u.

Connect the 8 outputs of a-to-d convertor to port 02 on the m.p.u.

Connect the status outputs on a-to-d convertor to "wait" on m.p.u.

Connect earth on a-to-d convertor to earth on m.p.u.

00	00	
01	00	
02	DB	} Set up "convert".
03	03	
04	DB	} load A from port 02.
05	02	
06	D3	} output A to port 01.
07	01	
08	C3	} jump to 0002.
09	02	
0A	00	

The following program loads a number from the keyboard into the accumulator, transfers it to the B register, loads a number from the input port to the accumulator. The output port displays the number read into the input port, then it displays FF if this is bigger than the number on the keyboard, 11 if it is smaller, 55 if the numbers are equal. The output port then displays the number put into the keyboard and the programme halts. This programme is used as an example of conditional jumps and to show the flow of information between ports.

00	00	
01	00	
02	00	
03	DB	} Load A from
04	04	
05	47	} Load B from A.
06	DB	} Convert command
07	03	} A-to-d.
08	DB	} Load A from
09	02	
0A	00	
0B	00	
0C	D3	} Output A
0D	01	
0E	00	
0F	00	
10	90	} Subtract B from A

11	CA	} Jump to 0022 if result is zero.
12	22	
13	00	
14	FA	} Jump to 0002A if result is negative.
15	2A	
16	00	
17	00	
18	00	
19	3E	} Load A with FF
1A	FF	
1B	00	
1C	00	
1D	D3	} Output A to port 01
1E	01	
1F	C3	
20	30	} Jump to 0030
21	00	
22	3E	} Load a with 55
23	55	
24	D3	
25	01	
26	C3	
27	30	} Jump to 0030
28	00	
29	00	
2A	3E	} Load A with 11
2B	11	
2C	D3	} Output A to port 01
2D	01	
2E	00	
2F	00	
30	78	} Load A from B
31	D3	
32	01	
33	C3	} Return to 0003
34	03	
35	00	

To load the keyboard with data press "keyboard clear" then type in 00 followed by the 2-digit number which constitutes the data.

## Digital Logic Design, by B. Holdsworth.

338pp., hardback and limp. Butterworth, £17.95 (£9.95).

Brian Holdsworth is Senior Lecturer in electronics at Chelsea College and is well known to readers of *Wireless World* for his series on logic design published a few years ago. This book is based on the material used at the College for ordinary courses and for the one-week courses run for practising engineers.

Although the emergence of the microprocessor means that hard-wired, small-scale-integrated logical solutions to design problems are not now economic, the author is of the opinion that students with a good grasp of combinational and sequential logic design will find the initial confrontation with micros less difficult than they otherwise might. Indeed, the final chapter on micros is intended to demonstrate that "a microprocessor is nothing more than a rather complicated synchronous sequential machine."

The first three chapters concentrate on basic logical concepts - Boolean algebra, Karnaugh maps and simplification, and Nand/Nor logic. Chapter four uses these ideas in a description of

# Books

combinational logic design. There follow five chapters on the design of sequential circuits - memory elements, counters, clocked circuits, shift registers and event-driven circuits in which the use of state diagrams and the avoidance of races are explained.

One chapter is devoted to medium-scale modules - multiplexers, memories, programmable arrays - and Chapter 11 is a treatment of hazard conditions in combinational circuits.

## Electronic Test Equipment: Operation and Applications,

Edited by A. M. Rudkin.

316pp., hardback, Granada Publishing, £20.00

This is a handbook for those who use test equipment as part of their everyday work; scientists,

engineers and technicians. Such people do not need to know the detailed design of the instruments but some knowledge of how they work helps in the efficient use of the instruments.

The book has a chapter on each of the types of equipment, contributed by an author connected with a firm that manufactures the equipment. For example, the editor is associated with Marconi Instruments and has contributed a chapter on Signal generators and another on modulation meters. Other authors are from Farnell, Racal-Dana, Fluke, Amber Electro Design (Canada), Tektronix, Hewlett-Packard and Wayne Kerr. The equipment covered includes oscillators and signal generators; voltmeters; a.f. and r.f. power meters, distortion meters; frequency meters and counter timers; modulation meters; oscilloscopes; spectrum analysers; component bridges, with a final chapter on microprocessors and programmable instruments.

Each instrument is explained in outline; how it works and what it does; how it is used, with a very useful section devoted to errors in measurement and the interpretation of readings.

A useful book, handy to keep on the shelf along with the instrument instruction books. It has some merit as an educational text for students of electronics, systems and the like.

# Nickel-cadmium secondary cells

## Characteristics, economics and charging circuits

by A. S. Henderson

**A circuit designer has two options – design the circuitry and then choose a suitable battery, or select the battery first and design the circuit accordingly. In both cases a knowledge of the characteristics of the available alternatives is necessary.**

Nickel-cadmium cells are manufactured in a range of sizes and ampere-hour capacities, including dimensional replacements for the more popular cylindrical dry cells. This guide to charge, discharge and storage characteristics covers their use in place of dry cells, together with charging circuits to meet manufacturers' recommendations for normal, fast and ultra-fast charging.

### Differences in operating characteristics

**Initial cell voltage.** Dry cells, both Leclanché and the more recent manganese-alkaline type, start their service life with a terminal voltage of 1.5 to 1.6V, whereas nickel-cadmium cells offer 1.2V per cell – in practice five replace four dry cells.

**Cell capacity.** Dry cells and nicads of the same physical size will offer roughly the same total useful (recoverable) energy. It is difficult to be more precise as both types are made in more than one version (at different prices, of course).

**Storage effect.** Dry cells are stated to offer 95% of initial service life after a year of storage at 20°C, and 90% after two years – these are minimum figures. Nickel-cadmium cells slowly discharge to reduce the available energy content to about 50% after nine weeks, leaving the cell virtually empty after six months. No damage results, and its energy content is fully restored by a full normal charge. For this

**Table 1.** Estimated service life at 20°C of SP2 (IEC R20SP) cell at different discharge rates and daily usage, to various end points.

Discharge current mA at	Service life (h)					Discharge current mA at	Service life (h)				
	1.5V	1.1V	1.0V	0.9V	0.8V		1.5V	1.1V	1.0V	0.9V	0.8V
<b>5 min/day discharge</b>						<b>4 h/day discharge</b>					
300	8	11	16	18	18	7.5	732	797	835	874	
500	2.6	6.3	9.6	11	11	10	564	616	651	681	
750	0.5	2.5	5.2	6.7	6.7	15	386	425	446	473	
1000	—	0.5	2.5	4	4	25	230	258	273	289	
<b>30 min/day discharge</b>						<b>50 h/day discharge</b>					
250	12	15	18	21	21	37.5	144	177	189	201	
375	6.1	9.2	11.7	15	15	50	98	113	123	133	
500	1.3	5.2	7.5	10	10	75	51	62	68	77	
750	—	1.0	3	5.1	5.1	100	30	38	44	50	
<b>2 h/day discharge</b>						<b>12 h/day discharge</b>					
25	234	246	251	267	267	2.5	2143	2272	2390	2548	
37.5	155	166	184	197	197	5.0	1163	1234	1306	1371	
50	108	121	129	140	140	6.25	845	1000	1056	1126	
75	65	75	81	89	89	7.5	793	848	895	931	
100	40	51	56	64	64	10	592	636	675	718	
150	17	26	31	36	36	12.5	458	507	540	587	
250	5.6	9	13	16	16	15	361	414	448	479	
<b>24 h/day discharge</b>						<b>300 h/day discharge</b>					
300	1.9	3.4	4.4	5.9	5.9	25	175	211	238	270	

**Table 2.** IEC test conditions and typical performance of three popular sizes of dry cell.

Service	IEC Test Conditions			AA/HP7/R6PP		Typical service life (h)			
	Disc. res Ω	Usage h/day	End point V	Initial	2 yr @20°C	C/HP11/R14PP		D/HP2/R20PP	
Hearing aid	300	12	0.9	276	248				
Transistor	75	4	0.9	65	59	187	168		
Radio	39	4	0.9			84	76	243	210
Transistor	10	1	0.9	4.5	4.0				
Tape	6.8	1	1.0			10.9	9		
Recorder	3.9	1	1.0						
Calculator	15	½	0.9	13.5	12.1				
	5.6	½	0.9			11.4	10.2		
Portable lighting	5	5min	0.9	4.3	3.8				
	5	10min	0.9			12	10.8		
	2.5	10min	0.9						
Cine camera	3.9	5min	1.0	2.3	2.0				
Toys	3.9	1	0.8			5.7	5.1		
	2.2	1	0.8						
Razors & toothbrushes	3.9	5min	0.8	3.4	3.1				
	2.2	5min	0.9			4.4	3.9	12.1	10.8

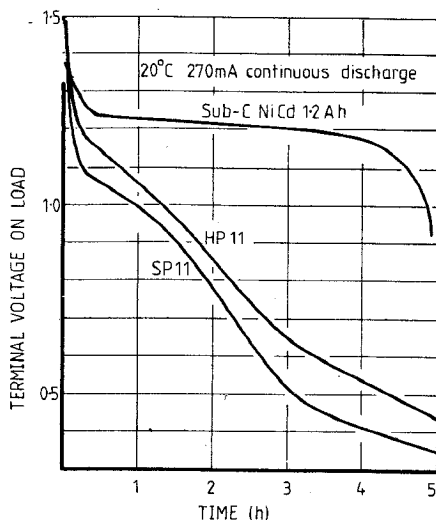
Types shown are not exact equivalents. Based on Ever Ready data.

reason, it is recommended that cells not in service should be given a normal (0.1C) charge every three months.

**Load effect.** Each grade of dry cell is specifically designed to perform most economically under different load conditions. This is well illustrated in the break-even chart shown, in which the HP11 cell outperforms the SP11 in tape recorder service, while the converse applies to the lighter load of a transistor radio. Nickel-cadmium cells offer the same energy content irrespective of load conditions

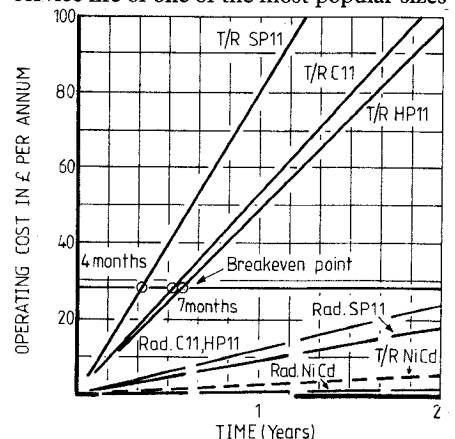
(within a few %) subject to the internal self-discharge already mentioned.

**End point.** Table 1 sets out the expected service life of one of the most popular sizes



**Fig. 1.** Nickel cadmium cells remain at their nominal cell potential of 1.2V for 90% of their service life.

**Fig. 2.** In radio applications nickel cadmium cells have a breakpoint at two years; for tape recorders it is reduced to six months.



**Table 3.** Comparative operating costs £ per annum under IEC conditions.

Service	SP11	HP11	C11	NiCd(C)
Radio	9.50	11.26	11.60	0.12
Tape recorder	80	49	53	0.54

of dry cell, operating to various end points beyond which presumably the circuitry can no longer function effectively. The terminal voltage declines steadily during the on-load period, but partially recovers during rest periods. The nicad cell maintains its nominal terminal voltage of 1.2 throughout 90% plus of its service life, and an end point of 1.0V is generally accepted – beyond this point the terminal voltage drops rapidly to zero. Fig. 1 shows the measured performance of two dry cells and a sub-C rechargeable cell when discharged continuously at 270mA.

Table 2 sets out the IEC test conditions and typical performance of three popular sizes of dry cell. In future we shall need to avoid references to AA, C or D cells and use R6, R14 and R20, with suitable suffix letters (LP, HP, PP etc) to denote the quality of the cell.

**Running cost**

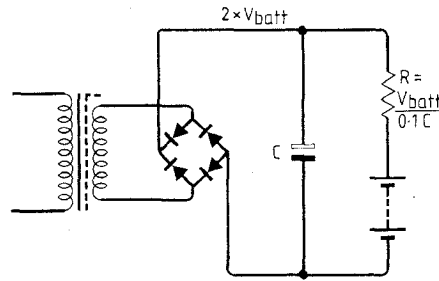
Table 3 was calculated on the assumption that a transistor radio and tape recorder were operated under IEC conditions of current drain and hours use per day, using four C cells in each case. Recharging costs for the equivalent rechargeable stack were based on 5p/kWh as the cost of mains electricity, 50% charging efficiency and 50% over-charge as recommended.

Table 3 takes no account of the “capital” cost or the constant-current charger which they need. At current prices, four C-size cells and a charger would cost £23.50, and this has been taken as a worst-case figure when constructing the break-even chart in Fig. 2. It is a worst-case assumption because it is unlikely that only one set would in course of time be found to be economic, and many readers will construct their own charging equipment using one of the circuits given later. It is clear from Fig. 2 that the radio alone falls into the same class as Ian Hickman’s example<sup>1</sup> in needing two years to break even, whereas the tape recorder shows an advantage after only six months. As the current drain and the amount of use increase, the breakeven point get shorter.

**Charging conditions**

Nickel-cadmium cells exhibit a very low internal resistance, especially the sintered plate variety which may be under 10mΩ, together with a relatively small increase in terminal voltage as the charged condition is neared. Constant-current charging conditions are essential if damage to cell and charger are to be avoided.

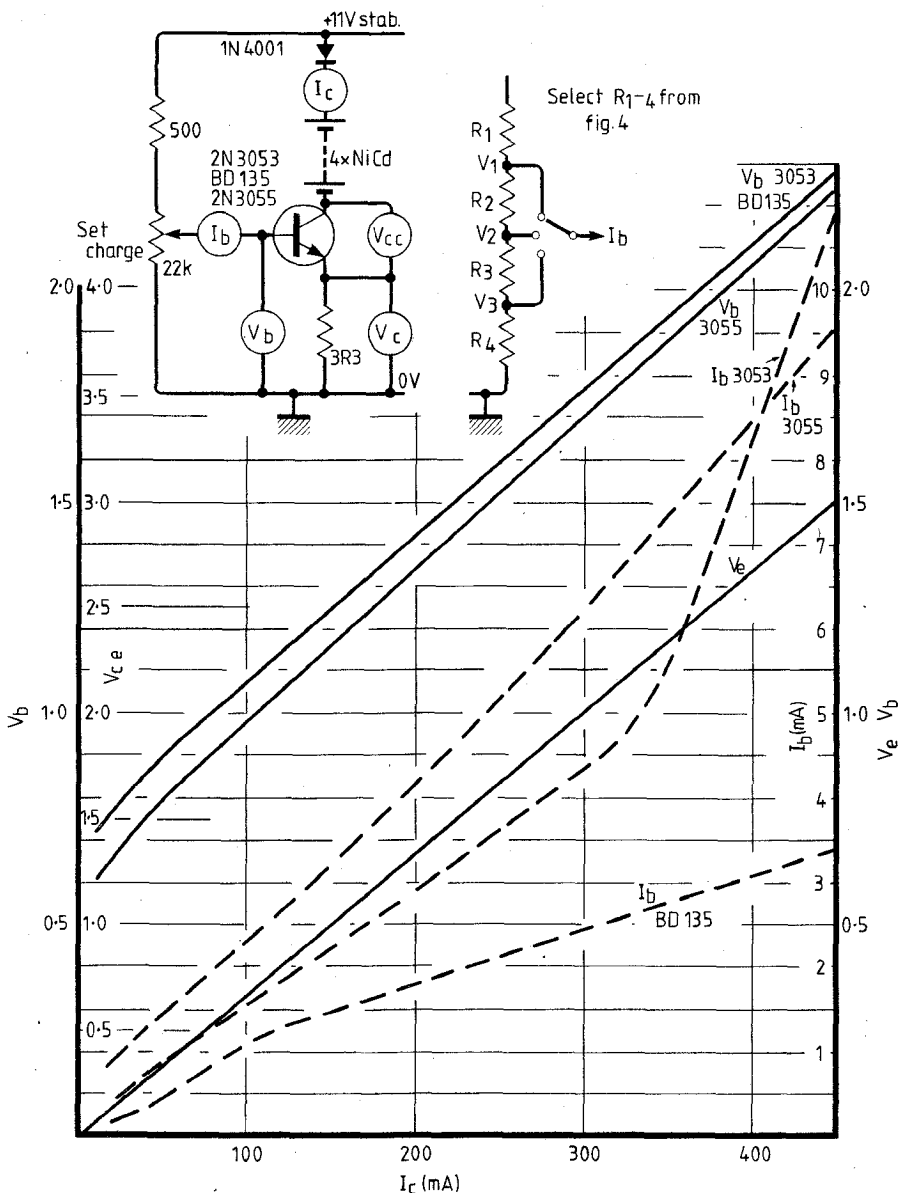
Charge rates are based on the nominal ampere-hour capacity of the cell, usually abbreviated to C. Thus, for a D-size cell of 4Ah capacity, a charge rate of 0.1C would be 400mA. Four charge rates are recog-



**Fig. 3.** Simple constant-current circuit is satisfactory for charging small cells at low voltages.

nised by consensus among the manufacturers – trickle, normal, fast and ultra-fast. Trickle charge is used mainly on standby duty, where cells are called on to deliver power only occasionally – but with absolute certainty. Examples are exit signs in public places and volatile computer memories. A charge rate of 0.01C will compensate for self-discharge while rates of 0.02 to .05 offer an increasing recharge

**Fig. 4.** Replacing set-charge pot with resistor chain and switch in evaluation circuit gives a 0.1C charger with rates of say 50, 100, 200 and 400mA to suit cells of AA to D size.



capability. Continuous indefinite charging at rates in excess of 0.06C are not recommended.

Normal charge at 0.1C replenishes an exhausted cell in about 10 hours, but when cells are used in stacks charging is recommended for 14 hours, by which time the cells will be warm to the touch – not hot, though (see Charging Process).

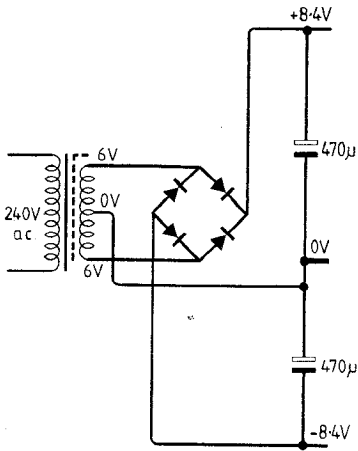
Fast charge at rates from 0.3C to 1C can be used provided that the necessary precautions are taken, enabling the cells to be used again after 1 to 3 hours charging.

Ultra-fast charge is used regularly by model boat and electric flight enthusiasts, who couple up a car battery and a length of resistance wire to recharge their battery stacks in a quarter of an hour or less. Charge rates of 20C have been reported, but great care and constant attention (human or electronic) are essential to avoid expensive replacements.

**Charging process**

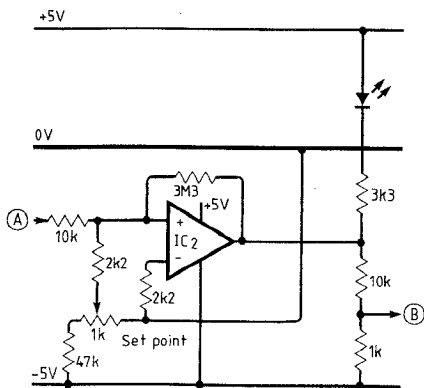
In the early stages of recharging an exhausted cell virtually all of the energy supplied is usefully employed in chemical conversion of the electrode materials, and





**Fig. 5.** Electronic thermometer detects rise in temperature as full charge is approached. Two diodes, one close to the cell the other at ambient, should be closely matched.

**Fig. 6.** As the cells approach full charge the rate is reduced to a safe level as the indicator lights.



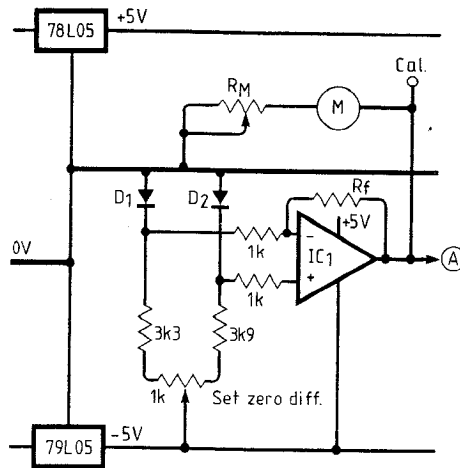
charging efficiency is high. As the cell approaches the fully charged condition hydrogen and oxygen are evolved at the electrodes, giving rise to an increase in internal pressure. Free oxygen migrates through the electrode structure and recombines with the hydrogen at the negative pole. This gives rise to a certain amount of heat, but for charge rates of 0.1C or less, energy supply and heat dissipation reach a balance; the rise in internal gas pressure is insufficient to lift the safety vent and no electrolyte is lost. This is known as 'safe overcharge'.

If the charge rate is substantially in excess of 0.1C, the rate at which gas is generated exceeds the rate of recombination; pressure exceeds the safety vent level, gas is vented to the atmosphere, electrolyte lost and the subsequent service life of the cells reduced.

### Charging arrangements

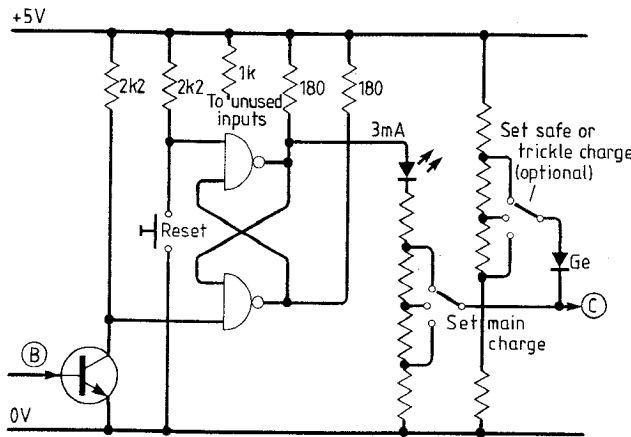
Charging rates cover a wide span — from 9mA for a PP3-equivalent to 16A if D-size cells are being ultra-fast charged at 4C. A number of compatible circuit modules have been devised and tested to cover this range.

Given a d.c. source of at least double the battery voltage, a series resistor of suitable value will ensure reasonably constant-current conditions, as the increase in cell voltage as charge nears completion is small



safe overcharge rate, the charge rate must be reduced to safe or trickle charge level once the cells begin to approach the fully charged condition. Three effects are available: the slight increase in terminal voltage, a marked increase in internal gas pressure and a marked increase in cell temperature. The first effect is small and variable from cell to cell, the second is impossible to monitor with standard cell construction; the third is common to all cells and is the parameter chosen to indicate time to reduce the charge rate.

To detect a rise in cell temperature above the prevailing ambient irrespective of its value calls for a differential configuration. Fig. 5 shows a simple and effective circuit, a differential version of a simple



**Fig. 7.** Input transistor  $Tr_1$  grounds lower gate when comparator switches high, removing base drive from following circuit.

relative to the excess voltage available. This arrangement is inefficient, at best it will be less than 50% overall. But for low stack voltages and small cells it may be sufficient, see Fig. 3.

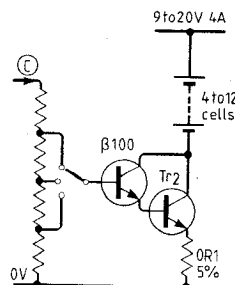
A silicon transistor is an extremely good constant-current source, and the circuit shown in Fig. 4 was assembled to evaluate the performance of three transistors of increasing collector dissipation. Replacing the set-charge potentiometer with a resistor chain and a single-pole switch results in may be used overnight in the knowledge that any overcharging will be in the safe region.

If the charge rate is to be in excess of the a 0.1C charger with rates of, say, 50, 100, 200, 300 and 400mA to suit cells of AA to D size. Provided that the charge rate is set to 0.1C for the cells in use, such a charger

electronic thermometer previously described.<sup>2</sup> With the gain of the amplifier set to around five, it offers the same 100°C range and 1% accuracy of the former design. As a 10°C rise above ambient is just about safe, the gain is increased to permit a 5° rise to be seen as a large signal, with consequent cleaner switching. Diodes  $D_1$  and  $D_2$  are signal diodes (preferably germanium) selected for  $V_f$  to within a few millivolts;  $D_1$  senses the ambient temperature, while  $D_2$  is inserted into the battery holder close to one of the cells. The set-zero potentiometer takes care of minor mismatching of the diodes, and of the unsymmetrical input conditions caused by the feedback resistor. With the gain of the amplifier set at something over 25, the voltage excursion at the CAL point is over 200mV for a 5°C rise in temperature.

The switching function is performed by a conventional comparator stage shown in Fig. 6. The non-inverting input is backed off by the set-point potentiometer and the output approaches the negative rail causing point B to be low; under this condition the indicator diode will light.

Once the cells are nearly charged the charge rate should be reduced to the safe charge level or less, and for this purpose the output of the comparator stage (point B) is applied to a 74 or 74LS latch stage shown in Fig. 7. The input transistor  $Tr_1$  acts as a crowbar, grounding the lower gate input only when the comparator stage is already switching high. This action sends



**Fig. 8.** Emitter follower provides current up to 4A for fast charging.

the upper gate low, and removes the bass drive from whichever constant-current stage follows.

The Darlington-connected emitter-follower stage of Fig. 8 is useful for fast charging at emitter currents from 500mA to 4A while still requiring only a minimal drive current from the latch.

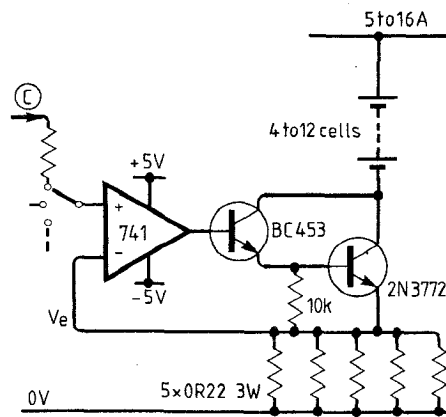
For much heavier charge currents, whether mains-derived or from a car battery, the compound emitter-follower circuit Fig. 9 has proved to be very stable and free from troubles.

When charging a small number of cells under extreme charge-rate conditions, even a transistor like the 2N3772 has dissipation limitations and a length of electric fire element of 15A rating between the car battery terminal and the stack positive is a useful power dump - inefficient but unavoidable.

**Construction and calibration**

For zero-frequency circuits of medium gain, Veroboard assembly is adequate, though of course a custom-designed printed board would enable the space to be reduced. Earthing the 0V line is always a good idea as although the gain of some stages is low input impedances may be high. The diode probes are mounted in thin-walled brass tubing, as previously described<sup>4</sup>.

Calibration presents no problem. Put both probes into a can of water at room temperature, and adjust the set-zero potentiometer until the output from IC<sub>1</sub> is zero. Check that the l.e.d. in the comparator stage can be extinguished by operation of the set-point potentiometer. Insert D<sub>2</sub> probe into a can of water at 5°C above room temperature, and operate set point until the l.e.d. goes out. The second l.e.d.



**Fig. 9** Stable compound emitter-follower shown for heavier charging currents.

in the feed line from the latch to the constant-current stage, is a necessary indication that the charging process is complete. The cells will quickly cool off when the heavy charge rate is removed, and the comparator stage will switch low again; however the latch will not reverse its state until the reset press-button has been operated.

The latch circuit can draw its power either from the positive rail to 0V, or from 0V to negative rail, so long as the 5V limit is observed. For charge currents in excess of 100mA the negative regulator (79L05) cannot cope so for all the hook-ups shown the latch is connected between positive rail and 0V, with the external power supply negative connected to 0V.

A final word of warning. Nickel-cadmium cells are not identical in their stored energy capacity, but all the same are normally used in stacks of up to ten or twelve cells. (For currents above 1A, connections

should be soldered, with care not to block the safety vent in the middle of the positive terminal). If such a stack is completely discharged, then inevitably one or more cells will be reverse charged by those cells still delivering power to the load. This is a very bad situation, as the gases generated cannot now recombine as they do during safe overcharge; excess gas pressure causes venting to the atmosphere and a reduction of subsequent cell life.

One manufacturer (Sanyo) states that the product of discharge depth (%) and the number of cycles is a constant.

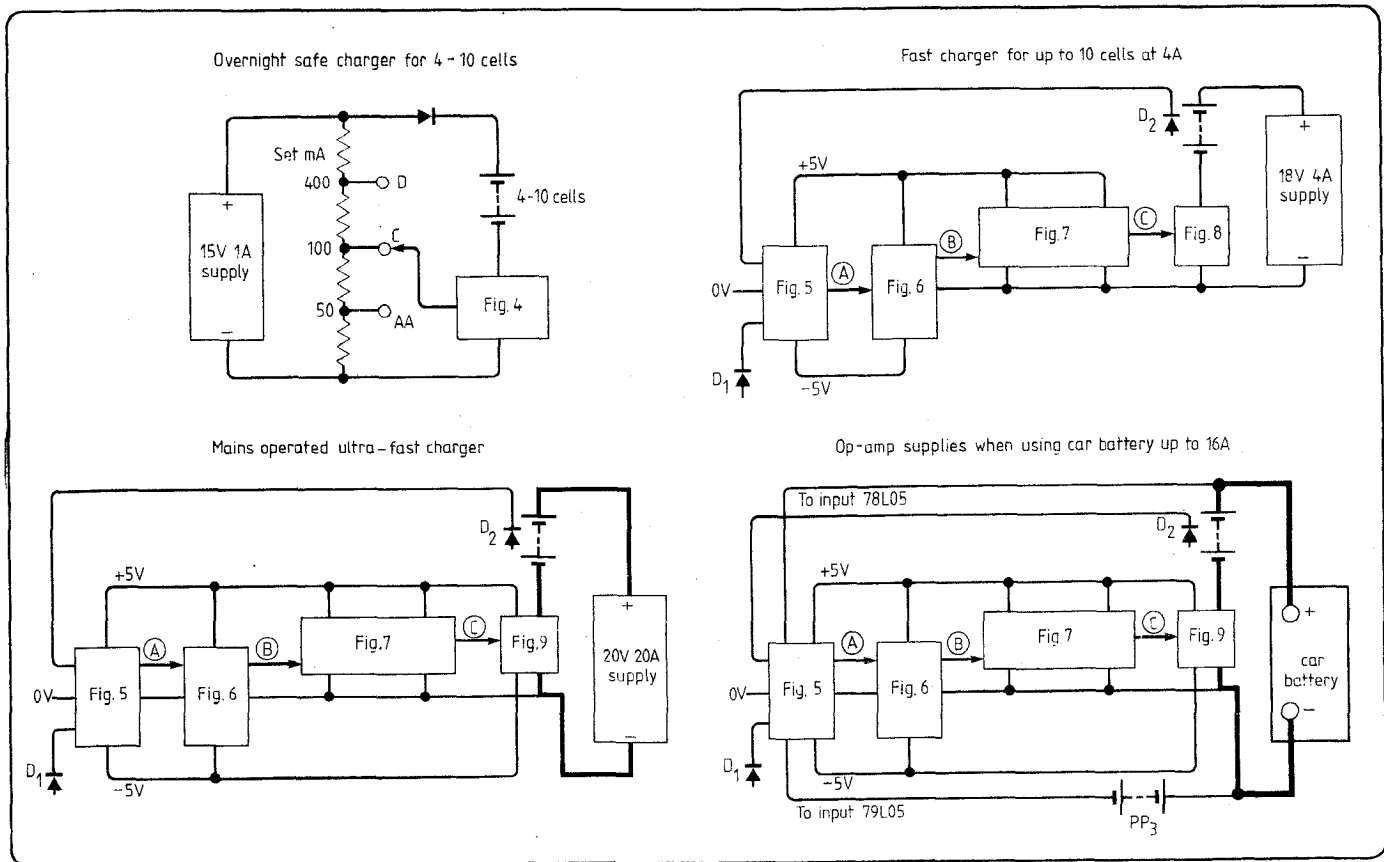
Although this statement and the accompanying graph are not quantified, it would seem that the 500 cycles (minimum) usually claimed is attainable only if the depth of discharge is limited to 25% of nominal capacity, while if 100% discharge is consistently employed, the expected working life would reduce to about 150 charge-discharge cycles.

**Further reading**

- Modern Portable Electricity, Ever Ready.
- Batteries for Modern Electronic Equipment, Ever Ready.
- Cadnica Battery Engineering Handbook, Sanyo.
- Nickel Cadmium Power. Sandwell Plant Co, (UK agents for GE).

**References**

1. Ian Hickman, Battery Powered Instruments, *Wireless World*, Feb. 1981.
2. A. S. Henderson, Electronics Thermometer, *Wireless World*, June 1981.
3. W W Cicard Set 6, no. 1



# Remote control for a hi-fi system

*Infra-red transmitter and receiver for switching and controlling a stereo pre-amplifier.*

by **Steve Kirby**

**Built by the author around the Advanced Pre-amplifier of Douglas Self, this infra-red remote control system may be easily added to most hi-fi amplifiers. It offers controls for input selection, volume, balance, treble and bass and can switch between loudspeakers and headphones. It eliminates the need for front panel controls.**

I have used an earlier version of this circuit for a year, and it has performed satisfactorily. The circuits are fairly easy to add to existing pre-amplifiers. My system presently consists of the Advanced pre-amplifier by D. Self (*Wireless World*, November 1976) with the loudspeaker system by S. Linkwitz (*Wireless World*, May, June and December 1978) and five 25W power amplifiers. Signal metering is by the Q. Rice L.e.d. p.p.m. meter (*Wireless World*, August 1980).

The present circuit was developed to replace the original and give additional facilities, such as balance and tone controls, and to remove the duplication of the remote functions by the front panel controls. In one year's operation I have never used the panel controls, so the second version will have a completely blank front panel.

## The remote transmitter

The transmitter uses a Plessey SL490 i.c. which has all the key reading, command encoding and output drivers stage integrated on a single chip. The only discrete components needed are for timing and for driving the transmitter infra-red l.e.ds with short high-current pulses (Fig. 1).

The i.c. has provision for transmitting 32 possible codes and there is a family of receiver i.c.s which can use all of them. The ML922 used in this system only responds to 21 codes. Because of this the crosspoint matrix keypad has to be divided into two sections, giving 24 keys, one with no function and two with duplicate functions to adjacent keys. The same transmitter could be used for other receivers in the series (including a microprocessor-compatible 5-bit receiver and a toy controller) and include the full 32 keys, in a 4 × 8 matrix.

A variable resistor adjusts the internal clock which controls the command repetition rate and sets the time to go from 'off' to 'full volume'. The output stage provides a 1A pulse to give a high power infra-red signal. To prevent the l.e.ds from being destroyed, the 3n3 capacitor is discharged through the l.e.ds via the transistors. The green l.e.d. indicates that a key has been pressed.

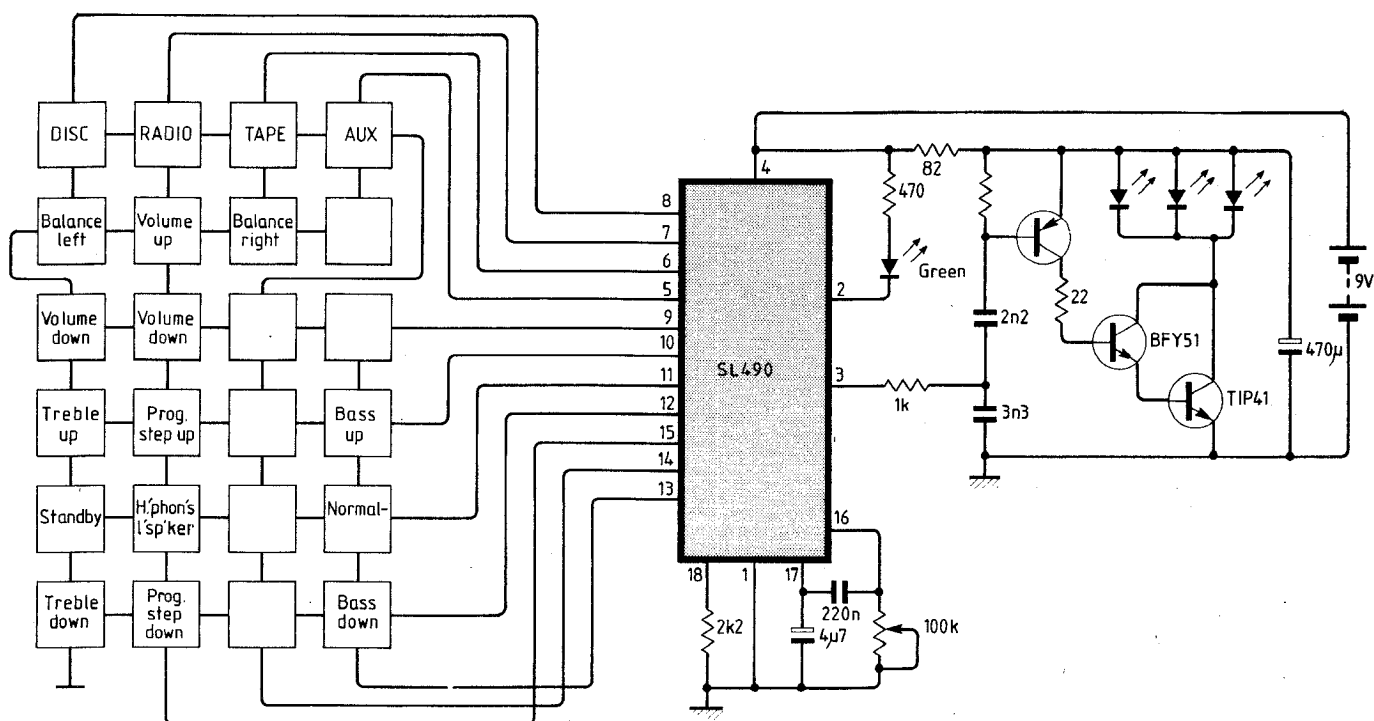
## The receiver

The receiver is based on a Plessey ML922 i.c. which decodes the p.p.m. signal from the SL480 i.r. pre-amplifier. It gives a four-bit digital output and ten different codes are used. There are also three analogue current outputs produced by the internal 5-bit d-a converters.

Referring to Fig. 2, the infra-red pulses are detected by the receiver diode. Noise from visible light is filtered out by a Kodak infra-red transmitting filter, type 87C. The SL480 is a high gain (100dB) preamplifier specifically designed for this application. It can suffer from oscillation caused by feedback, so layout is rather critical and an electrical screen around the preamp section is essential, along with good supply decoupling. The p.p.m. output is decoded in the ML922. The standby output, which is low until the first command is received, presets the up/down counters and resets the four-bit latch.

When a digital code is received, the pulse line triggers the 555 mono-stable which expands the pulse to drive the green l.e.d. ('command received' indicator). The digital outputs have a +15V '1' level, which is buffered by the 4049 inverters to give a 0-5V t.t.l.-compatible output to drive the r.o.m.

Fig. 1. The remote control transmitter



Keyboard (All keys single pole push to make switches)

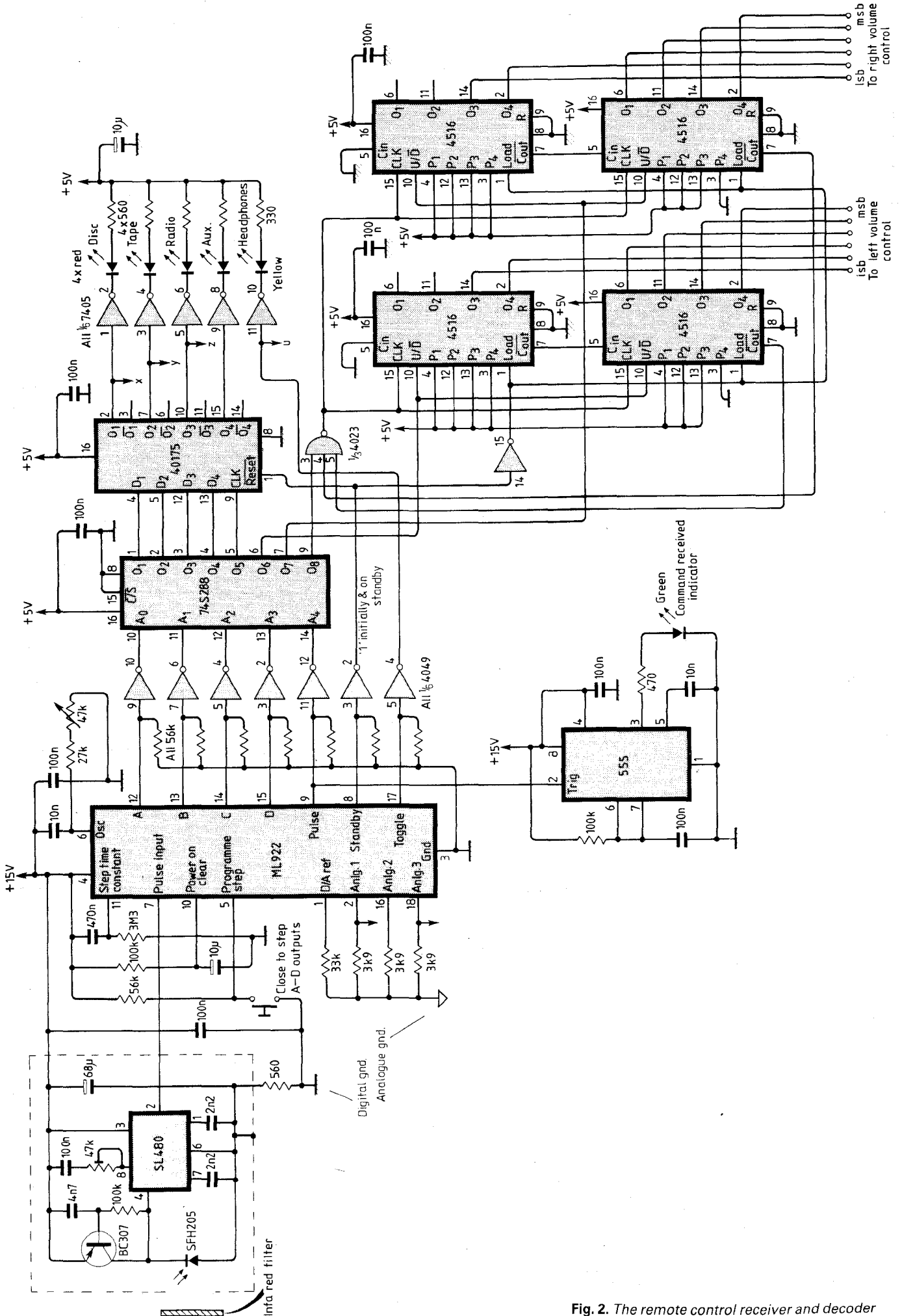
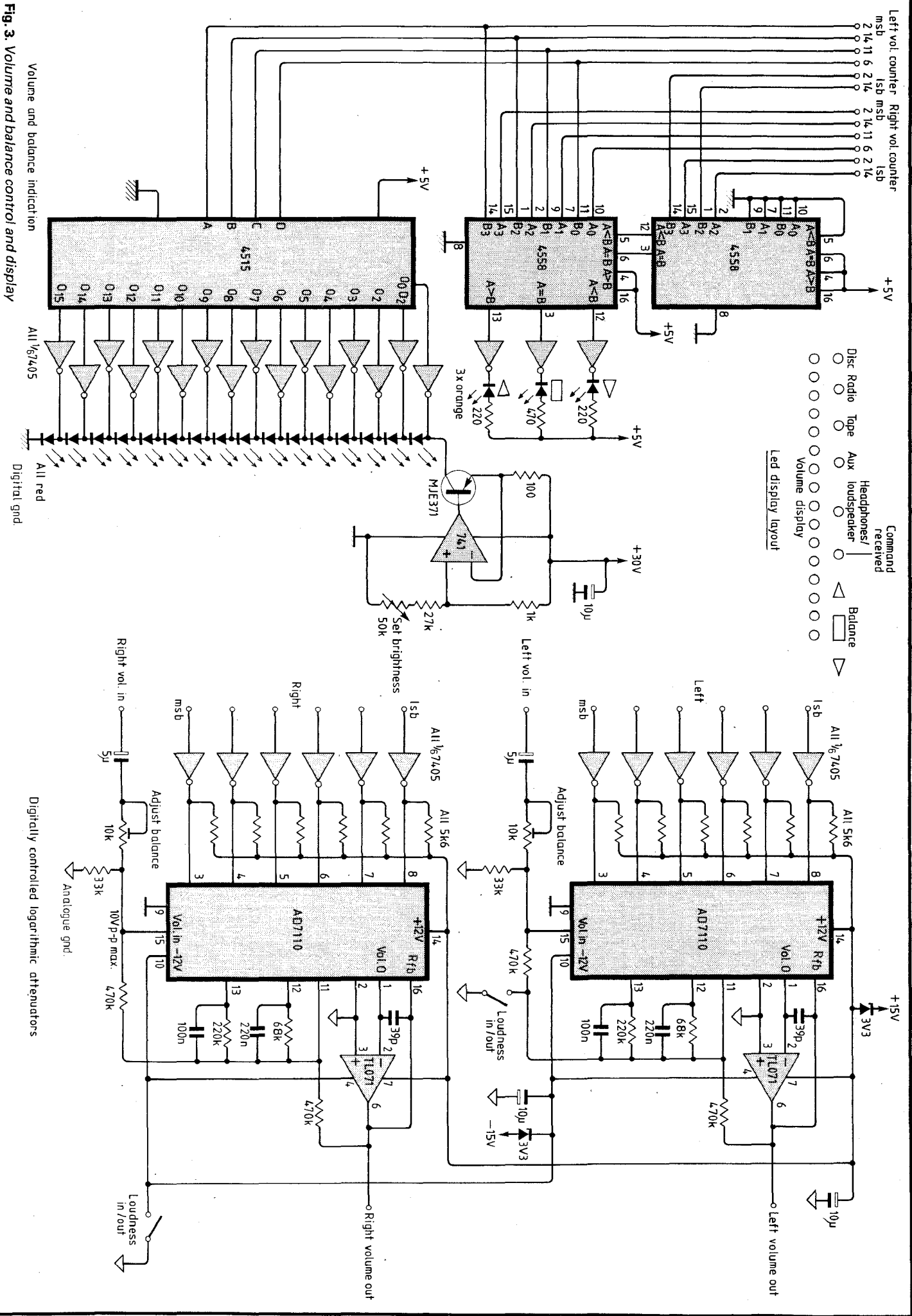


Fig. 2. The remote control receiver and decoder



Fig. 3. Volume and balance control and display



The analogue current outputs at pins 2, 16 and 18 are converted into voltages by the associated resistors with a step size set by the resistor at pin 1. There are transmission codes to step them up or down, or to go back to a preset level, (3/8 f.s.d). In our application they are used to drive the tone controls (Fig. 4).

The digital word is decoded by a 5 × 8 p.r.o.m. (74S288). A '1' on one of the four first p.r.o.m. outputs is latched by a pulse on the fifth output. When a input or headphone/speaker command is received it is displayed on the appropriate l.e.d.s, driven by the latch.

The remaining three r.o.m. outputs drive the up/down counters which are used to drive the 'volume control' attenuators in Fig. 3. They are counted up or down in parallel or in opposition to control both volume and balance. There is a 'standby'

command to return the volume to a set level.

### Volume and balance display

When the volume control knob is removed there is no longer any visual indication of the volume setting. For many people this may not be a problem; all that matters is how loud the music is! Others may like a display to set up a specific level for comparison. A balance indication can also be useful to answer such questions as to whether the second violins are really trying to drown the double basses.

The circuits on Fig. 3 give simple indication of volume and balance settings. A 4-to-6 line decoder is driven by the top four bits of the left volume control counter.

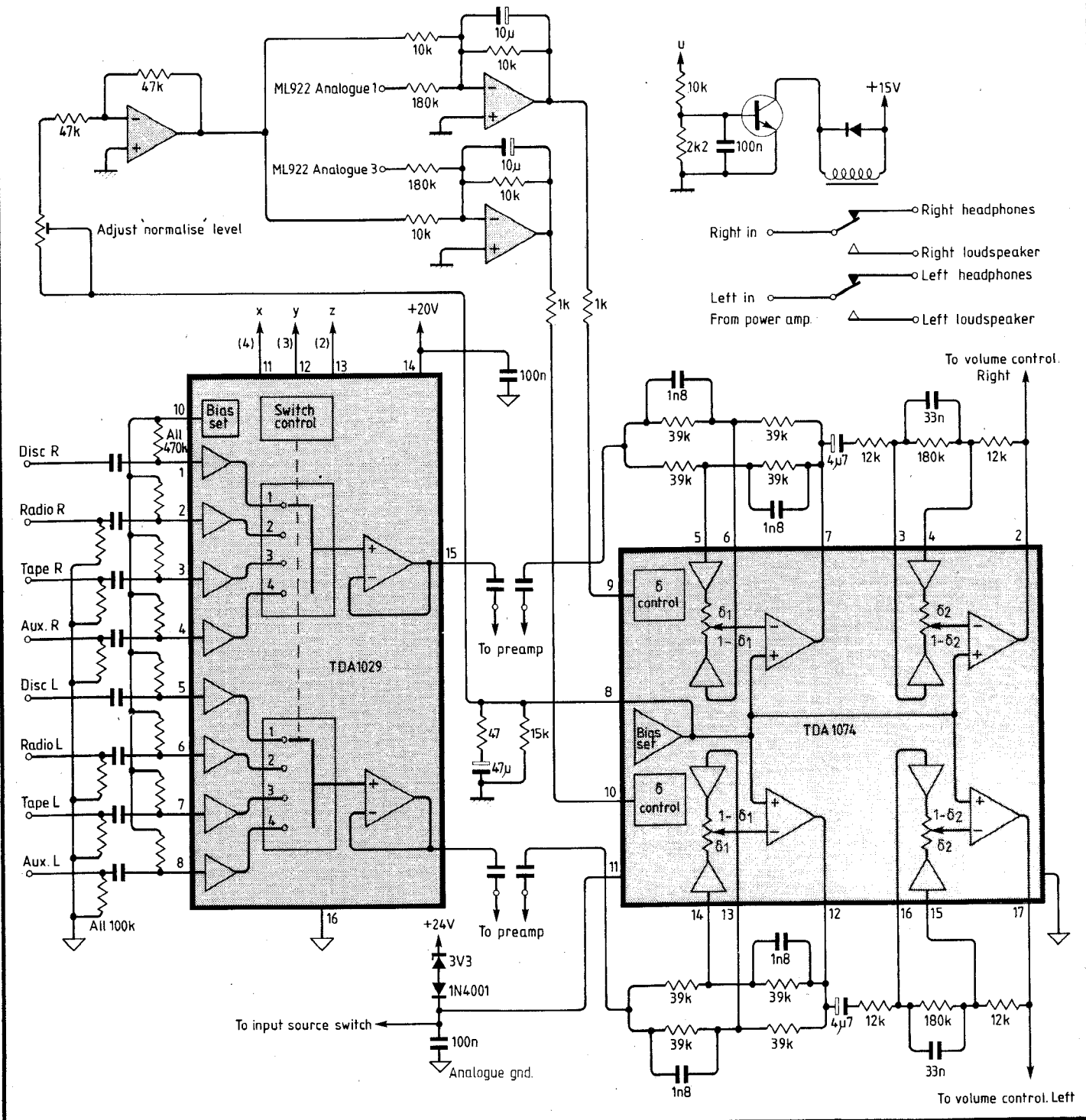
The outputs turn on the open collector inverters sequentially as the volume is in-

creased. With only the first inverter on, all the current from the source, the 741, flows only through one l.e.d. As lower inverters are turned on, the current flows through extra l.e.d.s before being diverted to ground. Power comes from the unregulated supply on the preamplifier.

Balance indication is by three l.e.d.s, a central square one flanked by two triangular ones. The two sets of counts are compared and depending on whether the right counter is greater than, less than or equal to the left, the appropriate l.e.d.s are lit.

More precise displays of volume or balance are possible but they consume a great deal more power, chips and money! Either or both displays could be omitted with no loss in the system performance.

Fig. 4. Input switching and tone control



## Digital volume control

The logarithmic attenuators shown on diagram 3 are multiplying digital-to-analogue converters specifically designed for audio volume control. The attenuation is set by a six-bit word, with 59 steps of 1.5dB from 0dB to -85dB. Steps 60 to 64 give complete isolation between input and output. T.h.d. is better than -85dB over the audio range, depending mainly on the quality of the op-amp used in the output feedback loop.

Low volume loudness frequency compensation is provided but can be switched out. The attenuator has a current output, converted to a voltage by the output op-amp and an internal feedback resistor. The attenuator is powered from  $\pm 12V$ , derived from the  $\pm 15V$  regulated supply of the audio preamplifier. If the loudness function is not required, the -12V supply can be omitted. The 7405 inverters are used to change a logic '1' from 5V to 12V for driving the attenuators.

When the attenuator is turned off, capacitive feedthrough, due to the board layout is the main source of noise, so input and output should be carefully separated in the layout. Separate analogue and digital grounds are provided. Switching noise as the volume is changed is practically inaudible, and certainly better than a good many log pots I've used!

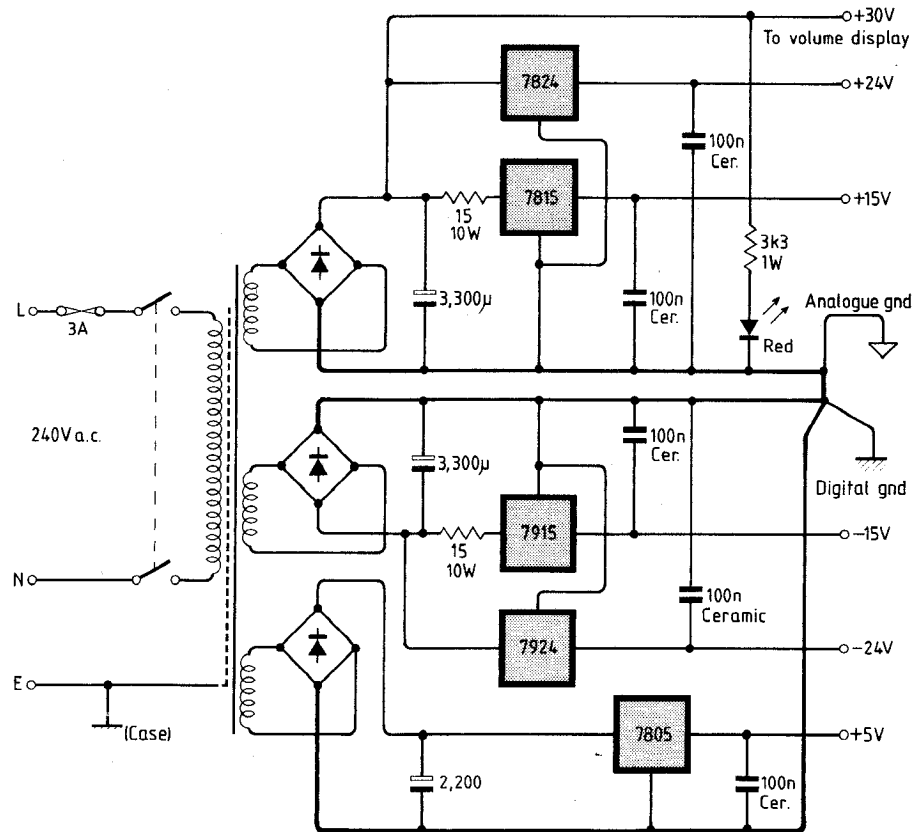


Fig. 5. A suitable power supply

## Input switching

The low level inputs can be switched either by good quality relays, or electronic switches designed for audio. In an earlier design I used relays, which worked well, and the audible click as they change was a reassuring feedback. Audibly there is no difference (except that there is now no click). They are cheaper than four relays.

On Fig. 4, a four-to-one stereo switch is driven by the latch on Fig. 2. The input capacitors selected depending on the impedance of the source driving them. The disc input comes from the magnetic cartridge preamp. Resistors bias the inputs to half the power supply level for maximum range.

In the Self preamplifier, there are additional switches around the feedback network, selected according to the source. I have kept these as relays because of the large voltages that could be passing. They are driven in parallel with the input switches.

## Tone control

Tone is not generally altered as often as volume, so for economy this section could be omitted, retaining the ordinary front panel controls. A Mullard TDA1074 is used in the remote controlled tone section. The i.c. contains four voltage-controlled potentiometers connected to high-gain op.amps. Frequency dependant feedback networks are connected around these to provide treble boost/cut of  $\pm 12dB$  at 10kHz and bass boost/cut of  $\pm 12dB$  at 100Hz.

The voltage controlling the potentiometers is relative to an internal bias, set to half of  $V_{cc}$ . The analogue outputs from the Plessey receiver/decoder are summed with the bias voltage by the two op.amps. Each time the system is switched on, the analogue signals are 'normalised' to 3/8ths of f.s.d. This can be set to give a level response by the adjustment of the preset potentiometer. However, because the level is set at 3/8ths f.s.d. less room for cut and more room for boost is available. I haven't provided any indication of tone settings; I prefer my ears to do that, but the l.e.d bargraph i.c. from National Semiconductor could be used.

The system as a whole gives an output noise voltage of about  $50\mu V$  and a total harmonic distortion of 0.05%, channel balance is within 0.5dB and channel separation 60dB. The dynamic range is not quite as good as Mr Self's original design.

## Construction

The receiver and decoder were built on a Veroboard with an edge connector. The system is built around a mother board for future up-dating. The transmitter was built in a standard Verobox and a keyboard taken from a calculator. Layout is not critical except where already mentioned.

The components are readily available

except for the p.r.o.m. which needs to be programmed. Many companies offer a programming service<sup>1</sup>. If all the sub-circuits are built the total component cost would be about £70, though various displays and the tone control section could be left out if the constructor wishes to reduce costs.

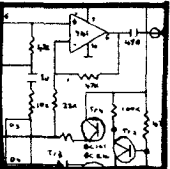
Future development of the system will replace the logic with a single chip microprocessor. Programmes for the remote control of solenoid operated cassette decks and synthesised radio receivers could then be easily configured.

## Power supply

The power rails necessary will be found in many modern stereo systems with the probable exception of the +5V. This could be provided by a small extra transformer and a 1A regulator if no existing transformer taps will do. For those starting from scratch, Fig. 5 gives a standard power supply unit. Note the connections of grounds.

<sup>1</sup>Programmed r.o.m.s may be obtained from Mr G. Long, York Electronic Centre, Department of Electronics, University of York, Heslington, York. The cost includes a programming and handling charge and will be about £4 in total.

# Circuit Ideas



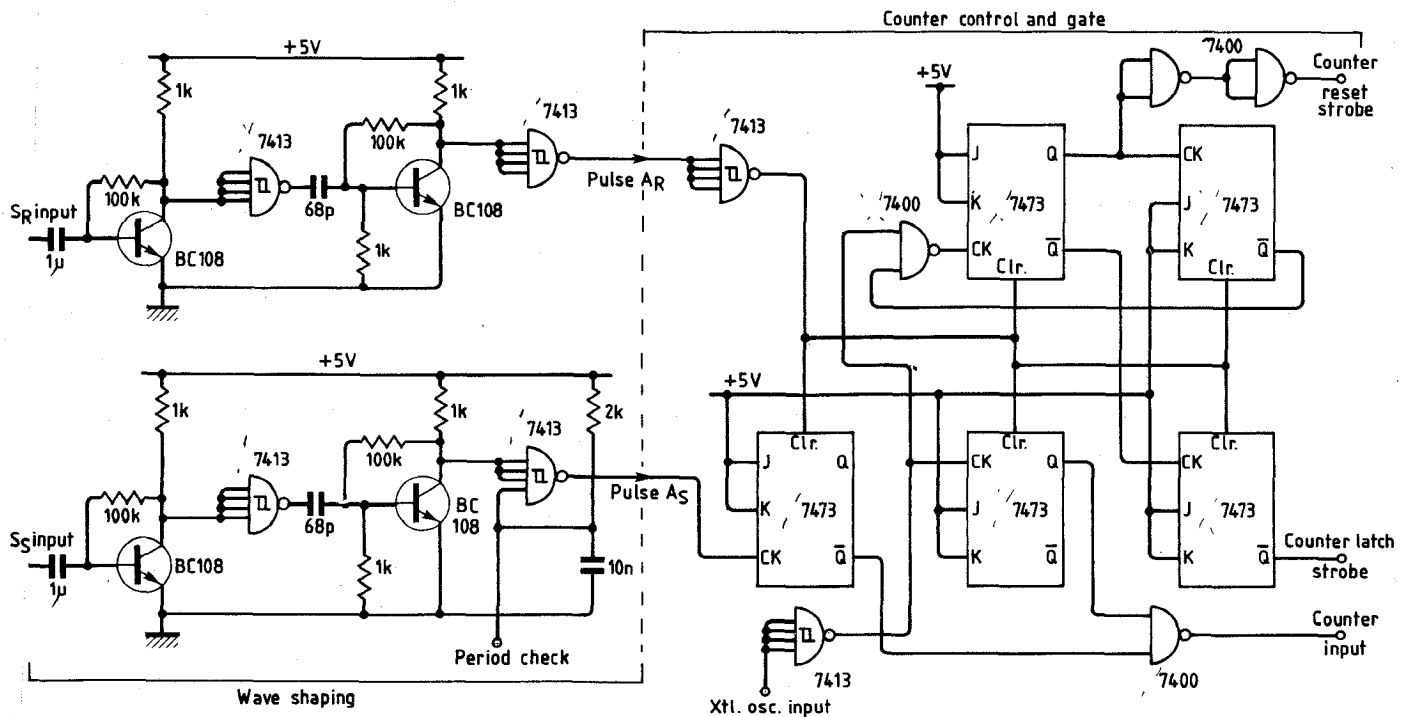
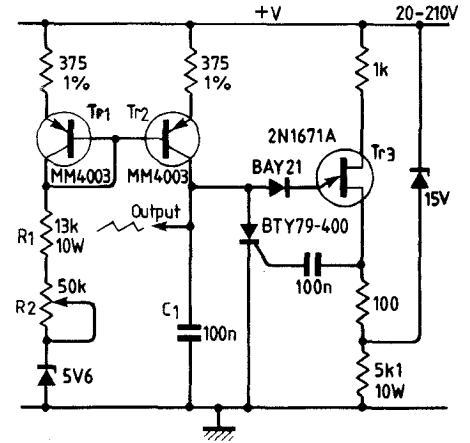
## High-voltage ramp generator

By combining a constant-current source and a unijunction transistor oscillator, linear ramps up to about 210V can be generated with a constant output frequency. Peak ramp voltage is set by adjusting the supply voltage, and the constant-current source/zener diode ensure that the charging rate of  $C_1$  is not affected by supply changes.

Charging current must be smaller than the holding current of the unijunction

transistor and this determines the value of  $R_3$ . For a holding current of  $17\mu A$  and the maximum supply voltage of 210V,  $R_1$  should be  $13k\Omega$ . Output frequency is set by  $R_2$  and the stability is dependent on the current source, within 1% on the prototype. All three transistors must be mounted on a heatsink and  $Tr_1, Tr_2$  should be next to each other for good thermal contact.

S. Ion, Romania

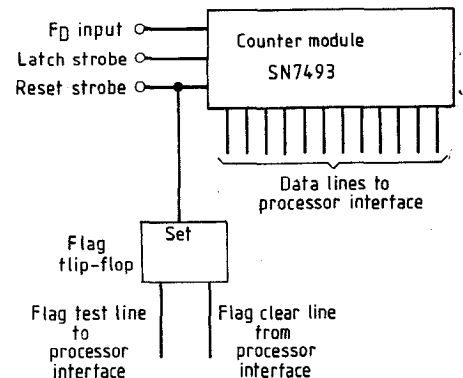


## Phase to binary converter

Fast and accurate measurements of the phase relationship between two signals of equal or similar frequency can be performed with this circuit. A measurement is made within a single period of one signal and is accurate to within a few minutes of arc. The converter provides a parallel binary output from about 30Hz to 15kHz. Operation of the circuit is straightforward,

a reference signal  $S_R$  and secondary signal  $S_S$  are fed to identical wave shaping circuits which produce pulse outputs. Pulses from a known source  $E_D$  are counted during the period a counter is enabled by the two input signals. Because the reference input opens the counter gate and the secondary input closes the gate, the counter contains a number which represents the period between the two pulses.

V. B. Mitchell  
Honiton  
Devon





## Solid-state relay

In power control systems where it is necessary to switch an even number of half-cycles, such as proportional heaters, this solid-state relay offers zero-voltage turn-on for minimum r.f.i., and full-wave conduction.

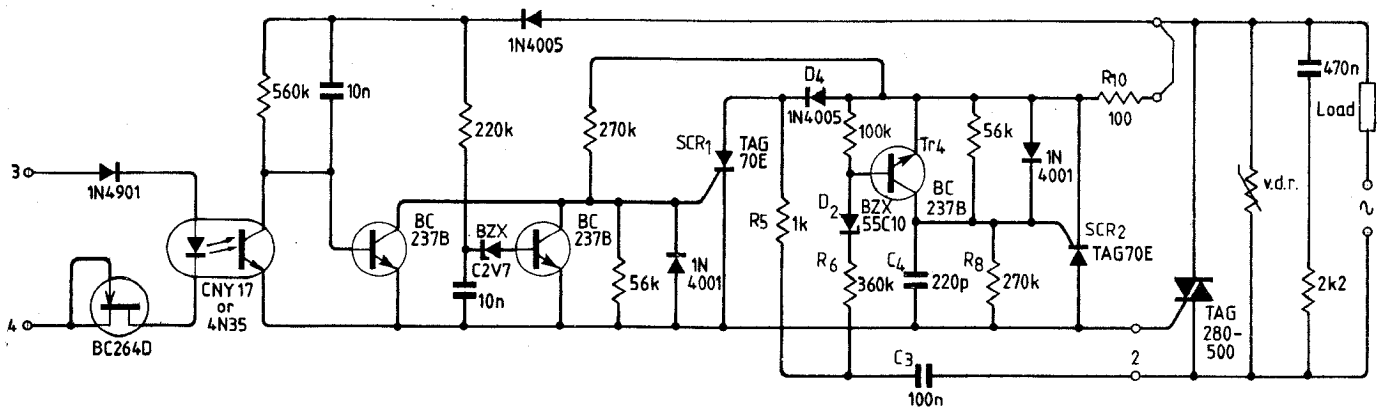
With s.c.r.1 in the blocking condition,  $C_3$  is charged during each positive half-cycle and discharged during every negative half cycle through  $R_6$ ,  $D_2$  and  $Tr_4$ .  $Tr_4$  is then saturated and prevents s.c.r. 2 from triggering via  $R_8$ . When s.c.r.1 is triggered,  $C_3$  discharges through  $R_5$  and the

gate of the triac, and cannot be recharged during the positive half-cycle because the voltage between the anode of s.c.r.1 and point 2 is small. The triac is triggered through  $R_{10}$ , and  $D_4$  and s.c.r.1. At the start of the negative half-cycle the voltage across  $C_3$  is lower than the voltage of  $D_2$  therefore  $Tr_4$  is not saturated and s.c.r. 2 is triggered through  $R_8$  and  $C_4$ , which in turn triggers the triac.

With this system the circuit can only be turned on at the start of a positive half-cycle and turned off at the end of a negative

half-cycle to ensure full-wave conduction. Because zero-voltage switching is used, the circuit can switch resistive and capacitive loads.

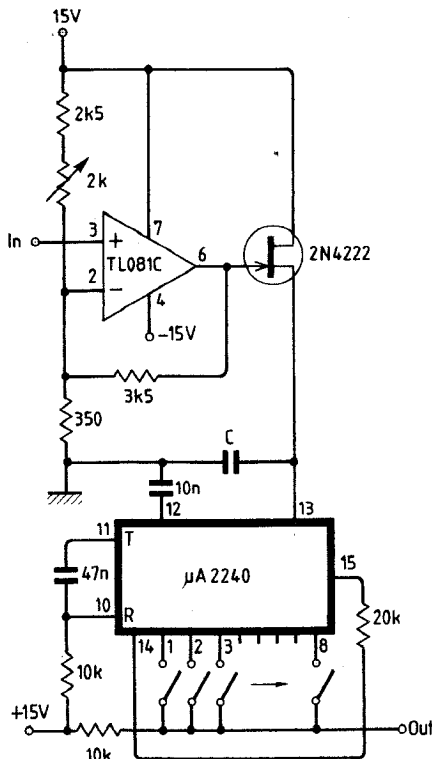
Norsem Electronics Ltd.



## Programmable v-to-f converter

The UA2240 timer can be used as a voltage-to-frequency converter with a programmable frequency range and linearity of within 0.01%. An f.e.t. is used in place of the resistor in a conventional RC network, which makes the output frequency proportional to the input voltage.

K. Kraus  
Rokycany  
Czechoslovakia

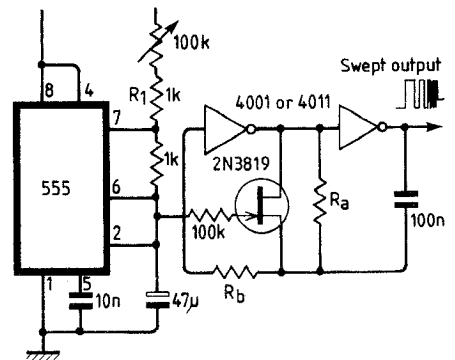


## Low-power sweeping oscillator

A simple low-power sweeping oscillator can be constructed using two i.c.s. The c.m.o.s. 555 is wired as an astable which provides a ramp waveform and exponentially increases the frequency of a c.m.o.s. oscillator. A variable resistor adjusts the sweep rate from around 0.1 to 10Hz. Resistor  $R_b$  should be between two and ten times the value of  $R_a$  and is included to compensate for variations in the supply voltage. Optimum performance is achieved with a 15V supply.

A more linear sweep can be obtained if  $R_1$  is replaced by a constant current source.

K. Kirk  
St. Andrews, Malta



Contributions for circuit ideas should be typed and include a day time phone number if possible. We now pay a minimum of £20 for all ideas which are accepted for first publication in Wireless World.

# Radiation resistance—a reply

*Considered in network terms, there is nothing mysterious about radiation resistance*

by T. S. M. Maclean, F.I.E.E. University of Birmingham

**Last August's article on radiation resistance may not remove its role of mystery, particularly in considering the receiving operation of a radio aerial. There is nothing mysterious about it, but it should not be regarded as a real resistance as suggested. In practice it is neither a significant source of Johnson noise at ambient temperature nor is it a sink for dissipating externally induced noise.**

The approach used here is to regard a receiving aerial as a network. This is legitimate provided the aerial is considered to be divided into a number of segments, each of which is short in terms of a wavelength. As an illustration of how short, a half-wave dipole for example would require to be divided into at least five segments so that each segment length is no longer than  $\lambda/10$ . Provided this condition is satisfied the current in each segment will not be able to change in magnitude or phase along its length to any significant extent. Thus the current in each segment is approximately constant, just like the current in every series branch of a network is constant, and hence the whole aerial can be described in network terms alone. This approach can be applied to a wire aerial of any type and is not restricted to dipoles, though this article uses a dipole for illustration.

## Output voltages from receiving aerial

In using a receiving aerial the two output voltages in which one is interested are the signal voltage and the root mean square noise output voltage. Normally the signal voltage is produced by a wave coming from a single direction and it is customary to align the receiving aerial so as to maximize this signal voltage.

The noise voltage on the other hand is commonly produced by waves of different strengths coming from different directions. It is therefore simplest to consider the case when the planar noise wavefronts coming from all directions with random polarizations are all assumed to be of equal strength. The aerial is then said to be in an isotropic noise field, as though the noise came from the surface of a large sphere maintained at a uniform temperature on the surface of which all the noise sources are uncorrelated. The aerial is then as-

sumed to be placed at the centre of this large sphere.

The noise power at the output terminals of this aerial is then produced by the noise fields arriving from this large spherical surface developing noise input voltages across every segment of the aerial. These voltages are then transformed through the separate mutual admittances between each input segment and the output segment to give a combined noise current through a resistive load. For the isotropic case considered here, although all the input voltages are equal, this does not imply equal contributions to the output current because of the different mutual admittances with the output segment.

If the aerial were surrounded by a perfectly conducting metallic enclosure this noise output voltage would disappear completely. In such a situation only the Johnson noise voltage of the complete aerial due to its loss resistance at ambient temperature would remain. But as aerials are normally constructed of high conductivity metal this Johnson noise is negligible in practice.

## Signal output voltage

Consider the linear dipole to be oriented so that its axis is parallel to the direction of the electric field of the incoming radio wave of strength  $E$  V/m. Suppose also that the dipole is considered to be divided into five segments, each of length  $l$ . Then equal in-phase voltages of magnitude  $El$  will be applied across each segment of the dipole. If the output terminals of the dipole are short circuited the current in each segment can be obtained from the solution of the following five equations

$$\begin{aligned} El &= I_1 Z_{11} + I_2 Z_{12} + I_3 Z_{13} + I_4 Z_{14} + I_5 Z_{15} \\ El &= I_1 Z_{21} + I_2 Z_{22} + I_3 Z_{23} + I_4 Z_{24} + I_5 Z_{25} \\ El &= I_1 Z_{31} + I_2 Z_{32} + I_3 Z_{33} + I_4 Z_{34} + I_5 Z_{35} \\ El &= I_1 Z_{41} + I_2 Z_{42} + I_3 Z_{43} + I_4 Z_{44} + I_5 Z_{45} \\ El &= I_1 Z_{51} + I_2 Z_{52} + I_3 Z_{53} + I_4 Z_{54} + I_5 Z_{55} \end{aligned}$$

where  $Z_{ii}$  is the self impedance of each segment,  $Z_{ij}$  is the mutual impedance between segments  $i$  and  $j$  and  $I_i$  is the current in segment  $i$ . Expressions for the self and mutual impedances  $Z_{ii}$ ,  $Z_{ij}$  are available in the literature<sup>2</sup>.

Consequently the open-circuit signal voltage available from the middle segment 3 of the dipole is readily found from the network equation

$$V_{oc}(3) = -I_3 Z_{13}$$

where  $Z_{13}$  is the input impedance of the aerial at these terminals. This is most easily found by first inverting the impedance matrix formed from the five equations above in, for example, a personal computer to give the corresponding admittance equations, from which

$$Z_{13} = \frac{1}{Y_{33}}$$

Thus the signal output voltage has been obtained without requiring any knowledge of the radiation resistance of the complete aerial. All that has been required is a knowledge of the electric field strength of the incoming radio wave and a network description of the short segments into which the aerial has been considered to be divided. This description in the form of the self and mutual impedances of the segments is sufficient, because the resistance associated with radiation forms part of these impedances. But it is emphasized that this radiation resistance is an accurate description of a *network*, and is not something which has to be introduced exclusively for radiation problems.

## Noise output voltage

Before the noise output voltage from this dipole aerial can be calculated it is first necessary to calculate the noise input voltage applied across each segment of the dipole. Since the aerial is considered to be placed at the centre of a large sphere at temperature  $T$ , on the surface of which all the noise sources are uncorrelated, the mean square electric field along any direction is obtained from the Planck distribution law as

$$e^2 = \frac{8\pi h}{3\epsilon_0 \lambda^3 (e^{hf/kT} - 1)} df$$

where  $h$  is Planck's constant,  $k$  Boltzmann's constant,  $\lambda$  the free space wavelength and  $f$  the frequency. Because this is true for all directions the orientation of the aerial for maximum signal does not alter the r.m.s. noise input to any of the aerial segments, which is simply  $el$  which  $l$  is the length of each segment.

But although the original noise sources on the surface of the large sphere are assumed to be uncorrelated this does not mean that the input voltages across each segment of the aerial are likewise uncorrelated.

lated. This is because the planar noise wavefront from a single direction is going to produce identical input voltages across successive segments, except that they are time displaced by  $(l/c) \cos \theta$  between adjacent segments, where  $\theta$  is the angle made with the axis of the dipole by the normal to the incoming wavefront, and  $c$  is the velocity of light. Since the total input noise voltage across any segment is the sum of all the voltage components due to waves arriving from all elevation and azimuthal angles  $\theta$  and  $\phi$ , there will thus be correlation between the applied voltages across the different segments. For such correlated input voltages the resultant current through short-circuited output terminals of an aerial divided into five segments with the output taken from the middle segment is given by<sup>3</sup>

$$i_o^2 = \sum_{j=1}^5 \sum_{k=1}^5 Y_{3j}^* Y_{3k} S_{jk} (e^2 l^2)$$

where  $Y_{3j}$ ,  $Y_{3k}$  are mutual admittances between the  $j$ ,  $k$  input segment and the middle output segment, the asterisk denotes complex conjugate and  $S_{jk}$  is the cross spectral density between the  $j$  and  $k$  segments. For the case of a linear dipole this cross spectral density between elements spaced by a distance  $d$  is<sup>4</sup>

$$S_{jk} = 3 \left( \frac{\sin kd}{k^3 d^3} - \frac{\cos kd}{k^2 d^2} \right)$$

where  $k$  is the free-space phase constant. Hence the open-circuit mean square output voltage is

$$v_{oc}^2 = \frac{i_o^2}{|Y_{33}|^2}$$

Thus the noise output voltage also has been found from a network description of the segments of the aerial plus the specified noise temperature of the surrounding sphere. No joule power dissipation of this external noise occurs unless a load with a resistive component is connected across the aerial terminals. With such a load dissipation takes place in that load resistance only and there is no dissipation of power in either the radiation resistance of the complete aerial or in the radiation resistance of the individual segments of which it is composed, provided that the aerial is assumed to be constructed of perfectly conducting material.

## References

1. Bell, D. A. Is radiation resistance real, *Wireless World*, August 1981, pp.73, 74.
2. Harrington, R. F. *Field Computation by Moment Methods*, Macmillan, 1968.
3. Davenport, W. B. & Root, W. L. *Introduction to the Theory of Random Signals and Noise*, McGraw-Hill, 1958.
4. Childers, D. G. & Reed, I. S. Space-time cross-correlation functions for antenna array elements in a noise field, *IEEE Trans.* vol. IT-11, 1965, pp.182-90.

# Battery power supply

*A portable supply for use with an LCR bridge or other testgear*

by K. J. Young, BA, MIEE.

**This 7.2V battery pack can supply a sinusoidal oscillator and one or more amplifiers as required, up to a maximum load of 50mA, although higher current demands can be met for a short period.**

The arrangement shown in Fig. 1 gives portability to the bridge or other testgear and is based on the use of six AA size nickel-cadmium sealed rechargeable cells, carried in a holder designed for six U7 size cells. Each cell is rated at 1.2V 0.50Ah, and the pack is recharged at 65mA for 12 hours, preferably from a constant-current power unit.

We needed a 1592 Hz sinusoidal oscillator giving 1.5V r.m.s. and the inverted Wien bridge lamp-stabilized oscillator described in *WW*, vol. 68, p.78, Feb. 1962 was chosen.

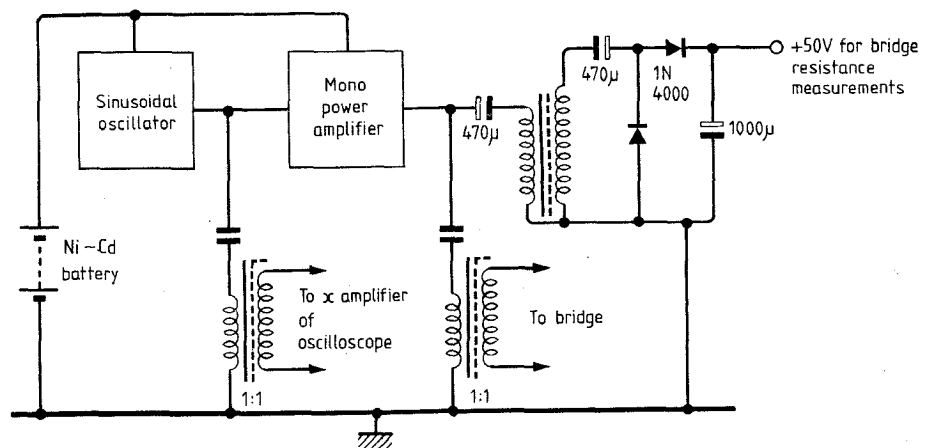
For resistance measurements utilizing a 50.0-50 $\mu$ A meter for balance, in parallel with two back-to-back 0A47 or similar diodes having a low forward resistance of guard against meter damage, the 7.2V supply is inadequate for measuring low values of resistance. Hence, a small audio power amplifier of the type supplied assembled on a small p.c.b. was used to amplify the output of the oscillator and feed a step-up transformer (in this case a 12V mains transformer with secondary used as primary). This was fed to a conventional cascade voltage-doubler, giving a d.c. supply of 50V, which can supply 2mA for short periods; the rather poor regulation is advantageous in guarding further against meter damage.

For the bridge itself a convenient switching arrangement providing for use in the Wheatstone, de Sauty, Maxwell or Hay configuration is described by L. Nelson-Jones in *WW*, vol. 74, p.434-439,

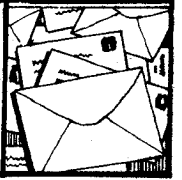
Dec. 1968; the only restriction with this design is a capacitance limit of 100 $\mu$ F. The original circuit uses a c.r.t. display with valves and needs mains supply. An adaptation for portability could use a battery-powered oscilloscope, or if the attractive elliptical display is sacrificed, the null indication for C and R measurement could be achieved by audio amplifier with input limiter and small loudspeaker or by amplifier, rectifier and meter. For greater versatility where speed of testing is not an important criterion, resistance and capacitance decade boxes could be patched as required to achieve whatever bridge configuration is required for the particular measurement, although it would then probably be necessary to use a lower frequency for the oscillator, to reduce the effects of stray capacitance.

Many other applications are possible. For example the oscillator with an amplifier capable of feeding a small loudspeaker can be used for demonstrations of phase difference with reflected sound waves, such as in the estimation of the velocity of sound in air by measurement of the distance between positions of the microphone at which maximum volume occurs.

The main purpose of this short article is to encourage the use of a sinusoidal oscillator for more than one purpose, saving weight and cost; many oscillators on the market are very limited in power output, and are often designed for 600 $\Omega$  loads. The addition of an amplifier gives the option of feeding a small loudspeaker, and/or using a step-up transformer to provide a low-current higher-voltage supply for resistance measurement or other purposes. The risk of interference, often present with inverters using peaky waveforms, is also avoided.



# Letters to the Editor



## Viewdata by satellite?

I was most interested to read the satellite broadcasting reprint you included with your October 1981 issue.

There are many people who are surprised at the public apathy to Prestel, the viewdata system in use in this country. Despite the fact that adaptors are available for only £195.50, there appears to be little interest. One would have thought that stockbrokers would be ideal people to buy sets. I know of one who is delighted with his teletext, but won't have viewdata in his offices.

The reason is the high cost of telephone calls, and also the high cost of pages of Prestel data. The charges for telephone calls rise at the whim of a monopoly over which the customer has no control.

Broadcasting is cheap because it is one way, and relies on relatively few people to operate the system. Viewdata also need rely on few people, as all there basically has to be is a central computer for the database. The expense comes in from the cables that connect the subscribers to the computer, and the monopoly institutions that grow wealthy from them.

Therefore may I suggest that satellites could be an alternative to the viewdata and "public" telephone network? The system would operate at the shortest possible infra-red frequency to get through clouds. Each subscriber would have a specific frequency, which would not be allocated to another subscriber with the resolution angle of the satellite's antenna. Thus a subscriber would be known by his frequency, and latitude and longitude co-ordinates, and the satellite he uses. For a densely populated area, there could be several different satellites using the same channels. They wouldn't interfere with each other because of the directional nature of the beams.

I appreciate that people will find specific faults with this proposal, but generally I am sure that solutions can be found to get over difficulties. A cable system, glass or copper, is idiotic if very few can afford to use it. It seems a pity to waste the viewdata technology.

John de Rivas  
Truro  
Cornwall

## The Rank organization

A news item entitled "After the crash", which I understand was published in your August issue, has just been brought to my attention through a colleague in the Far East.

The first paragraph seems to imply that The Rank Organisation as a whole has collapsed in some way. This is definitely not the case.

The Rank Organisation is a substantial international group with some 30,000 employees worldwide and pre-tax profits in 1980 of over £111 million, including its share of profits from Rank Xerox. Although it has been closing down and disposing of loss-making parts

of the Group in the past two years, including the television manufacturing joint operation with the Toshiba Corporation, to which the article referred, it has also made a number of new and profitable acquisitions as part of its strategy for the future development and further increase in profitability of the Group as a whole. The company's turnover in 1980 without Rank Xerox's contribution amounted to some £597 million, on which The Rank Organisation itself achieved a trading profit of £37 million. (I enclose a copy of the Report and Accounts for that year, for your information). These are hardly the results of a company on the point of "Crashing"! In January we shall publish our results for the trading and financial year to October 31, 1981. While these will obviously reflect the effects of the worldwide recession, nevertheless, it can be anticipated that the Group's profits will again be substantial.

Clearly, the statement published in your August issue was very misleading, and has caused considerable confusion, particularly among our customers, and probably far beyond those who have read the article embarrassment and consternation among some of our staff.

R. H. A. Rycroft  
Press and P.R. Executive  
The Rank Organization

## The new electronics

I could easily picture myself as the interviewee in Mr Jaques article, (*Wireless World*, January, 1982 p.46). I completed a degree course of the type Mr Jaques so despises, a couple of years ago, and I have yet to regret it at all. Despite the Institution of Electrical Engineers deeming it suitable to qualify me for Associate Membership, and despite my having obtained an honours degree at first class, I would still have been hard pressed to answer all his questions off the top of my head, and what is more, my spelling and grammar are not exactly perfect either — other attributes I strongly suspect Mr Jaques might have marked me down for.

However, within seconds from where I now sit, I could reach down a text book and be confident of answering all his questions correctly. What is more, I could similarly answer questions on tensor analysis or quantum mechanics, apply Pontryagin's principle or design a Chebyshev filter, and use a thousand other topics my exciting 'New Electronics' course has put me in touch with.

If I were required to use operational amplifiers in a specific application I could quickly familiarize myself with the details of the subject, because I have already encountered it, and I know where to find accurate, detailed information. To prove the effectiveness of this method I would recommend a glance through a selection of final year reports from my former university, Exeter. (My project was one of the microprocessor rhubarb rhubarb . . . d/a converter. . . rhubarb rhubarb . . . operational amplifier variety.) Such an investigation may astonish at how quickly such an education

produces such a variety of expert specialists.

This is Information Technology year. Gone are the days of learning by rote — there is no point in learning by heart, when information is available at the touch of a button or turn of a page. It would be a tragic waste to educate experts in subjects that will be rendered worthless in a few years time. What price a valve expert today?

Interviewing twelve square pegs for a round-hole post was as much a waste of time for the candidate as it was for Mr Jaques. Surely the ideal job advertisement should attract the right number and quality of candidate. From my own experience I would venture to suggest two areas for attention: 1.) Provide better information to the applicants, stating exactly the sort of person the company is looking for, and what it makes, if that is relevant. Too many companies only supply glossy publicity for university careers departments. 2.) Ask more informative questions on the job application form so unsuitable candidates may be weeded out before wasting time and money attending interviews. With final year examinations to attend to, students can hardly be expected to become expert in products and company style in the many companies recruiting each year.

The answer to Mr Jaques' final question is the most revealing. Why did the candidate want "to do a couple of years design work and then move on to management"? Possibly because engineering has a reputation of being tedious, unrewarded and a dead-end job. I am now earning an excellent living as a designer of microprocessor systems, helping to keep my non-military company competitive for the future, and enjoying it too. What are my ambitions?

Not to spend years grinding away with a rapidly outdated education, as you would have me, Grandpa.  
William Graham  
Reading  
Berks

## Nuvistor

In response to Mr. K. J. Treeby's letter on the Nuvistor in November I have come up with something that may be of further interest.

Aircraft Radio Corporation of Boonton, New Jersey, USA made a v.h.f. transceiver which used 15-6CW4, and 2-7587 Nuvistors. It is model RT-515A and measures approx 140×65×35mm which is very compact. The unit uses a transistor inverter for the h.t. supply, which is contained within the transceiver and except for this the rest seems to be completely valve. This set would probably be not easily damaged by electro-magnetic pulses.

In the 1960's RCA produced tv receivers using a 6CW4 Nuvistor as an r.f. amplifier in the v.h.f. tuner. Also the Pioneer SX 82, which is a valve stereo receiver, uses a 6CW4 in the first r.f. stage in the f.m. tuner.

With the recent interest in valves is there a possibility that *Wireless World* will run a project using valves?

Peter Dix  
Chilliwack, B.C.  
Canada.

## Electrical and magnetic units

That D. A. Bell's equation  $\text{div } \mathbf{H} = 0$  cannot possibly be correct can be demonstrated by considering the  $\mathbf{H}$ -field of a permanent bar magnet, as I hinted in my letter. The distribution of the  $\mathbf{H}$ -field is determined by the  $B$ - $H$  loop and the boundary conditions on  $\mathbf{H}$ ; the diagram may be found in any good text. Now using the divergence theorem and integrating over the surface  $S$  which encloses a volume  $V$  we have  $\int \text{div } \mathbf{H} \, dV = \int \mathbf{H} \cdot d\mathbf{S} = 0$  and therefore  $\text{div } \mathbf{H} \neq 0$ .

W. James  
Physics Department  
University of Aston

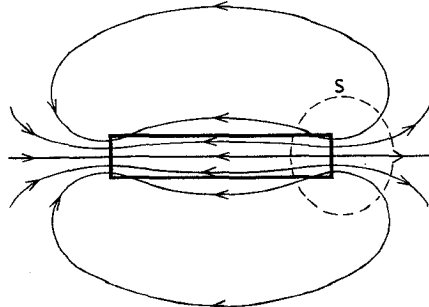


Fig.1

## Superstitions

With regard to Mr Yates letter (October, 1981, issue) on the ridiculous superstition known as 'spreading', I would like to draw attention to an equally ridiculous superstition known as 'intermodulation distortion'. This superstition, perpetrated by some malicious engineers, has it that if more than one frequency is applied at a time to an amplifier that is anything but linear, the amplifier will generate new frequencies of its own. Often these frequencies will lie outside the bandwidth of the applied signal! Apparently, the superstition draws no distinction between amplifiers in transmitters and receivers and is even applied to mixers and filters. Also, intermodulation distortion is said to be worse as the signal level to the offended stage is increased. (Hence another superstition known as 'overdriving'. This is obviously a superstition since it is impossible to overdrive a 'linear' amplifier.)

While not wishing to cast aspersions on the total linearity of amateur (or any other) transmitters, I would point out that if intermodulation distortion proved to be anything but a superstition, 'spreading' of transmissions could turn out to be a real problem and not just a superstition.

If the problem is at the receiver as suggested by Mr Yates, I think it unlikely to be due to the combined effects of selectivity and a.g.c. as stated. Firstly, it is usual to provide the main receiver selectively at intermediate frequency, i.e. after r.f. amplifier(s) (if any) and after a mixer. Virtually all tunable r.f. stages will be wider than 10kHz. The problem is more likely to be caused by intermodulation distortion in the r.f. stage or more likely (because the signals will be bigger) in the mixer. Now, if the signals causing the intermodulation distortion are at a frequency to which the receiver is not tuned, but, say, 10kHz away, it will pass through the r.f. stage and mixer but not through the i.f. stages. Therefore, the a.g.c. system of the receiver can have no effect on the distortion.

The best cure is a stronger r.f. stage and mixer, although an attenuator on the receiver input can help if the reduced sensitivity can be accepted. Of course, this will only help if the problem is in the receiver in the first place.

W. R. Barker, 5B4HY, G4JQ  
Limassol  
Cyprus

## Citizens' band

Your correspondent in the October issue missed the point. He is assuming that the blame for the effects of illegal c.b. lies with the c.b. operators. It doesn't. It lies partly with the arrogance and lethargy of civil servants who have neglected their duty to serve the people who pay them<sup>1</sup>; partly with an over-centralised system of government which reduces MPs to the status of elected rubber stamps, thereby allowing ignorant officials to hand down decisions from on high based on arbitrary whim instead of rational argument; and partly with the refusal of Parliament to give up its monopoly of power and grant a degree of direct democracy to the people, to whom it belongs by natural right.

(The solutions to these problems are clear, but a technical magazine is not the place to set them out.)

No-one is denying the seriousness of the effects of illegal c.b. which your correspondent mentioned, but we must get it absolutely straight where the blame lies. Readers may be interested in what Derek Robinson said on BBC radio a few months ago:

"I remember having considerable correspondence (at the time I ran a radio programme called 'Disgusted, Tunbridge Wells') with the Home Office, to ask them why they would not release more v.h.f. bands for use by the BBC; and we got absolutely nowhere. The Home Office simply would not reply; and the impression I got was that they rather resented the invention of radio and television and all these new-fangled ideas and were hoping that if they ignored them for long enough they would go away. I think they have very much the same attitude towards c.b. After all it did come from America so it can't possibly be any good to anybody in Whitehall. I have a strong feeling that the Home Office is not giving us what we want because we want it; and when they discover that we're determined to have it they suddenly discover that it's possible."<sup>2</sup>

We are always told that the civilised way to conduct affairs is by debate and not by violence or direct action, but what do you do if the government refuses to debate? If it won't even debate with the BBC what hope has the ordinary citizen got? If c.b. had been granted when it was first asked for none of the present problems would have arisen. The blame for the problems therefore lies with the officials who wrongly refused to grant c.b. when it was first asked for.

Readers may be surprised to learn that the riots which occurred a few months ago were partly caused by the same phenomenon which led to the c.b. situation, and that phenomenon is powerlessness. If the people have a legitimate demand of government, the government fails to do its duty to meet that demand, and people will take the law into their own hands; and the blame for the consequences rests with the government for failing to do its duty to serve the people. Consider what Raymond Williams said in 1961:

"If people cannot have official democracy they will have unofficial democracy, and any of its possible forms; from the armed revolt or riot, through the unofficial strike or restriction of labour, to the quietest but most alarming form; a general sullenness and withdrawal of interest."<sup>3</sup>

Parliament will not grant official democracy and so the people are taking unofficial democracy. Some are doing it by burning down vivisection laboratories; some by rioting; and others by the illegal use of c.b. This is what the Royal

Commission on the Constitution warned would happen if radical reform was not brought about: "The sense of powerlessness contributes to the growing alienation from our peaceful political process. The danger is that this will push us along the road to direct action, possibly violent action, when people and groups believe they have no other alternative to secure what they feel are their just demands."<sup>4</sup>

A few months ago on BBC radio, George Steedman gave an example of direct action: "C.b. has become just as much a symbol of young revolt as marijuana used to be. In an age when telecommunications are widespread how do British governments go on thinking year after year that you can deprive the young of the exciting ability to talk to each other across distances; at least till they've passed something like A-level physics. Successive Home Secretaries have tried to confine telecommunications to strictly licensed bodies so that thousands of operators at 27MHz a.m. are all criminals. When the recent legislation says that they can have c.b. but only if they scrap their existing sets and buy very expensive f.m. sets instead they just shrug that off as yet another attempt to make one law for the rich and another for the poor. Perhaps if the authorities were to stop prosecuting the c.b. people and start listening to what they have to say, things might be better."<sup>5</sup>

Finally, let us end with the words of a senior churchman, the Provost of Bradford. He was speaking about the tyranny which led to the recent riots, but his remarks also apply to the civil-service tyranny in respect of c.b.:

"If the youth of England were so wet that they sat down and did nothing, God help the future of England."<sup>6</sup>

S. Frost  
Edinburgh 2

## References

1. Read the story of neglect of duty and abuse of power by the civil service in "Your Disobedient Servant" by Leslie Chapman.
2. From a tape of "Any Questions", Radio 4, 10.7.81.
3. Culture and Society, p.316.
4. Vol. 2, para 78.
5. From a tape of "About Britain", 11.7.81, BBC World Service.
6. "World At One", Radio 4, 12.8.81.

## Virtues of valves

Bravo Pat Hawker for his "Dead as a triode?" item (World of Amateur Radio, June 1981). Having grown up with valves and "conventional" (i.e. old-fashioned) wiring, I had a sense of instant empathy with those whose feelings Mr Hawker so well summarised. For the kitchen table hobbyist as well as for those with a reasonable home electronic workshop, valves are, to quote my compatriot Mr Rechner, "incomparably superior". Valved equipment as a rule means more actual work in its construction than a solid state equivalent (my particular *bête noir* is the laying down of heater wiring) but is generally easier to get going, and going properly. Valves, possibly due to their tighter spread of characteristics, are often more predictable than transistors, and short of wiring the heaters to the mains or to a low impedance h.t. supply, are notably tolerant of abuse resulting from wiring errors or component failure.

In my own field of kitchen table activity — amateur audio, perhaps, rather than amateur radio — I have built hi-fi amplifiers and tuners and recorders in both technologies. Valve circuits are with rare exceptions a.c. coupled throughout, and the effect of any failure or mistake is usually confined, as far as fault finding is concerned, to the stage in which it occurs. Transistor circuits, by contrast, nowadays are predominantly direct coupled, often with direct coupled negative feedback. A fault condition in an early stage, whether due to failure or to error, and multiplied by the gains of



later stages, appears at the output as a frequently catastrophic and/or expensive aberration, the true source being masked by the effect of the d.c. negative feedback. And tracing "what goes to where" on an even moderately complex p.c.b. puts one in mind of the famous and classic Jacques Tati film sequence of M. Hulot vainly searching for the end of a convoluted garden hose in the midst of a monstrous cock-up of a fireworks display.

As far as performance goes, have we really gained by the transition to solid state? Does any current solid state amplifier actually *sound* any better, stereo apart, than the Immortal Three? The Williamson, the Leak Point One, the Mullard Five-Ten? The best amplifier I ever made, or heard, was a thing I built just on thirty years ago: EF86 driver, 6SN7GT floating paraphase phase splitter, a pair of the much-loved 2A3s in class AB1, and 24dB of feedback around an output transformer (the true heart of any good valve amplifier) modestly described by its makers as high fidelity but otherwise unremarkable. Ten watts output into 15 ohms; distortion at 10 watts unmeasurable on a Hewlett-Packard distortion analyser capable of resolving 0.01%; response at 1 watt flat, and I mean flat, from 15Hz to above 100kHz; damping factor, with triode output *plus* negative feedback, was as high as could be had with valves, and certainly sounded like it on transients. That amplifier driving a Goodmans Axiom Twelve in a vented enclosure was something to hear. Only the advent of stereo and the need to consider bulk forced me to abandon it in favour of something more compact and, I fear, a little inferior, if more cosmetic.

As a final word, the highly respected Luxman company of Japan, whose amplifiers are commonly thought of as second to none, have *valve* amplifiers on their very top line. A sure indication that valves are still alive and well when it comes to audio products of the highest quality.  
Douglas Bolton  
Mt Waverley  
Victoria, Australia

## Wien bridge oscillator

In the May 1981 issue J. L. Linsley Hood described a "new" design of Wien bridge oscillator with low harmonic distortion.

The same idea was published in 1953 by Louis W. Erath in *Electronics* with valve amplifiers. Two amplifiers variation of Wien bridge RC oscillator gives exceptional frequency stability and low harmonic distortion in an 1Hz-120kHz oscillator with 20V output, 0.1% t.h.d. in the range 20Hz-20kHz, 1% at 1Hz, with a 6W lamp as stabilizing device (0.2% at 1Hz with a 10W lamp and a longer stabilization time).

The Fig. 4 (formerly Fig. 5) outline in Linsley Hood's article is exactly the same as the Fig. 1 circuit of Erath's oscillator which more gives a proper output amplifier circuit, with differential inputs, cancelling the distortion of the oscillator amplifiers.

Nothing new under the sun?  
Camille Damian  
Paris  
France

### Reference

1 "Bridge stabilized ultrasonic oscillator" by Louis W. Erath, *Electronics*, Oct. 1953, p.174-175.

## Wafer-scale integration

I would like to congratulate Tim Thorpe (September Letters) on getting so much information and understanding out of presumably just the single July article.

I think the questions he raises and the ideas he puts forward are valuable, rather than obscurantist. I very much regret the positive feedback that has occurred in the past between contemporary computer architectures on the one hand and unscientific disciplines on the other, the latter trying to model their ideas on what I regard as the archaic Von Neumann machine in order to attract the glamour and prestige associated with science in general and computers in particular. The "Artificial Intelligence" community have helped along this decadent activity, and blocked the development of new machine architectures.

Since we have conceived two entirely different kinds of memory, the r.a.m. and the hologram, it is most likely that human memory will be of a third type not conceived by us.

Ivor Catt  
St Albans  
Herts

## DC power supplies

In the article "Simplified design of d.c. power supplies" in your August 1981 issue, the author claims that his method offers simplified formulae "which are easy to use and accurate enough for most purposes". Because my article "Single phase rectifier circuits with RC filters", published in *Electronic Components and Applications*, Vol. 1, pp. 153-165, 216-225, 1979, is also mentioned as one of the references, I would like to make some comments.

Strangely enough the last five pages (pages 226-230) of my article were not mentioned in the reference. These important five pages contain nomograms, based on previously derived equations of relative complexity which enable the designer, in only six very simple steps, to find out all values necessary for designing a d.c. power supply. All previously published methods, as far as I know, do not achieve the necessary precision for practical purposes, nor are of such simplicity.

The reader himself can try to compare both methods using, for instance, the first example proposed by Mr Richards. In trying to calculate the parameters according to Richard's method, one will find it impossible because the value of regulation  $r$ , needed to start calculations with equation (5), is not given in the text. Nevertheless we can conclude that the value  $Q = 0.473$  given in Mr Richards' article is obtained when  $r = 0.0661$ . This value the reader has to use to proceed with calculations, but I am afraid he will need a scientific calculator to cope with the "simplified formulae".

Using my method, instead of the regulation  $r$ , the total source resistance  $R_s$  is needed to start calculations. In order to enable the reader to compare both methods  $R_s$  can be determined from

$$R_s = \frac{r}{1+r} \cdot \frac{V_{OC}}{I_T} = 1.62\Omega$$

In those practical situations where a off-the-shelf transformer is used, the designer can calculate  $R_s = (R_1/n^2 + R_2)$ , as indicated at page 35 of Mr Richards' article, provided the diode rectifier forward resistance and the surge current limiting resistance are neglected.

The following table compares results obtained by both methods (mention is made only to values needed for design, disregarding irrelevant ones). Mr Richards' symbology is conserved.

In the course of calculations, using equation 6 of Mr Richards, one can find  $V_{DC} = 37.37V$  (not 39.2V as printed in the article), which differs from the starting value of 35Vd.c. I used the value of 37.37V to calculate parameters according to my method. Comparing the two sets of calculated values, one can see from the above table that for the most discrepant parameters like  $I_T$  and  $I_C$  Mr Richards in his article makes no mention of the corresponding measured values. Why? This fact does not allow us to judge how good is the accuracy of the proposed method for all important design parameters.

It is worth mentioning that my method was applied to several circuits and the very close agreement was always found between calculated values and measured results.

The reader can find my article in technical libraries or obtain it from the editor of EC&A, Mullard Ltd, Technical Publications Department, New Road, Mitcham, Surrey CR4 4XY, England.

A. Lieders  
Sao Paulo  
Brazil

### The author replies:

In the published version of my article a key statement was omitted from the first design example: a transformer rated at 30V, 1.6A with a nominal regulation of 9% was selected. Using these figures Mr Leiders will find that my theory gives the values quoted in the paper. I reproduce them here, with the experimental values given in brackets.

$$\text{At } I_{DC}=0A, V_{DC}=46.2V (45.8V)$$

$$\text{At } I_{DC}=0.6A; \theta=0.473;$$

$$V_{DC}=39.2V (38.4V); I_T=1.2A (1.1A);$$

$$I_P=3.0A (2.5A); I_C=1A (0.9A);$$

$$V_{rip}=1.9V (1.8V).$$

The experimental values for  $I_T$ ,  $I_C$  and  $I_P$  were omitted from the published article, but not because the theory got them wrong.

Both Mr Leiders and I follow A. F. Standing (*Electronic Engineering*, 27, pp. 532-35, 1955) in assuming that the ripple voltage has a triangular waveform. With this assumption, and using a

	Values found by Mr Richards' method	Values found using our method	Values measured by Mr Richards
Starting conditions ( $I_{DC}=0.6A$ ) $V_{DC}(V)$	37.73	37.73	38.4
$I_T(A)$	1.2	0.86	missing
$I_P(A)$	3.0	3.06	missing
$V_{rip}(V)$	1.91	1.92	1.8
$V_{OC}(V)$	31.56	32.47	missing
$I_C(A)$	1.04	0.62	missing

simple piecewise linear model for the rectifier, the calculation of performance is straightforward if somewhat tedious. The time and effort needed can be greatly reduced if Mr Leiders' nomograms are to hand. Alternatively, with a loss in accuracy which is usually acceptable, the very simple design formulae given in my paper can be evaluated with a slide rule or pocket calculator in a few minutes.

In our published work, both Mr Leiders and I use very simple models of components which ignore such factors as leakage inductance in the transformer, series loss in the capacitor, and any differences between the two halves of a centre tapped winding. It is also true that the large tolerances associated with most power supply components are likely to generate much bigger departures from the designed mean performance than imperfections in the theory.

The person who designs an occasional power supply can take his choice from the published methods, or devise his own. Anyone who has to design tightly specified supplies at all frequently will no doubt find it worthwhile to write a suitable computer program to deal with the routine calculations.

J. C. S. Richards

## Dangers of low $\alpha$ .f. sound

Mr Frost must be careful. He tells us that infrasound can cause unpleasant side-effects under some conditions and cites Dr Lyall Watson as his sole reference. If he had chosen to read the original accounts, instead of a somewhat compressed (and decidedly sensationalist) one, he would have found that the sound power levels associated with such 'side-effects' tend to be of the order of kilowatts. It is also worth mentioning that, so far, the only means of generating high power infrasound is by wiring compressed air-driven sirens.

M. Barrett  
Hove  
East Sussex

## Radio amateurs' licence

I was interested to read a letter in your October issue from M. Jackson and several hundred others concerning the radio amateurs' licence. While I do not agree with all the suggestions made in that letter, nevertheless I do feel that changes in the regulations are very desirable.

As a teacher of the RAE syllabus, I have had opportunity to present the licensing requirements to my students and note their disappointment. The rules are quite restrictive. By sticking to the letter of the law an amateur can do little more than discuss the weather and his radio equipment, the former being uninteresting by definition and the latter consisting usually of an exchange of model numbers. The licence is even restrictive in a technical sense by, for example, forbidding the use of ASCII.

The field of radio has progressed and amateurs do not make the contribution they once used to, unless they happen to be professionals by day. If this is so, then the change in emphasis from 'technical' to 'social' should be reflected in the legislation. The popularity of synthesised v.h.f. equipment attests to the idea that a lot of people just want to talk to each other. The amateur service, as

well as c.b., could go a long way towards fulfilling this need. C.b. users need to evolve some recognised operating procedure in order to allow coherent discourse; radio amateurs already have this etiquette but they have a problem in that they cannot do or say very much without breaking the law. Amateurs are very conscious of this. In few other walks of life do you have to learn a legal document by heart.

For this reason conversation among amateurs is very limited. I know a number of professionals in the field of electronics who will not become amateurs simply because they feel that amateurs are masters of the art of saying very little at great length. Unfortunately amateurs become like this if they wish to go on the air and stay legal. They do tedious things such as switching off the microphone if a member of the family comes into the room and starts to talk. By changing the licence the Home Office could go a long way towards improving things and still have no qualms about national security or whatever it is that amateurs might threaten.

The following are some suggestions for changes in the Class A licence:

1. The amateur should be licensed to transmit commonly used data codes, especially ASCII, and this means exchange computer programs and information. Surely many people must want this, or are they content with the inherent futility of performing ASCII-Baudot conversations?

Some more parallel forms of data transmission should be permitted, such as a system based on the Bell multitone telephone dialler. Amateurs could use this to call each other up efficiently by having receivers which unmute on receipt of their callsign in suitably encoded form.

2. An ambiguity exists in clause 9(2) of the licence, such that amateurs do not know if they should give their callsigns on every over, or just every 15 minutes. The clause should be altered by deleting 'sending' and inserting 'operation' in line 3.

3. I cannot see any reason why amateurs should be automatically given the right to use c.b., excepting that it should be the right of every citizen. It would, however, be sensible from an administrative point of view.

Since amateurs are deemed competent to operate non type-approved equipment on the amateur bands, they should be deemed so competent on the citizens' bands. By this means, they may contribute technically to this new area.

4. So long as it is the licensee who adjusts the transmitter controls, family and friends should be allowed to use the microphone. This would help to dilute the sexist nature of some amateur conversation and would encourage more women to take an interest in the hobby. It would also alleviate marital tension in some cases.

5. I understand that in the USA personal messages on behalf of third parties are permitted and amateurs are allowed to relay messages via telephone lines. Since it will soon be legal to connect personally owned equipment to the land line in this country, it should be made possible for amateurs to relay messages by means of a type-approved interface. This would create a market-place for a new durable.

6. When transmitting A5 high definition tv, amateurs should be allowed to give station identification by means of 6MHz intercarrier f.m. sound.

Since 70cm is close to band IV and can be reached with a slightly modified domestic tv set, I feel that tv should be given priority on this band.

7. Any attempt to channelise the 10m (28-29.7MHz) band or use it for mundane purposes such as mobile repeaters should be resisted.

Adequate services exist elsewhere. This band is

of genuine scientific interest, especially in times of sunspot activity, and might be used for wideband experiments from time to time.

With these modifications, the amateur licence could become the key to a wide range of social, scientific and technical activities. I hope that my suggestions will appeal to others and that people will support me in whichever of these issues they consider to be important.

D. W. Knight, G3YNH  
Bristol  
Avon

## Early radio valve

I have in my possession an early radio valve that I believe is at least 60 years old. I enclose a photograph. It consists of a cylindrical tube with (tungsten?) filament supported axially, its connections being at each end. The grid and anode are both cylindrical and their connections are short and brought out to side contacts. The whole is supported on a mahogany base with bronze spring clips.

I have been led to believe, by whom I do not recall, that it is a Marconi short wave receiving valve type VS24, but this information may be completely false. Incidentally, the filament voltage appears to be about 6 volts and I have in fact (many years ago) used the valve with success as a triode dynatron oscillator.

I would be most grateful if any of your readers could help me to identify this valve.

G. A. Hay  
Department of Medical Physics  
The General Infirmary  
Leeds LS1 3EX  
Yorkshire

## Simple superhet

Lest some of your readers be tempted to hunt for the fortune awaiting the inventor of a simple means for producing super-heterodyne radio reception (see C. B. V. Francksen's letter in the July 1981 issue), let them be informed that the principle is already used in Doppler radar and laser Doppler velocity measurements.

J. J. Bleeker  
CERN  
Geneva  
Switzerland

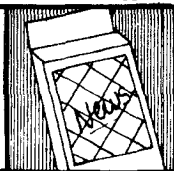
## Nanocomp e.p.r.o.m. programmer

Our attention has been drawn to an article in the January 1982 issue of *Wireless World*, entitled "Nanocomp e.p.r.o.m. programmer." in which reference is made to a u.v. lamp supplied by RS Components Limited. We would like to emphasize the hazard arising from the short-wave radiation emitted by such a lamp, and would suggest that it is important that an interlocking safety switch is included, to prevent accidental exposure of an operator to this radiation. This would be especially important in the suggested arrangement, which does not provide for any positive external indication of whether the lamp is running.

We would also advise that, to avoid damage to the lamp, the wattage rating of the "fluorescent light choke" should be specified, for example 8 watts.

Dr. T. R. Passmore,  
Technical Manager,  
RS Components Ltd.

# News of the Month



## The BBC and the micro

On the same day, Monday, 11th January, the BBC broadcast the first of *The Computer Programme* and officially launched the BBC Microcomputer. On the surface there seems to be little connection between them. The programme is a general introduction to computers; what they do, how they work with some projections as to what they may be able to do in the future. It is not specifically about programming or using the BBC computer. The computer will be used to illustrate certain points but will not be given any particular prominence.

The connection between the two goes back to the original conception of the programme which was intended to extend and fill in the gaps left in the programme *The Silicon Factor*, first broadcast in 1979, which had aroused much public interest. The BBC planned to launch a Computer Literacy Project, which would include a microprocessor to accompany the programmes. The computer originally selected was the Newbury NewBrain but this ran into production difficulties and it was announced in April 1981 that Acorn were to manufacture one based on their Proton model which was under development. Meanwhile, it was decided that computer programming would not be featured prominently in the tv programmes. So the computer has been produced as part of the Computer Literacy Project but not directly connected with any BBC programmes on tv or radio. Details of the computer can be found elsewhere in this issue.

### The tv programme

*The Computer Programme* is a series of ten 25-minute programmes which assume the viewer has no prior knowledge. They introduce the world of computing in, to judge by the first programme, a relaxed and informative way. Chris Serle and Ian McNaught Davis are the presenters. Gill Nevill is a 'roving reporter' and there are contributions from Rex Malik.

Each programme follows a particular theme after the first, which is a general introduction. Chris Serle acts as a novice being introduced to computing and the series offer a practical introduction to computing. Some of the themes in the order that they are presented are; the stored program; computer languages and the way we communicate with computers; information storage and data bases; communications and the linking together of computers; the sixth programme looks at some of the things that computers can do apart from numbers and words, these include graphics, sound synthesis and the ability of computers to interpret speech and to talk themselves. The following programmes will deal with modelling and simulation; artificial intelligence; computer control. The final programme looks at some of the social implications

of the technology, with particular reference to the banking and agricultural industries.

*The Computer Programme* started broadcasting to schools and colleges from the 11th January. There is to be a Sunday afternoon repeat commencing on the 14th February and a late-night Monday repeat starting on March 22nd. There are likely to be more repeats later in the year and a further series of ten programmes for the micro user is planned. A radio series, 'Learning about the Chip', which examines the challenge posed to the teaching professions by microtechnology, is to be re-broadcast on Radio 4 v.h.f. from March 16th at 11 pm.

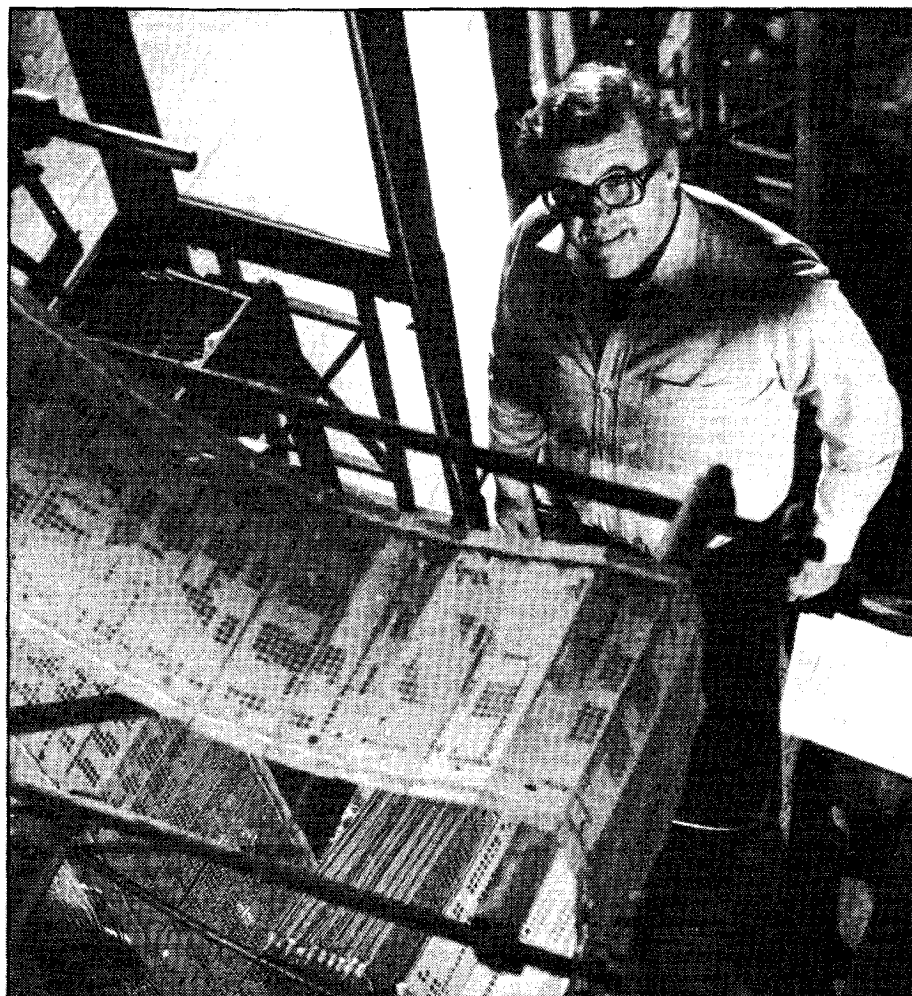
### The book

*The Computer Book* has been published by the BBC as a companion volume to the programmes. It is not the 'book of the film' but offers parallel information on similar topics. There is a chapter on the history of computing and others on problem solving, hardware and software, understanding programming; Chapter 5 gives examples of the uses of a personal

microcomputer and how they can be extended by the addition of peripheral equipment such as printers, extended memories, teletext receivers and so on. The final chapter takes a look at the future and concentrates on some of the things that a computer cannot (yet) do. It points out for example that something like 31 million bytes of information are needed for the human brain to recognise a face and a further enormous memory capacity to distinguish between faces.

### Software

The purchaser of a BBC micro is provided with a *User Guide* which explains how the computer is operated. It includes a very useful section on the Basic keywords with a page devoted to each of the keywords; how it is used, with programming examples. It does not teach to user how to program the computer and for this it would be necessary to follow a course in computing like the National Extension College *30-Hour Basic*. The user will also get a *Welcome* package including a cassette tape of several programs which demonstrate some of the functions of the computer.



Ian McNaught-Davis, one of the presenters of *The Computer Programme*, with the punched cards on a Jacquard loom, an early example of a stored program.

From May 1982, the BBC will have an initial inventory of program packages. These will include one directly connected with the *The Computer Programme*, designed to illustrate and reinforce ideas presented in the tv programmes. A home finance package has been commissioned from the Consumers' Association. Other packages include starter programmes for computer aided design, a music package, games, a home data base package and various programmes to develop skills in primary school maths and English, and in pattern matching. Later in the year a range of more substantial programs will become available, including programs for teachers and students, programs for business purposes, practical home programs, games and programs for hobbyists.

All the programs will be available on cassettes and/or discs and some will be available through telesoftware; a special adapter is being developed so that Ceefax can be displayed through the computer and programs listed on Ceefax can be loaded direct into the computer. A similar adapter is being developed by the Council for Education Technology for use with Prestel. Some of the software is being specially written, and some is being adapted from existing programs. Details of software will be announced as they become available.

### The course

The National Extension College in Cambridge has produced *30-Hour Basic* as part of the BBC computer project. This self-instructional programming course offers a step-by-step guide to learning the Basic computer language and to using Basic to program the computer. The course is contained in one book, accompanied by two cassettes. The cassettes are suitable for use only with the BBC microcomputer, but for the book there are adaptation sheets which show how to adapt the programmes to suit each make of computer. There is a separate edition of the book for the Sinclair ZX81 microcomputer.

### The Computer Referral Service

Any microcomputer is enhanced by the formation of a support group. Such a group has been organised by the Broadcasting Support Services, an independent charity, who provide a link between viewers of the tv programmes and over 1,000 sources of help and advice. The sources include colleges and computer clubs who are running classes and workshops in support of the BBC Project; national and local



The BBC computer.

organisations offering advice to small businesses or other specialist groups; organisations offering careers advice in computing; and specialist agencies offering help and advice on microcomputer aids for disabled people.

Some useful addresses: *The Computer Book* is available from bookshops or direct from BBC Publications or direct from BBC Publications, 35 Marylebone High Street, London W1M 4AA, price £6.75. Details of the 30-Hour Basic Course can be obtained from The National Extension College, 18 Brooklands Avenue, Cambridge CB2 2HN. The BBC Microcomputer is being marketed by B. L. Marketing, Aspen House, 14 Station Road, Kettering, Northants. They have all the details of the availability of the computer and will send details to enquirers who telephone them on Kettering 520 474. They have told us that there is a six-month back-log of orders caused by a high drop-out rate in a gate array integrated circuit from Plessey; there is a great number of computers ready to have just one chip fitted, and when this is done the waiting time should reduce rapidly. The Computer Referral Service may be contacted only by post at PO Box 7, London W3 6XJ.

## World Communications Year — 1983

The General Assembly of the United Nations has proclaimed that 1983 is to be World Communications Year and is to concentrate on the "development of communications infrastructures". The International Telecommunication Union has been appointed as the agency for the promotion and celebration of WCY 83.

WCY efforts will concentrate on national communications infrastructures and UN member states will set up national co-ordination committees. They will represent all the sectors concerned with the development and operation of communications systems; common-carrier telecommunications, broadcasting, aviation, shipping, transport, meteorology, education, agriculture, health, postal services and industry.

The proclamation of WCY 83 concludes four years of negotiations between governments after it was suggested that such a year be celebrated to use the achievements in communications technology to promote the harmonious development of mankind.

## Sinclair tie-up with ICL

At many branches of W. H. Smith they are now selling the Sinclair ZX81 microcomputer. They are also selling software packages for the computer produced by ICL. These include a course in Basic with an audio cassette and six cassettes of programs which may be loaded directly into the computer. More software to support the ZX81, and any future products using Sinclair's version of Basic, is to be developed. In return Sinclair are developing a 'One per Desk IT Work Station'; an ultra-low-cost integrated terminal and digital telephone workstation to be a peripheral to ICL's DNX 2000 digital PABX. It is scheduled to include Clive Sinclair's flat tv tube and employ Sinclair Basic. The ZX81 has attracted sales of over 250,000 and is now sold in Japan by Mitsui.

IT is a new acronym and does not represent what The 'It' Girl had, but Information Technology!

## UK backs L-Sat

The European Space Agency's L-Sat programme is to develop a large telecommunications satellite. The Department of Industry has announced that the UK is to take a one-third share in the £250M programme. British Aerospace is to construct the satellite as the prime contractors, with Marconi Space and Defence Systems manufacturing a business communications payload.

L-Sat will be of a modular design and carry a wide range of payloads including tv broadcasting and digital communications at a much higher frequency than those used at present. It is thought that it will play an important part in the spread of information technology by providing international links for integrated electronic offices.

The first L-Sat will weigh about 2,300kg and is to be launched on Ariane in 1986. It is planned to carry an array of solar cells that could develop over 3,500W, which is three times the power of current communications satellites. Future L-Sats would be even more powerful and British Aerospace are talking about 7kW. They envisage a market of at least 120 large satellites.

A similar combination of British Aerospace and Marconi were responsible for the Maritime Communications Satellite (MARECS) which was successfully launched on December 20th 1981. MARECS-A is in geosynchronous orbit over the equator and above the middle of the Atlantic. MARECS-B is due to be launched in April over the Pacific Ocean. Both are to be leased to INMARSAT, the International Marine Satellite Organisation to which 40 nations belong.



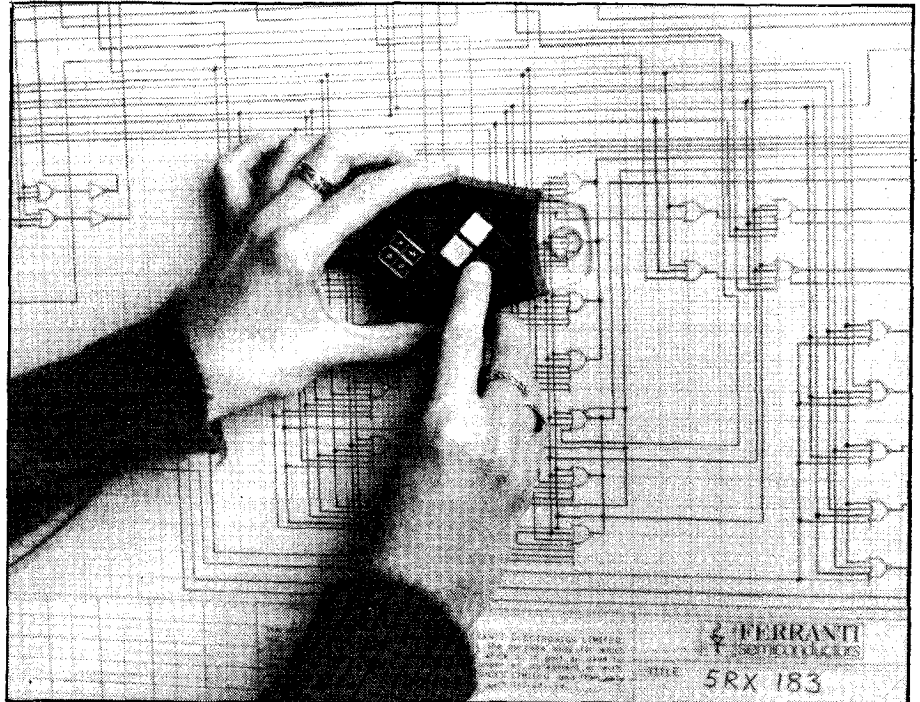
# Do-it-yourself integrated circuits (part 2)

Last December we reported on the 'design pack' offered by Marconi Electronic Devices, a system for engineers to design their own integrated circuits based on their gate arrays. Now Ferranti have come up with a system which they call the 'ULA Designer' which they describe as 'a powerful, easy to use, low cost interactive design system which provides the customer with all the computer aided design (CAD) facilities necessary to specify, design and verify ULA LSI and VLSI circuits'.

The customer uses a remote terminal which may be linked by voice-grade telephone lines to the Ferranti ULA host computer in Manchester, or in Scotts Valley, California. There is no need for expertise in computer systems or semiconductor technology.

This is claimed to be the world's first remote CAD system produced for this purpose. It has been produced in response to the desire of customers to design their own integrated circuits.

The ULA Designer terminal consists of a mini-computer, a graphics display and keyboard, a digitizing tablet, a control console and a check plotter, all of which can be accommodated in an area of 10 square metres. The computer uses the RSX-11M operation system, based around a number of specific tasks which are controlled by indirect command files, making the computer operation invisible to the user. The software package contains ULA libraries, guides to layout, logic description, test specification and communication utilities. The package is being continually added to with new ULA designs, which at the moment amounts to about 50 types.



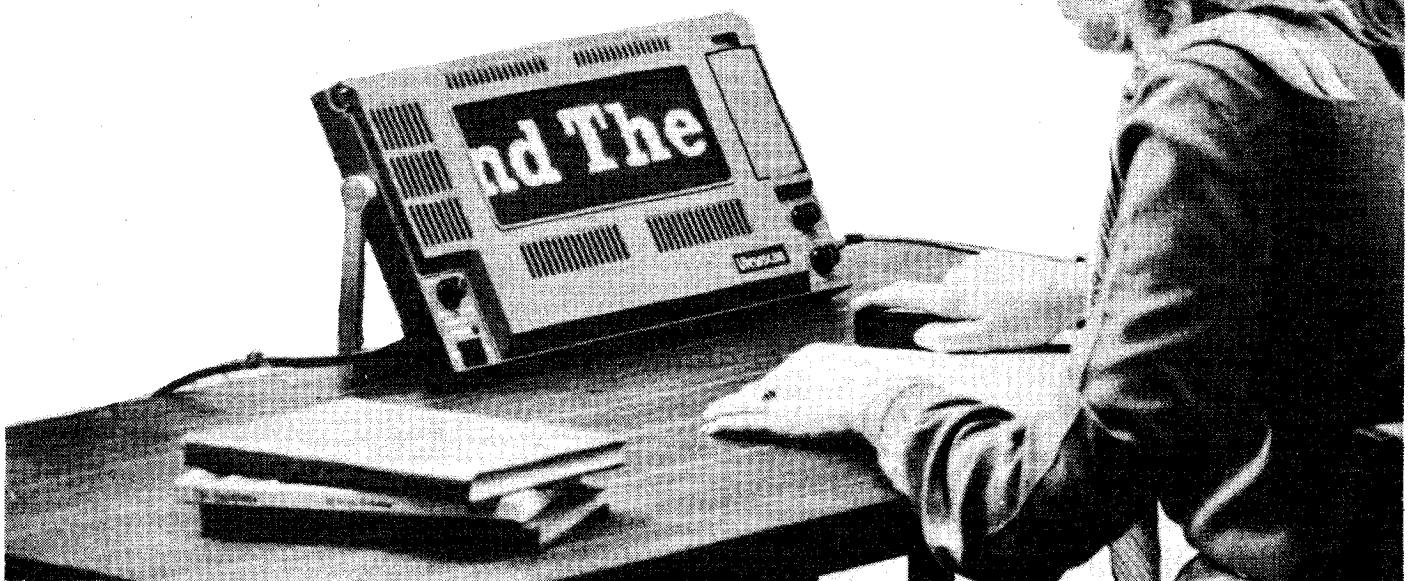
A logic design is entered into the computer using the digitizing tablet, a logic syntax test is carried out and the customer's engineer carries out the layout design check on the interactive graphics display.

The design is then tested on the host computer which can produce a logic simulation, layout checks and generate a test program. The customer's engineer remains in control and when the design is complete, the user can transmit an instruction to proceed with the mask and prototype device manufacture.

*A digitiser tablet is being used to enter a logic circuit diagram into the Ferranti ULA Designer CAD system.*

*Viewscan is an electronic system for enlarging written or printed text onto a video screen as an aid for the partially sighted. The text is illuminated by a 1/2W miniature bulb and the solid state camera transmits the signal to a photodiode array to two high-speed microprocessors. A buffer memory reassembles the information into moving lines of print. The display screen is a flat neon matrix panel with an orange colour which*

*has been found to give maximum visibility and clarity. It can be switched easily from a positive to a negative image and the magnification is controlled electronically between X4 and X64. The system is powered from internal rechargeable cells and so can be portable. Viewscan was developed in New Zealand by Wormold International who specialise in aids for the disabled.*







The chips shown here represent the heart of a modern all-electronic telephone exchange, and each chip can handle over a thousand telephone connections. They contain about 40,000 components and their dimensions are 5x7mm. Each chip contains a switching matrix, its own clock unit and the control logic. However, most of the chip area is taken up by a shift-register memory that stores the destinations of the telephone calls. The calls to be switched are converted from analog to digital by separate input circuits and then stacked in time multiplex before being directed to the correct output circuits by the chips shown here. The chips are displayed on a single column of the Eindhoven telephone directory at the entry for their manufacturer, Philips.

The ULA Designer costs about £37,500 exclusive of the plotter, which is an optional extra. It may be purchased or leased and Ferranti claim that the low cost will reach a break-even point after the design of five ULAs of average complexity. Ferranti are providing a training course to provide familiarisation with all aspects of the design system.

## British hi-fi news

Several items of news came to us at about the same time, all relating to famous British names in hi-fi. Neal/Ferrograph, manufacturers of tape recorders, both open reel and cassette, have been through a bad patch but are surviving. Alan Helliwell and Duncan Mitchell, two of the founders of Neal, have formed a new company, Lee James Electronics Ltd. They will continue to manufacture Neal cassette recorders and are developing new models expected to be introduced this year. Ferrograph tape recorders are to be manufactured by Spencer and Co. Ltd, but another company, Ferrograph Spares and Service will manufacture and supply spare parts for all Ferrograph products. This company, staffed by ex-Neal/Ferrograph employees can service or re-furbish Ferrograph products. Ferrograph test instruments will be manufactured by Park Naval Engineering Ltd in Blackburn, Lancs. All these activities are to be united with one sales and service centre, Audio Visual Marketing Ltd, who have been appointed sole and exclusive distributors for all Neal/Ferrograph

products. All this seems a bit complicated but at least the equipment will still be available to a number of devotees and future marketing could make converts.

Decca Special Products, now part of the Racal empire, are alive and well but no longer living at Ingate Place, behind the railway lines in Battersea; having moved their sales and marketing operations to Whyteleafe in Surrey and their service department to Bridgnorth, Shropshire. We haven't heard much from Decca recently, but this is because they have been busy selling abroad. The situation is to change this year when they are planning to market Decca record care accessories and a range of hi-fi products which have been hitherto available only overseas.

Jim Rogers is known for having designed some very good loudspeakers. He has not been so successful in some of his business ventures, however. There was the sale of Rogers Hi-Fi to Swisstone. A new company, J. R. Loudspeakers was formed and have achieved some success with the cylindrical JR149 compact loudspeaker. This has recently been up-dated to a mark II version and has been very well received by the hi-fi press. J. R. Loudspeakers is to have a major restructuring with changes in the top management. Jim Rogers will continue to head the research and development team.

Another loudspeaker company who went through a sticky patch, Tannoy, seem now to be well on the way to recovery and have announced they are buying themselves back from the American Beatrice Foods Co.

Let us hope for more good news in this area where some of these famous names have led the world; they can do so again, if they can give customers the right goods at the right prices.

## Cassette tape position coding

Today's better cassette recorders have attained a performance level that rivals many reel-to-reel machines with significantly higher tape speeds. In addition to their pursuit of further performance improvements, which tend to be ever more difficult to achieve, most manufacturers are also concentrating on improving the operating system. Several systems are offered which allow for winding the cassette to a specified tape position, for scanning the tape and playing the first few seconds of each recording, or even for playing recorded sections in a particular order.

In practice these systems are far from perfect:

- Tape counters, since they are usually not coupled to the capstan, move fast at the beginning and tend to become slower towards the end of the tape. Moreover, they are not very accurate and are usually incompatible among different machines.
- The automatic search for individual sections, as on microprocessor controlled recorders, is rather cumbersome and not very reliable. It requires silence periods of about 5 seconds; very inconvenient for most users. Even so, problems with pianissimo sequences on classical recordings are common.
- All systems use the beginning of the tape as their reference position (reset counter to zero, start of first section, etc). Therefore, using the programming features means rewinding the cassette.

Gretag Ltd. has come up with a new idea and filed a patent application that overcomes these disadvantages: Take a cassette which is wound to any position, insert it in the machine, key in the desired position code or codes, and the cassette will wind itself in the correct direction and in the shortest possible time to the location. Not only that; but, as soon as the tape starts to wind or play the tape counter will immediately display its correct position which is, of course, directly related to the remaining tape time.

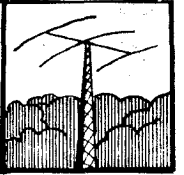
Gretag achieves this by printing an optically readable code on the back of the tape which supplies the required information during all tape movements automatically and with split second accuracy.

There would be no problem with compatibility if cassette manufacturers agree on the same code. The cassette housing remains unchanged. Code reading is accomplished via a sensor which automatically moves into a cassette opening; if it finds no code the tape counter is controlled via conventional means.

The sensor uses optical fibres and straight-forward detectors; it should be relatively cheap in mass production. Coded cassettes will sell at a slight premium, but the technology is available: The system uses a bar code similar to the one used on groceries sold in supermarkets.

There are advantages for both consumers and professional applications. With absolute repeatability on different machines and time resolution in fractions of a second, broadcasters could assemble, edit, and control their programs with ease and accuracy. Prerecorded cassettes provide appropriate positioning information for each section, so that you can find your favourite tune even easier than on an LP. Or use the coded information for accurate tape speed control. There are many applications.

# World of Amateur Radio



## 10.1 MHz in full swing

Came January 1, and 10.100 to 10.150 MHz was soon filled with c.w./r.t.t.y stations intent on exploring the characteristics of this welcome addition to amateur h.f. allocations. Many operators appeared to be using recent Japanese and American transceivers that incorporate the 10, 18 and 24 MHz bands. Others were using easily modified models such as the popular Yaesu FT101-series or some of the Drake models. Older equipments such as the Heathkit HW101 require rather more modification but can be successfully modified for the new bands, as T.C. Bryant, GW3SB has discovered. A few of us ventured on to the band using old home-built transmitters of the classic frequency-multiplication pattern (mine even had an old 807 power amplifier with a v.f.o. intended to work around 1750 kHz shifted to around 1680 kHz and a doubler-stage used as a tripler.

As expected, the 10.1 MHz band, though only 50 kHz wide, is proving an excellent all-round frequency with semi-local, medium-distance and long-distance propagation; of particular appeal is the excellent "long path" propagation to Australia and New Zealand in the mornings.

Less happily it looks as though 10.1 MHz will provide a searching test of the effectiveness of the "voluntary" band planning as practised over many years in Europe. The influx of stations included a small but vocal number of British s.s.b. stations proclaiming that their licence permitted them to use the new band and they intended to do so. The reason why IARU Region 1, RSGB, ARRL etc. have all recommended telegraphy (c.w. and r.t.t.y.) only is that with a band only 50 kHz wide there would be room for very few effective two-way 'phone contacts (about 15 channels) whereas several hundred c.w. operators can work simultaneously with relative ease. Even those of us who believe strongly that wherever possible it should be a case of letting everyone follow their own taste, may begin to wonder (if s.s.b. continues to be used on 10.15 MHz except in emergencies) whether some degree of band planning needs to be written into the British licence. National societies are also endeavouring to keep the band free of the "contests" that so regularly take-over the traditional h.f. bands at weekends.

## North Sea microwaves

Although the 10 GHz (3 cm) amateur microwave band has attracted a good deal of attention throughout Europe in recent years, there has been a tendency to ignore the 3.4 to 3.475 GHz (9 cm) and 5.65 to 5.85 GHz (6 cm) bands. Now however UK enthusiasts along the East Coast are

finding a growing interest in these bands among Dutch amateurs, with more opportunity to exploit the super-refraction conditions that exist very frequently across the North Sea.

About a dozen Dutch amateurs are now on 3.4 GHz (although restricted to the segment 3456 to 3458 MHz) and some are expected active soon on 6 cm. Last year, John Tye, G4BYV near Dereham, Norfolk worked PAoHJS on 9 cm over a 384-km path using a 0.5 watt cw transmitter with 4ft dish aerial. His receiver uses an HP 2656 interdigital diode mixer (no r.f. stage).

The Dutch amateurs tend to use travelling wave tubes with up to 10 watts output on 9 cm and 6 cm and some use s.s.b. On 10 GHz, Dutch narrow-band equipment with up to 20 watts output is increasing with contacts being made, from home locations, of over 100km. During one of the 1981 microwave contests, the East Coast amateur G3LQR worked six Dutch amateurs on 9 cm.

## UOSAT — OSCAR 9

During the six weeks following the successful launch on October 6, 1981 of the British-built UOSAT — OSCAR 9 amateur radio satellite most of the onboard systems were activated, checked and found to be working well, including the various telemetry modes; telecommand and computer up-links; power system; 145.825 MHz general data beacon; navigation magnetometer; primary spacecraft computer (RCA 1802); secondary spacecraft computer (Ferranti F100L) particle radiation detectors; primary magnetometer experiment; v.d.u. test pattern; speech synthesizer (under control of primary computer). On October 21 the particle radiation experiment successfully detected a major electromagnetic storm. The four solar panels provide a total average electrical power of about 17 watts.

## "Uncle Vic"

The recent death of "Two Uncle Vic" — Bill Corsham of Wembley, North London — severs a radio link that stretches right back to before World War 1. As a schoolboy his interest in radio-telegraphy was aroused by the sensational arrest of Dr Crippen by the use of marine radio.

After serving in the Royal Engineers, Bill Corsham obtained his licence in 1920 — a year in which he listened to the original Marconi Chelmsford "telephony tests" and the early music concerts from The Hague. The following year he participated (and won a prize) in the successful *Wireless World* Transatlantic Tests.

Without mains electricity, he at first relied on dry batteries for telephony trans-

missions and for telegraphy evolved, as he described it, "a fearful transmitter employing a tonic train system with a ¼-inch sparch coil fed from a 6-volt accumulator the output of which (without smoothing) was fed into the plate circuit of the transmitting valve with the note controlled by adjusting the contact breaker with a piece of elastic and a match stick." However this transmitter, with well below 10 watts input, was heard all over Europe and most of America, achieving a 4000-mile contact early in 1924.

"Uncle Vic", a life radio enthusiast, always played an active role in various societies, from his days as Traffic Manager of the old Transmitter and Relay Section in the 1920s to his recent work, after his retirement from the Post Office, for the Old Timers' association and his regular attendance and participation in the annual general meetings of the R.S.G.B.

## In brief

French amateurs have so-far been refused permission to use the AMTOR system of r.t.t.y on h.f. bands but this mode is now being used by amateur stations in South Africa, Ghana and Japan and 14075 kHz is becoming established as an AMTOR calling channel . . . . The R.S.G.B. announced late in December that Jack Anthony, G3KQF, who was due to be installed as the 1982 president on January 9, was unable to become president for reasons of ill health . . . . Eric Godsmark, G5CO, who for many years was involved with the administration of the amateur radio service by the Home Office/Post Office has been appointed to the post of I.A.R.U. Region 1 secretary, left vacant by the death of Roy Stevens, G2BVN . . . . The British Amateur Radio Teleprinter Group is this year to hold a rally rather than the usual convention (Sandown Park Racecourse, near London, August 29, 1982). Monday evenings are being designated 144 MHz r.t.t.y activity periods . . . . Jeff Harris, G3LWM has expressed disappointment that only 55 amateurs have joined the "10-UK" group which is seeking to encourage greater utilisation of the 28 MHz amateur band during all phases of the sunspot cycle, particularly by more use of narrow-band frequency modulation. In recent months long-distance contacts have been readily achieved with this mode . . . . British amateurs have noted with regret the rescinding of Polish amateur licences since last December and the increased jamming of h.f. broadcasting stations . . . . Pontefract & District Amateur Radio Society are holding a "Components Fair" aimed at the home constructor at Carleton Community Centre, Pontefract on Sunday, March 14 from 11 a.m.

PAT HAWKER, G3VA

# Cost-effective electronic ignition

*Well-proven design offers payback in less than a year*

by Rod Cooper

**There is not much point in fitting a high-cost high-performance ignition system to a low-performance four-cylinder car restricted to 6000 rev/min. Neither is there much point in fitting a cheap transistor switching unit which has the drawbacks of electronic ignition but few of the advantages. But there is a good economic case for fitting an inexpensive capacitor-discharge unit which uses the existing contact-breaker via an electronic filter – it can pay for itself in a year and provide a host of other benefits.**

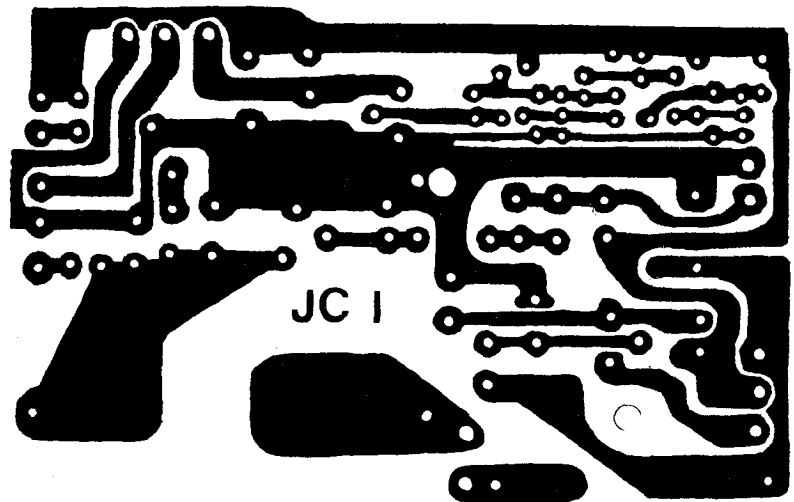
If your average year of motoring consists of 10,000 miles in a car that does 30 miles/gal then it is only necessary to increase this to 31 miles/gal at today's fuel prices to cover the cost of making this unit in just one year. In practice this modest increase is likely to be exceeded by a capacitor discharge system (how this is achieved is explained later). This alone was a sufficiently strong economic case but there are other money-saving facets to this type of system which are not immediately apparent. For example, battery life is extended. Firstly, the average time taken for the starter motor to start the engine is much reduced, so the total energy drained from the battery is also reduced, giving the battery an easier time. Secondly, with a stabilized-voltage system such as the one described, the engine can be started with an ageing battery long after the time it would fail to start with the conventional Kettering system. The reason for this is obvious – a full-power spark is still provided by the stabilized unit at reduced battery voltage when that from the Kettering system would become too feeble to be of use. The time does eventually come when the battery has to be discarded but it was found on the test car that battery life could reasonably be extended from a previous average of 2½ years to 4 years without jeopardising reliability, a considerable saving.

A smaller saving stems from the much longer life of the contact-breaker and spark plugs. The contact breaker lasts longer because it is relieved of handling heavy currents, so there is no arcing and sparking to cause burning or pitting. In fact over a 12-month trial period I was unable to detect wear at the points. The heel of the contact breaker wore however and it is necessary to lubricate this to realise long service life. The best way is to have a felt

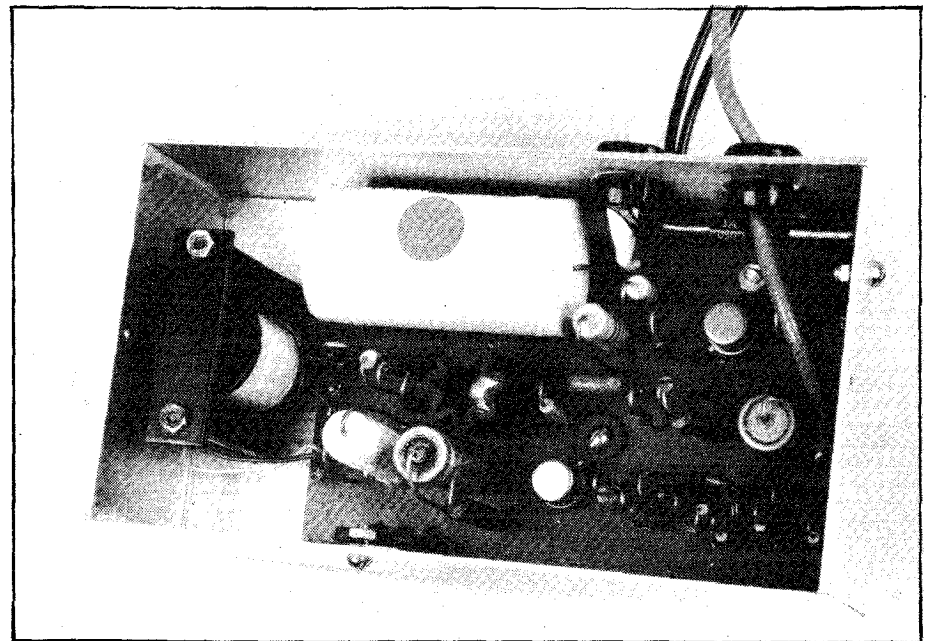
pad soaked in a non-spreading oil bearing lightly on the cam. This used to be common practice but seems to have been discarded by the manufacturers as a method of reducing wear; perhaps they want to sell more replacement parts! Needless to say a lubricated contact-breaker needs far less attention to adjusting the gap at the points than an unlubricated one. In conjunction with electronic ignition the ignition timing will stay in tune more readily over the same period than with the Kettering system and this saves fuel.

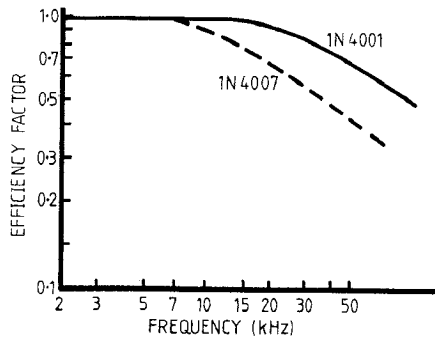
It is interesting that the pattern of current consumption of a capacitor discharge unit is just the opposite of that of the Kettering system; the first draws negligible current with the engine stopped and the consumption then increases with increasing spark rate, as one would expect, whereas the last draws a high current which perversely falls with increasing spark rate.

As for reduced wear of the spark plugs, this is said to be due to the more symmetrical nature of the electronic spark as compared to the Kettering spark, leading to less re-



*Mike Sagin, of 23 Keyes Road, London NW2, has agreed to provide glass-fibre circuit boards for £4 inclusive; wound transformers and other components may also be available given sufficient demand.*





**Fig. 1.** Square-wave efficiency of 1N4000 series diodes falls off after 15kHz so this was chosen as operating frequency. Efficiency factor is referred to value at 1kHz.

removal of material from the electrodes. It may be due as well to the shorter duration of the electronic spark but whatever the cause it is noticeably less.

### Retaining the contact-breaker

Whilst the contact breaker is regarded by many as a dismal contraption, its performance can be transformed when used with an electronic filter firing a thyristor, within the rotational speed limits given above.

With engines of more than six cylinders using a multi-lobe cam to operate the contact-breaker, it is probably a better solution to replace the whole mechanism with an electronic switch such as that described in last April's *WW*. However the contact breaker has inherent serviceability which is sacrificed if it is replaced entirely. This may not seem important until you are stranded miles from anywhere on a dark, cold winter's night, confronted by a bewildered garage mechanic who not only cannot diagnose the fault but has no spares either. This classic experience happened to me with a well-known car fitted with breakerless ignition as standard; it took two days to replace the electronics. On the other hand, all garages and the motoring organisations can attend to the conventional contact-breaker. (The reliability of the contact breaker is increased dramatically when connected to an electronic system of the type described because it is relieved of its duty of switching heavy currents.)

### Design criteria

Also it is a good safety measure to have a back-up system in case of electronic component failure. The consequences of failure of just one resistor during an overtaking manoeuvre could be catastrophic. All electronic ignition units regardless of the manufacturers claims to reliability should have a dashboard switch for instant transfer to a back-up system. If the contact breaker is retained a rapid changeover switch to the conventional Kettering system is easy to implement.

Of the published designs for capacitor-discharge ignition, many use an iron-cored transformer for a self-oscillating inverter. The result is a relatively heavy and bulky

unit which tends to run hot due to transformer losses. This design uses a ferrite transformer operating at high frequency to bring the size down as far as possible. Size was felt to be fairly important as today's cars have crowded engine compartments and there is not much space for extra equipment. This circuit can be put into an AB7 aluminium box measuring only 5½ x 3 x 1½in. Originally a pot-core was used for the transformer, but in 1975 Mullard introduced the FX range of ferrite power transformers and the circuit was adapted to use the smallest in the range, FX3720. Compared to an iron-core transformer, the FX ferrite is extremely easy to assemble and as there is very little wastage of energy in core losses this design runs cool.

It was decided to abandon self-oscillating inverters in favour of an externally-driven type to eliminate the drive windings on the transformer and so keep the bobbin winding as simple as possible. The other advantage of the inverter driven by a separate and independent source is that the frequency can be precisely fixed, thus enabling all the parameters of the circuit to be optimized for that particular frequency. For example, using Mullard's published design data an inverter transformer can be made accurately, of minimum size and of predictable performance, in contrast to the *ad-hoc* methods used in making iron-cored transformers for self-oscillating designs.

To provide the external drive a simple conventional two-transistor multivibrator is used. This circuit was designed some years ago and could probably be up-dated by the use of i.cs. However, the circuit has a proven reliability record over several years actually in cars which would be invalidated by an alteration of any sort, so it has been left in its original form.

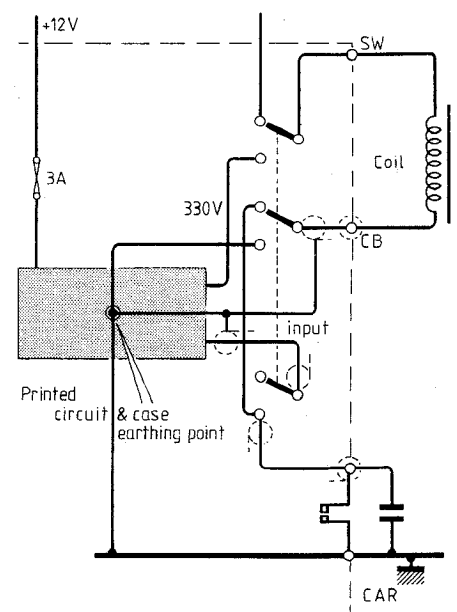
The frequency chosen was 15 kHz, for two reasons. Firstly it enables cheap and readily available semiconductors to be used, such as the 1N4001-7 series. The square-wave efficiency of these devices falls off markedly above 15 kHz as shown in Fig. 1. Secondly, this frequency is faintly audible and in practice this was a useful indicator that the unit was working correctly. When setting up the ferrite transformer, which needs close mating of the polished faces, incorrect assembly or the presence of foreign matter made itself immediately audible!

The inverter configuration is that of the single-ended forward converter, chosen because only one power transistor is needed, which simplifies the design and avoids the cost of a second power transistor and its drive circuit. Also the commutation problems of push-pull designs are non-existent with a forward converter, which is single-ended. Unlike the more familiar flyback converter which supplies energy to the load when the drive transistor is non-conducting, the forward converter supplies the load when the drive transistor is conducting. The advantage of the forward converter is the larger energy throughput for a given size of ferrite core.

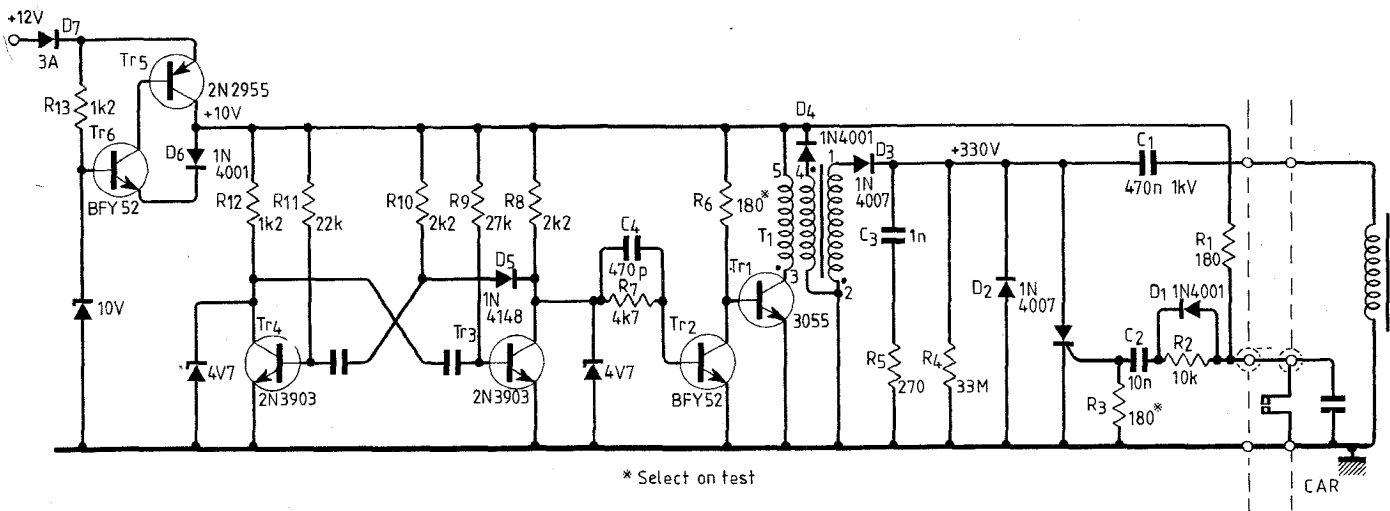
Because a capacitor discharge ignition system is similar to an audio amplifier in that a small input controls a large out-

put I decided to adopt standard audio practice and have a single-point earthing system. This means that the metal case of the unit must be insulated from the metalwork of the car by insulating pillars or brackets. The slight extra trouble of doing this has proved entirely justified, and I believe that some of the strange symptoms experienced on fitting some types of electronic ignition may be due to interference loops. Also along the lines of audio practice, it is worthwhile screening the input lead from contact-breaker to thyristor. This was a good remedy against an h.t. lead accidentally touching the input lead, which could cause false triggering; in one case with a high-sensitivity thyristor it caused destruction of the thyristor.

The thyristor effectively shorts the inverter output when it fires and various techniques are in common use to make the inverter short-circuit proof. One is to couple the inverter transformer only loosely to the load to minimize the effects of the short. A second is to stop the inverter during the firing cycle and re-start it afterward. A third method, used with iron-cored transformers, is to operate the inverter at a higher frequency during shorting, so reducing the efficiency of the inverter to the point where a short circuit is ineffective. With the first method, it is difficult to obtain good energy output at the higher firing rates, other factors such as transformer size, cost and complexity being equal. The second method is fraught with difficulties in getting the inverter to start again in sufficient time to re-charge the capacitor for a subsequent discharge at high repetition rates. The third method is workable but dissipates energy in the form of heat in the transformer, which is not welcome.



All electronic ignition units should have a dashboard-mounted switch to change back to the conventional ignition in emergencies.



\* Select on test

Fig. 2. Inverter is driven at 15kHz to reduce transformer size and weight. Although the circuit could be updated in some ways this might invalidate its proven reliability record. Driving inverter at 15kHz.

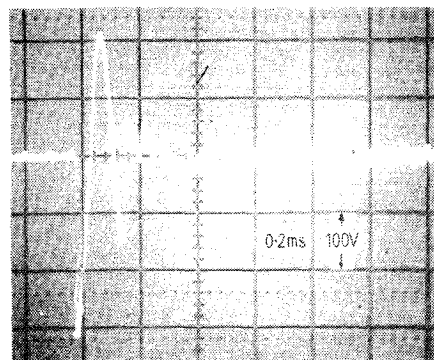
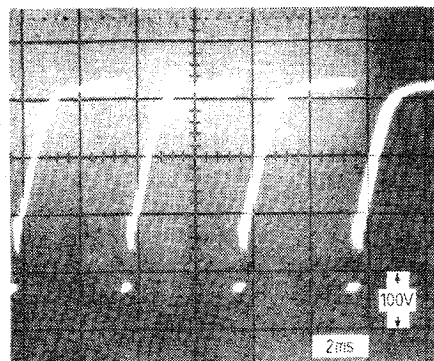
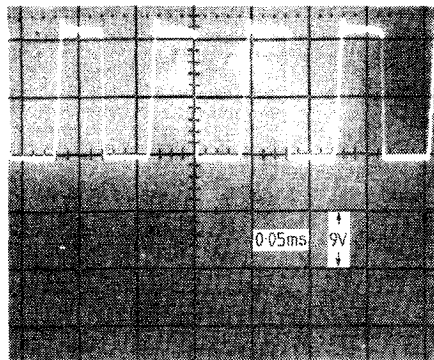


Fig. 3. Incorrect waveform at Tr<sub>1</sub> collector is easily diagnosed; one more on than off it leads to excessive current drain, whereas the opposite situation gives lowered voltage peak at the thyristor anode. (a) shows collector voltage, (b) thyristor anode voltage and (c) shows short rise time of ignition primary voltage.

In this design, the ferrite transformer is close-coupled and continuously driven at the fixed frequency the whole time. Short-circuit protection is provided by limiting the drive current to the drive transistor, which continues to give the transformer current pulses of fixed amplitude during a short circuit. Energy is dissipated in the power transistor but as it is in a position to dissipate heat anyway, the extra heat of a series of short-circuits is of no consequence. This is an effective, snag-free method which gets round the drawbacks of the techniques mentioned above.

It was decided to stabilize the supply line at about 10V at the outset. There are published designs around which do not attempt to stabilize either the supply voltage of the output voltage to the ignition coil. This is surprising in view of the fact that the car battery can provide much less than the nominal 12V on starting and yet over 14V on normal running. One can only assume that the energy content of the spark at the spark plugs wanders in unison with the battery voltage. As the energy content of the discharge capacitor is proportional to  $V_0^2$  where  $V_0$  is the inverter output voltage, the importance of stabilizing  $V_0$  is obvious. I found from experience that it was a much simpler and trouble-free method to stabilize the supply voltage than incorporate a feedback loop from the output of the inverter. The stabilizer circuit used is that due to Nye (WW June 1973 page 285.)

### Circuit description

Components Tr<sub>5</sub>, Tr<sub>6</sub>, D<sub>6</sub> and the Zener diode in Fig. 2 form the voltage stabilizer with Tr<sub>5</sub> heatsinked as it needs to dissipate about eight watts at peak engine speed. Transistors Tr<sub>3</sub> and Tr<sub>4</sub> form the multivibrator, while D<sub>5</sub> and R<sub>10</sub> improve the output waveform by providing a separate recharge path for C<sub>6</sub>. The output is fed to Tr<sub>2</sub> which clamps the base of the inverter drive transistor, Tr<sub>1</sub>. Base resistor R<sub>6</sub> is chosen to give a collector current of three amps, but Tr<sub>2</sub> should clamp Tr<sub>1</sub> with whatever value of R<sub>6</sub> is chosen; low values of  $h_{FE}$  for Tr<sub>1</sub> should be avoided.

The output of the multivibrator is asymmetric so that Tr<sub>1</sub> is turned off for a longer period than it is turned on. When the turn-off time is taken into account, this should give a symmetrical square wave at the collector, as shown in Fig. 3. It is easy to diagnose an incorrect waveform, as one that is on more than off will give excessively high current consumption when no spark is being drawn. A waveform more off than on will give a lowered peak reading at the anode of the thyristor. In some cases it may be necessary to adjust the timing resistors of the multivibrator slightly.

The primary and energy-recovery windings, L<sub>1</sub> and L<sub>2</sub>, are bifilar wound to give closest coupling — details are given in Fig. 4. The secondary L<sub>3</sub> can be layer-wound or sectionally wound. Components C<sub>3</sub> and R<sub>5</sub> protect the thyristor from being turned on by excessive values of  $dV/dt$ , and R<sub>4</sub> provides a slow discharge path for the main capacitor C<sub>1</sub>. Diode D<sub>2</sub> is the flyback diode, while R<sub>1</sub>, R<sub>2</sub>, D<sub>1</sub>, C<sub>2</sub> and R<sub>3</sub> form the thyristor firing and input-filter circuit. Resistor R<sub>3</sub> should be chosen to be as low as possible consistent with reliable firing to prevent spurious firing of the thyristor by transients.

### Discharge capacitor and thyristor

These deserve special attention as they are the most highly stressed part of the unit. On the prototype the Dubilier type

Continued on page 87

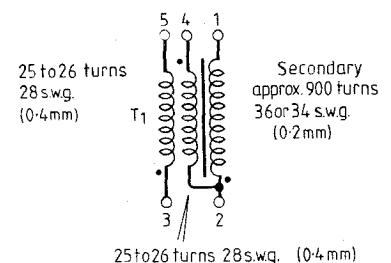


Fig. 4. Primary and energy-recovery windings are bifilar wound to give close coupling, secondary winding is layer or section wound.



# BBC microcomputer

*All things to all people?*

by J. D. Ferguson, B.Sc., M.Sc., M.Inst.P., J. Gordon, B.Sc., M.Phil., and P. Williams, B.Sc., Ph.D., M.Inst.P., M.I.E.E.

The BBC microcomputer has at last arrived, but even before the design was completed it had been surrounded by controversy. Clive Sinclair was furious at not being invited to quote for the system, the Government nominated Acorn's micro for special aid if purchased by a school, then the BBC chose Acorn to design their micro. If the new computer had been merely a copy of the Atom, all the criticism would have been valid. However, this has not happened, the BBC and Acorn together have produced a completely new device. This article describes the new computer and outlines the special hardware and software features.

The BBC microcomputer is based on a single board which, when fully expanded, includes 32K bytes of r.a.m., 80K bytes of r.o.m., a serial and cassette interface, real-time clock, floppy-disc controller, c.r.t. controller and video processor with light pen facility, PAL encoder, Econet synchronous communication interface, 6522 v.i.a. parallel printer driver, speech and music synthesis, r.o.m.-pack adaptor, and a 4-channel a-to-d converter. At the heart of the board, shown in Fig. 1, is a 6502A processor running at 2MHz. The 32K of r.a.m. is provided by 16 4816A d.r.a.ms and up to 20K of this can be used in the high-resolution graphics modes which, with the 3¼K used by the operating system, leaves only 8¼K for programs. However, Acorn feel that their add-on box containing a second processor and 60K of r.a.m. should satisfy users planning large programs. The machine operating system (MOS) is located in a 23128 16K r.o.m. at the top of the memory map shown in Fig. 2. The Basic interpreter and machine-code assembler are also located in a 16K r.o.m. starting at 8000H. An interesting feature of this computer is its ability to software page or select one of a group of four resident r.o.ms to operate in the same slot in the system memory map. This is achieved by the processor first writing to an addressable output latch which enables the user to switch easily between options such as Pascal, a word processing package or an enhanced operating system containing floppy disc and Econet communication software, which Acorn say will be available in the future.

## Input/output

The full qwerty keyboard, featuring two-key rollover and auto-repeat, is augmented by ten user-definable function keys and five special keys to ease on-screen editing. A 6522 v.i.a. interfaces the keyboard to the processor and a key stroke generates an interrupt which initiates a software scan routine to detect the depressed key.

The most impressive feature of the computer is the quality and diversity of its text and graphics display. Table 1 lists the eight graphics modes which range from 640×256 two-colour graphics with 80×32 text, to a 40×25 teletext display. The Motorola 6845 c.r.t.-controller chip and Acorn's uncommitted logic-array video processor handle the video display. In mode 7 an SAA5050 character generator provides the normal Teletext character set together with double height and flashing characters in eight display colours and eight background colours. Character generation in modes 0 to 6 is achieved by software routines, drawing the characters using high-resolution graphics. This technique allows the user to place characters anywhere on the screen and to reprogram the character set to provide, for example, the Greek alphabet. In modes 0 to 6, colours are selected from a palette of 16

effects; black, red, green, yellow, blue, magenta, cyan and white, either normal or flashing.

Another very useful feature is the ability to define the text and graphics windows over any area of the display. Fig. 3 shows two examples, one giving a display similar to the Apple screen in high-resolution graphics and the second showing a graphics window surrounded by text. Each window can be filled, cleared or scrolled independently of the other. Most of the graphics is controlled using the Plot statement which allows points, lines or triangles to be drawn on the screen in a range of colours, see Fig. 4. Three separate video signals are provided (two on the basic A model, but the addition of a socket provides the third). A 75Ω 1V pk-to-pk composite video output, PAL coded, is fed to a BNC socket for connection to a PAL monitor or video recorder. Domestic monochrome or colour television receivers can be driven from a u.h.f. modulator tuned to channel 36. Finally, four t.t.l. outputs provide red, green, blue and composite sync. pulses for an RGB monitor.

Although the board contains all the circuits necessary to control 5 or 8in floppy-disc drives using the Intel 8271 controller chip, see Fig. 5, the software will not be available until later in the year. At present, programs can be stored on audio cassette at either 300 baud (CUTS format) or 1200 baud. This interface uses a 6850 asynchronous communication interface (a.c.i.a.) and the u.l.a. serial processor as shown in Fig. 6. The cassette system seems to be more tolerant of varying level settings than the Atom. A relay is provided to switch the cassette motor on or off, which enables the computer to start and stop the tape at the beginning and end of each program. The

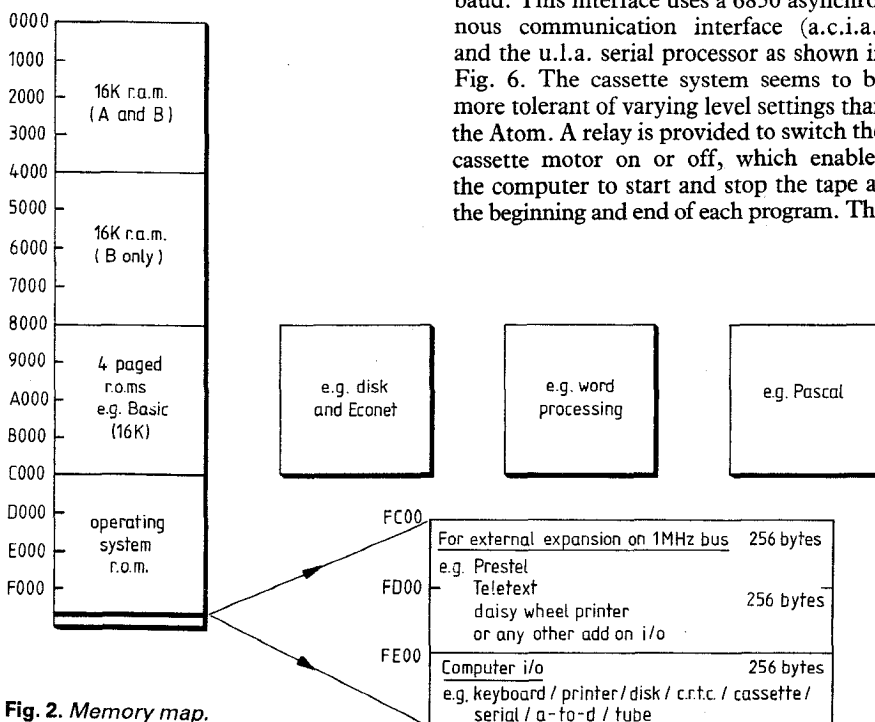


Fig. 2. Memory map.

a.c.i.a. and serial processor also provide a bi-directional RS423 ( $\pm 5V$ ) interface so the computer can act as an intelligent graphics terminal. The serial port can also be used to drive a printer with the statement \*FX5,2 which directs the printer driver routines to the serial port. Baud rate selection is also under software control, e.g. the statement \*FX8,3 switches the transmission baud rate to 300. Provision has also been made to drive a parallel Centronics type printer and the statement \*FX5,1 for example, switches the printer output to port A of a 6522 v.i.a. which is used together with a 74LS244 buffer to drive the printer as shown in Fig. 7.

Port B is left free for user applications. The software routines for the serial and parallel interfaces can be accessed by the user and redirected to other routines if special features such as automatic form feed are required.

To satisfy the growing number of computer users in measurement and control applications, the unit is supported with a four channel 12-bit a-to-d converter, using the PD7002 shown in Fig. 8. A 2.5V reference is used and the converter produces a number between 0 and 4095. The conversion time for each channel is 10ms, and completion of a conversion interrupts the

processor to store the value in memory for later access. The Basic ADVAL statement can be used to obtain a value from any input channel, e.g.

TEMPERATURE = ADVAL (3)

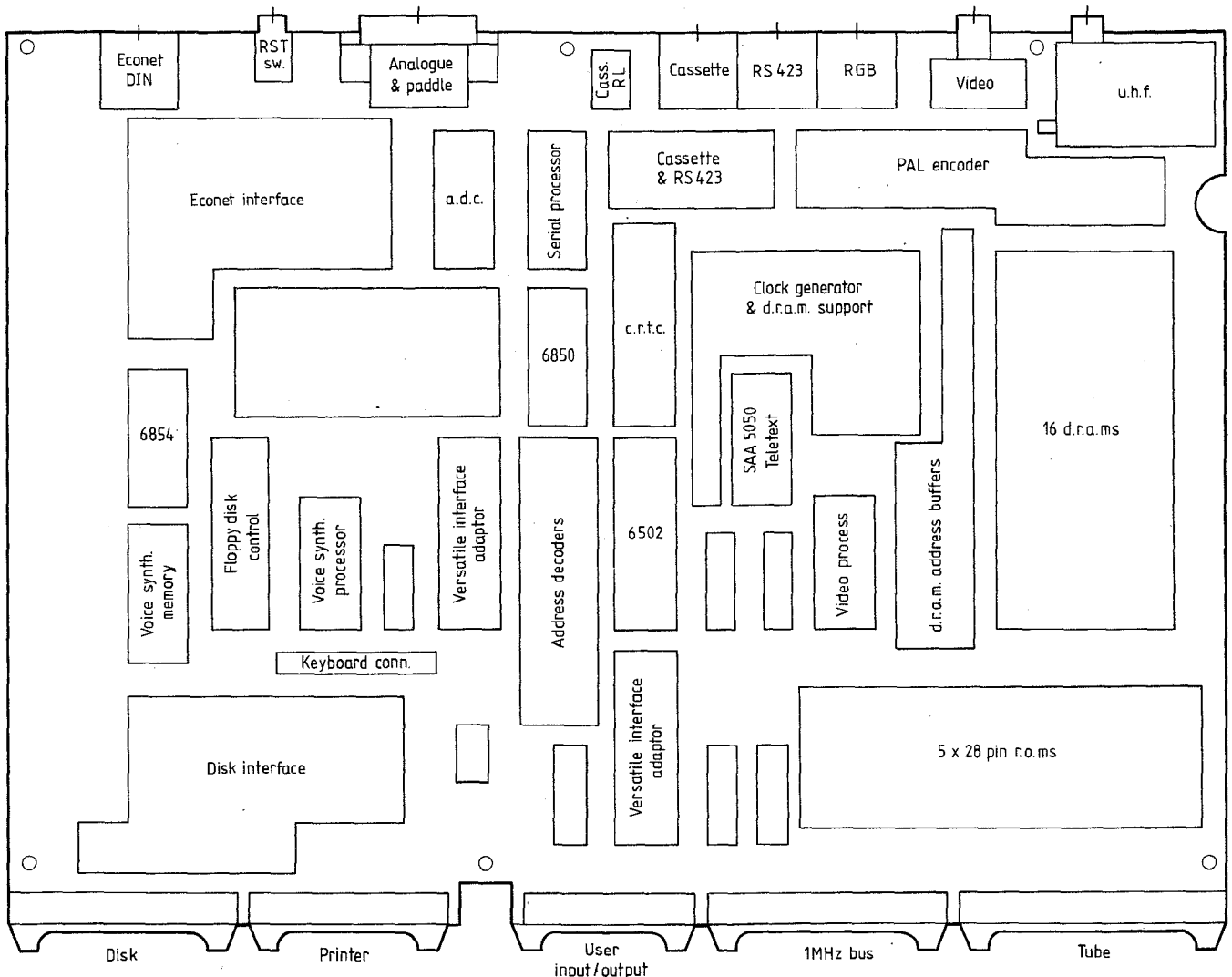
Other features include an internal loud-speaker that can be driven by either a three channel music synthesis circuit or by TMS 5220/6100 voice synthesis i.cs, an elapsed-time clock which gives time measurement with a resolution of 10ms, and an Econet interface which offers a communications network using the 6854 advanced data-link controller (a.d.l.c.) where a number of computers can share expensive peripherals such as a printer or disc system. Two

expansion buses are also provided. A 1MHz buffered bus is intended for peripherals such as Prestel or Teletext acquisition units where programs can be captured and stored for later use. It is worth noting that this bus contains two chip-select signals for pages FC00 and FD00, the only free memory space in the expanded system. The second interface, called the tube, has been designed for future add-on boards containing either a 3MHz 6502 and 60K of r.a.m. or a Z80 also with 60K of r.a.m. and with a CP/M compatible operating system. This will give users the best of both worlds, advanced graphics and peripheral control as well as access to standard software.

Table 1. Eight-graphics modes.

Mode	Memory used
0 640 x 256 2 colour graphics and 80 x 32 text	20 K bytes
1 320 x 256 4 colour graphics and 40 x 32 text	20 K bytes
2 160 x 256 16 colour graphics and 20 x 32 text	20 K bytes
3 80 x 25 2 colour text	16 K bytes
4 320 x 256 2 colour graphics and 40 x 32 text	10 K bytes
5 160 x 256 4 colour graphics and 20 x 32 text	10 K bytes
6 40 x 25 2 colour text	8 K bytes
7 40 x 25 Teletext display	1 K byte

Fig. 1. Printed circuit board component layout.



v.d.u. statement can be used to define separate or overlapping text and graphics windows anywhere on the screen.

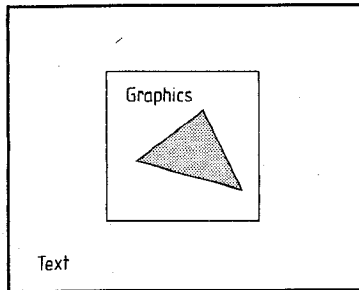
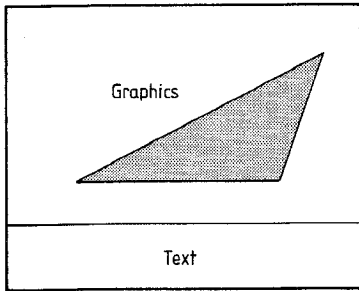


Fig. 3. Text/graphics windows.

**Software**

Although Basic is a popular and in most cases the standard high level language for microcomputers, it has several deficiencies, e.g. only two character variable names are allowed, no ELSE on the IF statement, programs are generally unstructured, and no multiple line statements. A cross section of computer users would never completely agree on the perfect language, but the following features would be a good compromise:

- structured and readable,
- interpreted,
- easy to learn,
- able to call other language programs,
- have the ability to embed assembly code within it,
- able to handle i/o a-to-d conversion,
- able to handle random and sequential files,
- good debugging features,
- high resolution/colour graphics,
- able to handle procedures and functions,
- mounted in a system that costs almost nothing, with a screen editor thrown in.

BBC Basic fulfills all of these.

Most programmers feel that the main detraction of traditional Basic is the lack of structure. One of the best languages for structure is Pascal which implements the three fundamental structures, PROCESS, IFTHENELSE and WHILE-DO, plus four additional elementary forms, IFTHEN, REPEATUNTIL, CASE, FOR-DO<sup>6</sup>. BBC Basic implements some of these structure as follows.

**Process**

As in Microsoft Basic,<sup>4</sup> more than one statement can be put on one line using the ":" as a delimiter, for example  
 100 A=10: B=7: PRINT A+B  
 Sets of statements can be placed together as subroutines, accessed via GOSUB.

**IF . . . THEN . . . ELSE . . .**

This is implemented with the following format, <line number> IF condition THEN statement ELSE statement. The condition can be complex using logical AND, OR and NOT, see routine a.

**REPEAT . . . UNTIL . . .**

Using this construct in BBC Basic, it is possible to loop around a section of code until a condition is satisfied, see routine b.

Other normal features of Basic are also present such as the FOR . . . NEXT loop, ON . . . GOTO/GOSUB strings and arrays.

One of the best ways to make programs readable is to use meaningful data names, e.g.

```
100 TAX_PAID=0.3*TAXABLE_PAY
110 PRINT TAXABLE_PAY
```

These are valid lines of BBC code. Variable names consist of the characters A-Z, a-z, 0-9 and underline.

In addition to writing Basic code, languages can be mixed using three constructs which allow other programs to be called in. USR (argument): this calls a machine code subroutine whose address is its argument and returns a 32-bit integer.

CALL location, parameter - 1, ---, parameter n: using this construct, control can be passed to a machine code subroutine, with parameters being passed to and fro, which allows complex and fast machine code subroutines to be written.

**CHAIN/PROGRAM NAME**

The CHAIN construct loads a new program into memory and clears all variables, except the integer static variables @%+A% to Z%. Therefore, programs can be segmented and overlaid in memory if care is taken with static variables. At present, Pascal is not available for the BBC computer, but when it arrives it should be possible to mix languages.

**Embedding machine code routines**

If it is not desirable to call an external machine code subroutine, sections of machine code can be placed within the Basic code. This is done by delimiting assembler statements with [ ] as in Atom Basic, for example<sup>1</sup>, see routine c.

**I/O and a-to-d handling**

BBC Basic has direct commands to handle i/o, and there are three separate file operating systems; cassette filing system (c.f.s.), disc filing system (d.f.s.) and network filing system (n.f.s.). These can be used for data-file handling programs. As well as data processing, the following commands are available;

ADVAl: returns the last known value of the a-to-d channel given in its argument.

EVAL: evaluates a mathematical expression entered as a string, which can be useful in mathematics programming, e.g.

```
100 INPUT A$
110 Value=EVAL(A$)
```

**File handling**

When using the d.f.s., the usual file handling commands, OPENIN, OPENOUT, CLOSE, PRINT, INPUT, BPUT, BGET are available except that information is PUT-ted and GET-ted a byte at a time.

**Debugging features**

Because interpreted Basic is used, syntax errors can be found and corrected immediately. For run-time logic errors the programmer can use the following constructs.

ERL: returns the line number where the last error occurred.

ERR: returns the error code of the last error.

ON ERROR GOTO <line number>: an error trapping function which replaces the normal machine action. If an error occurs, processing does not stop but control passes to <line number>.

ON ERROR OFF: switches off the error handler.

REPORT: print error message describing last error number given.

TRACE (ON or (OFF): prints out each line number before statement execution.

**Graphics**

This is considered to be one of the most important features of the BBC computer and provides one of the best low-cost graphics systems available. All graphics facilities can be accessed via Basic using the following functions;

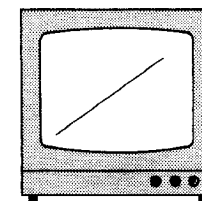
CLG - clear graphics screen.

CLS - clear text screen.

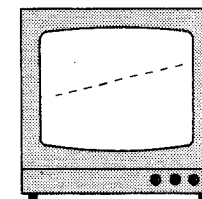
COLOUR - select foreground and background colour.

DRAW - draw a line on the screen.

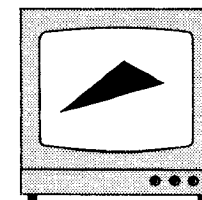
GCOL - sets colour to be used in graphics.



Plot 5, X,Y draw line to absolute position X,Y in current graphics colour



Plot 13, X,Y as above, but draw dotted line



Plot 85, X,Y plot and fill triangle formed by X, Y and the last two sets of points visited

Fig. 4. Examples of plot statements.

MODE — select mode on graphics, resolution up to 320×256, 16 colours, plus Teletext capability.

MOVE — move graphics cursor to position.

PLOT — draw points, lines or triangles on screen. Can also be used to fill triangle with colour.

POINT — find colour of point on screen, e.g. point (x,y).

## Procedures and functions

Procedures are a new concept for most versions of Basic. They are available in COMAL-80 (if this can be considered as Basic), and allow a small self-contained set of code to be written, in which parameters can pass in both directions. Within the procedure, certain variables can be declared as local, i.e. they are temporary variables only used with the procedure.

With a disc-based system a library of procedures can be assembled as an aid to program construction. Also, if a structured approach to programming is adopted, procedures can be used to decompose a program into a set of small self-contained procedures. The functions used are;

DEF PROC name (parameter list): procedure declaration, all procedure names begin with PROC.

## Program explanation and demonstrations

(a)

```
100 IF TAXABLE_PAY < 5000 THEN GOSUB 500 ELSE GOSUB 600
.
.
500 REM STANDARD TAX CALCULATIONS
.
.
600 REM SUPERTAX CALCULATIONS.
```

(b)

```
100 INPUT TOTAL_PAY, TAX_ALLOWANCE
120 TAX_TO_PAY=0: PAY_LEFT=TOTAL_PAY-TAX_ALLOWANCE:RATE=0.1
140 REPEAT
150 IF PAY_LEFT>100 THEN PAY_THIS_RATE=100
    ELSE PAY_THIS_RATE=PAY_LEFT
160 TAX_TO_PAY=TAX_TO_PAY + RATE * PAY_THIS_RATE
170 RATE=RATE + 0.1
180 PAY_LEFT=PAY_LEFT - PAY_THIS_RATE
190 UNTIL PAY_LEFT < 0.1
200 PRINT TAX_TO_PAY
210 END
```

(c)

```
10 oswrch=&FFF4
20 FORZ=1TO3STEP2:P%TOP+1000
30 [ opt Z : .start lda # ASC" "
40 ldx # 40
50 .loop jsr oswrch
60 dex:bne loop
70 rts:]NEXT
80 CALL start
90 END
```

(d)

```
10 DEF PROCHello(X)
20 LOCAL Z
30 FOR Z=0 TO X
40 PRINT "Hello - how about this for
BASIC!"
50 NEXT Z
60 END PROC
```

(e)

```
10 REM Tower of Hanoi problem
20 INPUT "Number of disks" ,F
30 PROCanoi(F,1,2,3)
40 END
50 DEF PROCanoi (A,B,C,D):IF A=0 ENDPROC
60 PROCanoi(A-1,B,D,C)
70 PRINT "Move disk" ;A; " from pile" ;B;
"to pile " ;C
80 PROCanoi(A-2,D,C,B)
90 ENDPROC
```

(f)

```
500 PROCTAXCALC(450,100,TAX_DUE)
600 PRINT TAX_DUE
1000 DEF PROCTAXCALC (TOTAL_PAY,TAX_ALLOWANCE,TAX_TO_PAY)
1010 LOCAL TAX_TO_PAY, PAY_LEFT, PAY_THIS_RATE
1020 TAX_TO_PAY=0:PAY_LEFT=TOTAL_PAY-TAX_ALLOWANCE:RATE=0.1
1030 REPEAT
1040 IF PAY_LEFT>100 THEN PAY_THIS_RATE=100
    ELSE PAY_THIS_RATE=PAY_LEFT
1050 TAX_TO_PAY=TAX_TO_PAY + RATE * PAY_THIS_RATE
1060 RATE=RATE + 0.1
1070 PAY_LEFT = PAY_LEFT - PAY_THIS_RATE
1080 UNTIL PAY_LEFT < 0.1
1090 PRINT TAX_TO_PAY
1100 END
```

(g)

```
1000 IF A < B THEN
1010 PRINT "A<B"
1020 FOR K = 1 TO 10 DO
1030 PRINT "K=",K
1040 NEXT K
1050 ELSE
1060 PRINT "A NOT <B"
1070 ENDIF
```

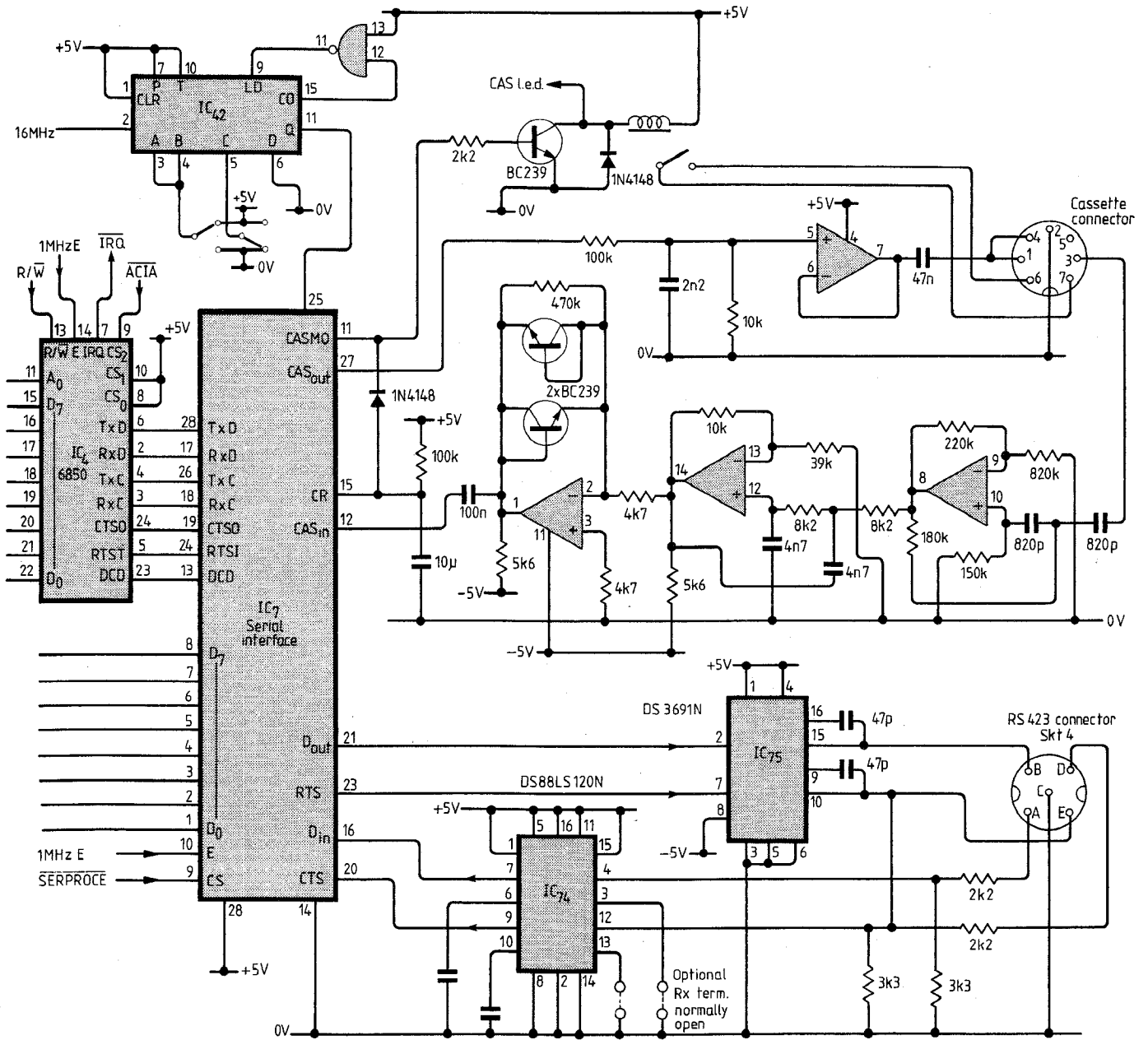


Fig. 6. Cassette/serial interface.



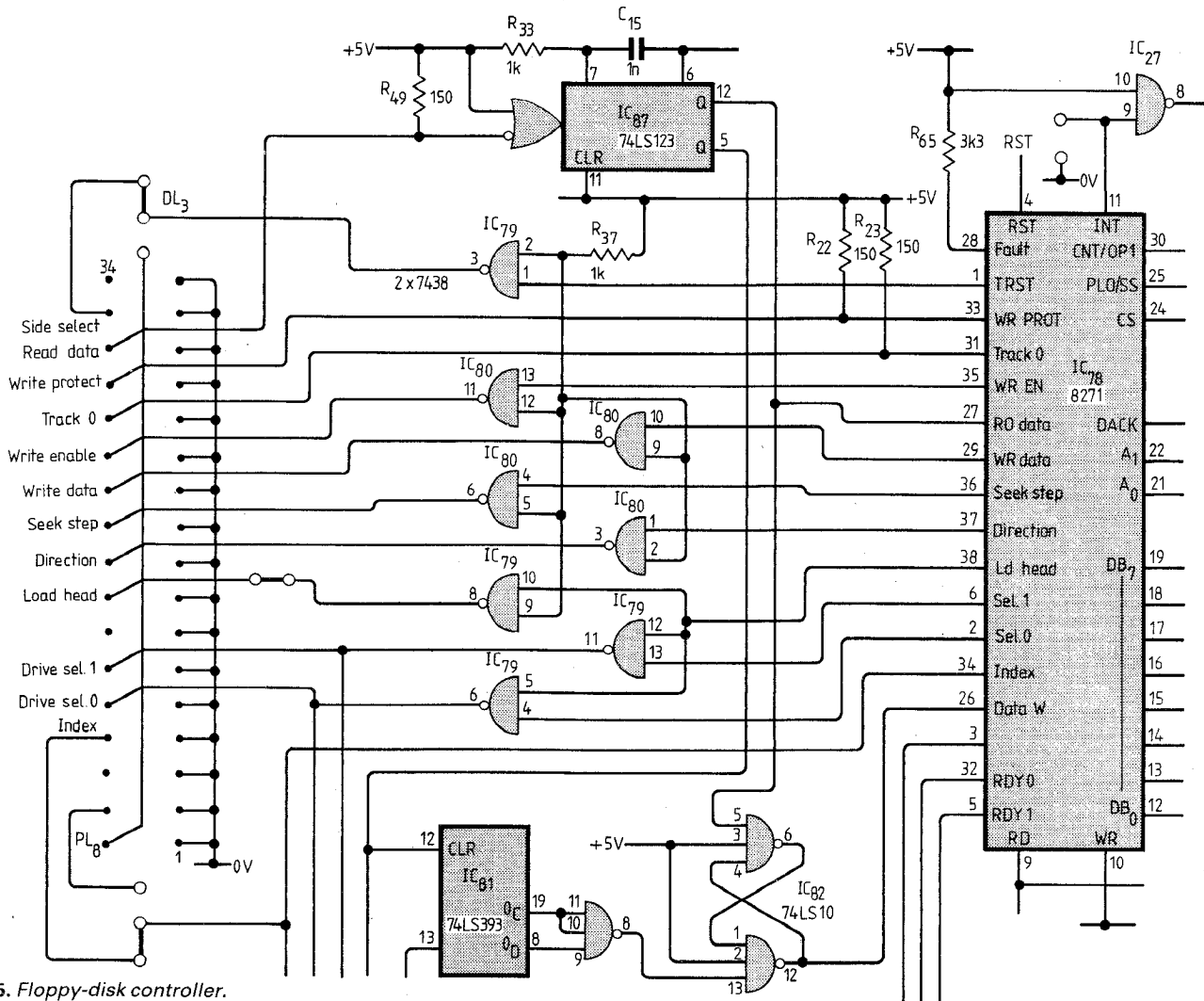


Fig. 5. Floppy-disk controller.

ENDPROC: end of procedure. Therefore, in BBC Basic, procedures can occupy more than one line of code.

LOCAL: defines local variables. To call a procedure, code PROC name (parameter list).

Procedures can be used recursively, for example<sup>2</sup>, see routines **d** and **c**.

Notice the use of recursion in the second program. With such procedures it is possible to use the techniques of top-down analysis to form programs. For example, if the earlier tax program is considered as a procedure to be used later, it can be coded as shown at **f**.

Although BBC Basic is not a fully structured language in that an instruction can only be placed on one line, e.g. the following COMAL-80 program segment would be illegal: see routine **g**.

COMAL-80 does not have features such as the assembler and graphics. BBC Basic is worthwhile exploring as a half-way house between traditional Basic and a fully structured language.

### Conclusion

As microcomputers find an increasing number of applications in areas as diverse as process control and word processing, most users have adopted the horses-for-courses approach. The BBC computer, after several design changes, now offers an

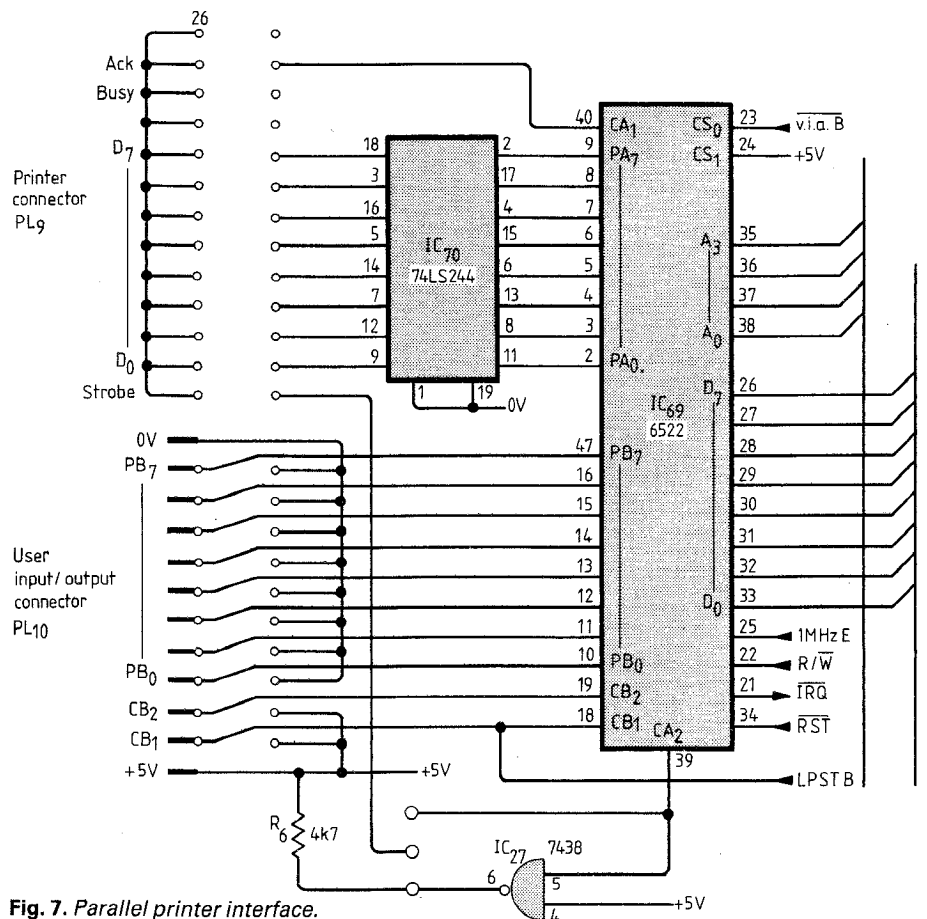


Fig. 7. Parallel printer interface.

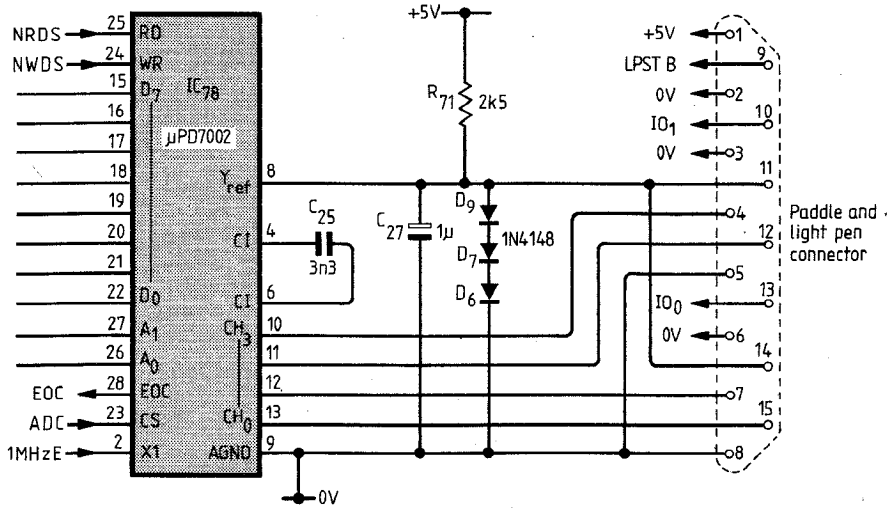


Fig. 8. Analogue-to-digital converter.

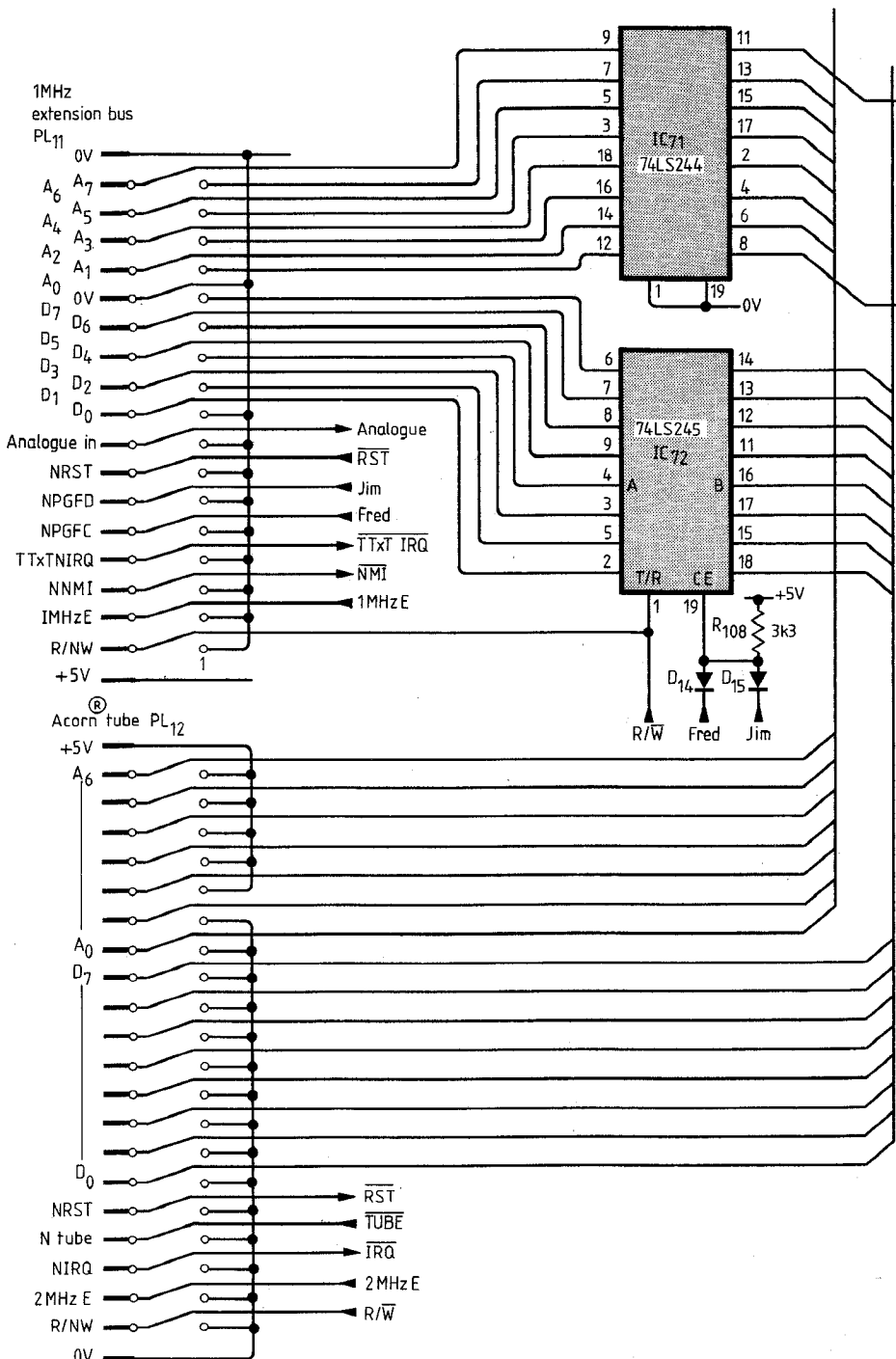


Fig. 9. 1 MHz bus and tube connections.

all purpose system which, with the promised add-ons, will compete in most areas of computing. BBC Basic is a significant improvement on the standard 8K version and is arguably the best available at present.

All in all the BBC and Acorn have produced an excellent design at a competitive price and have managed to keep its manufacture in Britain.

MEDC will be providing briefing seminars in Scotland on behalf of the BBC for those educational and training institutions planning to act as referral centres for the BBC project. We would like to thank Acorn Computers Ltd and the BBC for the opportunity to use some of the prototypes and for all the preliminary information provided.

**References**

1. BBC Microcomputer Systems Technical Spec., issues 2 and 3, April, September 1981.
2. BBC Microcomputer System Manual, release 1982.
3. Metanic COMAL-80 Syntax Diagrams and Examples, 1980, Metanic ApS, Denmark.
4. Microsoft Basic Manual, version 5.1.
5. Findlay & Watt, Pascal, 1979, Pitman.
6. Johnson-Davies, Atomic Theory and Practice, Acorn Computers Ltd., 1980.

## Step approximations and rounding errors

Apologies to those readers who had difficulty in tracing a paper referred to in J. H. Dawson's article on direct digital frequency synthesis in last December's issue. The pagination for the article mentioned, on distortion due to step approximations and rounding errors, was incorrect; the reference should have read *IEEE Trans* vol. AU-19, March 1971 pp. 48-56.

## Acceleration feedback loudspeaker

Some readers have told us of difficulty in obtaining the drive units for this design, which appeared in the September 1981 issue. Philips say that orders should be addressed to Mr Edwards, Spares Sales, Philips Service, 604 Purley Way, Waddon, Croydon CR9 4DR. The prices given in the article are correct, and cheques should be payable to Philips Service. Order numbers as follows must be quoted.

Type	Order No
AD8067/WMFB4	240 60067
AD02110/SQ8	240 50155
AD0141/T8	240 70017

## Cardboard clock

An apology. The ferrite magnets specified for use in the above project (January issue) were chosen with availability in mind, and are larger than those in the prototype. The effect of this is to raise the pendulum bob 3 mm, and so the clock as described gains about seven minutes per day. This error disappears if the height of the pendulum support rod is also increased by 3 mm. Thus, the critical height noted on p.75 should be increased to 287 mm. Starting from this corrected figure, similar adjustments may also be made to allow the use of other ferrites of nearby sizes.

# Computer control of projectors

## Simple interface for random access of slides

by P. G. Barker

In audio-visual applications, situations often arise where it is necessary to gain random access to graphic data or visual images. For example, in several areas of experimental psychology, subjects are presented with randomly selected pictorial data and their responses to the images are recorded. With computer-assisted learning (c.a.l.) schemes, a student may be presented with a visual image selected from a data bank and asked to respond. By analysing the students response, further images are then selected. Presentation of graphic material can be achieved via a computer graphics terminal, a television screen, a printed picture catalogue or a projector. Slide projectors provide a useful and inexpensive means of presenting static information and are available with either a sequential mode or sequential and random access modes. A typical computer-controlled learning system is shown in Fig. 1. In most applications the projector can use either a keyboard control or thumb-wheel switch to enter a two-digit code (N) which specifies the next slide. The value zero causes the slide magazine to rotate to the start position for unloading or initialisation of a retrieval or instruction sequence. Within the allowed range of integers there are no restrictions on the choice of N. This interface enables a computer under program control to determine the sequence in which slides are presented by emulating the manual keyboard. The manual keyboard or rotary switches used for conventional slide selection function as two-way switches. Internally the switches are connected by a suitable bus which terminates externally with a 30-way interface port for connection to the projector via a 30-way cable. The pins on the 30-way plug and the corresponding socket are configured in a 10 x 3 matrix so each matrix position has a code consisting of a digit from 0 to 9 for its row position, and a character a, b or c for its column position.

This form of selector switching can easily be emulated by reed relays controlled by a computer. The 8-bit parallel input to the interface from the computer is used as two 4-bit b.c.d. numbers which are fed to a 7145N b.c.d.-to-decimal converter to drive the reed relays as shown in Fig. 2. Because the interface was developed for use with a PET computer, the labelling convention is the same as the eight programmable pins on the user port. Each of these pins may be set as an input or output using a Basic initialisation instruction, and each pin can be set high or low by the statement POKE 59471, X where X=0 for 0V and X=255 for 5V. The outputs from the SN7145 are fed to inverters which also act as voltage-level shifters and

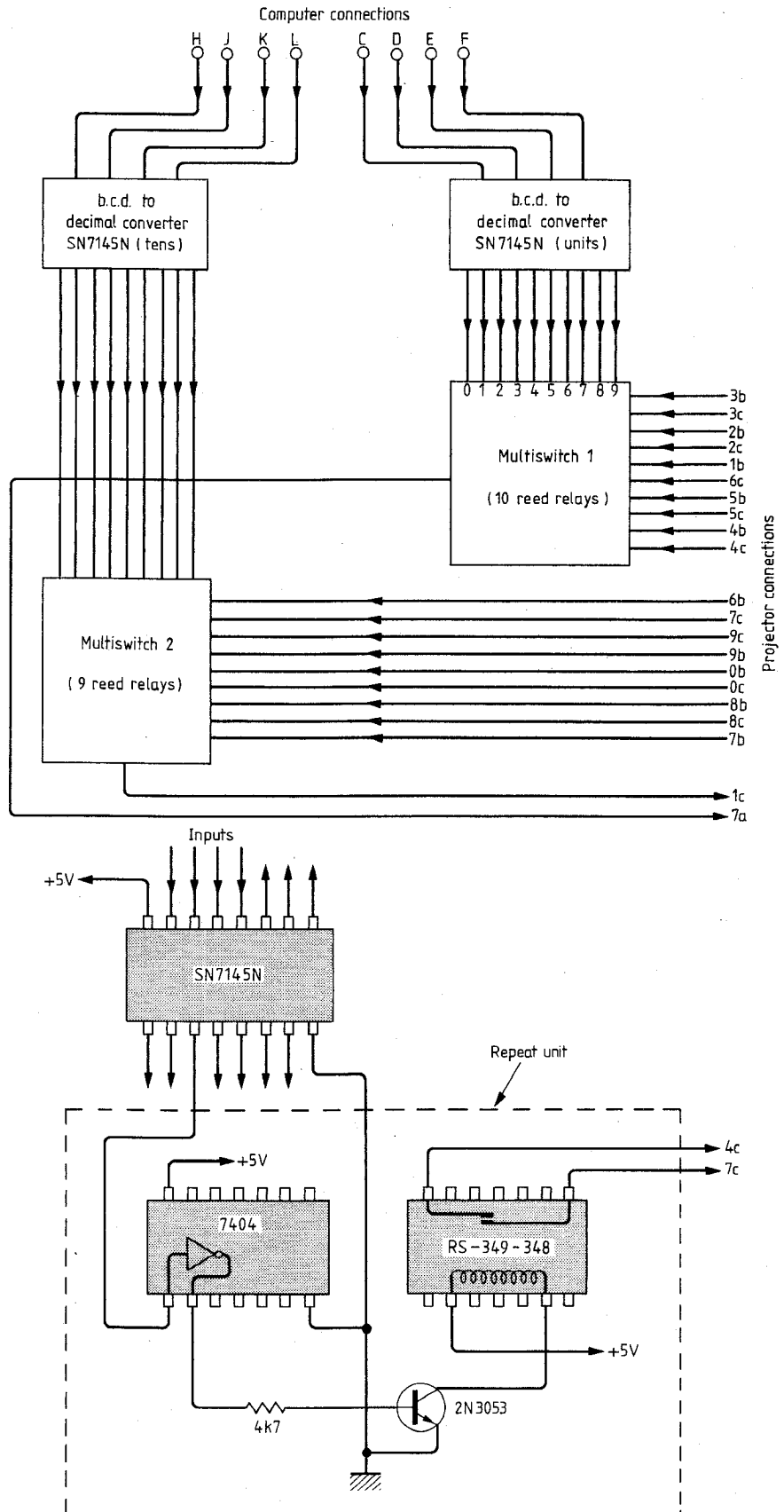


Fig. 2. Reed-relay interface connections and drive circuit.

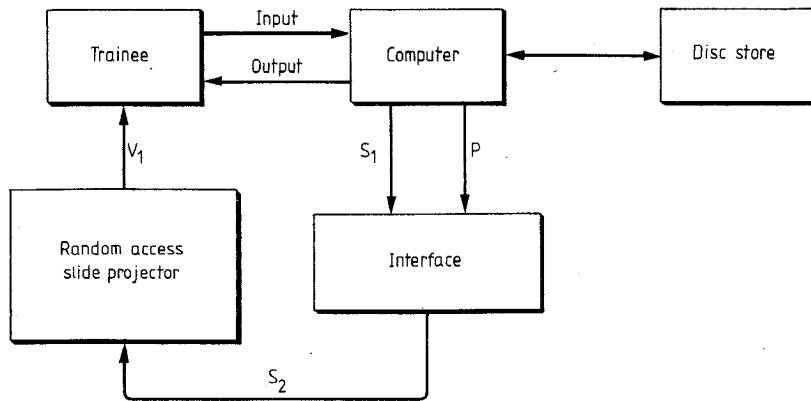


Fig. 1. Basic c.a.i. system using a random-access slide projector.

drive n-p-n transistors to switch the relays. Pairs of relays in the two switches operate synchronously to correctly emulate the manual selector system.

Software control of the interface is simply achieved by generating the appropriate bit pattern for any number in the range 0 to 80. In the following example, statement 10 sets the data-direction register of the PET user-port to outputs, and input to the program via the keyboard is initiated by line 20. Validation of input responses from

the user takes place in lines 20 and 30 with appropriate diagnostics generated by statements 90 to 106 if required. Provided a valid slide number is selected, statement 50 computes the required bit pattern to control the projector and this is passed to the interface by statement 60. The program then loops back to service a further request from the user.

```
5 REM PROGRAM TO CONTROL RA
SLIDE PROJECTOR
10 POKE 59459,255
```

```
20 INPUT "@£&&&&ENTER SLIDE
NUMBER"; NS
30 IF NS>80 THEN 90
40 IF NS<0 THEN 90
50 K=
(INT(NS/10)*16)+NS-INT(NS/10)*10
60 POKE 59471,K
70 GOTO 20
90 PRINT "INVALID SLIDE
NUMBER"
100 PRINT "TRY AGAIN"
105 K2=TI
106 IF TI<K2+120 THEN 106
110 GOTO 20
```

The program can be terminated by an appropriate interrupt sequence generated with the Run Stop key on the computer. In statement 20, special cursor control characters are used in conjunction with the timing loop at statement 106 to produce dynamic graphics effects on the computer screen. These control characters are denoted in the INPUT statement by @ (clear the screen), £ (home the cursor) and & (cursor down one line).

The prototype interface was housed in a box measuring 5.1 x 8.4 x 3.3in fitted with 25-way and 37-way connectors. A 5V supply to power the interface was taken from the microcomputer for convenience.

Continued from page 76

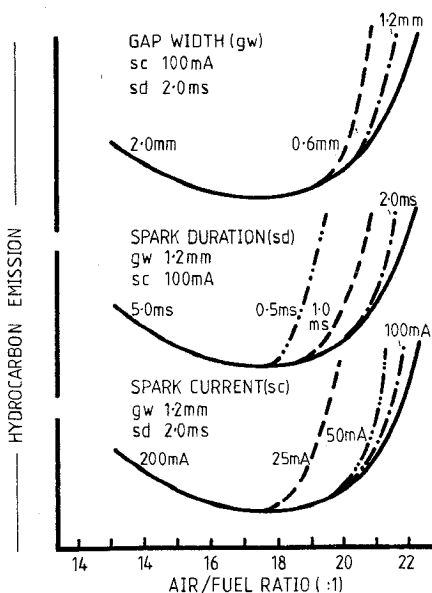


Fig. 5. Combustion efficiency as measured by unburnt hydrocarbon emission is improved by increasing energy content only on engines running on lean fuel-air ratio. Curves are for six-cylinder engine at 2000rev/min.

660MFR mixed-dielectric capacitor was rated at 1500V d.c. 0.5µF and this proved satisfactory at an output voltage of 350V over many years. However, there are other capacitors available with improved characteristics and of these the polypropylene

dielectric type is noteworthy, as besides being a low-loss dielectric it offers smaller size and can withstand higher pulse repetition rates. It withstands very well the rapid rise and fall times during discharge and recharge and has comparable voltage ratings.

As for the thyristor, this should be generously rated. The engine compartment is a hostile environment for any device but especially so if highly stressed, so a rating of at least 3amps average and at least 600V is recommended. Usually, if the unit is abused either by short-circuit at the output, by unusual conditions on the h.t. side, or if connected to a faulty ignition coil it is the thyristor that is first to fail.

The techniques dealt with in the excellent pamphlet entitled "RFI suppression in switched-mode power supplies" by L. E. Jansson and published by Mullard, primarily concern interference via the mains, but they can quite easily and successfully be applied to this unit. Interestingly enough, a unit with no r.f.i. suppression at all did not interfere with the car radio, but of course this is not the end of the story.

**Further development**

The system described works perfectly well with  $V_o$  at 350V and  $C_1$  at 0.5µF in conjunction with a standard 12V ignition coil. There are other types of ignition coil in common use such as ballasted 6V coils on a 12V supply and so-called "sports coils"

and it may be necessary to lower  $V_o$  and increase  $C_1$  to cater for these. On some motorcycle engines two or more ignition coils may be used and there is no reason why additional capacitors and thyristors should not be added to the output of the inverter to suit, provided the original spark rate is not exceeded.

The energy content of the discharge capacitor ( $\frac{1}{2}CV_o^2$ ) at  $V_o$  350V is 30mJ, which may be considered to be on the low side. Some authorities\* recommend a much higher energy content to achieve greater fuel economy, but the graphs in Fig. 5 show that combustion efficiency as measured by unburnt hydrocarbon emission is only radically improved by this means on engines running on lean petrol-air mixtures. The further ramifications are not dealt with here; the graphs are included if you want to experiment with the basic unit, which readily lends itself to modification.

The performance of the basic unit can be simply increased by raising the operating frequency, the power throughput being very approximately proportional to this frequency; the limit for the FX range is 25kHz. It would be necessary to substitute the 1N4000 diodes with high-speed rectifier diodes as used in switched-mode power supplies and probably substitute the TIP3055 drive transistor as well.

\* D. Anderson, Letters to the editor, WW Nov. 1974, page 426.

# Cepstrum analysis

## Theory, applications and calculation – 2

by R. B. Randall B.Tech., B.A. and J. Hee, M.Sc. Brüel & Kjaer

**The detection of periodic patterns in spectra – harmonics, sidebands or echoes – is the basis of a host of cepstrum applications, in seismology, engine noise analysis, loudspeaker measurements, and speech analysis. Part 1 in the last issue discussed theory, this part explains echo detection and removal, while part three discusses speech analysis and machine diagnostics.**

The application of the cepstrum to echo detection and removal is based on the fact that echoes give a periodic structure to the spectrum which becomes a series of delta functions in the cepstrum and which are easy to locate and remove. In the case of non-ideal reflections the cepstrum contains the impulse response of the reflection instead of a delta function and can thus be used to measure the properties of a reflecting surface.

Starting with the case of an ideal reflection, a signal containing an echo can be modelled as the convolution of the original signal with a pair of delta functions, one of unit area at time zero and one at the echo delay time with reduced weighting, corresponding to the attenuation of the echo, Fig. 6. This convolution in time corresponds in frequency to a multiplication of their respective Fourier spectra (by the convolution theorem) and on taking the logarithm of the spectrum the effect of the echo becomes additive. The spectrum of the pair of delta functions can be derived intuitively by considering the analogous case of a spectrum consisting of two such delta functions and determining the corre-

sponding time signal by virtue of the symmetry of the Fourier transform. As illustrated it could be considered as a unit d.c. component with a smaller additive vector rotating with a period of  $1/\tau$  where  $\tau$  is the echo delay time. The resultant has periodically varying amplitude around zero dB and periodically varying phase around zero, the periodicity in both cases being at intervals of  $\tau$  in the spectrum. The effect of a forward rather than an inverse transform is only to reverse the direction of rotation of the vector.

This periodicity in the logarithmic spectrum transforms by an inverse Fourier transform to a series of harmonics in the cepstrum (either power or complex) with a spacing equal to  $\tau$ . Thus, the existence and delay time of echoes is much easier to establish in the cepstrum than in the autocorrelation function, where even perfect reflections would give a scaled-down version of the autocorrelation of the original signal at the echo delay time. Only in the limiting case of white noise would this be a delta function. Thus, the cepstrum is much less sensitive to the shape of the power spectrum, and this can of course be considered a direct result of the logarithmic conversion.

The other advantage of the cepstrum over the autocorrelation function is that the effect of the echoes is additive, and thus subtracting the delta functions from the cepstrum removes the effect of the echoes completely. The use of the cepstrum for locating echoes and measuring their delay time has been found useful in seismological investigations and underwater measurements and is described inter-

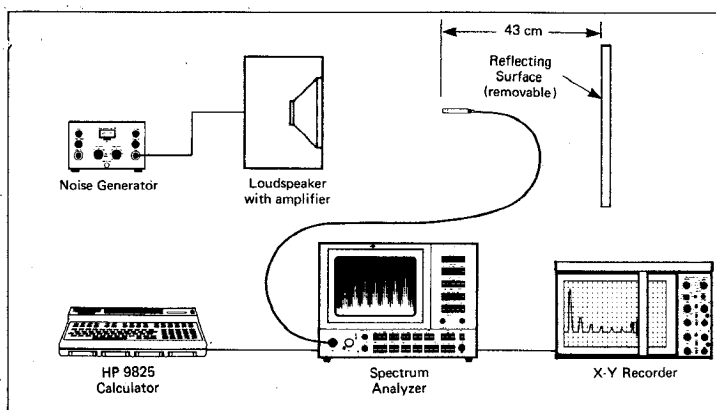


Fig. 7. Instrument set-up for echo removal.

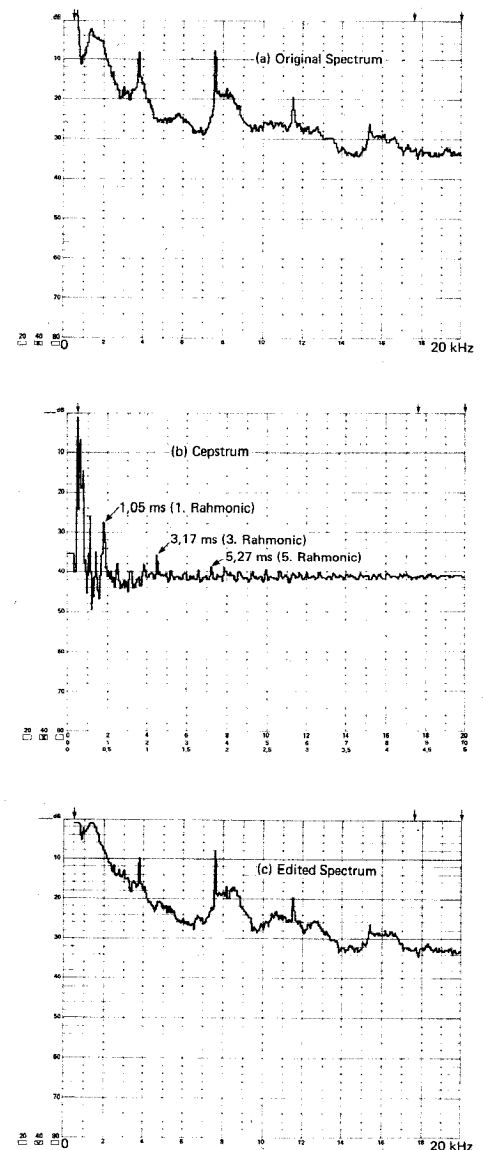
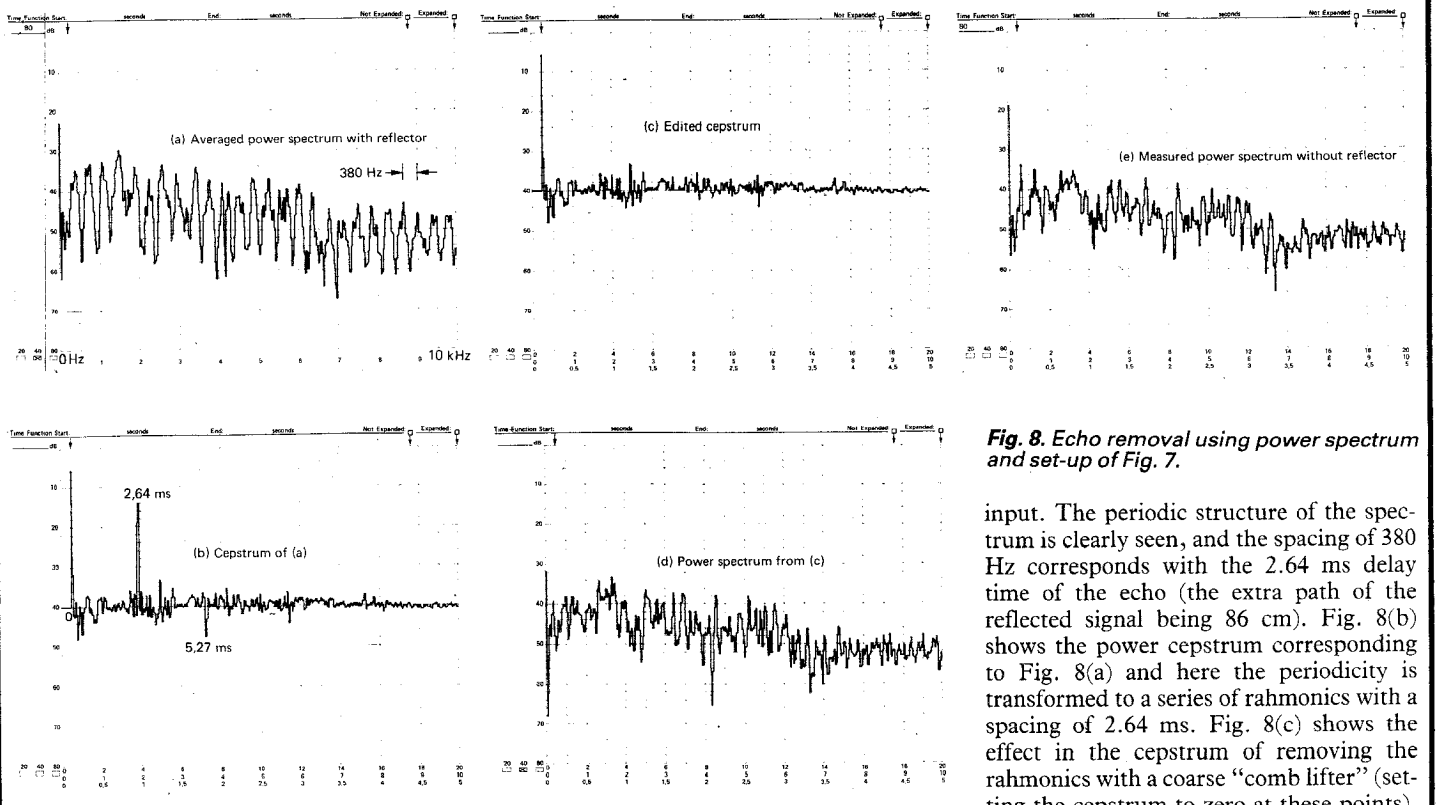


Fig. 9. Removal of ground reflection delay time of 1.05ms results in edited spectrum at (c).

al. in ref 5, some describe the use of the complex cepstrum for removing all echoes in seismic signals and recovering the original wavelet.

An example will be given here of the use of the cepstrum for removing the effect of an echo from the power spectrum of an acoustic signal from a loudspeaker with a reflecting surface behind the microphone. The instrument set-up is shown in Fig. 7. and the measurement results in Fig. 8. Fig. 8.(a) shows the averaged power spectrum of the signal received at the microphone when the loudspeaker is supplied with a white noise signal at the

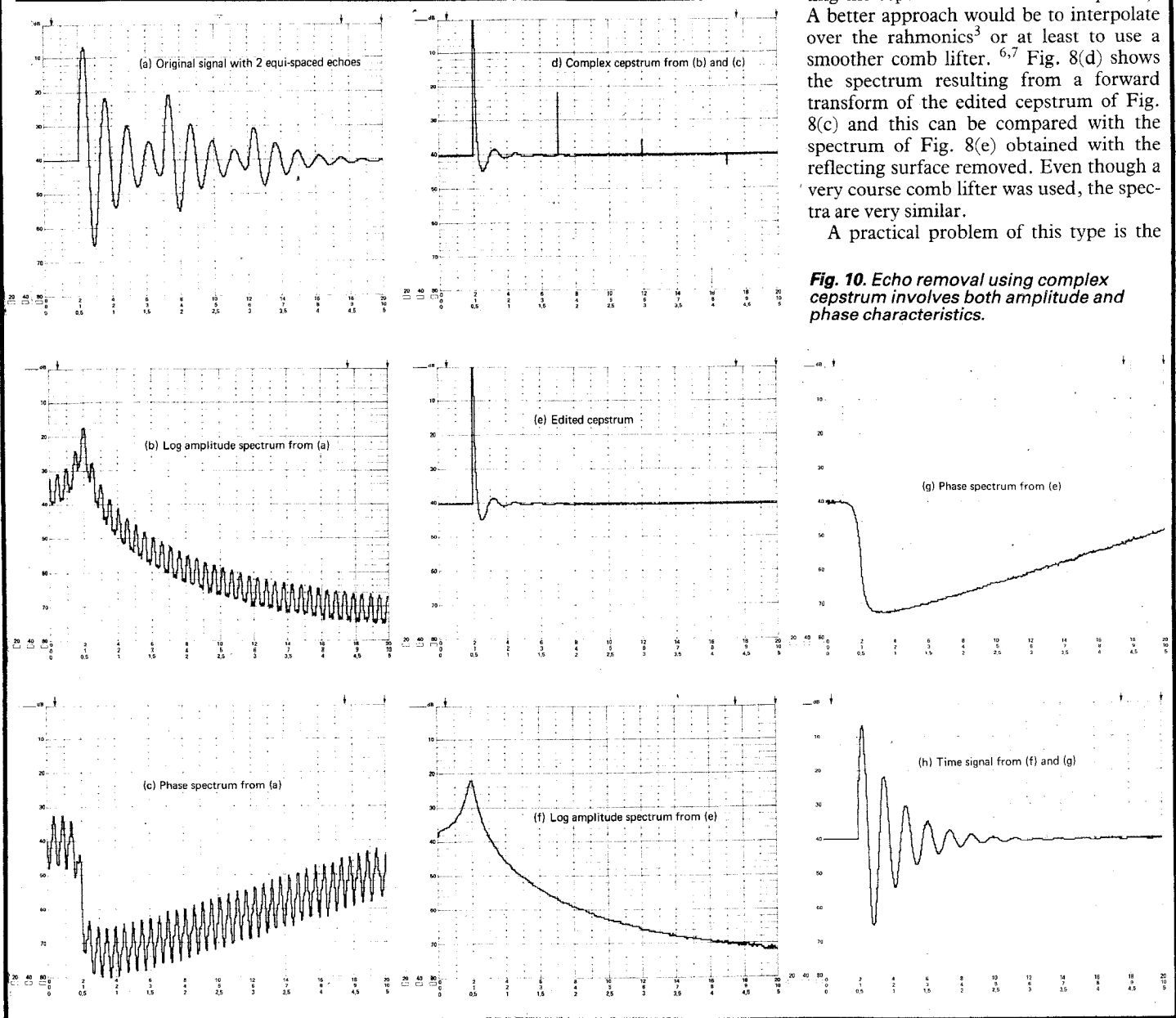




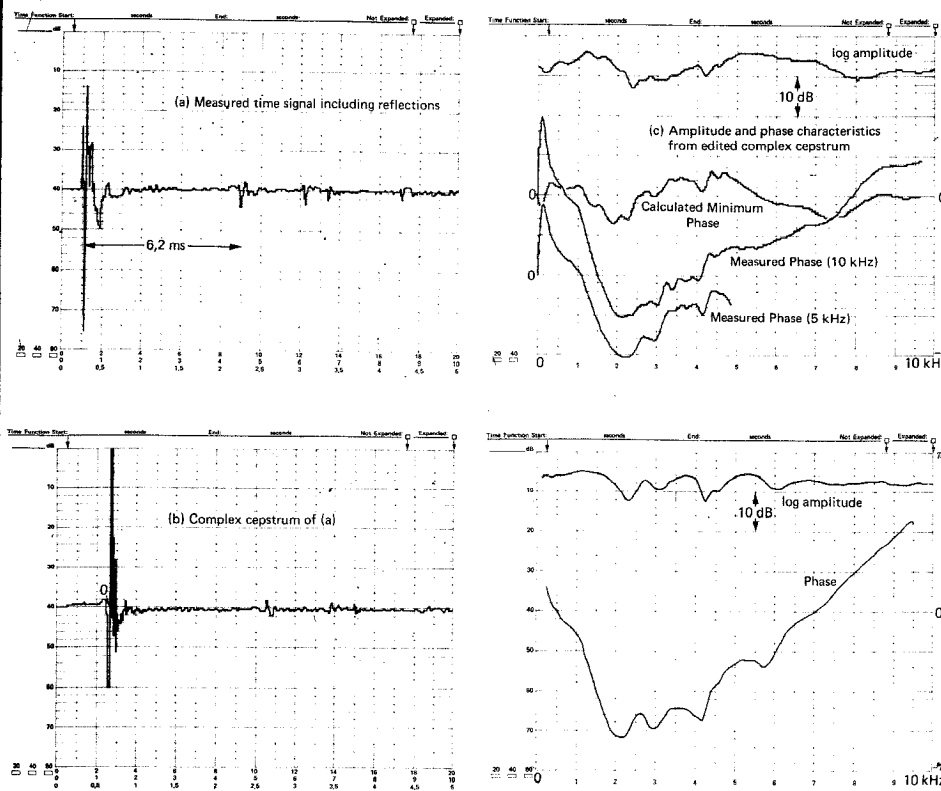
**Fig. 8. Echo removal using power spectrum and set-up of Fig. 7.**

input. The periodic structure of the spectrum is clearly seen, and the spacing of 380 Hz corresponds with the 2.64 ms delay time of the echo (the extra path of the reflected signal being 86 cm). Fig. 8(b) shows the power cepstrum corresponding to Fig. 8(a) and here the periodicity is transformed to a series of harmonics with a spacing of 2.64 ms. Fig. 8(c) shows the effect in the cepstrum of removing the harmonics with a coarse "comb lifter" (setting the cepstrum to zero at these points). A better approach would be to interpolate over the harmonics<sup>3</sup> or at least to use a smoother comb lifter.<sup>6,7</sup> Fig. 8(d) shows the spectrum resulting from a forward transform of the edited cepstrum of Fig. 8(c) and this can be compared with the spectrum of Fig. 8(e) obtained with the reflecting surface removed. Even though a very coarse comb lifter was used, the spectra are very similar.

A practical problem of this type is the



**Fig. 10. Echo removal using complex cepstrum involves both amplitude and phase characteristics.**



**Fig. 11. Measurement of loudspeaker characteristics in a hard room using complex spectrum, compared with results obtained by time delay spectrometry (bottom right).**

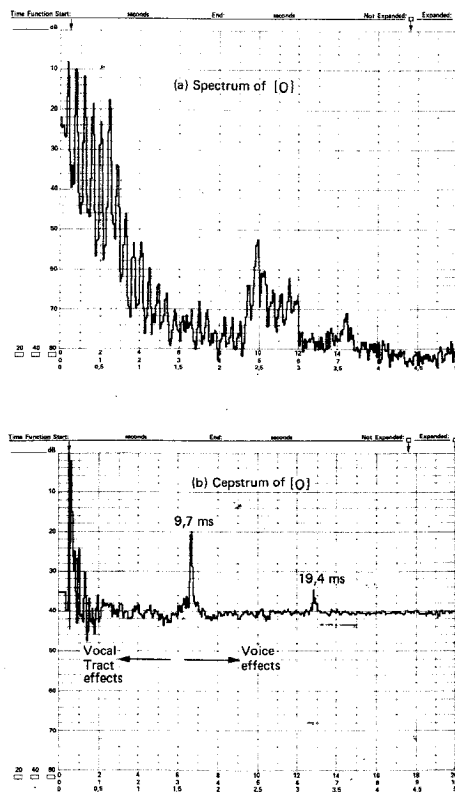
measurement of aero engine noise on the ground, where ground reflections become mixed with the direct signal. Fig. 9 shows the results of measurements in a case where the delay time was 1.1 ms. Removal of the 1, 3 and 5 harmonics of this frequency in the power cepstrum results in quite a different spectrum shape. Reference 8 discusses the potential of this technique based on a successful preliminary investigation.

A similar procedure can be used to measure the amplitude characteristic of a loudspeaker in a room, obtaining virtually the same results as in an anechoic chamber<sup>7</sup>. Impulse excitation was used rather than noise. The reflections from the three pairs of walls were edited away in the cepstrum using three comb lifters adapted to the three reflection times. Very good results were obtained as low as 50 Hz, whereas editing of the reflections directly in the time signal only gave good results down to 1,000 Hz.

The complex cepstrum will give both amplitude and phase characteristics: numerically generated example illustrates the basic principle, Fig. 10. Even though the reflection overlaps the original signal, the delta functions in the complex cepstrum are reasonably well removed from the cepstrum of the basic signal: it is much shorter than the original signal because the logarithmic spectrum is much flatter than the direct Fourier spectrum. It is simple to remove the effects of the echo from the cepstrum, and transforming back to the time signal shows that the removal has been efficient.

Fig. 11 shows the result of applying the same technique loudspeaker excited by a 50  $\mu$ s square pulse in a normal room. The first part of the time signal shows a

number of reflections starting at about 6.2 ms delay time. In contrast to the numerically generated example the phase spectrum had to be unwrapped and scaled down appropriately before calculation of the complex cepstrum (b). Reflections in the cepstrum are spread out, indicating non-ideal reflections (see next section) and so a fairly drastic short-pass lifter was ap-



**Fig. 12. Spectra and cepstra for vowel sound O, discussed in part three.**

plied to remove the reflections (a Hanning window falling to zero at 5 ms).

For comparison with the resulting phase and amplitude characteristics shown at (c), a measurement was made on the same loudspeaker using time delay spectrometry. Though made in a different room, the similarities are striking (d).

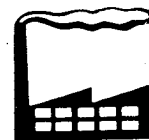
At the same time as the 10 kHz results of Fig. 11 another measurement was made using the cepstrum technique but with an upper limiting frequency of 5 kHz. Because of the double length of record, the added noise and reflections caused problems with the phase unwrapping algorithm. There were three places in the spectrum where the algorithm jumped the wrong way, introducing a discontinuity. The problem was solved by applying a decaying exponential window to the original time signal, thus reducing the effect of noise (and reflections) at the end of the record. After removal of the reflections in the cepstrum, the signal was transformed back to the impulse response, which was then compensated for the exponential window before forward transforming again to obtain the amplitude and phase characteristics. The phase result is drawn in (c) on the same scale but with twice the resolution.

The application of the complex cepstrum to loudspeakers is one case where the phase unwrapping is not difficult because the phase spectrum should be smooth and the amplitude spectrum should not contain zeros. For more general signals, the phase unwrapping can present problems<sup>3</sup>. As a matter of interest, Fig. 11(c) also includes the minimum phase characteristic corresponding to the measured log amplitude characteristic to 10 kHz, calculated as outlined previously.

**References**

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# New Products



## Microprocessor emulator

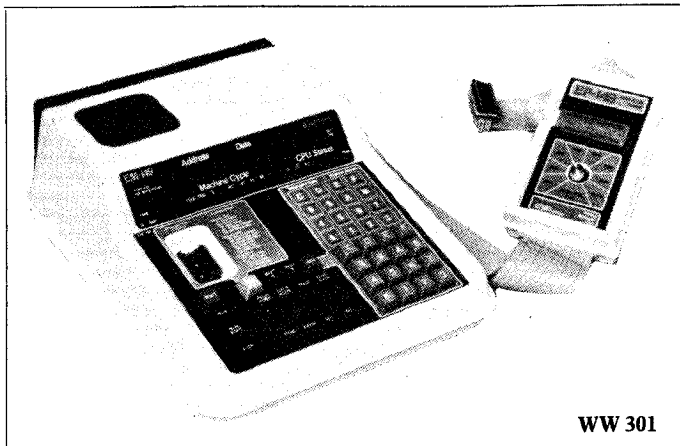
Both emulator and logic-state analyser functions are included in two instruments from Applied Microsystems. These emulators, available through Technitron, are the EM149, for Intel's 8035, 8039, 8040, 8048, 8049, 8050, 8078 and 8749 processors, and the EM189 for Motorola's 6809 devices (with internal or external clock). Emulation is in real time. In the case of the EM149, the internal trace-memory holds 254, 64-bit-wide machine cycles. The EM189's memory holds 255, 32 bit cycles. L.e.d.s and an alpha-numeric display indicate address, data, machine cycle and c.p.u. status while additional indicators show clock/reset faults and pause and breakpoint enable. Nineteen keys are used for controlling the emulator.

Technitron (UK) Ltd, Doman Road, Camberly, Surrey.

WW 301

## Lightweight video

Small size and low weight are retained in a modified version of Sony's portable Betacam 5 unit. The colour camera-recorder combination developed for ENG and first shown in prototype form at last year's Montreux tv exposition will be available in PAL format later this year. The camera and recorder units have been separated to take account of the different lifetimes of recorder and camera — in the ratio of 1:4, according to Sony's information. The camera section has identical facilities to the BVP110 including the single  $\frac{2}{3}$ in Saticon tube, whilst the tape section records five tracks (chrominance, luminance, two audio and time code) onto an L500 Beta cassette for 20 minutes. Cassettes are played on a front-loading replay-only machine, designated BVW10, resembling a BVW800 U-matic re-



WW 301

cord with which it will interface for editing. This features variable-speed picture search, time code reader, direct interface to time base corrector, RS422 control interface, and dub or composite outputs. "Target" price is under \$25 000 including lens, battery and microphone.

Sony Broadcast Ltd, City Wall House, Basing View, Basingstoke, Hampshire RG21 2LA.

WW 302

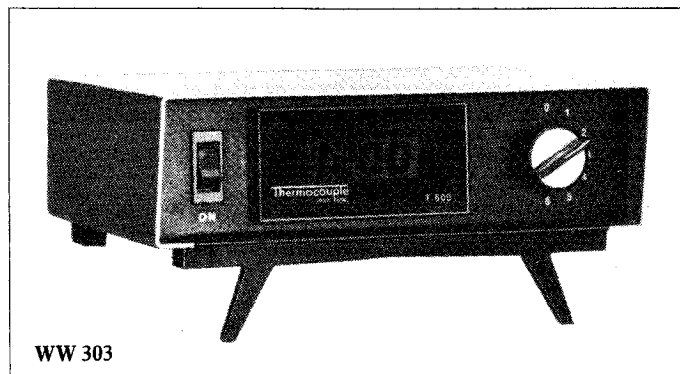
## Thermocouple temperature indicator

Once upon a time, it was considered that the more flashing lights,

knobs and switches a product had, the better it would sell. Lately, it seems as if things are going in the opposite direction. This product illustrates the trend as it indicates thermocouple temperature readings between  $-150^{\circ}$  and  $1200^{\circ}\text{C}$  with an error of  $\pm 0.2\%$ ,  $\pm 1$  digit, and the only operator controls are an on/off switch and a selector switch for one of six temperature probes. Negative or positive temperature and open-circuit thermocouple indications are given and cold-junction compensation is automatic. Readings are given on a  $3\frac{1}{2}$  digit l.c.d. The T800 can be used with any six 'K' type thermocouples.

Thermocouple Instruments Ltd, Pentwyn, Cardiff CF2 7XJ.

WW 303



WW 303

## Bubble support

Write-driver and sense functions for magnetic-bubble memories are provided by two i.c.s from Plessey Research. The CL9001 sense amplifier's sensitivity is programmable in the range 2 to 10mV and d.c. offsets of up to  $\pm 100\text{mV}$  can be tolerated at the input. Four input channels are multiplexed into two, three-state t.t.l. outputs after being latched. An externally applied voltage sets the switching threshold. The CL9002 write driver provides output currents of up to 300mA, depending on the value of an external limiting resistor, and

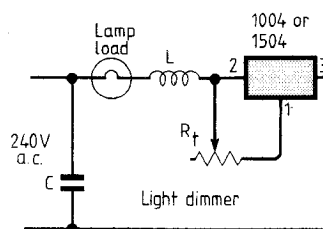
comprehensive protection circuitry is incorporated to protect the bubble memory should a fault occur. This i.c. requires a single 5V supply and the sense amplifier requires +5V and -5V supplies.

Plessey Research (Caswell) Ltd, Allen Clark Research Centre, Caswell, Towcester, Northants NN12 8EQ.

WW 304

## Triac with firing circuit

Mains power controllers in the form of a triac with integral phase-control firing circuit are now available to the electronics enthusiast from United Automation Ltd. Additional components required to make, say, a light dimmer are a



control potentiometer, a heatsink, and an inductor and capacitor for reducing r.f.i. There are two basic devices, one the 1004 rated at 10A and the other the 1504 rated at 15A, both with isolated-tab plastic packages and suitable for 240V mains operation. To encourage sales in the hobbyist field, the company are offering one device at the 100-off price, instead of the normal one-off price, to each reader sending in a copy of this item. This makes the price of a 10A device £4.71 as opposed to £6.27, of the price of a 15A device £5.28 as opposed to £7.04. These prices are exclusive of v.a.t., and UK postage and packing for the offer is 30p. Type A, with a 3.6mm mounting hole, or type B, with a 10.3mm hole, should be specified on ordering. These devices can also be obtained with a control potentiometer fitted, and with potentiometer and heat sink.

United Automation Ltd, 237A Liverpool Rd, Birkdale, Southport PR8 4PJ.

WW 305

## Eight-channel p.g.a.

In applications such as computer-controlled data acquisition systems, where a number of analogue signals may need to be selected and amplified with different gains, Burr-

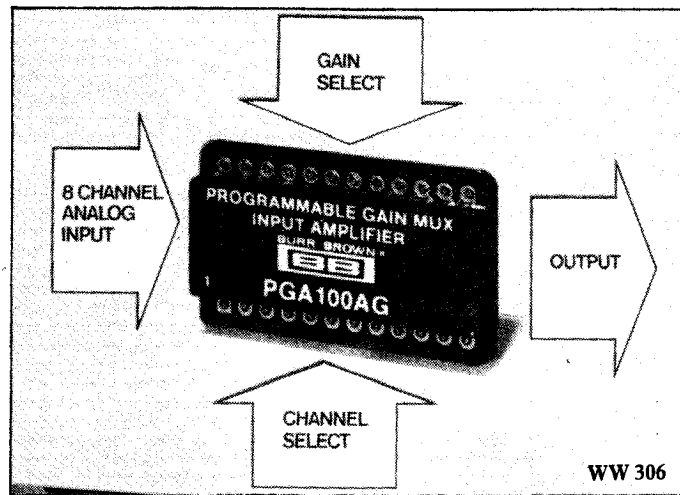


WW 302

Brown's PGA100 may be of use. Six t.t.l.-input bits are required to control the p.g.a. (programmable-gain amplifier), three for selecting one of eight analogue-input channels and three for setting one of eight amplifier-gain steps. Scaling of the amplifier's gain range between 1 and 128 is possible using an external resistor or potentiometer. Channel and channel gain are selected simultaneously and if the average source-signal level is variable, a detector circuit may be added to modify the gain-select input. Some specifications of the p.g.a. are, a maximum gain error of  $\pm 0.02\%$ , a maximum linearity error of  $\pm 0.005\%$ ,  $5\mu\text{s}$  (to  $0.01\%$ ) settling time and  $\pm 10\text{p.p.m./}^\circ\text{C}$  gain drift. A typical gain-bandwidth figure of 5MHz is also quoted for the amplifier.

Burr-Brown International Ltd, Cassiobury House, 11-19 Station Road, Watford, Herts WD1 1EA.

WW 306



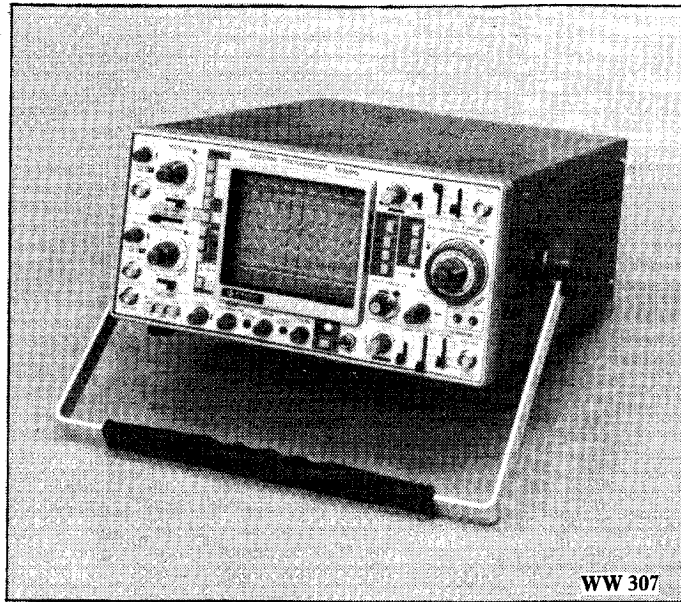
WW 306

## 100MHz oscilloscope

This 5-channel oscilloscope is, "almost certainly the lowest-cost 100MHz oscilloscope currently available in the UK", claim Telonic Berkeley. The Kikusui COS6100's voltage range for 100MHz bandwidth is 5mV to 5V/div; with magnification, the sensitivity is increased to 1mV/cm, but the bandwidth is reduced to 10MHz. Channels 1 to 5 may be displayed simultaneously or in any combination and channels 1 and 2 may be added together. When using sweep delay, both the original and delayed waveforms may be viewed together. Bandwidth limiting, various triggering modes and other functions are also included. The price, with probes and terminal adaptors is £1095, excluding v.a.t.

Telonic Berkeley (UK) Ltd, 2 Castle Hill Terrace, Maidenhead, Berks.

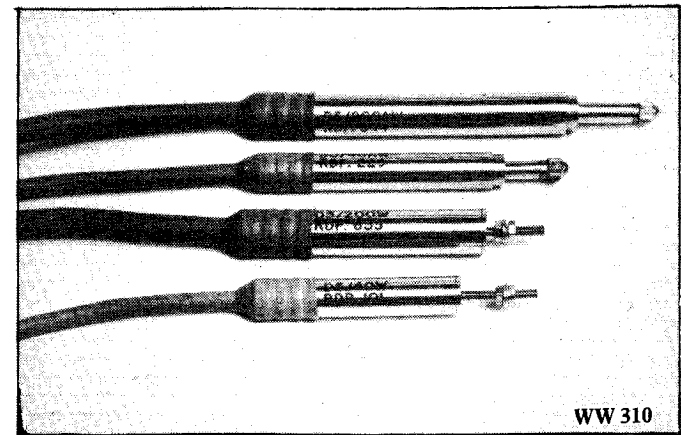
WW 307



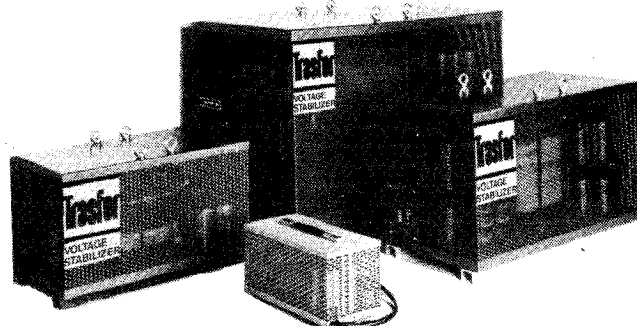
WW 307

## Line-voltage stabilizers

Some 20 different constant-voltage transformers for a.c.-line stabilization and isolation form Powerline's latest range. The largest of these is 30kVA, the smallest 150VA, and, as is often the case with this type of transformer, current limiting is inherent. Input variations from 176V to 264V a.c. give output fluctuations of  $\pm 1\%$  on versions with ratings greater than 1kVA, or  $\pm 1.5\%$  on versions below. Providing the input voltage is higher than 176V, half-cycle mains drop-outs do not appear at the 220V a.c. output and efficiencies in excess of 85% are claimed. Powerline also point out that environmentally-safe capacitors are used - this might seem



WW 310



WW 308

insignificant now, but by the time you come to discarding the transformer, who knows?

Powerline Electronics Ltd, 5 Nimrod Way, Elgar Road, Reading RG2 0EB.

WW 308

## Low-power Z80

This offspring of the Z80 microprocessor, the Z80L, is intended for use in battery powered products, and situations where continuous processing is imperative and battery back-up thus essential. Power consumption of the 80L is 75mW - around one tenth that of its parent - and three versions are available for 1, 1.5 and 2.5MHz clock rates. The i.c.s are pin and software compatible with the standard Z80 and require a single 5V supply. Zilog say that peripheral devices with similar power-consumption ratings will be announced in the near future.

Zilog (UK) Ltd, Babbage House, King Street, Maidenhead, Berks SL6 1DU.

WW 309



## Displacement transducers

Extensions in RDP's range of submersible l.v.d.t. (linear variable-differential transformer) displacement transducers have been made. These devices are made from stainless steel and have a hermetically-sealed cable to withstand submersion in up to 250ft of liquid. Measuring ranges covered by the six new types are  $\pm 1.0\text{mm}$ ,  $\pm 2.5\text{mm}$  and  $\pm 5\text{mm}$ . Three versions are in what RDP call 'precision-gauging form' to give repeatability better than 0.25 microns.

RDP Electronics Ltd, Grove Street, Heath Town, Wolverhampton WV10 0PY.

WW 310

## High-voltage m.o.s.f.e.t.s

Yet another encroachment on the bipolar's field has recently been made by Hitachi. Their 2SK351 power m.o.s.f.e.t. has a breakdown voltage of 800V and a switching time of 80ns. Among other specifications of this TO-3 packaged device are 5A drain current and 125W channel dissipation. Its on resistance is  $3\Omega$  maximum and 1.7 $\Omega$  typical.

Hitachi Electronic Components (UK) Ltd, PIE Building, 2 Rubastic Rd, Southall, Middx UB2 5LL.

WW 311



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Model CS-BP £5.30

SK5-BP Kit 7.00

Model X6-BP £5.30

SK5 Kit £6.20

Model XS £4.50

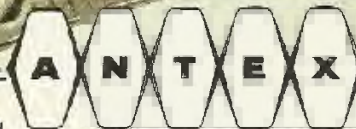
Model CCN £4.70

Model C £4.50

SK6-BP Kit £7.00

SK6 Kit £6.20

WW-002 FOR FURTHER DETAILS



WW3  
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