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March 1987

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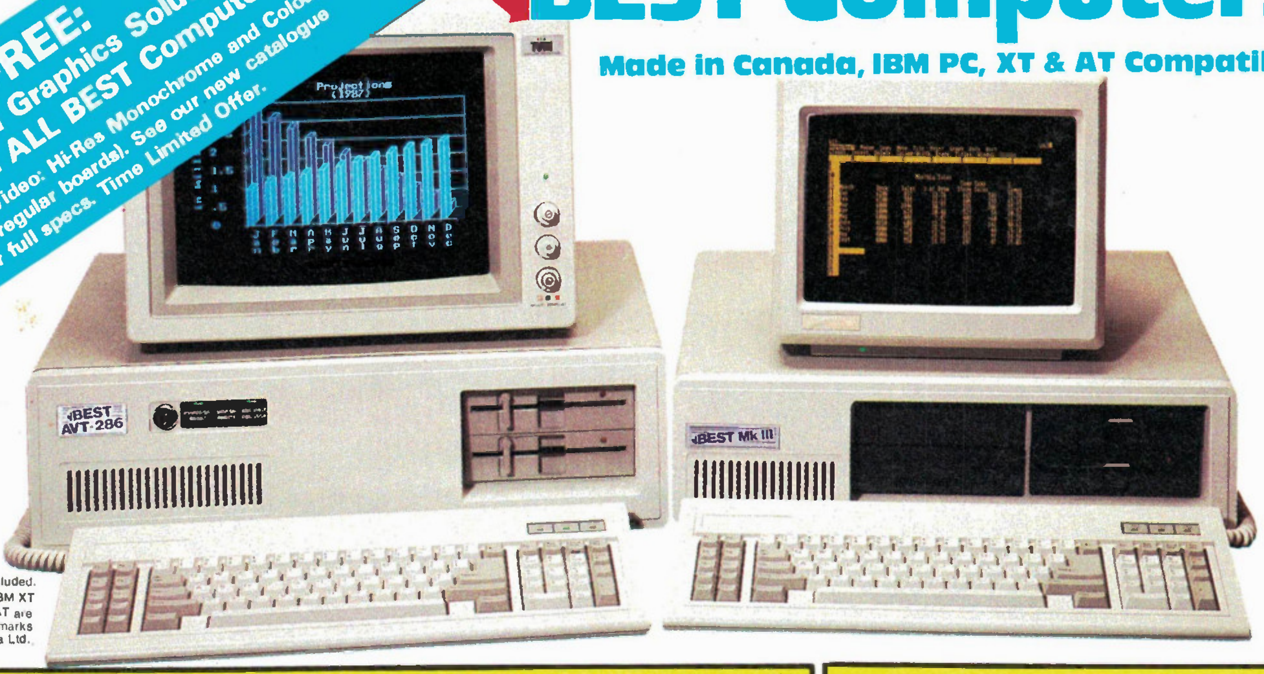

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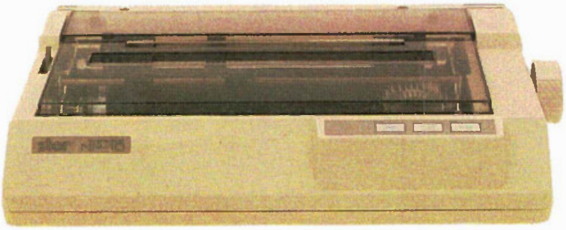

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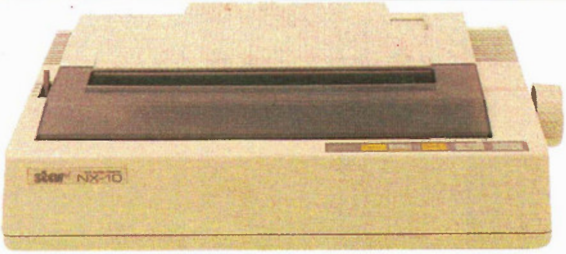

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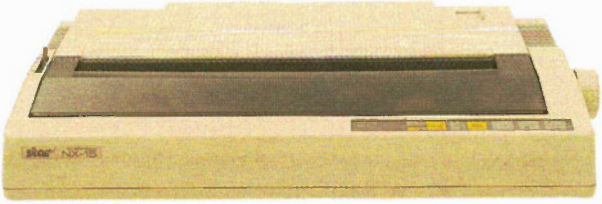

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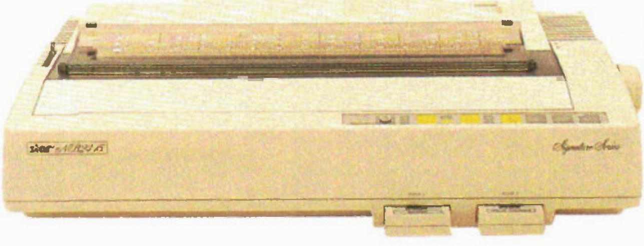

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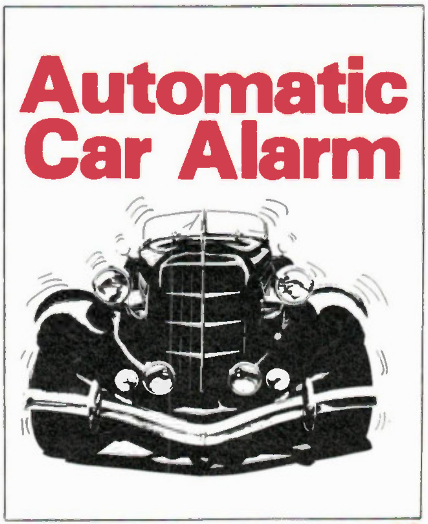

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Columns, and Information

Our Cover

The Tracer computer troubleshooter checks out a Z80 board under control of a Radio Shack Model 100; see page 34. Photo by Bill Markwick.

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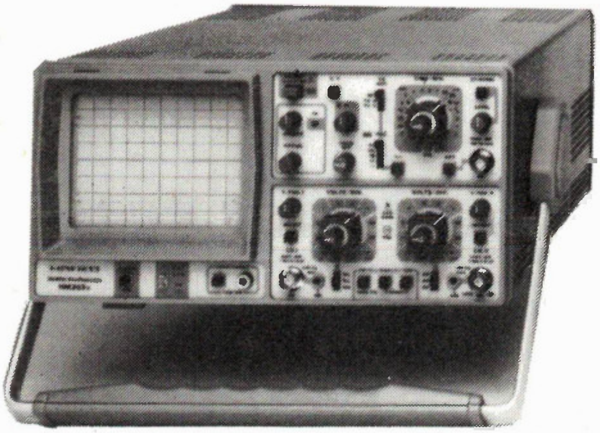

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For Your Information

The Editor's Corner

By Bill Markwick

THE Autodesk company, producers of the popular AutoCAD software, has removed the hardware device copy protection from their software and will supply unprotected versions to previous purchasers. John Walker, chairman, said that the protection was removed because of adverse public opinion and bad press. In their defence, he said that freedom to copy has resulted in a lack of good engineering software for the mass market because software developers are afraid of uncontrolled copying.

Maybe. On the other hand, he also said that implementing the protection device had no effect on sales, and that he didn't expect its removal to change things either. I suspect that there is more responsible for the lack of good software than copy protection problems that frighten off talented developers.

I think the problem has a lot to do with the popularity of the IBM PC. It was introduced as IBM's bottom-of-the-line economy model, and unfortunately became the industry standard before long. Perhaps it was advanced for its day (1982), but as is always the case, it didn't take long for software developers to run up against its limitations. These included the Intel 8088 CPU running at 4.7MHz with only an 8-bit data bus, a tortoise of an I/O system, slow 360K disks, and memory limited to 640K.

If you want to see what I mean, try running AutoCAD or other large program on a regular PC or clone. Even with an 8MHz clock and an 8087 coprocessor, you still spend lots of time gazing out the window while the disks groan and grind and the screen repaints pixel by pixel.

Then there's the problem of compatibility. The use of PC-DOS or MS-DOS is a start toward standards, but then there's the problem of graphics cards, proper I/O ports, monitors and so on.

'I know you just bought a $200 monitor. You'll have to go and buy another one. And a hi-res card while you're at it. And then your mouse needs another serial card...'

No wonder there's a lack of engineering software. Technical programs require both fast number crunching and extremely flexible graphics capabilities. Why would you bother writing a complex program for the PC when users will turn up their noses at the hardware? Computer aided design, huh. Give me my VAX, man.

I think that's all to change soon. The true-16-bit PC AT, which should have become the standard but was too expensive, is coming down in price as the cloners get to work. Waiting in the wings is the 32-bit 16MHz 80386 CPU, still too expensive for widespread desktop use, but hopefully its price will follow the usual downward trend. It'll be interesting to find out how long it will take for software writers to exceed the limits of the 386. 'How do they expect me to write a program with only 16 megabytes of RAM? When are they going to bring out a *real* computer?"

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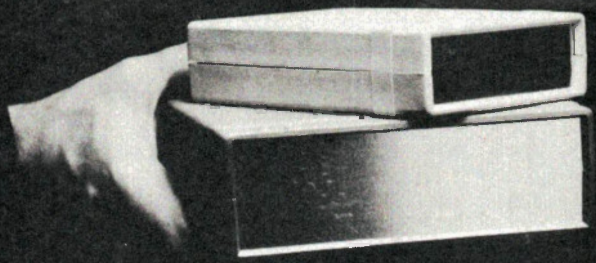

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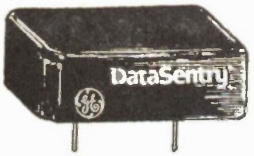

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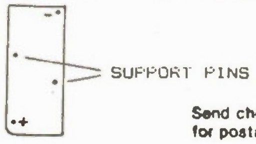

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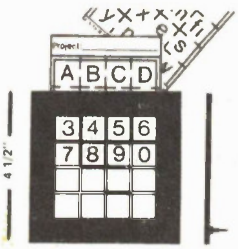

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By R.A. Penfold

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It would, of course, be possible to have two independent thermometer circuits with separate displays, but this is a rather expensive soulution to the problem. The alternative utilized here is to have a single display with the reading being taken from the sensors alternately. Switching from one sensor to the other is automatic, and a couple of LED indicators show which sensor is being read at any given time. In practice this system is easy to use, and is not really any less convenient in this respect than having twin displays.

The unit is not restricted to the application outlined above, and it has many other possible uses. It could be used in photographic applications, another use is in heat experiments in schools. Here it is often necessary to monitor two temperatures simultaneously, and for demonstration purposes an electronic instrument with a fairly large and easy to read display is obviously ideal. The unit could also be used in the home to show inside and outside temperatures although it will not read below 0 degrees.

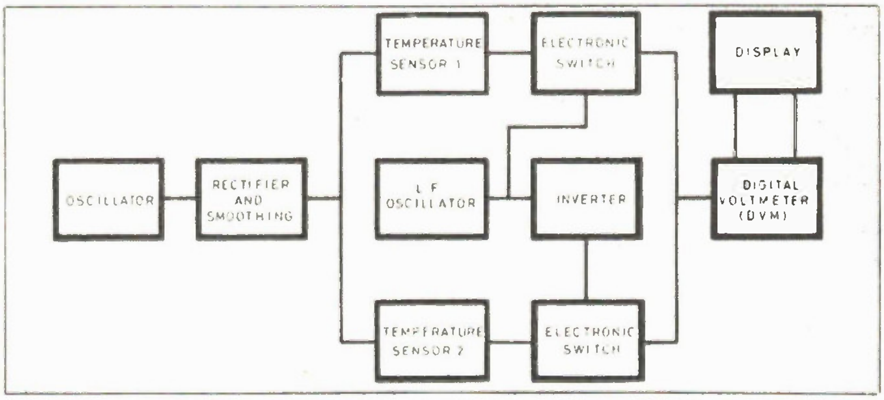

Fig. 1 Block diagram of the thermometer

The temperature range covered is 2 to 100 degrees Centigrade, but this can be extended to 2 to 110 degrees Centigrade if desired. The display is a 3½ digit liquid crystal type, giving a resolution of 0.1 degrees Centigrade, although the accuracy of the unit does not require this level of resolution over the full range. However, for comparison purposes a high degree of resolution can be very useful. The use of a liquid crystal display and a low consumption chip to drive it results in the unit having a low enough current consumption to permit economic operation from a small nine volt battery. In fact, the majority of the nominal nine milliamp current consumption of the unit is accounted for by the two LED indicators. The finished unit is very easy to calibrate, and either an accurate thermometer or a good quality digital voltmeter is all that is required.

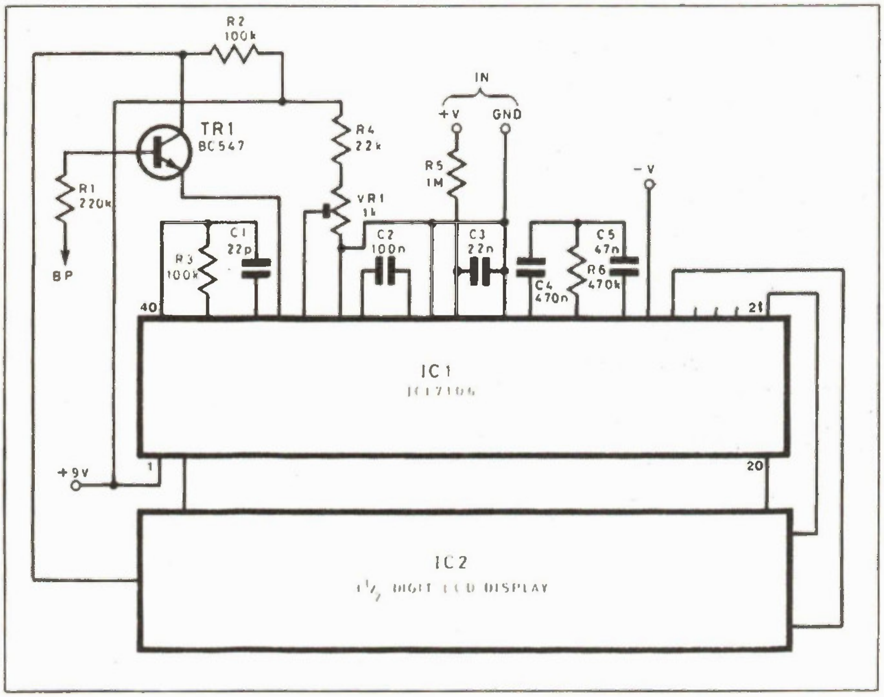

Fig. 2. Circuit diagram of the voltmeter circuit.

System Operation

A unit of this type is a highly complex piece of equipment, but the use of a digital voltmeter chip as the basis of the circuit dramatically reduces the component count. Most of the components are involved with converting temperature to a linearity proportional voltage, and with the automatic switching between one temperature sensor and the other. **Fig. 1.** shows the block diagram for the unit.

The temperature sensors are modern integrated circuits designed specifically for this purpose, and they provide an output equal to ten millivolts (0.01 volts) per degree Centigrade. This is very convenient, as with the voltmeter having a full scale value of 1.999 volts, and with the appropriate decimal point of the display switched on, this gives a direct reading in degrees Centigrade with 0.1 degree resolution. With most temperature sensors there is a DC offset to balance out, but this problem is avoided with the particular type used here.

The output of each temperature sensor connects to the input of the digital voltmeter by way of an electronic switch. One of these switches is operated direct from the output of a low frequency squarewave oscillator, and it connects temperature sensor 1 through to the input of the voltmeter during positive output half cycles from the low frequency oscillator. The other switch is fed from the oscillator via an inverter, and it connects temperature sensor 2 through to the input of the voltmeter during negative half cycles from the oscillator. This gives the required alternate switching action at a rate which is governed by the oscillator. The oscillator and inverter drive the two LED indicators.

The temperature sensors require a supply voltage in the range four to 30 volts, and with the circuit powered from a nine volt battery, on the face of it there is no problem in this respect. In reality things are not as simple as this, and the problem stems from the fact that the negative input to the voltmeter is not at zero volts, but is nominally 2.8 volts below V+. This effectively gives a supply potential of just 2.8 volts for the temperature sensors, which is obviously inadequate.

In order to avoid the need for a second battery, an oscillator, rectifier, and smoothing circuit are used to provide a voltage doubler action. Due to inefficiencies in the circuit this gives a supply potential for the temperature sensors of about +15 volts rather than +18 volts. This boost of about six volts gives a true supply voltage to the temperature sensors of almost nine volts which is comfortably more than the minimum requirement of four volts.

Voltmeter Circuit

The circuit diagram of the voltmeter section of the unit is shown in **Fig. 2**. This is centred on IC1, which is an ICL7106 DVM chip. This is the version of the chip designed for use with liquid crystal displays, and there is also a version of LED displays (the ICL7107). Where battery operation is required the latter is not a very practical choice due to the relatively high current requirement of LED displays.

IC1 uses an integration process to provide the voltage to digital conversion. It consists basically of a 3½ digit decimal counter fed from a clock oscillator, plus the integrator and some complex control logic. Looking at its operation in a somewhat oversimplified manner, the integrator converts the input voltage to a pulse of proportional duration. The clock signal is allowed to pass to the input of the counter circuit only for the duration of this pulse, and the longer the pulse, the greater the final count that is displayed. The circuit includes latches so that a valid display is always provided, and the counting action is not apparent to the user. The circuit automatically takes several readings per second.

Resistor R3 and C1 are discrete components in the clock circuit. The exact clock frequency is unimportant except in that it controls the number of readings per second. Usually a rate of just two or three per second is used, but in this case a higher rate is preferably. This is due to the switching of the input voltage source, which is not synchronised with the taking of a new readings (and cannot easily be synchronised with this). Switching of the input source inevitably occurs during the course of a reading being taken, rendering that reading invalid. Having a high reading rate results in any invalid readings being almost instantly up-dated by correct readings, and prevents misleading or ambiguous results from being obtained. The specified values give about a dozen readings per second.

Resistor R4 and VR1 are part of a reference voltage generator circuit; VR1 is adjusted to give the circuit precisely the correct level of sensitivity. R5 and C3 form a lowpass filter at the input of the circuit. The purpose of this is to combat noise on the input signal which might otherwise give unstable readings. Most of the other components are concerned with the integrator and the automatic-zero circuit (which avoids the need for any manual zero adjustment).

A simple inverter stage is formed by R1, R2 and TR1. This is used to drive the appropriate decimal point of the display with the inverted BP (back plane) signal. For those who are unfamiliar with liquid crystal displays it should perhaps be explained that they are not driven from a DC source like LED displays, but must be driven with an AC signal. A DC drive will, in fact, operate segments of a liquid crystal display perfectly well for a while, but "burning" would result after a few hours

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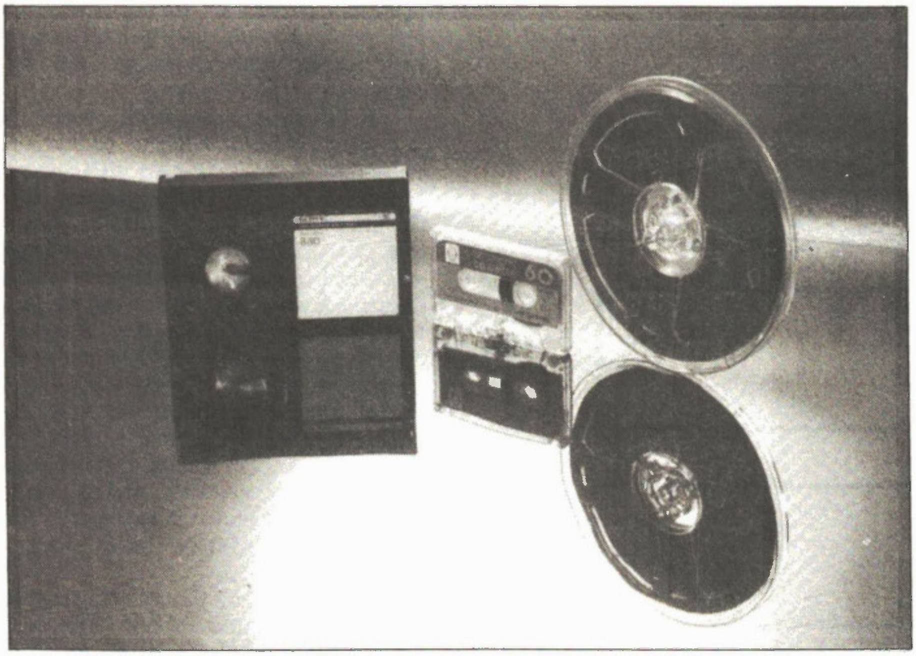

Bulk Eraser

Build this bulk eraser for your Audio Tapes

By Harold Wright

HERE'S a simple and easily built eraser for audio tapes that doubles as a demagnetizer for shop tools. It is built almost entirely from scrap parts: a few small pieces of wood, a discarded tube-type TV receiver power transformer, a switch and a power cord.

First locate one of these old transformers, the heavier the better (most experimenters have a couple kicking around in the basement). It must be in good condition and show no signs of overheating or burning. Remove the four long bolts that hold the laminations together; the laminations must be removed and this is not as difficult as it may seem. The trick is to first remove the wooden wedges that hold the laminations tightly in the coil form. Sometimes they can be pried out or drilled out using a long, thin drill in several places in each wedge. Be careful not to let the drill penetrate the coil form.

Once the wedges are out, break the first lamination away from the others using a thin bladed pocket knife. The laminations are made in an "E" form with a straight strip to close the ends of the "E" legs. The laminations are stacked so that the "E" section positions alternate with the adjacent lamination. This is shown in **Fig. 1**. The strips come loose easily, but the centre leg of the "E" section, particularly the first two or three laminations, is more difficult. Free it with a knife blade around the outside and if possible, part way down the center leg, working from both ends. Set the transformer on a wooden block, with the lamination to be removed just clear of the edge of the block. Drive the first lamination from the core using a hammer and a flat ended screwdriver that has a good square face on its blade end. Don't be worried about damaging one or two laminations at this early stage. They will not be missed during the re-assembly, in fact it may be necessary to leave a few out. The varnish coating makes it difficult to return all the laminations to the original stack. Once the first few are free, the difficult centre leg can be freed by pushing a knife or a long, thin screwdriver down between the laminations. Try to avoid bending the laminations; bent ones must be discarded because it is almost impossible to straighten them.

After the laminations are all out, remove the outer, low voltage windings and the high voltage winding leaving only the 120 volt primary in place. Be very careful not to damage the connections between the primary leads and the primary winding. Re-assemble the laminations into the coil form, with all the "E" legs facing the same way; the striaght sections are discarded. Two of the long bolts should be replaced in the two remaining holes. Slip a small angle bracket on each bolt before replacing the nuts. These will be used to fasten the transformer onto the wooden base. Tighten the nuts only slightly at this point. Brush urethane varnish liberally on the ends of the "E" section and down the sides of the outside legs, letting it seep between the laminations as much as possible. This will reduce buzzing noises. Clamp the ends of each leg with a "C" clamp and tighten the two nuts. Set the assembly to one side until the varnish dries.

Re-stacking the laminations in this fashion reduces the primary impedance to a marked degree. If it was connected to a power line and left turned on, it would likely overheat badly and be damaged or even set on fire. It is for this reason that the switch used must be a spring loaded type that goes to "OFF" automatically when released; the switch should have a 10 amp 120 volt rating. Mount the switch so

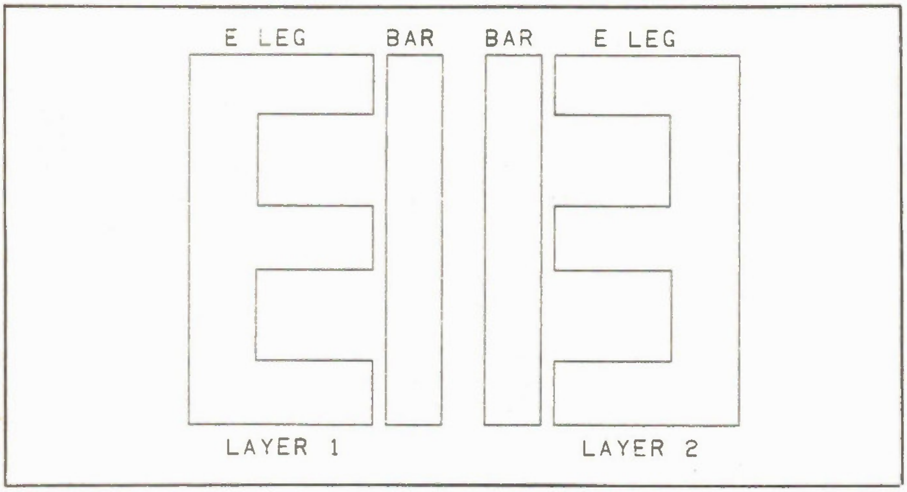

Fig. 1. Showing how, in the transformer, the E leg and bar sections alternate in position. The E leg and bar are fitted together very tightly.

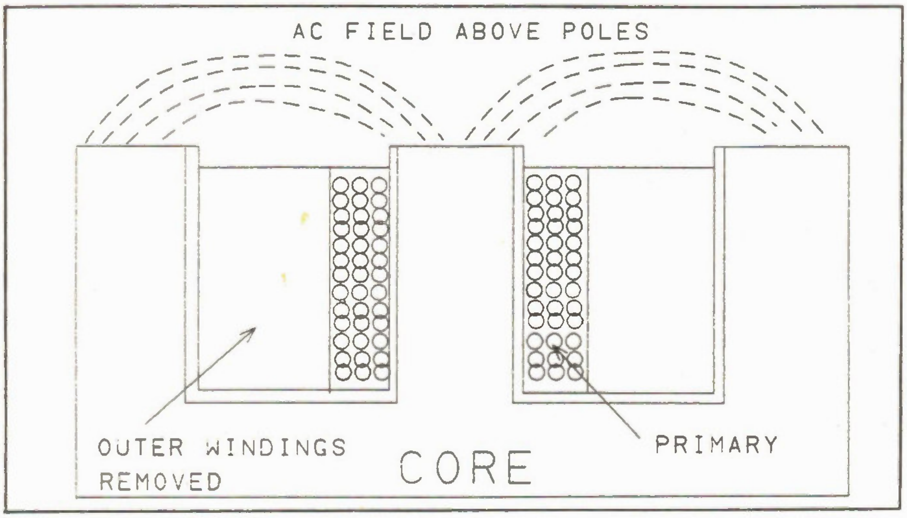

Fig. 2. Showing the concentrated AC field that exists between the poles of the redesigned transformer.

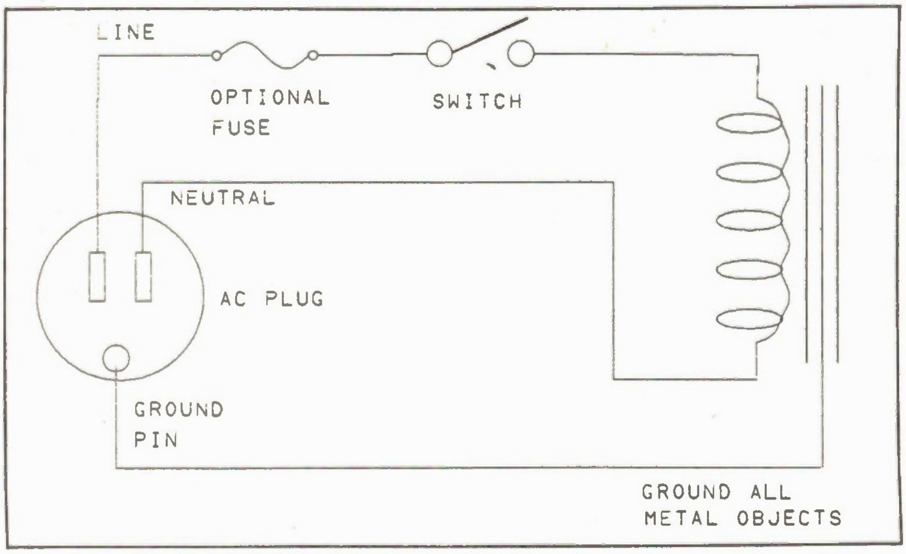

Fig. 3. The electrical wiring diagram.

that "on" is down. A fuse is necessary safety precaution. The value required will be determined by the type and size of the transformer used. The prototype transformer drew about 6.0 amps when "ON". If you have a meter with a ten amp rating (AC), finding the proper value will be easy.

No dimensions are given for the box. The size of the surplus largely determines this. Room will be needed at one side for the switch and fuse holder. The back, bottom and sides can be made from scraps of 3/4 inch pine lumber, the top and front may be made from scraps of thin panel board. The inside height of the box is important. It must match exactly the height of the "E" legs of the core so that the three ends of the "E" are flush with the top faces of the box sides. It is necessary for the ends of the "E" legs to be as close as possible to the object being erased. A piece of thin plastic panel would be even better than the panel board for the top of the box. There is a very powerful and concentrated magnetic AC field above the poles. This is shown in **Fig. 2**. The top must NOT be made of metal, not even non-ferrous metal. Make a hole in the back wall to pass the power cord through. Anchor the cord inside the box with a small clamp. The wiring circuit is delightfully simple and appears in **Fig. 4**.

Operation

Plug the unit into a power receptacle. Hold the switch down and place the reel or cassette on the top face for a few seconds, sliding it around in a rotational pattern. Keep the switch down and slide the tape slowly off the top until it is completely clear of the magnetic field, then release the switch. Tapes erased this way are less noisy than those erased by recording over the top of a previously recorded program. Professional audio personnel and broadcasters use a similar system for erasing audio and video tapes. For video tapes the device is usually larger. The prototype was tried on a video cassette and did an "almost" job of erasing the tape. If you are lucky enough to have one of the large, low voltage transformers from an early type computer power supply, you could have an eraser that could handle video cassettes.

The unit is also excellent for demagnetizing shop tools. It will demagnetize screwdrivers, drills, pliers and wrenches, even quite large wrenches. The same rotational and withdrawal techniqes described for tapes should also be used for tools. Tools come off this eraser completely clear of residual magnetism. A commercial version of this eraser, in a Toronto wholesaler catalog, is priced at $182.00. Your cost for the unit described here might be $2 to $3 for the power cord. ■

BUILDING with VERO

Veroboard is a familiar material to most constructors. Here are some facts you may not have known, along with plenty of hints and tips for its use.

By Vivian Capel

THE BEST and easiest way of building a circuit is undoubtedly by using a ready-made, custom-designed, printed-circuit board. All the layout problems have been solved by someone else, all the components will fit providing they are as specified, so all that is required is to mount them and solder.

But a ready-made board may not be available, and will not be if the design is your own. The next option is to etch one yourself. For this you will need etching solution, a suitable plastic bath, an etch-resist pen or transfers, and a drill to make the holes for the component wires. If you make a lot of PCBs all these will be at hand and you'll take the job in your stride. But if your project building is less frequent, making a one-off board is expensive and something of a chore.

So we turn to the humbler Veroboard, which consists of a board printed with copper strips along its length and drilled with a matrix of holes. The strips can be cut at any desired point, so a wide variety of circuit configurations can be created. Many experienced constructors tend to look down on Veroboard, and indeed it has some disadvantages, but this disdain is unjustified, for most of the snags can be overcome with considered layout.

The pitch of the strips and that of the holes along them is 0.1 inches (how did this escape metrication?) which means that IC pins can be inserted readily in the board. There is also a 0.15 matrix which is less popular now because it is incompatible with IC pins. It is useful, though, for larger discrete components if you can get hold of it.

Some variants of the normal Veroboard are Verostrip in which the strips run across the width of the board instead of the length, and V-Q board. The latter has the strips cut after every four holes thus avoiding the need of cutting (**Fig. 1**). It also saves space because you lose a hole with each cut on Veroboard, whereas the V-Q cuts are between holes. The snag is that there are no complete uncut strips which are needed for supply and ground lines. An improvement would be to have every fourth or fifth strip uncut for this purpose.

Electrical Characteristics

There are two factors which are sometimes queried with matrix board, and these are the capacitance between strips, and their resistance. Neither are mentioned in the supplier's catalogues. It may be though that the inter-strip capacitance would be quite large; however, capacitance is proportional to the facing area of the adjacent conductors. As the strips are laid edge to edge, the facing area is quite small.

Actual capacitances measure 2.5p per inch between adjacent strips for the 0.1 matrix, and 1.6p for the 0.15. The smaller capacitance of the latter is because the conductors are farther apart.

Capacitances of this order should prove no problem for any circuit other than those involving the higher radio frequencies in the megahertz range. It should be remembered, though, that transient pulses can contain frequencies in the RF spectrum and a sensitive part of the circuit could be triggered by a large pulse on an adjacent strip. The rule is, then, to keep such ill bedfellows well apart.

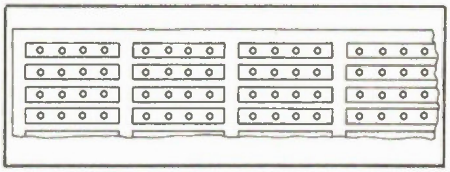

Fig. 1. VQ board consisting of matrix board divided into groups of four holes.

The other factor is resistance. If you connect an average ohm meter across a Vero track it will read zero resistance. That doesn't mean that there isn't any, only that it is too low for the meter to register; most will not indicate readings below around half an ohm.

The disadvantage with Vero, is what is said to be an advantage with a certain popular domestic product - all those little perforations! Each hole takes up over half the track and so conductivity is reduced at each one.

The resistance for 0.1 matrix is 10 milli-ohms per inch length. For the 0.15 matrix it is 7.5 milli-ohms per inch. If, for example, a one-amp signal current flowed along a five-inch length of 0.1 vero, there would be a 50mV drop across it. Currents of several amps are by no means unusual in output or even driver stages, so supply or ground lines common to earlier stages could be feeding back sizeable signals, resulting in instability and other ills.

There could be significant feedback with much smaller currents, such as between the input and output circuits of high-gain op. amps with common tracks. Another possibility is that decoupling capacitors could actually inject unwanted signals on an ground run common to another part of the circuit. One very troublesome fault experienced by the author on a prototype proved to be due to this very cause.

In power circuits, grounding points must be carefully chosen, especially for reservoir capacitors. These carry ripple current which is equal to the total supply current, so appreciable hum voltages can be developed over quite short print runs.

For vulnerable tracks, such as those for supply and ground, the resistance can be lowered by running solder along the entire length of the track. This has been found to drop the resistance by nearly a half, from ten to six milli-ohms per inch. Another solution is to use two adjacent tracks for the same supply but link them only at the supply end. One should feed the output or high current stages and the other the input sections.

Layout

The first thing to do when devising the layout for a circuit is to plan it out on paper. To construct it "as you go" rarely works out unless the circuit is a very simple one or you have plenty of board space to spare. Usually you find that an extra hole or connecting strip is needed where there isn't one, so several components must be re-sited to make room.

It would be nice if pads of Vero planning paper were available so that components could be sketched in, just as it is for Veroblock, the solderless prototype breadboard system. Unfortunately none has been produced as yet; perhaps some enterprising manufacturer will take the hint and fill the need, but until then paper planning means ruling your own. This is quite a chore, but well worth it as once you have got it right on paper, construction is much easier.

It helps to make the plan larger than the actual board, say twice normal size. Components too will have to be scaled up proportionately. When ruling the paper make several carbon copies to save repeating the job if more plans are needed. Better still, if you have a computer and printer with graphics capability, make a plan and store it for future use.

A common pitfall is to allow too little space for some components, so check in advance how many holes are covered by each. Resistors and capacitors can be mounted either vertically or horizontally. When resistors are mounted horizontally they span about three or four holes, but when fitted vertically they can usually be connected across adjacent ones. Vertical mounting is more economical, but horizontal fitting can be useful when the component must bridge across to another part of the board.

Capacitors are generally available in two formats: radial, with the wires coming from the same end for vertical mounting, and axial, with a wire at both ends for horizontal fitting. Axials can be mounted vertically, but take an extra hole in this position than their radial counterparts.

Planning

Having determined the space required for each component, positioning on the plan can commence. The first step is to establish the power supply and ground strips. It is usually most convenient to put these at the two edges of the board. If there are two supply lines, a positive and negative, these could go on opposite edges of the board, and the ground conductor along the middle. Alternatively, the two supply lines can be two adjacent strips at one edge with the ground at the opposite edge. With this layout there is less likelihood of confusing them when the board is turned over than if they were at opposite edges.

Next, sketch in the components lightly in pencil so that alterations can be made, and ink in when finalized. Remember to mark in the polarity of diodes, transistors and electrolytics. Position the major components in such a way that their associated small components can be mounted around them and link easily with their feed circuits. Usually this means orientating the component with its positive electrode toward the positive supply line, and the negative and ground wires toward their respective supplies. Sometimes a sideways aspect facilitates the connection of other related components without hindering the connection to the supply strips.

Remember that the board has to be supported, so extra room must be allowed for fixing screws or stand-off posts. Alternatively, Veroboard can be obtained with the strips terminated with edge-connector contacts. These can be plugged into a mating connector which both connects and supports the board. This is ideal for equipment where boards need to be quickly changed to provide alternative functions or for quick substitution servicing.

Connections to conventional boards should be brought out as near to the edge as possible to make the later soldering of connecting leads easier. Terminal points buried amid a forest of components are not easy to locate or connect.

One of the drawbacks with matrix board is that all connections to a single point in the circuit are strung out in a line, instead of being grouped in a cluster as they are with custom-made PCBs. This means that stages tend to spread horizontally, merging with other parts of the circuit, thereby making later circuit identification difficult.

A cluster can be achieved with Vero by using two adjacent strips (**Fig. 2**). The snag is that they have to be linked and this means the loss of one hole from each for the linking wire. To avoid this, one of the wires from a component can be extended from its hole to a hole in the adjacent strip, thus losing only one hole, or it can just be soldered flat on the adjoining strip without losing any. Other holes would be lost, though, because four cuts, each using a hole, would be needed to isolate the two strips instead of only two for the single one. Cuts between holes can be made with a sharp knife if space is at a premium, but it is better to use a cutting tool on the hole.

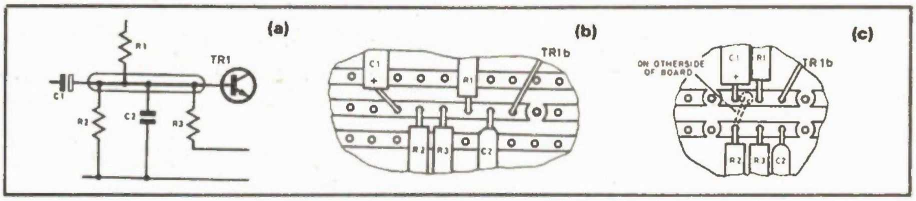

Fig. 2. When several connections have to be made to a single point as in circuit (a), the result on Vero can be elongated as in (b). A more compact and convenient group can be made if two adjacent strips are used. A link can be made by soldering a wire from one component across the two strips (c).

It is not essential that all connections be made via the print; if two or three small wire-ended components are vertically mounted close together, their free ends can be easily connected. Instead of twisting the wires which makes them difficult to free later if required, a spiral wire connector can be made up and fitted. This is formed by winding a short length of 22 AWG wire on a small screwdriver shaft to make a spiral some 5mm in length (**Fig. 3**). Slip this over the wires and solder. To remove a wire, just melt the solder and lift off the spiral. All the connections in pre-war Philips radios were made in this manner.

But back to our planning. Give particular regard to the possibility of common-impedance coupling discussed earlier. Avoid it by arranging the return from any high current components to be

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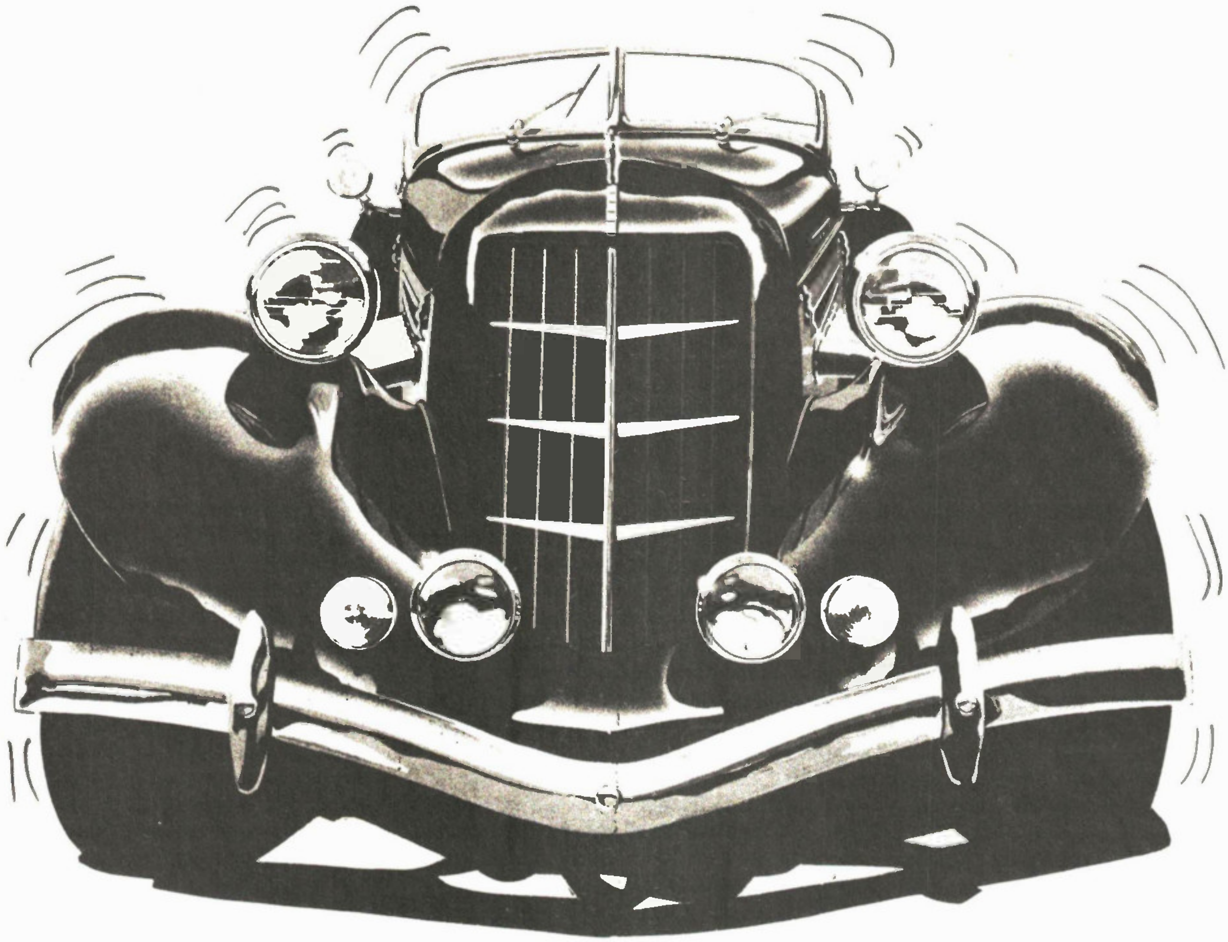
Automatic Car Alarm



Protect your car and its contents with this easy to use alarm.

By Paul Harding

MANY DIFFERENT methods of detecting illegal entry to a vehicle have been tried, from motion or vibration of the car itself to small voltage drops appearing at different parts of the car electrics. This design uses the large voltage swing that occurs at the ground end of the courtesy light, as the car door is opened, as a trigger source.

No holes need be cut for keyswitches in the body of the car since the circuit is both fully automatic and is provided with entry and exit delays.

The circuit is enabled and disabled by the ignition switch—it will arm within about ninety seconds of turning the ignition off (the exit delay), and can be disarmed at any time by turning the ignition to Phase 1. To act as a preliminary warning to both authorised and unauthorised users, a buzzer sounds during the entry delay period of approximately twelve seconds. The courtesy light is also held switched on, so that the ignition switch can be found quickly and easily even on wet evenings when the user will far prefer to have the car's door closed.

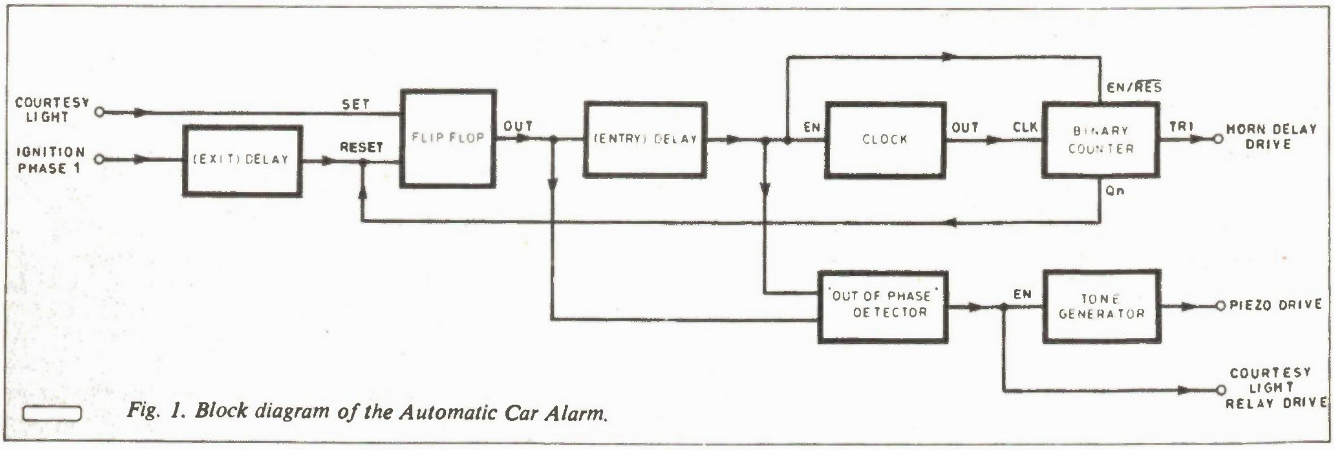


Fig. 1. Block diagram of the Automatic Car Alarm.

As is required by law, the circuit will switch off after a preset time. This time is set with a link to be either 1.25, 2.5 or 5.0 minutes, approximately. The relays specified for the project are rated at 10A for the horn and 2A for the courtesy light; in most cars this will mean that additional relays will not be needed. The project is suitable for negative ground vehicles only.

Circuit Operation

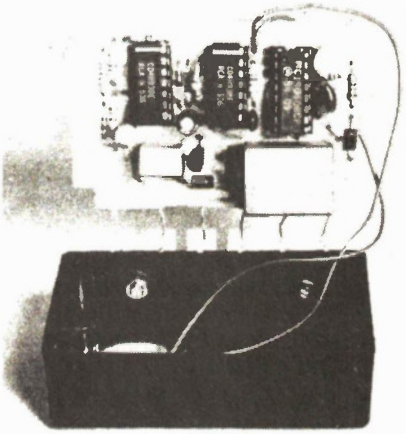
Consider the block diagram (Fig. 1), and assume that the exit delay has timed out. If one of the car's doors is opened, the courtesy light line becomes active, and the flip flop is set. The entry delay introduces a pause before the main alarm is triggered. If during this time, the ignition switch is moved to phase I the alarm resets and no further action is taken. If this is not done, however, the entry delay will time out, enabling the clock, and hence, via the binary counter, and driver stages, the car's horn.

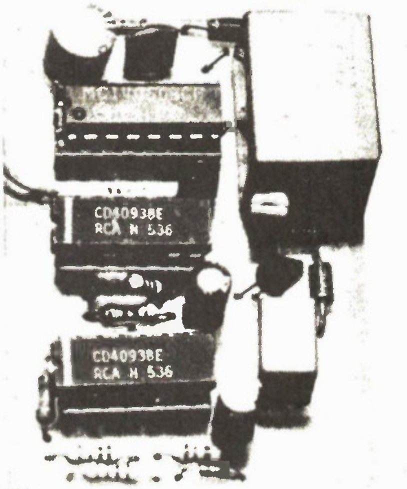
After a preset number of clock pulses, Qn will swing high and reset the flip flop. If the car door has been closed, the circuit will switch off and rearm itself. If the car door is still open, the above procedure will repeat. To prevent the alarm being triggered as the user leaves the car the exit delay holds the flip flop reset for a short time after the ignition phase 1 line becomes inactive.

The "out of phase" detector is active during the time that the flip flop's output is high and the entry delay's output is low, i.e. during the entry delay period. During this time, the warning buzzer is sounding, and the courtesy light is held on regardless of whether the car's door is open or closed.

Note that the logic levels referred to above do not necessarily agree with those in the actual circuit.

Looking now at the circuit diagram, **Fig. 2**; Cars are intrinsically electrically noisy places, and R1 to R4 protect the circuit's inputs from spikes, D6, R11 and C5 remove spikes from, and decouple, the supply lines.





The exit delay function is provided by C1, R2 and IC1a. When the voltage across C1 is greater than the upper input threshold of IC1a, as is the case when the IGN line is high, and for a short time after it goes low, the gate's output holds the flip flop around IC1b, and IC1c reset, and hence C2 fully charged, regardless of the status of the CL line. As C1 discharges, the voltage across it will cross the CMOS lower input threshold, IC1a's output will swing high, and the circuit will arm. D1 ensures that any other items connected to the IGN line do not rapidly discharge C1 as the ignition is turned off, thus disabling the delays.

With the exit delay timed out, circuit operation is as follows: When the car's door is opened, IC1b's output swings high, and IC1c's goes low. This condition is latched. Capacitor C2 starts to discharge through IC1c via R6. When the voltage across C2 reaches the CMOS low input threshold, the combined clock and counter IC2, is enabled, and the relay is driven from the now pulsing output.

The Qn output of IC2 will go high after (2 to the power of n-1)/16 pulses as measured at the Q4 output, where n = 12, 13 or 14. When this happens, pin 12 of IC1c is pulled low by the output of IC1d via D2, the former's output swings high and C2 rapidly charges to Vdd via D3. The counter is reset, the clock disabled, and the circuit rearms. Taking the IGN line high at any time will have a similar effect. With the component values shown the turn off time is approximately 1.25, 2.5, or 5.0 minutes, with n = 12, 13, or 14 respectively.

The tone generator is a standard Schmitt trigger oscillator driving a piezo resonator, X1. Three of the NAND gates in the circuit are required to be Schmitt trigger types, because they are fed from slowly changing voltages. These are shown with the Schmitt symbol on the circuit diagram. For ease of PCB design, however, all the remaining NAND's are also Schmitt's although this is not necessary for correct circuit operation.

The relay drivers are standard common emitter switching circuits. Diodes D4 and D5 protect their respective transistors from reverse EMF's as the relays switch off.

Construction

Construction should not present any problems, assuming a soldering iron with a fairly fine tip is used. Insert and solder the three topside links, into the PCB (Fig. 3), first; one of them is partially covered by IC2 and so must not be forgotten at this stage! The links should be followed by the resistors and diodes. Link 1 on the underside of the board can then be made to the appropriate pad using, preferably, PTFE insulated wire (the insulation does not melt at normal soldering temperatures). Do not forget R5, R8 and R9, which also mount under the PCB IC sockets are recommended for the ICs. Next come the capacitors and transistors. Ensure that the transistors, diodes, and C1, C2 and C5 are orientated correctly. C5 must have a lead pitch of 2.5mm; if a 100*u* device to this specification cannot be found, a 47*u* component will suffice.

Lastly, solder in the relays and insert the ICs into their sockets, again ensuring correct orientation. They all point towards the top of the board.

If the specified case is used, the connector block can be screwed onto one of its long sides. Cut some small notches along the side of the case. Then, with the completed PCB placed upside down in the case, short lengths of tinned wire (use heavy gauge for the horn and the courtesy light connections) can be screwed into one side of the connector block and the other end soldered to the correct pad on the PCB, passing over the notches. An adhesive foam pad stuck onto RLA and the case bottom will ensure that the board is mounted securely. It would be wise, however, to test the circuit first.

If the cased version of the piezo-resonator is being used, it can be glued or bolted to the outside of the case and its leads brought inside through a small hole (Fig. 4). The uncased version needs a larger hole cut in the case; its brass face will then glue under the hole. Two fine wires needed to be soldered to the uncased resonator, one to the silvered centre, the other to the brass surround. Leave the iron in contact with the silvered face for a short time as possible.

Testing

Connect the circuit to a 12V power supply. Connect a multimeter switched to resistance across the two horn connectors. Briefly short the IGN pad to the positive line. Connect the CL pad to ground; the resonator should not sound. A high impedance voltmeter or oscilloscope monitoring pin 5 or 6 of IC1 should show a slowly falling voltage. Using a standard (one megohm) oscilloscope probe the rate of decay will be about ten times faster than it will be in normal use.

As the observed voltage reaches about four volts the buzzer will sound. Remove the CL-ground connection. A short time later a pulse train should be apparent at pin 9 IC2, and the multimeter should indicate alternately an open and short circuit at the horn pads. If not, ensure that C2 has fully discharged, pin 11 IC1 is low, and R6 is not open circuit.

After the appropriate time delay, the circuit should switch off the rearm. An extremely thin pulse will be observed at the Qn ouput of IC2. Retrigger the circuit by briefly taking CL low. With the multimeter, check that the CL pad is grounded during the time that the buzzer is sounding.

Installation

The unit should be mounted in a dry place, because the case is not particularly watertight. The most convenient place will probably be near the steering column, since all the required leads will be nearby. The connection diagram (Fig. 5), although not exhaustive, show the basic idea. Use heavy gauge wire for the horn connections, as they will probably have to carry the full horn current of perhaps 8A.

The easiest way of making the connections to the existing wiring will be with Scotchlock connectors. Alternatively, cut the relevant wire, slip on a length of heat

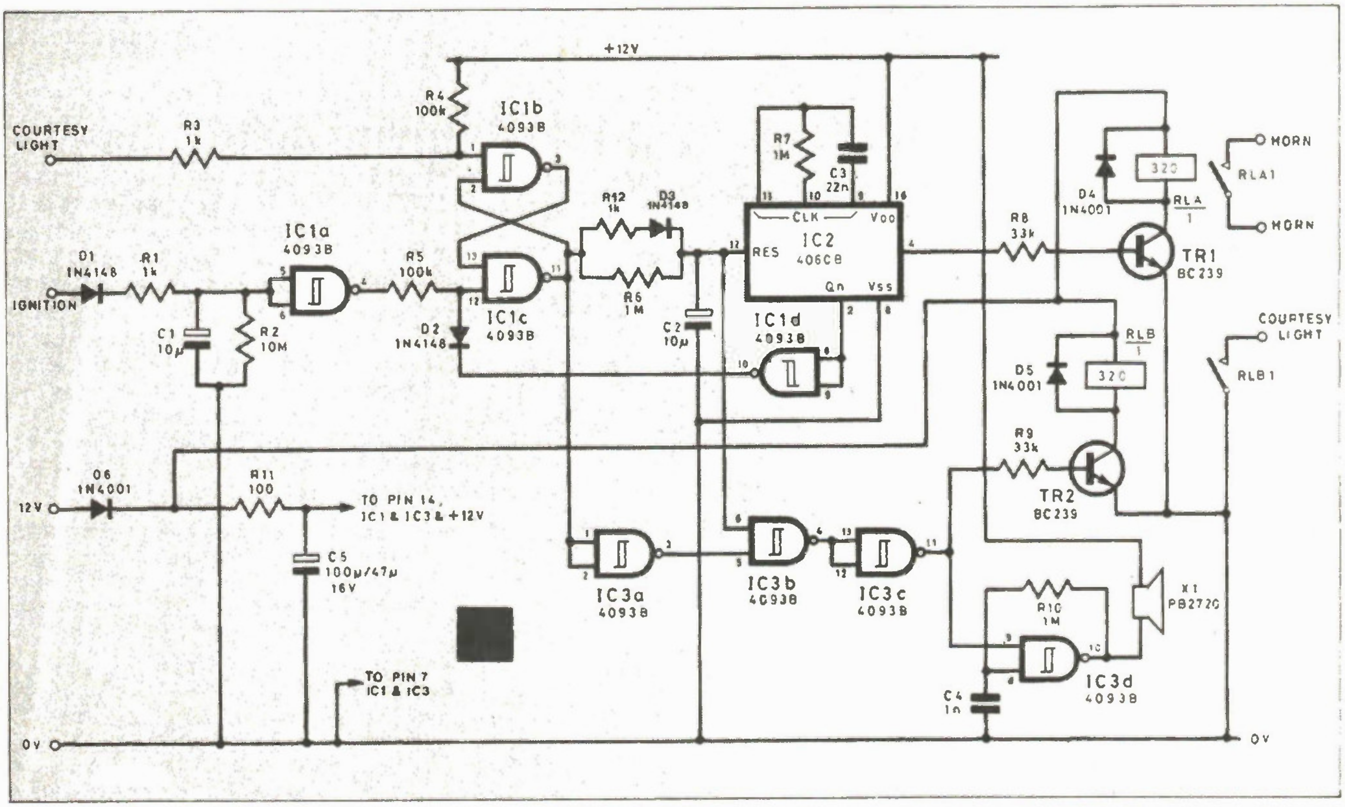


Fig. 2. Complete circuit diagram of the Automatic Car Alarm.

shrink tubing, and solder the new wire and the original two ends together, insulating the joint with the tubing. In locating the correct wires, and annotated circuit diagram for the car will be found very useful.

Parts List

Resistors — All 0-25W, 5% tolerance

R1, R3, R12	1k
R2	10M
R4, R5	100k
R6, R7, R10	1M
R8, R9	33k
R11	100

Capacitors

C1, C2	10*u* electro 16V
C3	22n
C4	1n
C5	100*u* or 47*u* electro 16V

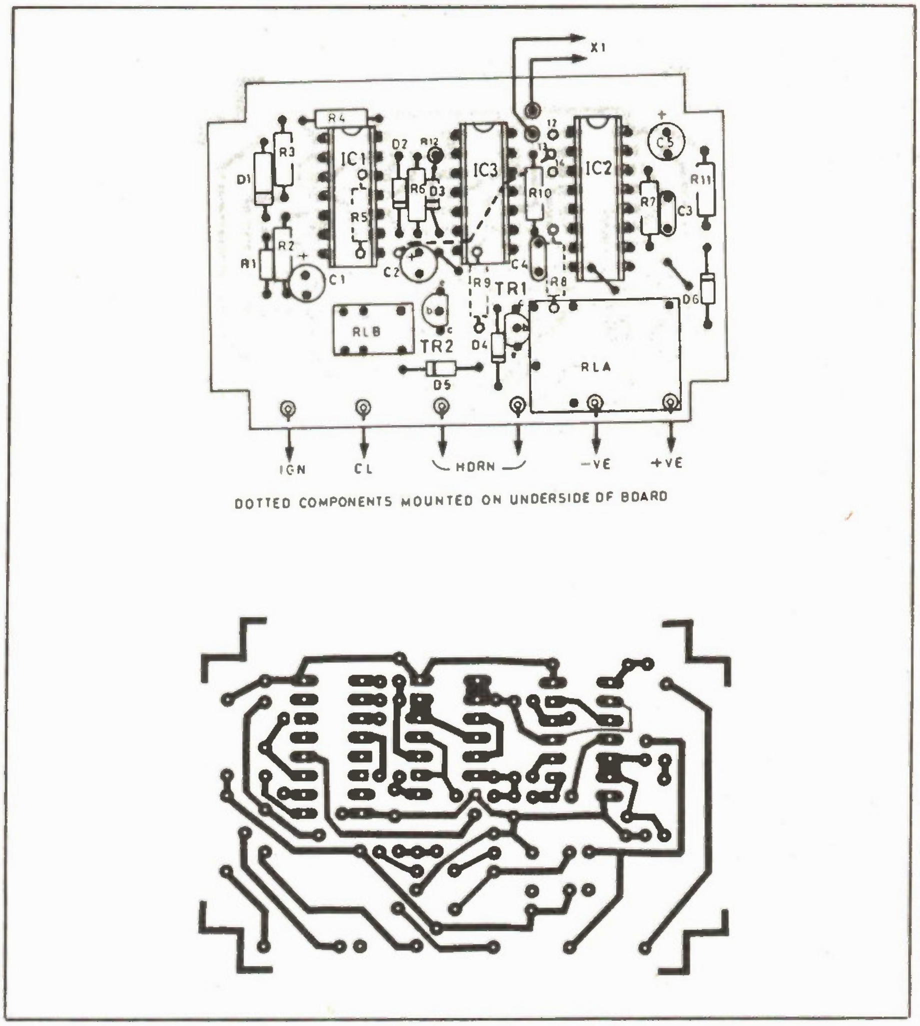
Semiconductors

D1 to D3	IN4148
D4 to D6	IN4001
IC1, IC3	4093B Quad 2-input NAND Schmitt
IC2	4060B 12-stage ripple-carry binary counter
TR1, TR2	BC239

Miscellaneous

X1	piezo buzzer, Radio Shack 273-073
RLA	12V 320 ohm coil 10A relay
RLB	12V 320 ohm coil 2A relay

Case, printed circuit board, 6-way 5A connector block; mounting hardware; wire; heatshrink sleeving, etc.



DOTTED COMPONENTS MOUNTED ON UNDERSIDE OF BOARD

Fig. 3 PCB layout and wiring.

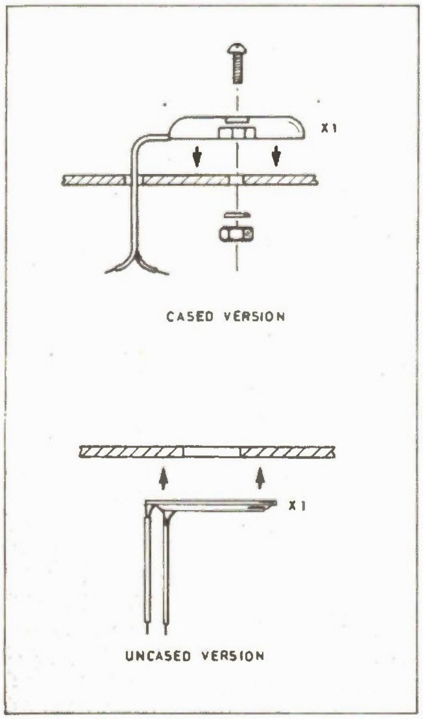


Fig. 4. Mounting details of the two types of piezo-electric sounders.

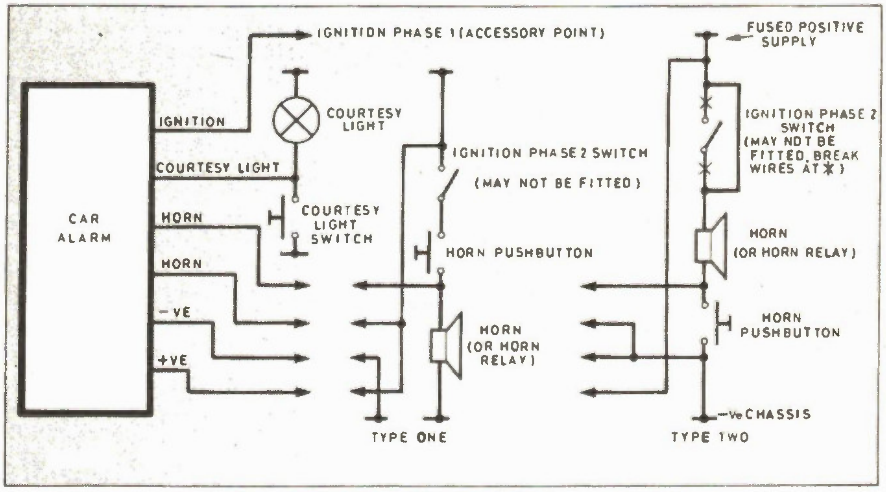
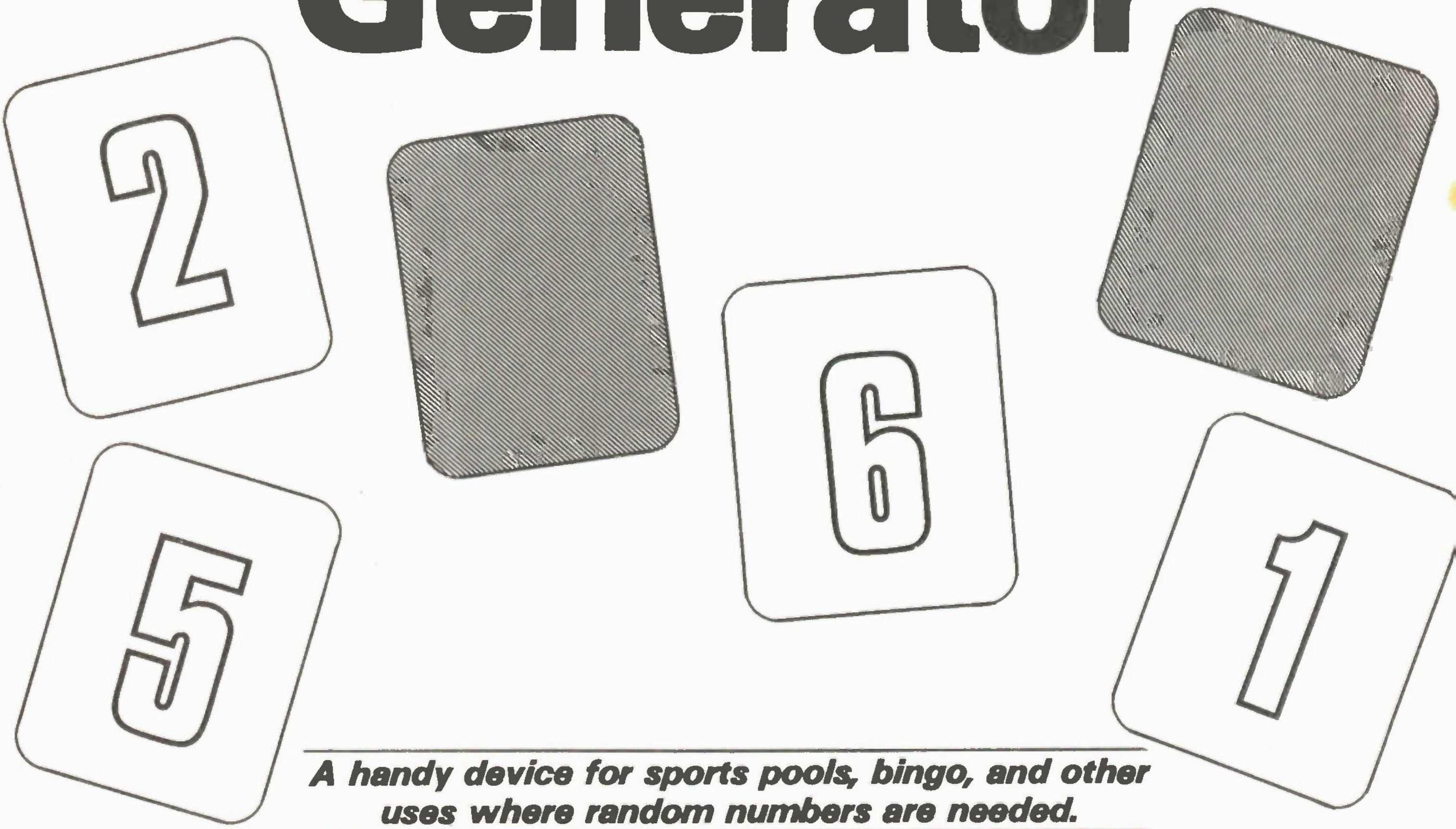


Fig. 5. Connection details. ■

Random Number Generator



A handy device for sports pools, bingo, and other uses where random numbers are needed.

By N.P. Naughton

THERE IS MUCH evidence to suggest that the "form book" is no guide to success on the football pools. This is why so many people adopt door numbers, birthdays or other random ways of making match selections - and often win! Others frequently do not have time to study form. This project offers a simple, time-saving method of producing random numbers from 1 to 55 for standard pools coupons and also numbers from 1 to 90 for playing bingo with the family or some local group, perhaps.

When the project's pools/bingo switch is in the desired mode, the select button is pressed and after this is released a random number appears in the display. Although there may be some repetitions of numbers, these should not be so numerous as to be bothersome. A double zero which sometimes occurs is ignored.

The project uses 74LS TTL ICs and all components are readily obtainable from most suppliers.

Principle of Operation

Driven by a clock pulse generator operating at around 50kHz, the main logic circuitry of **Fig. 1** counts up to 56 or to 91 several hundred times per second. After a burst of clock pulses from S1 to the counting circuits, the display freezes on the number corresponding to the last particular pulse counted so that selected numbers are quite random.

Every number from 1 to 55 or 1 to 90 exist for an equal period resulting in there being no bias towards or against any particular one. Numbers 56 and 91 are used purely to produce reset pulses and are much too short lived to be seen in the display.

Circuit Description

In the circuit of Fig. 1 IC1 is the versatile 74LS13 dual NAND Schmitt Trigger. The first half of this is connected in the multivibrator mode and with the values of C1 and R1 given, oscillates at a fixed frequency of about 50kHz. The second half acts as a pulse shaper ensuring clean pulses which are applied, via S1, to the CK A input of the decade counter IC2. This IC operates as a units counter alongside IC4 which counts tens.

It will be helpful to keep in mind that IC2 does not respond to the leading (positive going) edge of a pulse applied to CK A. A pulse is counted only on its trailing (negative going) edge. Also a 74LS90 can only count if at least one Reset 0 pin and one Reset 9 pin are low. So long as this last condition is true, IC2 repeatedly counts incoming pulses in decades, from 0 to 9. At any instant the number thus far counted appears at the Q0, Q1, Q2 and Q3 outputs and these BCD voltage levels are applied to the inputs of IC3.

IC3 is a BCD-to-Seven Segment Decoder Driver designed to drive common-anode LED numerals Table 1 shows how this IC composes decimal numbers from the BCD input levels. The 74LS47 is an active low driver which simply means that a segment is illuminated only when its associated output is low. X1 displays the counted units.

In order to create a Carry pulse for the tens counter, the Q0 and Q3 outputs of IC2 are routed to the three inputs of IC6a which is connected as a two input AND gate. When the IC2 count reaches 9 (see Table 1 and 2) IC6a turns on and its output sets up a high positive level on the CK A input of IC4. But when IC2 resets to 0, IC6a turns off and the high level on CK A goes to low. This negative transition is the trailing edge of the carry pulse which is then counted as mentioned earlier. IC5 decodes the tens which are displayed by X2.

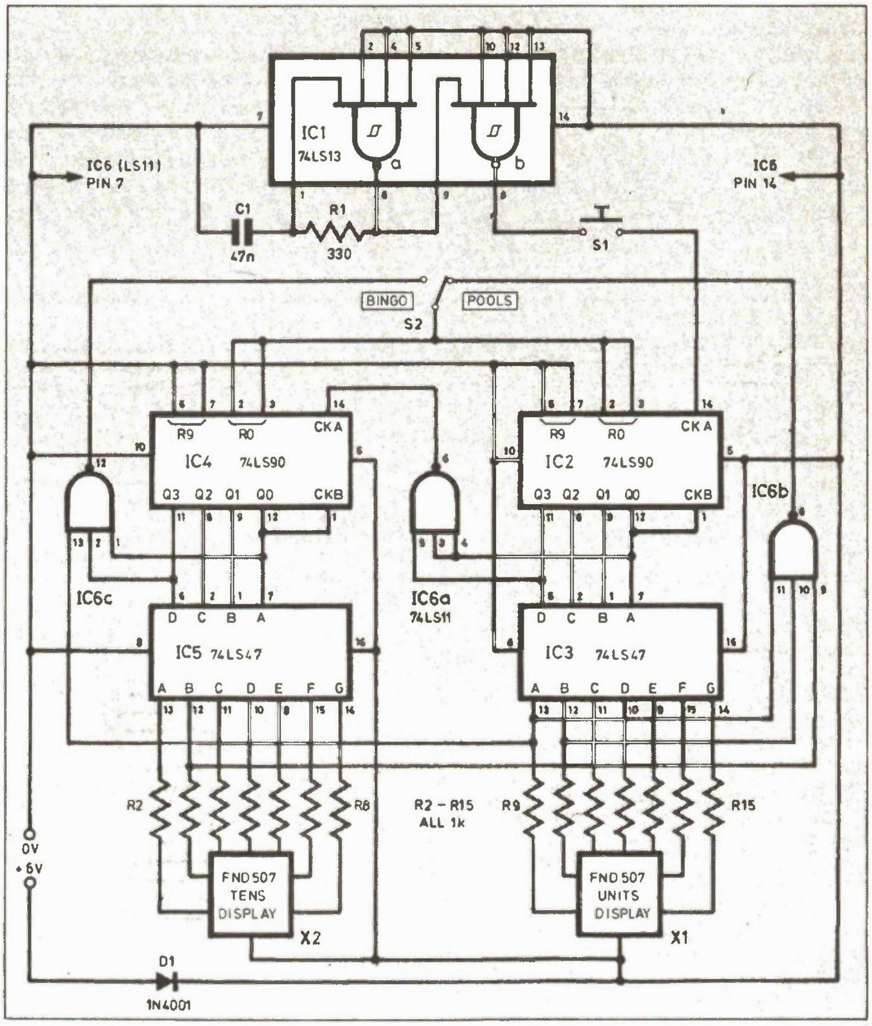


Fig. 1. Circuit diagram of the Random Number Generator.

	D	C	B	A	a	b	c	d	e	f	g
0	0	0	0	0	0	0	0	0	0	0	1
1	0	0	0	1	1	0	0	1	1	1	1
2	0	0	1	0	0	0	1	0	0	1	0
3	0	0	1	1	0	0	0	0	1	1	0
4	0	1	0	0	1	0	0	1	1	0	0
5	0	1	0	1	0	1	0	0	1	0	0
6	0	1	1	0	1	1	0	0	0	0	0
7	0	1	1	1	0	0	0	1	1	1	1
8	1	0	0	0	0	0	0	0	0	0	0
9	1	0	0	1	0	0	0	1	1	0	0

Table 1. BCD codes

Resetting

The 74LS47 is functionally identical to the older 7447 it replaces and both ICs compose sixes and nines without "tails", that is, segments a and d, respectively, are not illuminated. This simplifies the problem of resetting the counters at the required times.

All reset 0 inputs must go high in order to reset both counters to 0. When S2 is in the Pools position, all reset 0 inputs receive the output of AND gate IC6b whose three inputs utilise decoder outputs. Remember that unilluminated segment outputs are high and a study of the tables will show that counting from zero—at least one low is always present on an input of IC6b until the count reaches 56. When this happens, IC6b turns on, both counters are reset to 0 and, momentarily, stop counting. However, number 56 cannot exist in the display for more than the few nanoseconds it takes to reset the counters. Because resetting produces two zeros in the display, IC6b turns off and its output returns all reset 0 inputs to low so that counting is resumed. When S2 is switched to Bingo, IC6c controls resetting. Further study of the Tables 1 and 2 and the circuit reveals that IC6c turns on only when the count reaches 91. At this time, the counters are reset in the manner described for count 56.

Operating S2 also resets the counters. This is because unconnected TTL inputs go high and for some brief instant during

INPUTS			OUTPUT	
0	0	0	0	OFF
0	0	1	0	OFF
0	1	0	0	OFF
0	1	1	0	OFF
1	0	0	0	OFF
1	0	1	0	OFF
1	1	0	0	OFF
1	1	1	1	ON

Table 2. Reset codes.

switching, the switch arm is somewhere between and not touching either of the two contacts. All reset inptuts therefor go high during S2 switching and so the counters are reset.

Diode, D1 is a silicon type and its purpose is to drop the 6V supply to the 5V or so necessary for TTL.

Construction

In order to facilitate construction, and all-parallel method of wiring is used for the main circuit board, and the numeric display is built as a sub assembly. The main board is 0.1 inch pitch stripboard, 43 holes by 33 strips. This includes a spare strip and rows of holes to cover edge damage or provide an alternative route in the event of a minor constructional disaster.

Begin by drilling the two clearance holes used for mounting the main board. Next make all the circuit breaks and, afterwards, brush the strips thoroughly to remove copper swarf. (The writer finds an old, cut-down shaving brush ideal for this.)

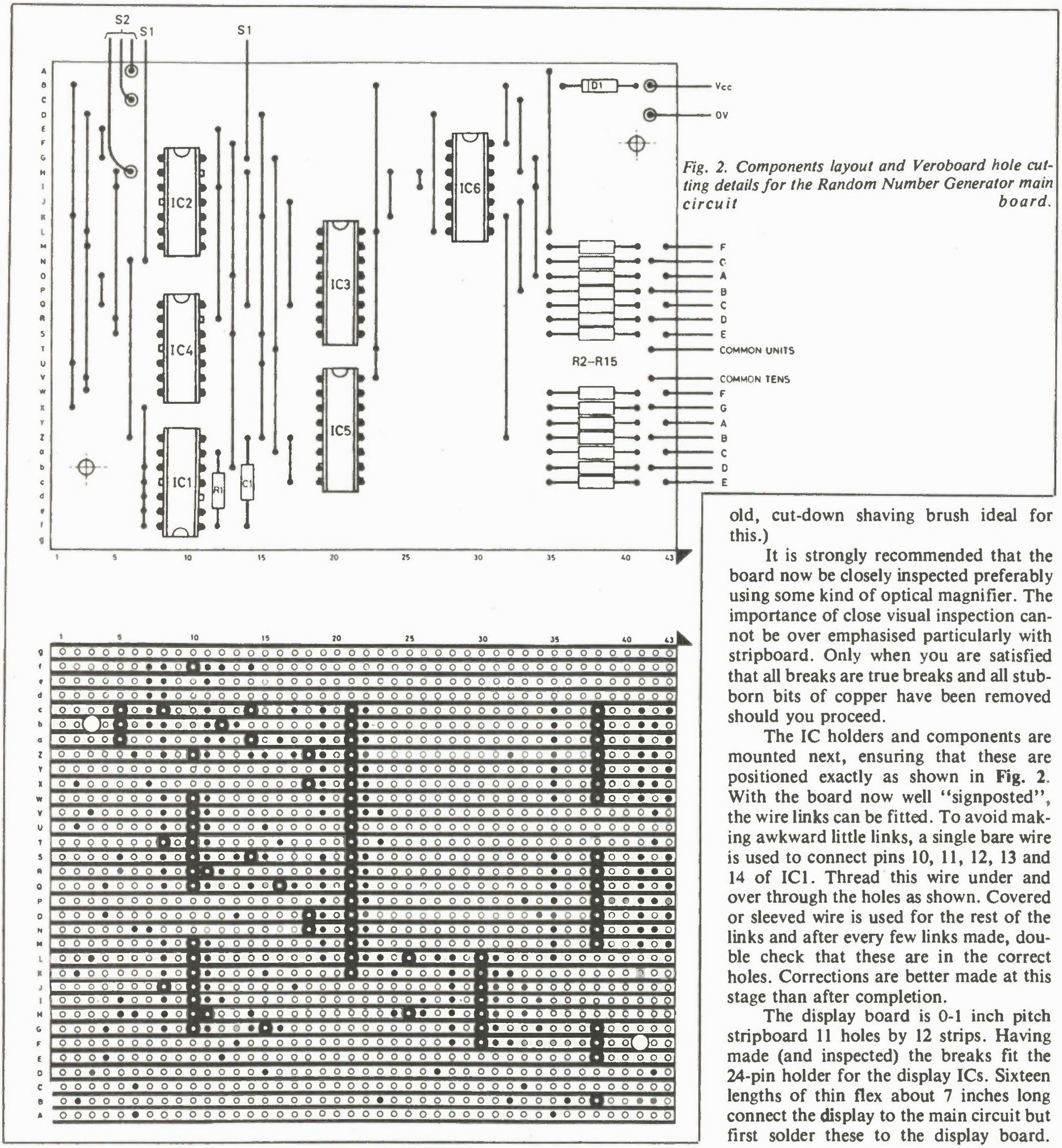


Fig. 2. Components layout and Veroboard hole cutting details for the Random Number Generator main circuit board.

It is strongly recommended that the board now be closely inspected preferably using some kind of optical magnifier. The importance of close visual inspection cannot be over emphasised particularly with stripboard. Only when you are satisfied that all breaks are true breaks and all stubborn bits of copper have been removed should you proceed.

The IC holders and components are mounted next, ensuring that these are positioned exactly as shown in **Fig. 2**. With the board now well "signposted", the wire links can be fitted. To avoid making awkward little links, a single bare wire is used to connect pins 10, 11, 12, 13 and 14 of IC1. Thread this wire under and over through the holes as shown. Covered or sleeved wire is used for the rest of the links and after every few links made, double check that these are in the correct holes. Corrections are better made at this stage than after completion.

The display board is 0-1 inch pitch stripboard 11 holes by 12 strips. Having made (and inspected) the breaks fit the 24-pin holder for the display ICs. Sixteen lengths of thin flex about 7 inches long connect the display to the main circuit but first solder these to the display board.

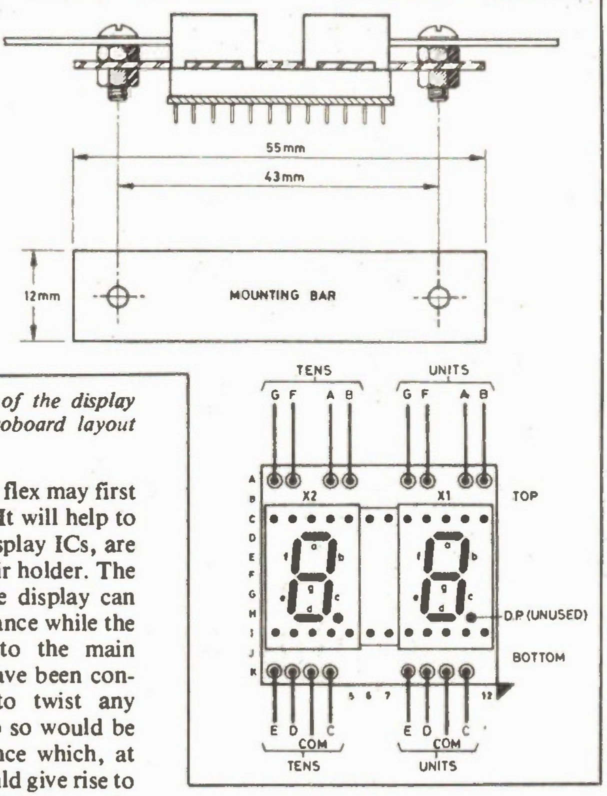


Fig. 3. Constructional details of the display board assembly including Veroboard layout and track cutting details.

Similarly, suitable lengths of flex may first be soldered to the switches. It will help to avoid wiring errors if the display ICs, are now correctly inserted in their holder. The top from the bottom of the display can then be distinguished at a glance while the conctions are now made to the main board. After the switches have been connected, resist temptation to twist any wires into neat cords. To do so would be to add extra stray capacitance which, at the frequencies involved, could give rise to anomalies. However, twisted flex can be used for connection to the external battery or power supply and this will complete the electrical work.

Any suitable box may be used to house the completed assembly but a standard aluminum case measuring 105 x 133 x 38mm was used for the prototype. The aperture for the numeric display was made by first drilling a ¼ inch hole, enlarging this with a file, and finally, shaping the aperture with a small flat file. It will be found that the display ICs are a tight fit in the holder and because this is a low profile type, there will be a gap between the holder and the ICs. Into this gap is slid the display mounting bar, the dimensions of which are given in **Fig.3**. Where necessary, the bar holes may be elongated or enlarged which, together with free lateral movement of the display, should absorb any small drilling and filing errors. A piece of stripboard was used to make the prototype bar but any material of sufficient rigidity will serve.

Testing

Parts List

Resistors — All resistors ¼ watt 10%

R1	330
R2–R15	1k

Capacitors

C1	47n poly.

Semiconductors

D1	1N4001
IC1	SN74LS13
IC2, IC4	SN74LS90
IC3, IC5	SN74LS47
IC6	SN74LS11
X1, X2	FND 507

Miscellaneous

S1	miniature non-locking push to make
S2	SPDT miniature toggle

DIL holders 14-pin, 16-pin, 24-pin (low profile types); 0.1 inch stripboard, 11 holes by 12 strips and 43 holes by 33 strips; nuts & bolts, ¼ inch grommet; aluminum case.

Ensure that all ICs are correctly inserted before connecting the 6V supply, then, using crocodile clips, connect a 1000*u* electrolytic across C1 (plus sign to pin 1 of IC1). This will reduce the clock frequency to about 1Hz or so. Holding down the Select button will then enable the constructor to check that all numbers are formed correctly; appear in correct sequence; and, lastly, that resetting appears to occur after numbers 55 and 90. As has been explained, resetting numbers 56 and 91 will not be seen. ■

FerroMagnetic Cores in RF Circuits

Core components are making the feasibility of home constructed RF circuits a more appealing proposition than ever before.

By R. Sanders

MODERN COMMUNICATIONS equipment has changed a lot since the tube circuits gave way to solid state devices. One obvious result of the 'newer technology' has been the reduction in size of the equipment.

Because of the nature of solid-state circuitry, which tends to use lower impedances and lower voltages (not to mention the absence of heat from filaments), different methods of coupling and matching between stages have come into widespread use. The old familiar large diameter coils (remember how we took great care with the shape of our coils to get the best Q?) have largely vanished, replaced by small ferromagnetic devices which seem to be stacked into odd spaces throughout the RF sections of our black boxes. One might well wonder how 'they' get away with it, when we think how much trouble we had with unwanted coupling.

There are still plenty of problems left in producing well designed RF equipment, but some things are certainly easier now that the newer components are readily available to the home constructor. This article will cover general aspects of the ferromagnetic cores and provide the home constructor with sufficient information to select a suitable core for a particular application.

Continued on page 43

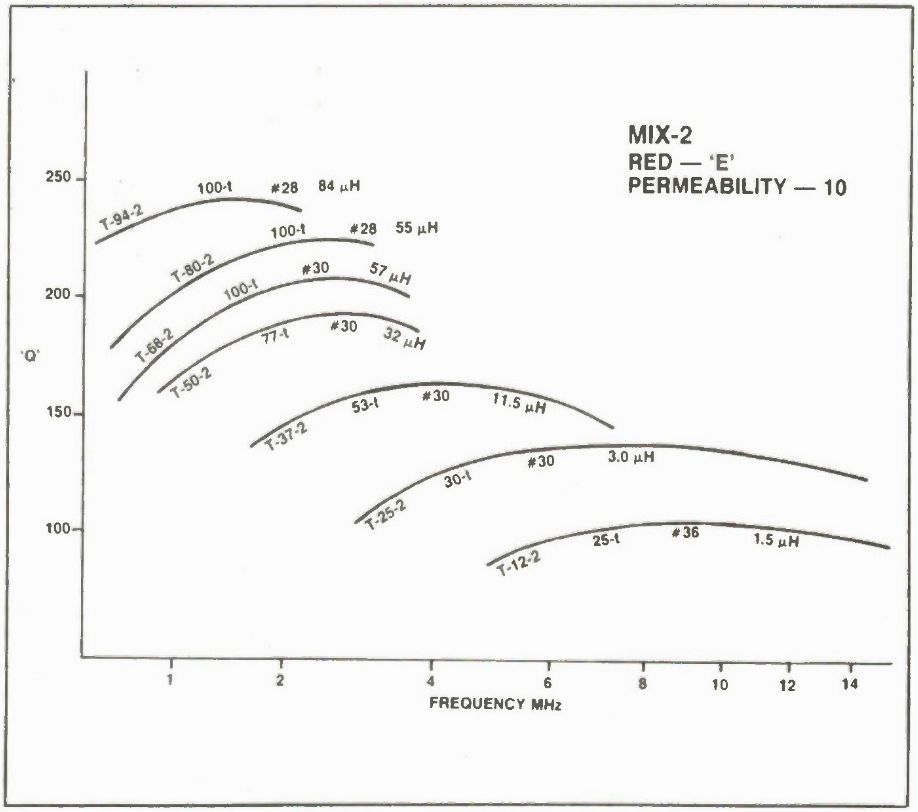


Fig. 1 Typical Q curves for various sized cores made from 'mix-2'.

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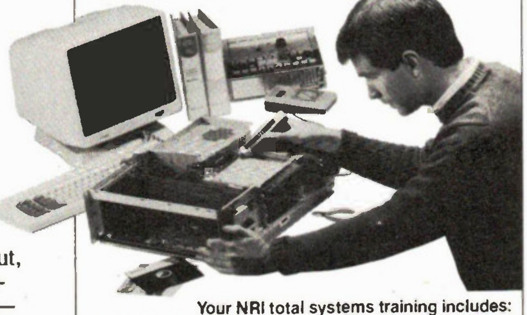

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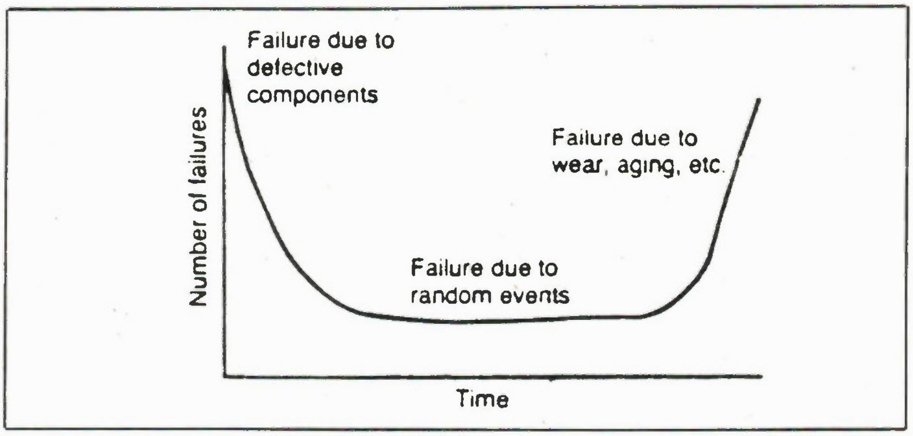

Fig. 1. Classical bathtub curve showing instances of failures in phases of a product life cycle.

data are available quantifying this aspect of reliability. The most comprehensive information can be found in references prepared for use in military applications. MIL-HDBK-217 is employed extensively for electrical and electronic components and provides reliability figures based on design and environmental operating conditions. The RADC reliability notebook and the AVCO Reliability Engineering Data Series are also widely used. For military purposes, reliability specifications are usually expressed in terms of the expected number of failures per million hours. This is appropriate because the performance of large numbers of devices are usually the issue.

For process monitoring and control users are generally concerned with individual instruments and how long they can be expected to operate. The reciprocal of failures per unit time, the meantime between failures (MTBF), then provides better intuitive understanding.

Reliability can also be described using probabilities calculated on the basis of exponential of poisson distribution which describe independent random events occuring in a continum. The probability of successful operation (R) is related to the expected number of failures per unit time (K) by the exponential function of Eq.1. Conversely, the probability failure (F) is found in Eq.2. For any finite K, R will be unity at time t = 0, and will be zero as time approaches infinity. This is the same as saying that an assembly works when you put it into service and fails if you wait long enough.

$$R = e^{-kt} \qquad (1)$$

$$F = 1\text{-}R \qquad (2)$$

Estimating System Reliability

Users are especially concerned when components are combined into systems. This information is not only useful in determining whether equipment will be satisfactory for an application, but can also indicate which components are the most cost-effective candidates for upgrading.

An estimate of the reliability of an assembly can be made by summing the failure rates of the individual components. As an example, Table 1 lists the components of an automated non-dispensive infrared (NDIR) total organic carbon (TOC) analyser; this instrument was configured in 1975 using analog electronic circuity and an NDIR carbon dioxide monitor. Table 1 shows reliability data for the various components, expressed as failures per million hours. Values for electrical and electronic components were derived from mil standards, assuming commercial grade components and stationary installation with normal ambient conditions.

Figures for the recorder, and analyser were estimated from data for assemblies of similar complexity. Table 1 shows the complete system could be expected to experience 281 failures per million hours. The reciprocal of this value yields and MTBF of 3558 hours or 148 days. Probabilities of successful operation over various time periods calculated using eq.1, are shown in Table 11.

An MTBF of 148 days indicates that the TOC analyser would not be suitable for use as a continuous on stream-instrument. The actual application involved analysis of storm run off at a wastewater treatment plant. Total usage would therefore be under 65 hours per year. At this rate the instrument could be rebuilt periodically or replaced by equipment employing new technology.

Table 1 also provides means to determine whether the analyser could be upgraded to

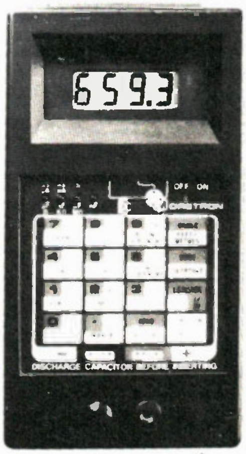

TABLE I failure rates for components of a stormwater TOC monitor.

Component	Failure rate (failures/ million hr)
reservoir & stirrer	0.58
homogenizer	4.5
sample delivery system	13.5
oxygen pressure reg	4.25
span gas pressure reg	4.25
filter	0.3
2-way valve	0.5
intake-pump	13.5
acid pump	13.5
sparge gas controller	13.5
T-tube	0.5
sample pump	13.5
carrier gas controller	3.5
check valve	2.3
combustion reactor	4.9
flush pump	13.5
condenser	1.7
filter	0.3
solenoid valve	11.0
span gas valve	11.0
NDIR monitor	75.0
recorder	50.0
control unit	25.0
TOTAL	**281**

TABLE II Probability of survival for the TOC monitor Table I.

Period (hours)	Probability of survival
100	0.972
200	0.945
400	0.894
800	0.799
1600	0.63
3200	0.41
6400	0.17
12800	0.03

a readability level appropriate for continuous on streaming monitoring. The table shows that the lease reliable components in the instruments system are the NDIR monitor, the recorder, and the control unit - which alone contribute 150 failures per million hours to the toal. This also suggests that reliability might be most effctively improved by replacing these devices with more reliable solid state elements such as a digital recorder and control unit and an improved IR sub system. Assuming that the new components had MTBFs three times greater than those in the original instruments, the overall failure rate would be reduced to 181 failures per million hours, for an overall MTBF of 5524 hours or 230 days - still too low for most on-stream applications.

Maintaining Reliability

MTBF and other measures of reliability are not performance guarantees. They indicate the likelihood of successful operation over a period of time - for equipment that is free of factory defects and not yet at the stage when cumulative disintegration has become the dominant failure mechanism.

Another prerequisite is operated within its design limits and not exposed to extreme ambient conditions or loads. For instance, elevated temperature can induce cumulative damage in the form of loss of moisture, differential expansion and contraction at interfaces, or crystallization, such that failures become a matter of equipment degradtion rather than random phenomena.

Maintenance also affects reliability. Equipment often is designed with the assumption that periodic maintenance will be performed for tasks such as changing reagents, cleaning contacts, or lubricating bearings. If the maintenance is neglected, the assumption of independent random failures becomes invalid and MTBF or other reliability specifications no longer apply.

Misapplication

Failures can also result because a product is applied incorrectly or an engineering error is made - aside from any life cycle considerations. For instance, a screwdriver may not work properly as a chisel or a dam designed to retain an 8 foot flood may crumble when it is hit by a 10 ft. crest. These are not questions of reliability, but of design and applications expertise. ■

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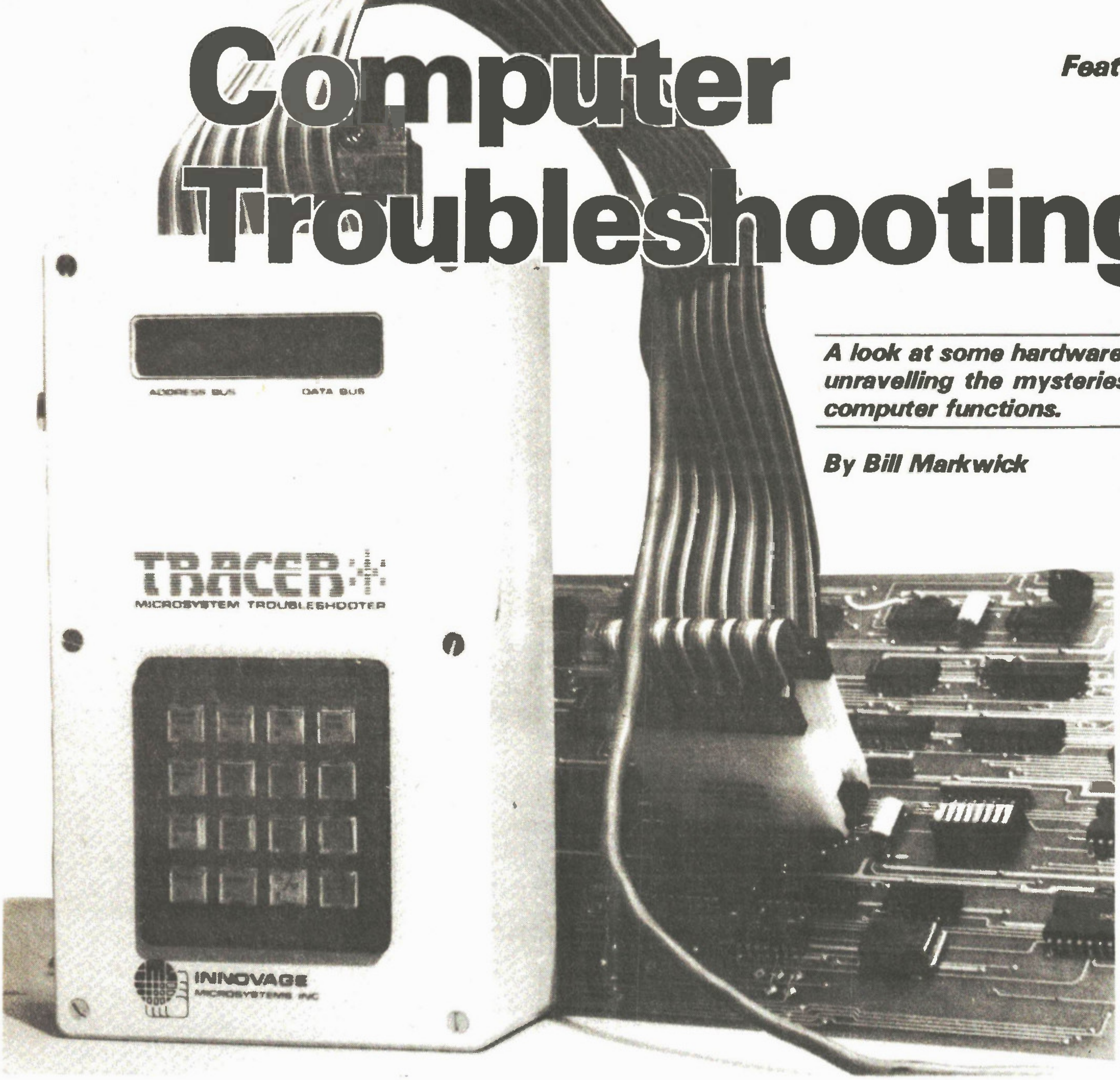
Computer Troubleshooting



A look at some hardware for unravelling the mysteries of computer functions.

By Bill Markwick

TROUBLESHOOTING a computer is radically different from repairing an audio amp, say, or a radio. Not only is there an immense amount of circuitry courtesy of the microchips, but the problem is compounded by the software: is the program messing up somehow, or is the circuitry providing its own faults? Or is it a mix of both?

If you know that the trouble is confined to a faulty logic circuit, then it's always possible to track it down with one or more of the old standbys, such as a scope, meter or logic probe. However, when it comes to tracking down the elusive glitch in hardware and/or software, it saves an enormous amount of time to use one of the more sophisticated troubleshooting aids that are closer to logic analyzers. Here are a few of the available units. The list is by no means complete, and we hope to keep you informed of other units that we couldn't obtain by press time.

The Tracer 100XTR

The Tracer 100XTR is the top-of-the-line model from Innovage Microsystems Inc., 5-6125 12th St. S.E., Calgary, Alberta T2H 2K1, (403) 255-9590. The main difference between this and the other models is its ability to communicate with a remote computer via an RS232 port, allowing use of the more convenient computer keyboard plus the ability to upload and download files.

The Tracer, without its RS232 facility, was originally reviewed in *Electronics Today*, September, 1986. Here's a brief review of the features we described then.

The Tracer resembles a small utility box; a ribbon cable exiting from the top terminates in a multi-pin connector that slips over the pins on your CPU. The unit is designed for use with a particular CPU; at the moment these consist of the more popular 8-bit types: Z80, 8085, 6502, 6809, etc.

If you use the 100XTR as a stand-alone unit, you simply slip the connector over the CPU pins; power (5V, 125mA) is supplied by the unit under test. It now becomes possible to examine and write to memory while your program is running. The information is entered via the 16-key pad and read out on an 8-character LCD display.

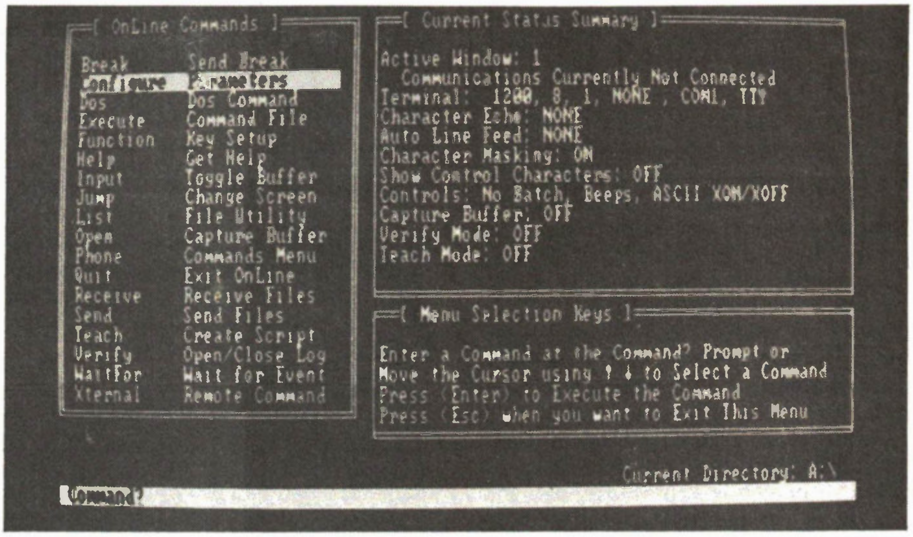
It's possible to set breakpoints or framepoints to detect specific occurrences in the program, such as a specific byte written to a particular address. In the breakpoint mode, the CPU is halted when the desired conditions occur. In the framepoint mode, the execution of the program is not interrupted when the condition is detected.

There are also a number of memory-checking functions. MEM EXAM will read out the contents of any address in RAM and ROM. MEM TEST will check the host RAM using pattern checking; the contents of the RAM cell are replaced after the test, so the test can even be done during program execution. ROM can be checked using the CHECKSUM test. There are also Bus Tests consisting of RAMP and SHIFT functions; these produce an increasing count on the address and data lines and can be used in conjunction with an oscilloscope to detect chip or PCB faults. There are also four port tests, and an Opcode Fetch function will watch for execution of a particular CPU instruction and can single-step the execution of the program.

The RS232

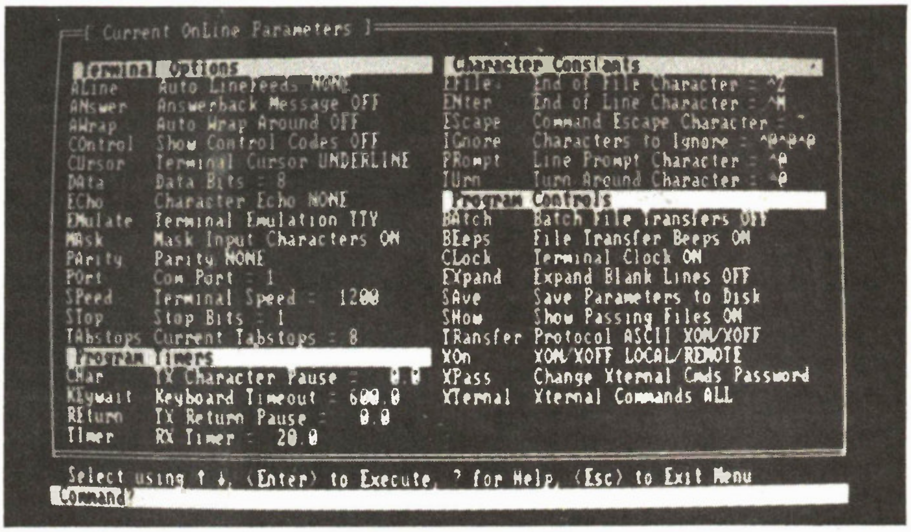
Although the Tracer as a stand-alone is a real powerhouse of a tester, it's the computer connection that really lets it shine. The RS232 connector on the end of the Tracer is connected to the serial port of your computer. The necessary software for Innovage diagnostics is contained in the Tracer, and the disk supplied with the unit featured a communications program called *Online* for the IBM PC and compatibles. As you can see from our cover, it isn't absolutely necessary to have Online; any communications software will do for the basics. However, the many features provided with Online expand the capabilities of the already potent Tracer.

To begin, connect the Tracer to the serial port of the PC and load Online. When the main menu appears, type Escape and the screen of the Tracer should say REMOTE. **Fig. 1** shows the main menu of the Online program. Under Current Status you can see that Innovage has preset both the Tracer and the software to 1200 baud, 8 bits, no parity, providing adequate operating speed, though it's a bit slow for memory dumps; the Tracer internal software allows stepping up the rate to 9600 baud. **Fig. 2** shows the submenu that you get if you select Configure Parameters from the main meter, and as you can see, Online provides a wealth of options; nearly all the submenus are this comprehensive. Getting back to the main menu: there are some very convenient functions, among them DOS, which allows you to temporarily suspend the program and return to the operating system for file handling or running another program. Typing "exit" instantly returns you to the unchanged Online.



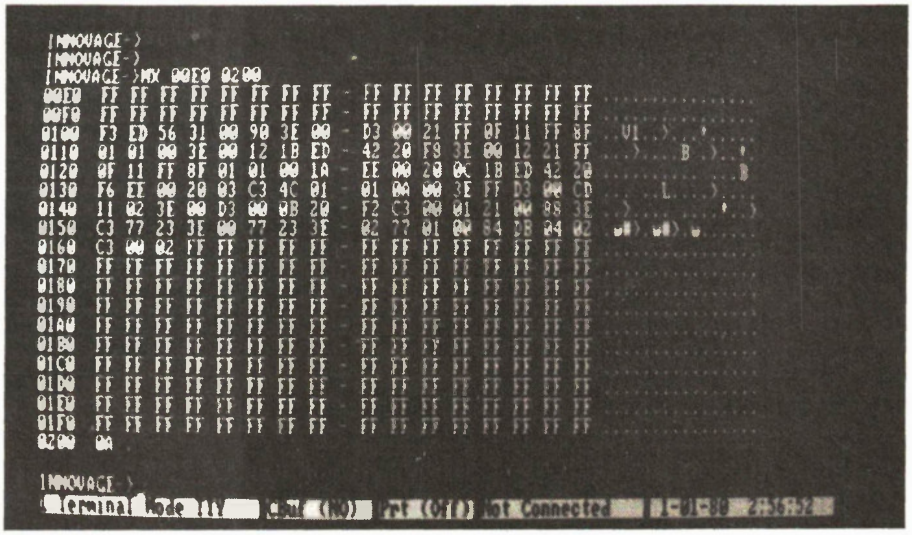
```
[ OnLine Commands ]              [ Current Status Summary ]

Break      Send Break             Active Window: 1
Configure  Parameters               Communications Currently Not Connected
Dos        Dos Command            Terminal:  1200, 8, 1, NONE , COM1, TTY
Execute    Command File           Character Echo: NONE
Function   Key Setup              Auto Line Feed: NONE
Help       Get Help               Character Masking: ON
Input      Toggle Buffer          Show Control Characters: OFF
Jump       Change Screen          Controls: No Batch, Beeps, ASCII XON/XOFF
List       File Utility           Capture Buffer: OFF
Open       Capture Buffer         Verify Mode: OFF
Phone      Commands Menu          Teach Mode: OFF
Quit       Exit OnLine
Receive    Receive Files
Send       Send Files             [ Menu Selection Keys ]
Teach      Create Script
Verify     Open/Close Log         Enter a Command at the Command? Prompt or
WaitFor    Wait for Event         Move the Cursor using ↑ ↓ to Select a Command
Xternal    Remote Command         Press (Enter) to Execute the Command
                                  Press (Esc) when you want to Exit This Menu

                                                    Current Directory: A:\
Command?
```

Fig. 1. The main menu of the Tracer's Online software.



```
[ Current OnLine Parameters ]

Terminal Options                          Character Constants
ALine     Auto Linefeeds NONE             EFile     End of File Character = ^Z
ANswer    Answerback Message OFF          ENter     End of Line Character = ^M
AWrap     Auto Wrap Around OFF            EScape    Command Escape Character = ~
COntrol   Show Control Codes OFF          IGnore    Characters to Ignore = ^@^@^@
CUrsor    Terminal Cursor UNDERLINE       PRompt    Line Prompt Character = ^@
DAta      Data Bits = 8                   TUrn      Turn Around Character = ^@
ECho      Character Echo NONE             Program Controls
EMulate   Terminal Emulation TTY          BAtch     Batch File Transfers OFF
MAsk      Mask Input Characters ON        BEeps     File Transfer Beeps ON
PArity    Parity NONE                     CLock     Terminal Clock ON
POrt      Com Port = 1                    EXpand    Expand Blank Lines OFF
SPeed     Terminal Speed =  1200          SAve      Save Parameters to Disk
STop      Stop Bits = 1                   SHow      Show Passing Files ON
TAbstops  Current Tabstops = 8            TRansfer  Protocol ASCII XON/XOFF
Program Timers                            XOn       XON/XOFF LOCAL/REMOTE
CHar      TX Character Pause =    0.0     XPass     Change Xternal Cmds Password
KEywait   Keyboard Timeout = 600.0        XTernal   Xternal Commands ALL
REturn    TX Return Pause =    0.0
TImer     RX Timer =  20.0

Select using ↑ ↓, (Enter) to Execute, ? for Help, (Esc) to Exit Menu
Command?
```

Fig. 2. The Online Configure Parameters submenu, showing some of the many features available.



```
INNOVAGE->
INNOVAGE->
INNOVAGE->MX 00E0 0200
00E0  FF FF FF FF FF FF FF FF - FF FF FF FF FF FF FF FF  ................
00F0  FF FF FF FF FF FF FF FF - FF FF FF FF FF FF FF FF  ................
0100  F3 ED 56 31 00 90 3E 00 - D3 00 21 FF 0F 11 FF 8F  ..V1..>...!.....
0110  01 01 00 3E 00 12 1B ED - 42 20 F8 3E 00 12 21 FF  ...>....B .>..!.
0120  0F 11 FF 8F 01 01 00 1A - EE 00 20 0C 1B ED 42 20  ..............B
0130  F6 EE 00 20 03 C3 4C 01 - 01 00 00 3E FF D3 00 CD  ... ..L....>....
0140  11 02 3E 00 D3 00 0B 20 - F2 C3 00 01 21 00 08 3E  ..>.... ....!..>
0150  C3 77 23 3E 00 77 23 3E - 02 77 01 00 84 DB 04 02  .w#>.w#>.w......
0160  C3 00 02 FF FF FF FF FF - FF FF FF FF FF FF FF FF  ................
0170  FF FF FF FF FF FF FF FF - FF FF FF FF FF FF FF FF  ................
0180  FF FF FF FF FF FF FF FF - FF FF FF FF FF FF FF FF  ................
0190  FF FF FF FF FF FF FF FF - FF FF FF FF FF FF FF FF  ................
01A0  FF FF FF FF FF FF FF FF - FF FF FF FF FF FF FF FF  ................
01B0  FF FF FF FF FF FF FF FF - FF FF FF FF FF FF FF FF  ................
01C0  FF FF FF FF FF FF FF FF - FF FF FF FF FF FF FF FF  ................
01D0  FF FF FF FF FF FF FF FF - FF FF FF FF FF FF FF FF  ................
01E0  FF FF FF FF FF FF FF FF - FF FF FF FF FF FF FF FF  ................
01F0  FF FF FF FF FF FF FF FF - FF FF FF FF FF FF FF FF  ................
0200  00

INNOVAGE->
Terminal Mode TTY   COM1 (NO)   Prt (OFF)   Not Connected   1-01-80   2:36:32
```

Fig. 3. Examining memory contents from 00E0 to 0200.

Very handy. Execute allows you to run a sort of batch file; these are very convenient for repetitive tests that require a lot of keystrokes.

To make these batch files, Online has a remarkable function called 'Teach". Select this mode and type in your commands: Teach writes the commands into a disk file executable by Online. The file is written in the syntax used by Online (the C programming language). Another useful feature is the Phone menu. This allows field service people to send or receive computer data to or from a main computer; a modem is then necessary at both ends.

Yet another essential feature is the Capture Buffer. If you want to examine ROM or RAM contents at your leisure, say, you can dump the contents into a memory buffer in your computer, and then print them out or write them to a disk file. You can also print out all screen activity as it happens.

So it isn't entirely necessary to use the Online program if you have any telecom software (we ran the Tracer with both QModem and the internal software in the Radio Shack 100), but Online is ideally designed for the specific needs of the computer troubleshooter.

Fig. 3 shows a screen dump for a small Z80 computer, from location 00E0 to 0200. The format is similar to that used by Debug or DDT; the essential difference is that the Tracer, being external, can examine memory (or even print out a memory map) while the program is running. The breakpoint and framepoint work in much the same way as Debug or DDT, but with the essential difference that the computer under test can go as crazy as it likes due to hardware or software faults and the Tracer's operation is unaffected. Software debuggers such as Debug suffer from a serious weak point: if the computer under test won't work, the software debugger can crash, assuming it can load at all.

We haven't room to cover the great range of possibilities in the Tracer and its RS232 link. For instance, there's a 50-ohm TTL level trigger output; you can specify the conditions on which the trigger should work, and use it to synchronize an oscilloscope to display the desired data signals.

Hopefully the Tracer will soon be available in a 16-bit version for the 8086/8088 CPU. Innovage has come up with a great unit for 8-bit work.

The Ferret

A computer tester in a briefcase is the Ferret, from Duncan Instruments, 121 Milvan Drive, Toronto, Ontario M9L 1Z8, (416) 742-4448. Said by the manufac-

Fig. 4. The Ferret computer analyzer fits in a briefcase.

Fig. 5. The Soar Model 1000 portable storage scope.

Fig. 6. The Leader LCD-5840 portable storage scope.

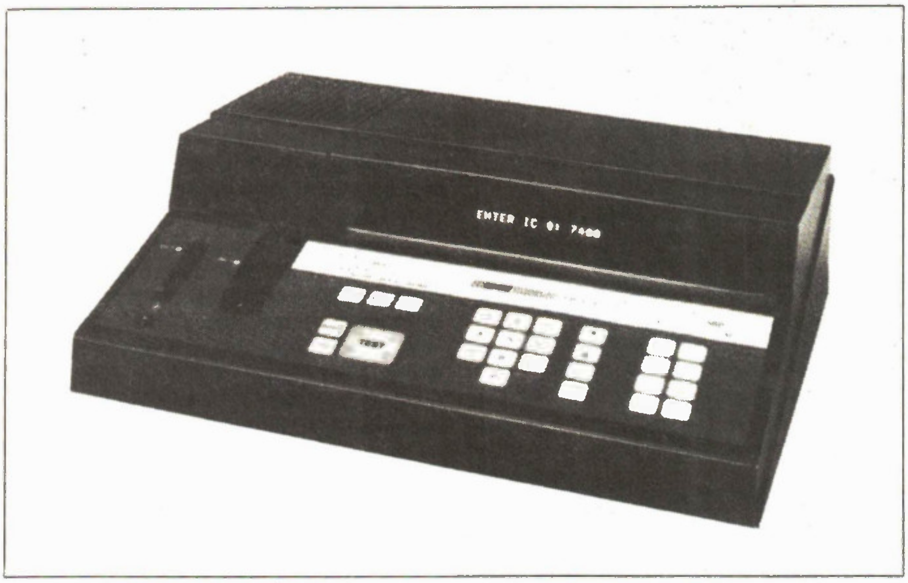


Fig. 7. The BK-Precision Model 560 programmable IC tester.

turer (GCS Ltd. of the UK) to be a dozen conventional instruments in one case, the Ferret features a terminal emulator, a 32-character LCD display, an alphanumeric keyboard (condensed onto 20 keys) and a tiny 16-column printer. Confused by the many variations on the RS232 wiring standard? The Ferret has a built-in breakout box with LEDs, allowing you to quickly configure the connection to match any computer. There's also a Centronics-compatible parallel connector and a current-loop interface, so mating with the unit under test should be easy.

The communications ports can be set from 50 to 19,200 bits per second, and if you don't know what the rate should be, there's even an automatic 'baud finder'. The host computer is used to send a string of upper case "A" characters; the Ferret will step through its available baud rates until it gets a match, then reconfigure itself. Smart stuff.

Two zero-force EPROM sockets are provided. These can be used to read, write or execute from most EPROMs; an EPROM burner that can load data from either the communications ports or from the other socket is an unusual feature on any tester. The sockets can be used to run troubleshooting programs; the Ferret uses a Z80 CPU internally, and any equipment that can assemble Z80 code can be used to write programs.

The Ferret can be used to test out peripherals such as disk drives or printers; once communications are established, the appropriate codes are sent down the link to activate whatever it is you want to test.

The Ferret has the advantage that its own Z80 is programmable by the user to suit a variety of test procedures, and the programs can be permanently stored in EPROMs using the tester's own burner. The interface system is flexible and should allow connection to a wide variety of computers. The Canadian price is $4000.

Portable Scopes

Looking at computer data usually means reading the presence or absence of signals rather than looking for subtleties in the waveform. LCD display scopes are ideal as portable test units. One such scope is the Soar Model 1000, also from Duncan Instruments (see above). It's a dual-trace storage unit with a bandwidth from DC to 200kHz. Rechargeable NiCads run it for six hours.

The screen resolution is 128 by 160 dots, adequate for most testing purposes. There's also a built-in 3 1/2 digit multimeter, with the usual ACV, DCV, ohms, continuity and diode tester.

Another portable storage scope is the Leader LCD-5840, available from Omnitronix Ltd., 2410 Dunwin Dr., Unit 4, Mississauga, Ontario L5L 1J9, (416) 828-6221. It also has a 200kHz bandwidth and a built-in multimeter. The screen is more rectangular in format with a resolution of 64 by 192 dots. 64 by 32 of these dots are reserved for on-screen data displaying.

IC Tester

Once you use your troubleshooting aids to pin down a suspect IC, you need a way to confirm the diagnosis. One way is substitution of the part, but you're going to have to carry an awful lot of ICs. The BK-Precision Model 560 is an in-circuit/out-circuit IC tester that tests TTL and CMOS ICs, including counters and flip-flops, from 14 to 24 pins. The internal test routines are used to test over 90 percent of popular ICs, which amounts to over 1,500 devices. Results are displayed on a 20-character dot matrix fluorescent display. The logic thresholds can be preset, and the inputs are protected to plus or minus 50VDC. The tests give a go, no-go result, eliminating the need to interpret scope curves or logic levels, and the unit even tells you the failed pin number of the IC. The test procedure does not stress the IC or related circuit under test.

The Model 560 is available from Atlas Electronics, 50 Wingold Avenue, Toronto, Ontario M6B 1P7, (416) 789-7761. ■

8088 Programming: Textfile Encryption

An example of encoding and decoding your textfiles.

by John Rudzinski

NERVOUS authors, scribes, business executives and literary washerwomen can spend serious money on file encryption schemes for their computer-generated text. Somewhere, I'm convinced, there's a textfile filled with ASCII garbage which, when unencrypted, will finally put to rest the eternal question of how they *do* put the goo into those chocolate bars.

There *are* serious applications to file encryption, though. The ad agency hired by an encryption device's manufacturer appealed to the paranoia inherent in competitive companies by depicting a janitor reading with great interest the salaries of a company's better-dressed employees on a micro's monitor. In business there are things best kept from cutthroat competition, not to mention computer-friendly custodial (for example) staff. Read on: Computer crime waits for no man.

Wargames

Since wars came into fashion among civilised peoples, codes have been fashioned to safely pass messages from the guys smoking pipes in their palaces to the morsels of cannon-fodder doing field work. For the most part, the coding was accomplished through character substitution. Should the substitution table fall into enemy hands, however, a replacement regiment or serious peace talks would be in order.

Though they've done little for world peace, computers have done much to both improve and accelerate the encryption and decryption of text, and there are myriad ways of accomplishing this objective on a micro. We're going to have a look at the method responsible for the program that accompanies this article.

Scrambled Megs

SCRAMBLE.COM is a small (less than 2K when assembled) program which can scramble or unscramble a textfile of any length, so long as you have on-disk space for a temporary duplicate of the file you wish to scramble or reassemble. Hard drives come in handy with files over 180K.

The en/decryption method involved in SCRAMBLE is actually quite a simple one. Every byte, save a few exceptions, is e*X*clusive-*OR*ed with the hexadecimal value of 0B5H. The exceptions are 0B5H, which would result in zero; 00H, which would interfere with the previous exception; and 0AFH, as 0AFH XOR 0B5H equals 1AH, the end of file value.

XORing value ‘A’ with value ‘B’ changes ‘A’s value considerably. XORing value ‘A’ with value ‘B’ *twice* restores ‘A’s original value. This is why the same code is used for both encrypting and decrypting in this program. The only reason the initial menu asks the user to choose which action is to affect his file is personal edification, which is always important when making decisions. That said, a brief description of what SCRAMBLE.COM does when executed is in order.

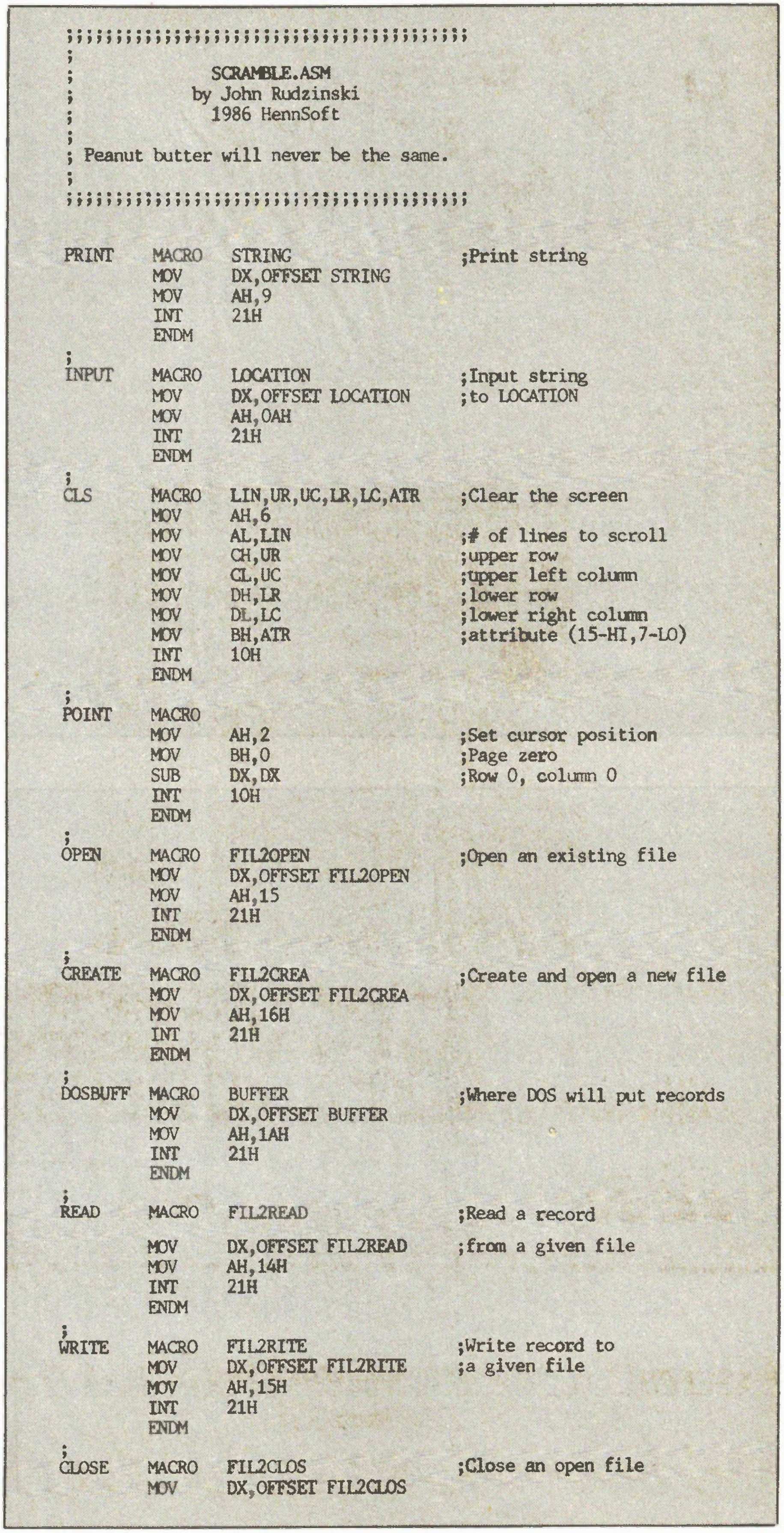
Should the user not choose to exit the program, a request to enter a password is written to the screen. As anyone can run the program to this point, a password was necessary to stop in their tracks those who mean your files harm. A DEBUG dump of SCRAMBLE won’t display the password, which is in memory with each byte *RO*tated *L*eft one bit. The password routine, albeit slightly improved, is the same one that appeared as PASSWORD.EXE in this column a few issues back. Two chances are given to type, in capital letters, CLAMBAKE. The letter ‘X’ is substituted on-screen for each character typed. If the proper password isn’t forthcoming, the program calls ROM BASIC, which rarely exists in clones, and usually crashes the system.

The filename to encrypt or decrypt is then asked for. It must exist, or the program will return to DOS. Next, the user is prompted for a new name to call that file. This allows the user to select an extension that would enable him to determine which files on his disk are in a scrambled state. In figure 1, the extension . is shown.

Once valid data is entered to both prompts, the program inhales the textfile in 128-byte chunks, scrambles the bytes, writes the 128 bytes to the new file, purges the buffer with zeroes, then goes back for more. Should a control-Z end of file character be encountered, the buffer is written at that point, both files are closed, and the file that was read is erased from the directory. You are left with either garbage or a restored textfile. If a partial 128-byte record was written, your file’s length will be padded with ‘0’ bytes and will expand in the directory to a size divisible by 128. The maximum expansion possible is 127 bytes, and shouldn’t visibly affect your text.

Social Security

Extensive use of macros was made in SCRAMBLE.ASM due to the listing’s length, which would have been a bit too long to publish. The macro assembler, MASM, will be necessary to assemble the listing. After assembling, LINK it, ignoring the No Stack Segment error, then EXE2BIN it. SCRAMBLE.COM will emerge to delight and excite your friends and



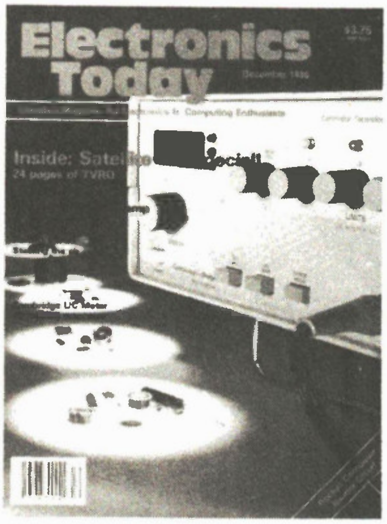
```
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
;
;              SCRAMBLE.ASM
;            by John Rudzinski
;              1986 HennSoft
;
; Peanut butter will never be the same.
;
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;


PRINT    MACRO   STRING                  ;Print string
         MOV     DX,OFFSET STRING
         MOV     AH,9
         INT     21H
         ENDM
;
INPUT    MACRO   LOCATION                ;Input string
         MOV     DX,OFFSET LOCATION      ;to LOCATION
         MOV     AH,0AH
         INT     21H
         ENDM
;
CLS      MACRO   LIN,UR,UC,LR,LC,ATR     ;Clear the screen
         MOV     AH,6
         MOV     AL,LIN                  ;# of lines to scroll
         MOV     CH,UR                   ;upper row
         MOV     CL,UC                   ;upper left column
         MOV     DH,LR                   ;lower row
         MOV     DL,LC                   ;lower right column
         MOV     BH,ATR                  ;attribute (15-HI,7-LO)
         INT     10H
         ENDM
;
POINT    MACRO
         MOV     AH,2                    ;Set cursor position
         MOV     BH,0                    ;Page zero
         SUB     DX,DX                   ;Row 0, column 0
         INT     10H
         ENDM
;
OPEN     MACRO   FIL2OPEN                ;Open an existing file
         MOV     DX,OFFSET FIL2OPEN
         MOV     AH,15
         INT     21H
         ENDM
;
CREATE   MACRO   FIL2CREA                ;Create and open a new file
         MOV     DX,OFFSET FIL2CREA
         MOV     AH,16H
         INT     21H
         ENDM
;
DOSBUFF  MACRO   BUFFER                  ;Where DOS will put records
         MOV     DX,OFFSET BUFFER
         MOV     AH,1AH
         INT     21H
         ENDM
;
READ     MACRO   FIL2READ                ;Read a record

         MOV     DX,OFFSET FIL2READ      ;from a given file
         MOV     AH,14H
         INT     21H
         ENDM
;
WRITE    MACRO   FIL2RITE                ;Write record to
         MOV     DX,OFFSET FIL2RITE      ;a given file
         MOV     AH,15H
         INT     21H
         ENDM
;
CLOSE    MACRO   FIL2CLOS                ;Close an open file
         MOV     DX,OFFSET FIL2CLOS
```

```
        MOV     AH,10H
        INT     21H
        ENDM
;
DELETE  MACRO   FIL2DEL                 ;DEL a given file
        MOV     DX,OFFSET FIL2DEL       ;from directory
        MOV     AH,13H
        INT     21H
        ENDM
;
CODEX   SEGMENT PARA PUBLIC 'CODE'
        ASSUME CS:CODEX,DS:CODEX,SS:CODEX,ES:CODEX
        ORG     100H
BEGIN:  JMP     START

        DB      8,8,8                   ;For .COM file TYPE'ers
HEADER  DB      0C9H
        DB      22 DUP(0CDH)
        DB      0BBH,0AH,0DH
        DB      0BAH
        DB      22 DUP(' ')
        DB      0BAH,0AH,0DH
        DB      0BAH,'   SCRAMBLE: PC-DOS    ',0BAH,0DH,0AH
        DB      0BAH,'   Textfile Utility    ',0BAH,0AH,0DH
        DB      0BAH
        DB      22 DUP(' ')
        DB      0BAH,0AH,0DH
        DB      0C8H
        DB      22 DUP(0CDH)
        DB      0BCH,0AH,0DH,0DH
        DB      0FAH,' by John Rudzinski',0AH,0DH,0DH
        DB      0FAH,' 1986 HennSoft',0DH,0AH,0AH,0AH,'$'
        DB      8,20H,1AH
HEADER2 DB      '0) ENcrypt a textfile',0AH,0DH
        DB      '1) DEcrypt a textfile',0AH,0DH
        DB      '2) EXIT program',0AH,0AH,0DH
        DB      'Choose (0,1 or 2): $'
LFCR    DB      0AH,0DH,'$'
ENWORD  DB      'ENcrypt',0AH,0AH,0DH,'$'
DEWORD  DB      'DEcrypt',0AH,0AH,0DH,'$'
ENNOTE  DB      0AH,0AH,0DH,'Encrypting ..... $'
DENOTE  DB      0AH,0AH,0DH,'Decrypting ..... $'
FIN     DB      'Done.',0DH,'$'
ASKPASS DB      07H,'ENTER ACCESS PASSWORD: $'
NOWAY   DB      0AH,0AH,0DH,'FILE ACCESS DENIED.',0DH,'$'
EOF     DB      0
ERR     DB      0

ENCR    DB      0
TRY2    DB      0
QUERY1  DB      'If NO extension follows these filenames, '
        DB      '(ie: filename.EXT)',0DH,0AH
        DB      'then type periods after them (ie: filename. )',0AH
        DB      0AH,0DH,'Enter filename to $'
```

```
          SUB     DI,DI                 ;Clear DI
ROTATE:   CLC                           ;and carry bit, then
          ROR     REALPAS[DI],1         ;unscramble a password byte
          INC     DI                    ;Point to next byte
          LOOP    ROTATE                ;Unscramble password
          SUB     DI,DI
          MOV     CX,14H                ;Allow 20 characters
GET:      MOV     AH,0CH                ;Clear keyboard buffer
          MOV     AL,07H                ;and get (no display)
          INT     21H                   ;a password character.
          CMP     AL,0DH                ;Return typed?
          JE      FORCE                 ;Yep. Do next step.
          CMP     AL,08H                ;Backspace typed?
          JNE     PUTPASS               ;No. Place chr in buffer.
          CMP     DI,00H                ;DI at minimum?
          JE      GET                   ;If so, forget backspace.
          MOV     AH,2
          MOV     DL,08H                ;Print backspace chr
          INT     21H
          MOV     DL,20H                ;Print space character
          INT     21H
          MOV     DL,08H                ;and backspace. Rubs X out.
          INT     21H
          INC     CX                    ;Correct CX (TWICE!)
          INC     CX
          DEC     DI                    ;and DI index
          JMP     GLOOP                 ;and try again.
PUTPASS:  MOV     USERPAS[DI],AL        ;Put character into USERPAS
          MOV     AH,2
          MOV     DL,58H                ;Print an X on the screen
          INT     21H
          INC     DI
GLOOP:    LOOP    GET                   ;Get user's next character
FORCE:    PRINT   LFCR                  ;Password's been entered,
          PRINT   LFCR                  ;so print LF/CR twice.
          CLD                           ;Clear direction flag
          LEA     SI,REALPAS            ;Move REALPAS address and.
          LEA     DI,USERPAS            ;USERPAS to SI and DI
          MOV     CX,8                  ;Gonna check out 8 bytes
REPE      CMPS    USERPAS,REALPAS       ;of each for match
          JE      Q1                    ;They match. Do program.
          CMP     TRY2,1                ;Already had last chance?
          JE      HANG                  ;Yep. Crash into ROM BASIC
          MOV     TRY2,1                ;No. Set up for last chance
          SUB     DI,DI
          MOV     CX,8
REDO:     CLC
          ROL     REALPAS[DI],1         ;Restore garbage to
          INC     DI                    ;REALPAS
          LOOP    REDO                  ;(8 times)
          JMP     GETPASS               ;and try once more.

HANG:     PRINT   NOWAY                 ;Make nasty message and
          INT     18H                   ;go to cassette BASIC.

Q1:       PRINT   QUERY1                ;Get file to encrypt or
          CMP     ENCR,1                ;decrypt (same code does
          JNE     ED2                   ;both) from user. The only
          PRINT   ENWORD                ;reason I differentiate is
          JMP     Q2                    ;for on-screen messages.
```

```
QUERY2   DB     0AH,'Enter NEW name for above file',0AH,0AH,0DH
PROMPT   DB     '> ','$'
OPENERR  DB     07H,'Major problem opening file ... sorry$'
DISKFUL  DB     07H,'Not enough disk space available!$'
NOFILE1  DB     07H,'You MUST enter an existing filename$'
NOFILE2  DB     07H,'You MUST enter a NEW filename$'
ARGH     DB     07H,'The second filename must be DIFFERENT!$'
FCB1     DB     36 DUP(0)
FCB2     DB     36 DUP(0)
BUFF     DB     128 DUP(0)
USERPAS  DB     22 DUP(0)                   ;Space for password entry
;
MSIZ1    DB     0FH                         ;Size allowed for entry
CHRS1    DB     0                           ;Size of typed filename
FNAME1   DB     20 DUP(' ')                 ;Filename #1 goes here
;
MSIZ2    DB     0FH                         ;16 characters allowed
CHRS2    DB     0                           ;Size of typed filename
FNAME2   DB     20 DUP(' ')                 ;Filename #2 goes here

REALPAS  DB     86H,98H,82H,9AH,84H,82H,96H,8AH
         ;      C   L   A   M   B   A   K   E   ROL'ed

START    PROC   NEAR

         CLS    0,0,0,24,79,15              ;Clear screen (hi intens)
         POINT
INTRO:   PRINT  HEADER                      ;Show title
         PRINT  HEADER2                     ;Skip the ·Z fake EOF
GET1:    MOV    AH,0CH
         MOV    AL,8
         INT    21H                         ;Get character
         CMP    AL,'0'                      ;Want to encrypt?
         JNE    GE1                         ;No. Try decrypt
         MOV    ENCR,1                      ;Yes. Tell program
         JMP    ENCDEC                      ;and continue.
GE1:     CMP    AL,'1'                      ;Wanna decrypt?
         JNE    GE2                         ;No. Try the exit.
         JMP    ENCDEC                      ;Yes. Continue.
GE2:     CMP    AL,'2'                      ;Take a powder?
         JNE    GET1                        ;No. Turkey key hit.
         CLS    0,0,0,24,79,7               ;Yes. Program over.
         POINT
EXIT:    PRINT  LFCR                        ;Move cursor down.
         CLS    1,24,0,24,79,7
         RET                                ;Back victorious to DOS

ENCDEC:  CMP    ENCR,1                      ;Are we encrypting?
         JNE    ED1                         ;No. Tell the monitor.
         PRINT  ENWORD                      ;Print 'ENcrypt'
         JMP    GETPASS
ED1:     PRINT  DEWORD                      ;Print 'DEcrypt'
GETPASS: PRINT  ASKPASS                     ;Ask for password
         MOV    CX,8                        ;8 letters in REALPAS
```

```
ED2:     PRINT  DEWORD                      ;(like DEWORD or ENWORD)
Q2:      PRINT  PROMPT                      ;Prompt for input (>)
         INPUT  MSIZ1                       ;Get name of file#1
         MOV    SI,OFFSET FNAME1            ;Have DOS parse filename
         MOV    DI,OFFSET FCB1
         MOV    AH,29H
         INT    21H
         PRINT  LFCR                        ;Do linefeed and return
         MOV    AL,[DI + 1]                 ;Was a legal filename
         CMP    AL,0                        ;actually entered?
         JNE    ASK2                        ;Yep. Goto ASK2
         PRINT  NOFILE1                     ;Nope. Display error
         JMP    EXIT                        ;and haul it home.
ASK2:    PRINT  QUERY2                      ;Ask for 2nd file's name
         INPUT  MSIZ2                       ;and get it.
         MOV    SI,OFFSET FNAME2            ;Let DOS know about the
         MOV    DI,OFFSET FCB2              ;new file's name
         MOV    AH,29H                      ;(ie: PARSE that baby!)
         INT    21H
         PRINT  LFCR                        ;Move cursor down and
         MOV    AL,[DI + 1]                 ;check if we actually have
         CMP    AL,0                        ;a good file to play with.
         JNE    SAME                        ;Yes. Continue.
         PRINT  NOFILE2                     ;No. Print error and
         JMP    EXIT                        ;bow out.
SAME:    CLD                                ;Clear flag (incrementing)
         LEA    SI,FNAME1                   ;Move both typed filenames
         LEA    DI,FNAME2                   ;into SI and DI.
         MOV    CX,14H                      ;Check 20 bytes.
REPE     CMPS   FNAME2,FNAME1               ;Are both filenames the same?
         JNE    GP                          ;No. Good. Continue.
         PRINT  ARGH                        ;Major error message ...
         JMP    EXIT                        ;I dislike major errors.
GP:      CMP    ENCR,1                      ;Are we encrypting?
         JE     ENW                         ;Yes. Branch.
         PRINT  DENOTE                      ;Print 'DEcrypting ....'
         JMP    OFCB                        ;Jump to grand openings.
ENW:     PRINT  ENNOTE                      ;Print 'ENcrypting ....'

OFCB:    OPEN   FCB1                        ;Open file to encrypt
         CALL   ERRCHK                      ;Do errorcheck
         CMP    ERR,1                       ;Did we glom an error?
         JNE    GP2                         ;No. Do CREATE for file2
         JMP    EXIT                        ;Yep. Bow out.
GP2:     CREATE FCB2                        ;Create scratch file
         CALL   ERRCHK                      ;Similar error check
         CMP    ERR,1                       ;Did we snag a problem?
         JNE    GP3                         ;No. Branch.
         JMP    EXIT                        ;Yep. Say g'night.
GP3:     DOSBUFF BUFF                       ;Tell DOS where to put data

RDFCB:   CMP    EOF,1                       ;End of file marked?
         JNE    RDMORE                      ;No. Read in a sector.
         CLOSE  FCB2                        ;Yep. Close both files.
         CLOSE  FCB1
         DELETE FCB1                        ;Kiss file #1 g'bye ...
         PRINT  FIN                         ;Print 'Done.'
         JMP    EXIT                        ;Program completed.

RDMORE:  CALL   FBLANK                      ;Fill buffer with zeroes
```



```
          READ   FCB1                 ;Read file1 record
          CMP    AL,1                 ;EOF reached?
          JNE    DOPASS1              ;No. Process data.
          MOV    EOF,1                ;Yep
R1:       JMP    RDFCB                ;Go back and explain.
DOPASS1:  MOV    SI,OFFSET BUFF       ;Point SI to buffer
          MOV    CX,80H               ;We want 128 iterations
DELOOP:   MOV    AL,[SI]              ;Look at a buffer byte
          CMP    AL,1AH               ;Is it Control-Z? (EOF)
          JNE    CHECK                ;No. Look for exceptions.
          MOV    EOF,1                ;Set EOF byte
          JMP    W1                   ;and write record.
CHECK:    CMP    AL,0AFH              ;0AFH is 1AH (Control Z)
          JE     SKIP                 ;when XOR'ed with B5H, so DON'T XOR!
          CMP    AL,0                 ;Leave zeroes alone, too.
          JZ     SKIP
          CMP    AL,0B5H              ;B5 XOR B5 = 0 so skip.
          JE     SKIP
          XOR    AL,0B5H              ;Scramble record byte in AL
          MOV    [SI],AL              ;and replace into buffer.
SKIP:     INC    SI                   ;Move SI to next address.
          LOOP   DELOOP               ;Do YOU go to de loop?

W1:       WRITE  FCB2                 ;Write scrambled record.
          CMP    AL,1                 ;Disk full?
          JNE    R1                   ;Nah. Keep it up.
          PRINT  DISKFUL              ;Yes. Print error and
          JMP    EXIT                 ;hit the showers.
;
FBLANK:   PUSH   DI                   ;Dunno why I did that ...
          MOV    DI,OFFSET BUFF       ;Buffer blank subroutine
          MOV    CX,80H               ;where 128 zeroes are
BLANK:    MOV    BUFF[DI],0           ;written to the buffer
          INC    DI                   ;after each record write.
          LOOP   BLANK
          POP    DI                   ;Since it was PUSHed, POP it.
          RET                         ;Go read another 128 bytes.
;
ERRCHK:   CMP    AL,0                 ;Error opening file?
          JNZ    E1                   ;Yep. Ominous.
          RET                         ;Nope.
E1:       PRINT  OPENERR              ;Mention to user
          PRINT  LFCR                 ;with LF/CR
          MOV    ERR,1                ;Mention to program
          RET                         ;and scram.
;
START     ENDP                        ;Procedure and
CODEX     ENDS                        ;Segment terminates here.
          END    BEGIN                ;That's that.
```

neighbours. You can spare yourself a bit of typing if you wish by sending $10.00 to

John Rudzinski
c/o HennSoft
208 - 2525 Bathurst St.,
Toronto, Ontario M6B 2Y9

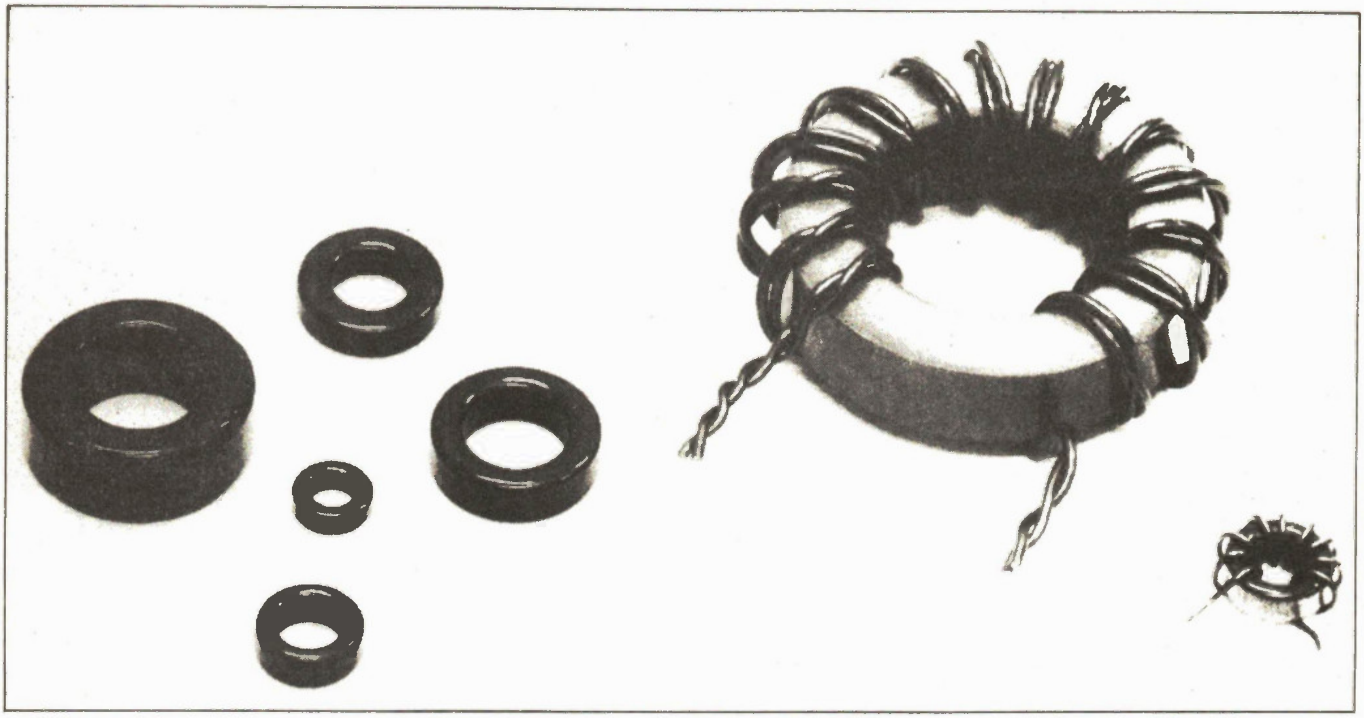
You'll get a disk with the listing and program on it, and a brief instruction sheet. Be sure to state the 8-letter password you want (unless you like CLAMBAKE), and ensure I have your return address.

The only caveat I can think of is that you don't try to encrypt or decrypt a non-textfile. Because control-Z characters may occur freely in these, you could well end up with a truncated, unrecoverable mess for your trouble. My textfile encryptions and subsequent recoveries have been flawless, but textfile-producing software can be strange. Experiment on file back-ups first to get the feel of the program, and to ensure it works with textfiles your applications programs produce.

This article was submitted in encrypted form. I only hope ET's editors run SCRAMBLE before having it typeset ... ■

(We did. All that came up on the monitor was a re-run of Dallas - Ed.)

Continued from page 24



Advantages

The main advantages we get from using toroids are higher Q, self-shielding and compactness. Let's consider each of these benefits in turn.

Having selected an appropriate core for the operating frequency, and power (this will be clear later) we find that for a given inductance the toroidal inductor has fewer turns on it than an equivalent air cored inductor, because of the permeability of the material used in the core. This also means that the winding resistance is lower, and since both inductors have the same inductance and therefore the same value of inductive reactance, the value of XL/R will be greater for the toroid winding. This expression is the same as that for the Q of a coil and so the Q will also be greater. An additional benefit is gained with low voltage equipment which passes dc current through the inductor, by reducing voltage drop and hence heating in the component.

Unlike normal (solenoid wound) coils which have large external magnetic fields, the toroid winding has a field which is almost completely contained within itself. This means there is almost no magnetic coupling between toroidal coils and other circuit elements. (Try coupling a gdo [grid dip oscillator] to a tuned circuit containing a toroid!). We are therefore free to place toroid coils fairly close to other circuit components (including ground plane) without complicated shielding. It should be noted that capacitive coupling can occur and normal precautions must be taken against this.

The two benefits mentioned above allow us to create a much more compact circuit layout when toroid coils are employed. This is particularly important when portable equipment is being considered or when an expensive pc board is used.

Choice of Core Material

Contrary to information which sometimes appears in magazines, the choice of material is of prime importance if the expected results are to be realized from any design using ferromagnetic cores. Let's look at the two most common core materials in use: ferrite and iron powder. The choice between the two is made by considering whether the core will be used in a wideband or narrowband application and how much signal power will be handled.

For a given size core, ferrite material will saturate at a much lower flux density than one made from iron powder. Permeability for ferrite materials ranges from 20 to 5000 while for iron-powder it is from 2 to 75 As a 'rule of thumb' the higher the permeability of the material the greater the temperature coefficient will be, so that it is desirable to use a material which exhibits the lowest practical temperature coefficient in a narrowband circuit. On the other hand this is not so important in wideband use.

For wideband circuits a ferrite is commonly used because it has a higher permeability and hence can provide a larger inductance for a given number of turns than is possible with an equivalent size iron powder core. The grade of ferrite chosen must exhibit low loss over the range of operating frequencies; refer to the manufacturer's data. The common rule for the design of wideband transformers is that the reactance (XL) of a winding must not be less than four times the design impedance at the lowest frequency.

'What about the effects of this at the high frequency end?' you may ask. Well luckily there is no cause for concern, as the effective permeability of the core material decreases with increasing frequency, and the core tends to 'disappear' so that the inductance of the winding is also reduced. With the proper selection of core material it is easy to make wideband transformers which cover one decade in frequency; eg 3-30 MHz.

Narrowband applications (tuned circuits) above 1.5MHz usually use iron powder cores which can provide good Q values into the VHF frequencies. Wideband circuits by their very nature cannot have a high Q (circuit Q = centre frequency/bandwith). The characteristics of iron powder are less temperature sensitive so with changing temperature the circuit remains more closely tuned o the design frequency than is possible with ferrite materials. When tuned circuits are used in RF amplifiers at almost any power level, we should choose an iron powder core.

Ferrite materials can be divided into two groups: those with initial permeabilities below 1000 which are nickel-zinc compounds, and those above 1000 which are made from manganese-zinc compounds. Nickel-zinc ferrites exhibit high volume resistivity, moderate stability and can offer high Q factors for the 0.5 to 100 MHz frequency range. They are well suited for low power, high inductance applications and their high permeability factors make them very useful for wideband transformer applications. The manganese-zinc group has fairly low volume resistivity and moderate saturation flux density. It can give high Q factors for the 1 kHz to 1 MHz frequency range, and some are suitable for switched-mode power conversion transformers operating between 20 and 100 kHz.

Apart from the physical dimensions of a toroid (outside and inside diameter thickness) there is a value given for each particular core size and material, which is usually called the 'Al value', and is the manufacturer's inductance index for the core. Manufacturers' data for iron powder and ferrite cores are given in Tables 1-6 and show all the required core information. The Al figure for powdered iron cores is normally given as uH/100 turns, but for ferrite cores it is usually quoted as mH/1000 turns. The relevant Al value is used in many calculations involving toroids. One of the most common uses is to calculate the turns required to produce a given value of inductance on a particular core, as shown below:

iron powder:

$$\text{turns} = 100\ (\text{desired } L\mu H / A_L)^{0.5}$$

ferrite:

$$\text{turns} = 1000\ (\text{desired } LmH / A_L)^{0.5}$$

What size Toroid?

Toroid cores come in sizes ranging from 3 mm up to 150 mm outside diameter, with the common sizes between 6 mm and 50 mm. The power rating of a given size core will depend upon the particular ferromagnetic material used, and the calculation of this is probably the most complex consideration of all.

Ferrite materials are basically limited by flux saturation and iron powder by temperature rise. Many ferrites can permanently change their permeability after being subjected to relatively high power (flux) levels, whereas powdered iron cores return to their original values after they cool down. In circuits up to 500mW, saturation is not usually of any concern, but when we use a ferromagnetic core at levels above 1 W it must be taken into account in the design. Another 'rule of thumb': when in doubt use the largest core which will conveniently fit into your layout. At high power levels considerable heat can be generated in ferromagnetic cores and the constructor must make provision for adequate ventilation and removal of heat, which can affect nearby circuit components. The surface area of the core largely determines the allowable dissipation, so once again 'use the largest core which is practical', and don't try to build a high power solid state amplifier into a closed box without ventilation.

TABLE 1. IRON POWOER TOROIDAL CORES PHYSICAL DIMENSIONS

Core Size	Outer Diam (in)	Inner Diam (in)	Height (in)	Cross Sect (cm²)	Mean Length (cm)
T-520	5.218	3.081	0.800	5.50	33.10
T-400	4.000	2.250	0.650	3.66	24.93
T-300	3.048	1.925	0.500	1.81	19.83
T-225A	2.250	1.405	1.000	2.73	14.59
T-225	2.250	1.405	0.550	1.50	14.59
T-200A	2.000	1.250	1.000	2.42	12.97
T-200	2.000	1.250	0.550	1.33	12.97
T-184	1.840	0.950	0.710	2.04	11.12
T-157	1.570	0.950	0.570	1.14	10.05
T-130	1.300	0.780	0.437	0.73	8.29
T-106	1.060	0.570	0.437	0.69	6.50
T-94	0.942	0.560	0.312	0.385	6.00
T-80	0.795	0.495	0.250	0.242	5.15
T-68	0.690	$.370	0.190	0.196	4.24
T-50	0.500	0.303	0.190	0.121	3.20
T-44	0.440	0.229	0.159	0.107	2.67
T-37	0.375	0.205	0.128	0.070	2.32
T-30	0.307	0.151	0.128	0.065	1.83
T-25	0.255	0.120	0.096	0.042	1.50
T-20	0.200	0.088	0.070	0.025	1.15
T-16	0.160	0.078	0.060	0.016	0.95
T-12	0.125	0.062	0.050	0.010	0.76

TABLE 2. IRON POWOER TOROIDAL CORES A_L VALUES (μh/100 turns)

Core Size	26-mix ylw-wht μ = 75 0 –1.0 MHz	3-mix grey μ = 35 0.05-0.5 MHz	15-mix red/wht μ = 25 0.1 –2 MHz	1-mix blue μ = 20 0.5 –5 MHz	2-mix red μ = 10 1 –30 MHz	6-mix yellow μ = 8 2 –50 MHz	10-mix black μ = 6 10 –100 MHz	12-mix grn/wht μ = 3 20 –200 MHz	0-mix tan μ = 1 50 –300 MHz
T-520 —	1500	NA	NA	NA	205	NA	NA	NA	NA
T-400 —	1320	NA	NA	NA	185	NA	NA	NA	NA
T-300 —	825	NA	NA	NA	115	NA	NA	NA	NA
T-225A —	1600	NA	NA	NA	215	NA	NA	NA	NA
T-225 —	950	425	NA	NA	120	100	NA	NA	NA
T-200A —	1550	460	NA	455	218	180	NA	NA	NA
T-200 —	895	425	NA	250	120	100	NA	NA	NA
T-184 —	1640	720	NA	500	240	195	NA	NA	NA
T-157 —	970	420	360	320	140	115	NA	NA	NA
T-130 —	785	350	250	200	110	96	NA	NA	15
T-106 —	900	450	345	325	135	116	NA	NA	19
T- 94 —	590	248	200	160	84	70	58	32	10.6
T- 80 —	450	180	170	115	55	45	32	22	8.5
T- 68 —	420	195	180	115	57	47	32	21	7.5
T- 50 —	320	175	135	100	49	40	31	18	6.4
T- 44 —	360	180	160	105	52	42	33	19	6.5
T- 37 —	275	120	90	80	40	30	25	15	4.9
T- 30 —	325	140	93	85	43	36	25	16	6.0
T- 25 —	NA	100	100	70	34	27	19	12	4.5
T- 20 —	NA	90	65	52	27	22	16	10	3.5
T-16 —	NA	61	55	44	22	19	13	8	3.9
T- 12 —	NA	60	50	48	20	17	12	7	3.0

μ = relative permeability

NA — not available in that size
Add mix number to core size in space provided (—) for complete part number)

$$\text{Turns} = 100\sqrt{\frac{\text{desired L } (\mu h)}{A_L \text{ value } (\mu h/100\ t)}}$$

To determine the operating flux density (Bop) of a core we must take into account the applied voltage (Erms), the equivalent area of the magnetic path in cm2 (Ae), the number of turns (N) and the operating frequency (f). These terms are used in the following formula:

$$\text{Bop} = \frac{\text{Erms} \times 10^{8}}{4.44\, f\, N\, Ae\ (\text{gauss})}$$

and if dc is passed through the winding add the following:

$$+\ \frac{N\, Idc\, A_L}{10\, Ae}$$

The manufacturer's data will give the saturating flux density of the core, and the calculated value of Bop should be quite a bit below this value to be on the safe side. The formula shows that we should use the lowest operating frequency expected in our design (3 MHz in a 3-30 MHz wideband circuit) and the highest value of Erms (calculated from the required RF power and the winding impedance) to give a conservative design figure for flux density. The saturating flux density (Bsat) for iron powder materials is about 10,000 gauss, while for ferrites below 1000 u it is 1500 gauss, and for those above 1000 u it is about 3000 gauss.

Using the Data Sheets

Two principal sets of data are given in Tables 1 to 6, and cover iron powder and ferrite toroids. First, let's look in detail at Tables 1 and 2 which give all the essential information for some iron powder toroids.

Iron powder toroids

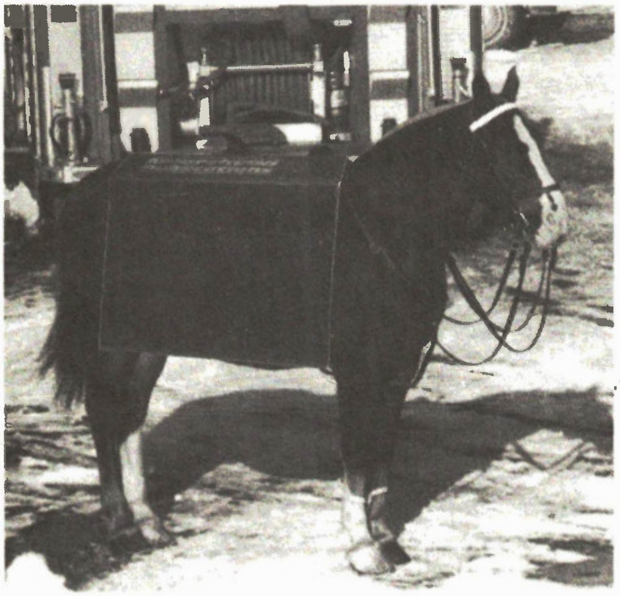
The physical dimensions are important since we must know how big the toroid is to allow sufficient space in our project. The cross sectional area and mean length (magnetic path length) are included so that flux density and magnetizing force calculations can be made. You will notice that this manufacturer uses a type number which begins with 'T' for iron powder cores and is followed by a figure which denotes the outside diameter in hundredths of an inch.

Table 2 lists the Al values for all the combinations of core size and mix (material types) that are available. The different materials have different values of relative permeability (u), which also determines the useful range of frequencies for each material, and the cores are colour-coded for easy recognition. The formula for turns calculation is also given.

Another useful table (Table 3) gives the maximum turns vs wire gauge and core size for single layer windings. This saves a lot of 'cut and try', so we can make a good 'first approximation' for our winding. Figure 1 shows typical Q curves for

Continued on page 47

The Electronics Today Horseblanket/Magazine Binder



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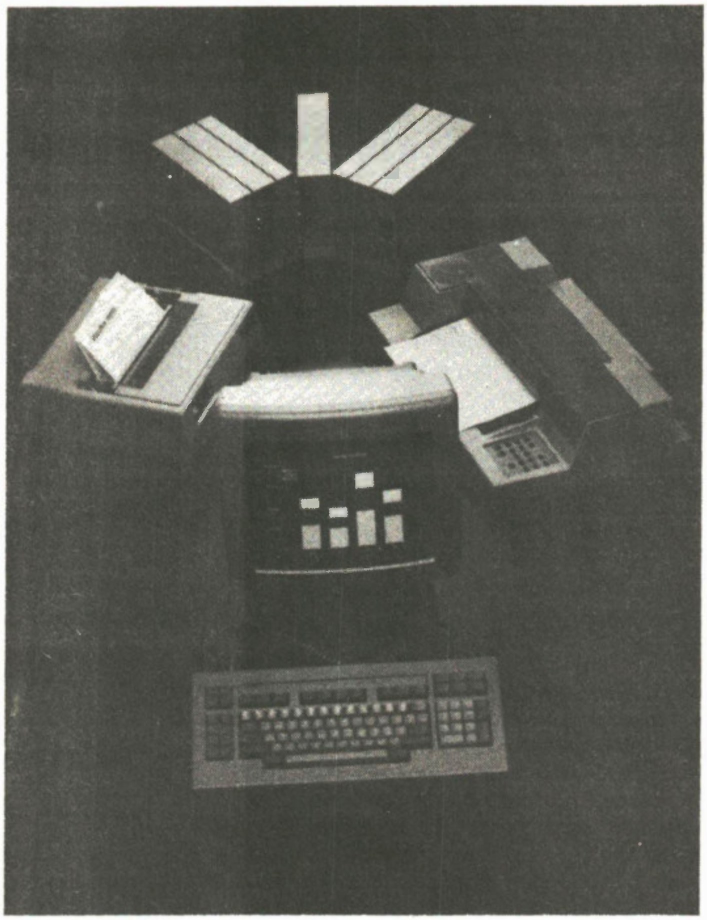

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Continued from page 44

different sized cores made from mix-2. Notice that the larger cores are used at the lower end of the frequency range for mix-2 and they produce correspondingly larger values of Q. This principle is used generally for all core materials.

Suppose we wish to wind a toroid coil for use in a receiver front-end tuned to 7 MHz. Since there is no RF 'power' involved we do not have to worry about saturation of the core and can choose almost any size core. Without going overboard it is best to choose the largest size consistent with our circuit layout as that will enable us to achieve a better Q, which is a common requirement in receiver front-ends. If we want to tune this coil with a 100 pF capacitor we will require an inductance of approximately 5 uH.

With a frequency of 7 MHz we have a choice of mix-2 or mix-6, but let's decide on a (red) T-50-2 as our core. The Al of this core is given as 49 and so we can calculate the required turns to produce 5 uH from the formula given in section 2. This works out to 31.9 which we will round up to 32 since we cannot have fractional turns on a toroid.

Next we look up the table showing turns vs core size for different wire gauges and see that we can fit 39 turns of 24 g enamelled wire on a T-50-2 core. Our toroidal inductance would have an unloaded Q of about 200, which is quite a respectable figure for this application. If a coupling link is required on the toroid, it should be put on at the 'cold end' of the winding, and in this case, could consist of two or three turns.

Ferrite toroids

Tables 4-6 list all the data for ferrite toroids. Table 4 shows the physical dimensions of the various sized ferrite cores, which are different to the iron powder cores and are all prefixed by FT (ferrite toroid).

Table 5 lists the Al values for all the combinations of core size and ferrite material, and also gives the formula for calculating turns. Notice that these cores are not colour coded, so be careful to keep track of the types if you acquire some ferrite cores, otherwise you will finish up with a heap of cores with unknown characteristics. A good idea is to paint coloured dots on the core to indicate the material type: eg blue and brown dots for 61 material.

Table 6 is interesting in that it gives information for narrowband (tuned circuit) and wideband use, as well as the permeability for each different ferrite mix. This enables us to select the correct mix for any particular application.

Let's work out an example. Suppose we want to design a wideband transformer for use between 3.5 MHz and 30 MHz and it has to match a 200 ohm source to a 50 ohm load. From the previous rule we know that the primary winding should have an inductive reactance of not less than 800 ohms at 3.5 MHz. Using the formula (LuH ' XL/2pif, where f is in MHz) we see that we need a primary winding of 37 uH. Similarly, the secondary winding would need an XL of 200 ohms which works out to be a winding of 9.2 uH. Since these are minimum values let's round them off to 40 uH and 10 uH.

Now let's work out the turns required for a ferrite core of suitable material for the frequency range. Assuming that this is a low power application (eg receiver) we will decide on a ferrite toroid of 12.5 mm OD and with an initial permeability of 850, which, according to Table 6 is suitable for 1-50 MHz. The Al value for an FT-50-43 is given in Table 5 as 523. Using the formula for ferrite cores, the turns required to give 40 uH will be 8.7 (don't forget that this formula uses mH in the Al value calculation!). Since we require an impedance ratio of 4 to 1 in our example, the final transformer should have a turns ratio of 2 to 1. A toroid core cannot have partial turns (see 'Winding hints') so we cannot have a primary with 817 turns and a secondary with 4.35 turns. Our original rule stated that a wide-band winding should have a minimum of four times the load impedance, so we are able to increase our calculated secondary turns to 5 (instead of the 4.35) and the primary turns will then become 10, which preserves the 2 to 1 turns ratio.

Although the rule states a minimum of four times it should be notes that if too many turns are wound on the core, troubles can arise at the high frequency end of the wideband transformer; it would be wrong to put say, 40 turns on

TABLE 3. NUMBER OF TURNS v WIRE SIZE and CORE SIZE

Approximate maximum number of turns — single layer wound — enamelled wire

Wire Size	T-200	T-130	T-106	T-94	T-80	T-68	T-50	T-37	T-25	T-12
10	33	20	12	12	10	6	4	1		
12	43	25	16	16	14	9	6	3		
14	54	32	21	21	18	13	8	5	1	
16	69	41	28	28	24	17	13	7	2	
18	88	53	37	37	32	23	18	10	4	1
20	111	67	47	47	41	29	23	14	6	1
22	140	86	60	60	53	38	30	19	9	2
24	177	109	77	77	67	49	39	25	13	4
26	223	137	97	97	85	63	50	33	17	7
28	281	173	123	123	108	80	64	42	23	9
30	355	217	154	154	136	101	81	54	29	13
32	439	272	194	194	171	127	103	68	38	17
34	557	346	247	247	218	162	132	88	49	23
36	683	424	304	304	268	199	162	108	62	30
38	875	544	389	389	344	256	209	140	80	39
40	1103	687	492	492	434	324	264	178	102	51

Actual number of turns may vary slightly according to tightness of wind

TABLE 4. FERRITE TOROIDAL CORES PHYSICAL DIMENSIONS

Core Size	Outer Diam (in)	Inner Diam (in)	Height (in)	Cross Sect (cm^2)	Mean Length (cm)	Volume (cm^3)
FT-23	0.230	0.120	0.060	0.021	1.34	0.029
FT-37	0.375	0.187	0.125	0.076	2.15	0.163
FT-50	0.500	0.281	0.188	0.133	3.02	0.401
FT-50A	0.500	0.312	0.250	0.152	3.18	0.483
FT-50B	0.500	0.312	0.500	0.303	3.18	0.964
FT-82	0.825	0.520	0.250	0.246	5.26	1.29
FT-87A	0.870	0.540	0.500	0.522	5.42	2.83
FT-114	1.142	0.750	0.295	0.375	7.42	2.79
FT-114A	1.142	0.750	0.545	0.690	7.42	5.13
FT-150	1.500	0.750	0.250	0.581	8.30	4.82
FT-150A	1.500	0.750	0.500	1.110	8.30	9.21
FT-193	1.930	1.250	0.750	1.460	12.30	18.00
FT-240	2.400	1.400	0.500	1.570	14.40	22.70

the primary and 20 turns on the secondary in our example.

Winding Hints

One aspect of toroidal windings which often causes newcomers some trouble is counting turns. A toroidal coil cannot have partial turns. If a straight wire passes through the centre of a core it counts as one turn, even though the ends are not brought back together. With any toroid winding it is good practice to have the winding cover 300-330 degrees of circumference. If the winding covers the whole length of the core 'end capacity' effects cause unwanted resonances which are particularly troublesome with tuned circuits, and cause a lowering of the effective Q of the winding. With tuned circuits any coupling winding should be placed over the 'cold' end of other windings on the core to prevent undesirable capacitive coupling between windings.

Broadband transformers are often made up with 'multi-winding' windings which are then joined in series to form one larger winding. this method of winding is referred to as a multifilar winding. The most common types are bifilar, trifilar and quadrifilar, which refer to two, three and four separate windings wound on the core at the same time by using two, three or four separate pieces of wire. The groups of wires are often twisted together before winding (about 3 turns per cm) by holding one set of ends in a vice and the other ends in the chuck of a hand drill which is then slowly rotated while keeping the wires taut. Since all the wires are wound together they are also wound on the core in the same sense; ie all the starts are at the same end. With the aid of an ohmmeter the separate wires can then have their starts and finishes identified, so that it is an easy matter to join up the finish of one winding to the start of another.

If two windings are series connected in this way the winding is called a bifilar winding. The purpose of this type of winding is to reduce the stray winding capacitances which would result from a single winding of the same number of turns. This is most important at the higher frequencies. Another benefit with this type of winding is that it is easy to make up transformers with turns ratios of 1:1, 2:1 or 3:1 by joining 1, 2 or 3 windings in series for the high impedance winding and using a single winding for the low impedance. In practice it is difficult to make a good broadband transformer with a turns ratio greater than 4:1, and for greater ratios it is better to use two separate transformers which, when combined, produce the required ratio.

TABLE 5. FERRITE TOROIDAL CORES A_L VALUES (mh/1000 turns)

Core Size	#68 μ = 20	#63 μ = 40	#67 μ = 40	#61 μ = 125	#43 μ = 850	#77 μ = 1800	#72 μ = 2000	#F μ = 3000	#75 μ = 5000	#J μ = 5000
FT-23 —	4.0	7.9	7.9	24.8	188	356	396	NA	990	NA
FT-37 —	8.8	17.7	17.7	55.3	420	796	884	NA	2210	NA
FT-50 —	11.0	22.0	22.0	68.0	523	990	1100	NA	2750	NA
FT-50A —	12.0	24.0	24.0	5.0	570	1080	1200	NA	2900	NA
FT-50B —	NA	48.0	48.0	150.0	1140	2160	2400	NA	NA	NA
FT-82 —	11.7	22.4	22.4	73.3	557	1060	1170	NA	2930	NA
FT-87A —	NA	NA	NA	NA	NA	NA	NA	3620	NA	6040
FT-114 —	12.7	25.4	25.4	79.3	603	1140	1270	1900	3170	3170
FT-114A —	NA	NA	NA	146.0	NA	NA	2340	NA	NA	NA
FT-150 —	NA	NA	NA	NA	NA	NA	NA	2640	NA	4400
FT-150A —	NA	NA	NA	NA	NA	NA	NA	5020	NA	8370
FT-193 —	NA	NA	NA	NA	NA	NA	NA	4460	NA	7440
FT-240 —	NA	53.0	NA	173.0	1240	NA	3130	NA	NA	NA

μ = relative permeability
NA — not available in that size
Add mix number to core size in space provided (—) for complete part number

$$\text{Turns} = 1000\sqrt{\frac{\text{desired L (mh)}}{A_L\text{ (mh/1000 t)}}}$$

TABLE 6. FERRITE MAGNETIC PROPERTIES

Property	#68	#63	#67	#61	#43	#77	#72	#F	#75	#J
Relative Permeability (μ)	20	40	40	125	850	1800	2000	3000	5000	5000
Saturation Flux (Gauss)	2000	1850	3000	2350	2750	4600	3500	4700	3900	4300
Curie Temp °C	500	450	500	350	130	200	150	250	160	140
Temp Coef %/°C	0.06	0.10	0.13	0.15	1.0	0.60	0.60	0.60	0.90	0.90
Tuned Circuit Frequency (MHz)	80-180	15-25	10-80	0.2-10	0.01-1	0.001-1	0.001-1	0.001-1	0.001-1	0.001-1
Wideband Frequency (MHz)	200-1000	25-200	50-500	10-200	1-50	0.5-30	0.5-30	0.5-30	0.2-15	0.2-15

It is often necessary to adjust the inductance of a toroidal winding in tuned circuit applications to achieve resonance with a fixed capacitor in the circuit. Apart from adding or removing turns (a coarse adjustment) it is possible to make fine adjustments by slightly closing up or spreading apart the turns around the core. Pushing the turns together will increase the inductance and, conversely, spreading them apart will decrease the value. Finished windings can be fixed in place with polystyrene dope, and complete toroidal inductors may be attached to a printed circuit board with silastic adhesive so that the assembly can be removed later if necessary. When fixing to an earthed base be careful of unwanted capacitive coupling to the winding itself.

Ferromagnetic materials are hard and brittle, so do not clamp cores in a vice or pliers. To prevent any sharp corners form cutting through the insulation on the wire it is good practice to wind a layer of PTFE tape (as used by plumbers for sealing threaded joints) over the entire core before laying on the winding. Always put the winding with the largest number of turns on first so that additional windings have an even base to sit on. The sealing tape can also be used as insulation between windings.

It is important to know how to measure the resonant frequency of a tuned circuit containing a toroid inductor. As mentioned earlier, toroidal coils have very little external field, so it is almost impossible to couple a GDO to such a winding. To overcome this, use a 1 or 2 turn link coupling between the GDO coil and the 'cold end' of the toroid winding.

Where ferromagnetic cores are used with transmitters quite high RF voltages can exist across windings and ordinary enamel insulation is often not sufficient to prevent breakdown between turns or breakdown between turns and the core. In these cases good spacing between turns and good HV insulation (eg PTFE insulation) must be used. Because of these restrictions, it is not usual to use ferromagnetic cores at high power levels (200 W) where the circuit impedance exceeds 600 ohms. Fortunately, most solid state circuits operate at much lower impedances.

Suppliers

Toroidal cores are available from:

Electro Sonic, 1100 Gordon Baker Road,
Willowdale, Ontario M2H 3B3 (416)
494-1555.

Carsten Electronics, 3791 Victoria Park
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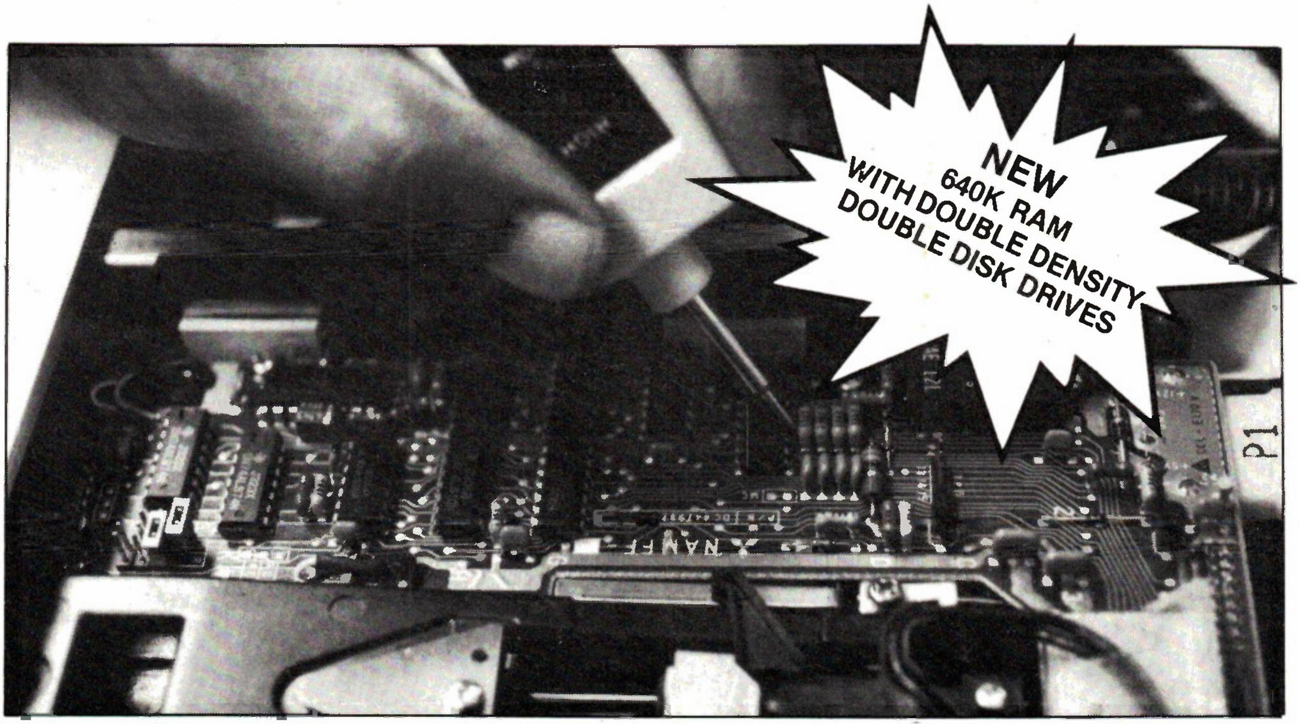

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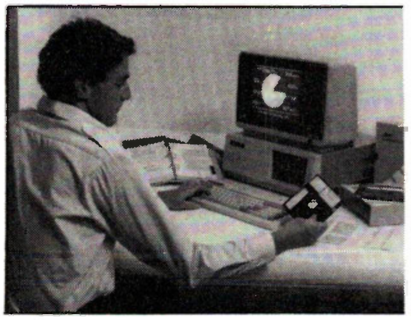

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Circle No. 13 on Reader Service Card

Continued from page 28

Dual Reading Thermometer

act as a display window must be made in the top panel, together with a couple of holes for the LEDs. These must be carefully positioned so that they accurately match up with LEDs and the display when the lid of the case is put into place.

The rectangular cutout for the display can be made using a fretsaw or a miniature round file, with a small flat file being used to finish it off neatly. The size of the cutout is 19 by 50 milimetres. It is advisable to fit some thin transparent plastic behind the display window to protect the front of the display against accidental scratches.

Resistors — All 0.25W 5% carbon

R1	220k
R2, R3	100k
R4	22k
R5	1M
R6	470k
R7	18k
R8, R9	1k
R10	10M

Potentiometers

VR1	1k sub-min horizontal preset

Capacitors

C1	22p ceramic plate
C2	100n carbonate
C3	22n ceramic
C4	470n carbonate
C5	47n carbonate
C6	100*u* radial elect, 10V
C7	220p ceramic plate
C8, C9	22*u* radial elect. 25V
C10	330n carbonate

Semiconductors

IC1	ICL7106 DVM
IC2	3½ digit LCD display
IC3, IC7	4001BE CMOS quad 2-input NOR gate
IC4, IC5	LM35DZ temperature sensor
IC6	4016BE CMOS quad analogue switch
TR1	BC547 silicon *npn*
D1, D2	IN4148 silicon diode
D3,D4	TIL209 red LEDs

Miscellaneous

S1	SPST miniature toggle switch
B1	9V battery.

Case about 205 x 140 x 40 mm; two 3.5 mm stereo jack sockets and matching plugs; battery connector; two 40-pin DIL IC holders (see text); three 14-pin DIL IC holders; wire; solder; pins; etc. The LM35DZ is available from Electro Sonic: 1100 Gordon Baker Road, Willowdale, Ontario, 416-494-1555.

The sensors can be wired to the printed circuit board using two lengths of twin screened cable with the outer braiding of each cable carring the "V–" connection. Rather than using direct connection to the board it is likely to be more convenient in use if the board is connected to a couple of three-way sockets fitted on the rear panel, and the leads from the sensors are fitted with matching (and correctly connected) three-way plugs. On the protoype stereo 3.5mm connectors are used, but any type of three-way connector should be perfectly suitable. Whichever method of connection is used, the cables can be many metres long if necessary. The on/off switch can be mounted on the front panel or the rear panel, as preferred.

Ajustment and Use

Start with VR1 at a roughly mid setting. When the unit is switched on the display should show a realistic but not necessarily a very accurate reading, and the two LEDs should flash on and off alternately with an "on" time of around 1.5 seconds. Switch off immediately and recheck all the wiring if either or both of these conditions are not met.

If all is well, one way of calibrating the unit is to measure the output voltage from one of the sensors using an accurate digital multimeter, and to then adjust VR1 for the corresponding reading. For example, if the measured voltage is 0.249 volts, VR1 would be adjusted for a display of 24.9 degrees. VR1 must be adjusted very carefully in order to obtain exactly the required reading, but adjustment is not so critical as to merit the use of a multiturn potentiometer.

A more accurate method is to calibrate the unit against a precision thermometer. With the thermometer and the sensors placed side-by-side and allowed to settle to the same temperature for a minute or so, simply adjust VR1 for a display reading which matches the temperature indicated by the calibration thermometer.

If the sensors are to be used in liquids it is essential that they be fitted into protective probes, such as small test tubes. Some silicon grease can be used to give a good thermal contact between sensor and tube, but it will always take at least a few seconds for the sensors to adjust to any large changes in temperature. If the sensors are not to be used in liquids it is a good idea to at least insulate each leadout wire using insulation tape so that there is no danger of accidental short cuircuits arising. ■

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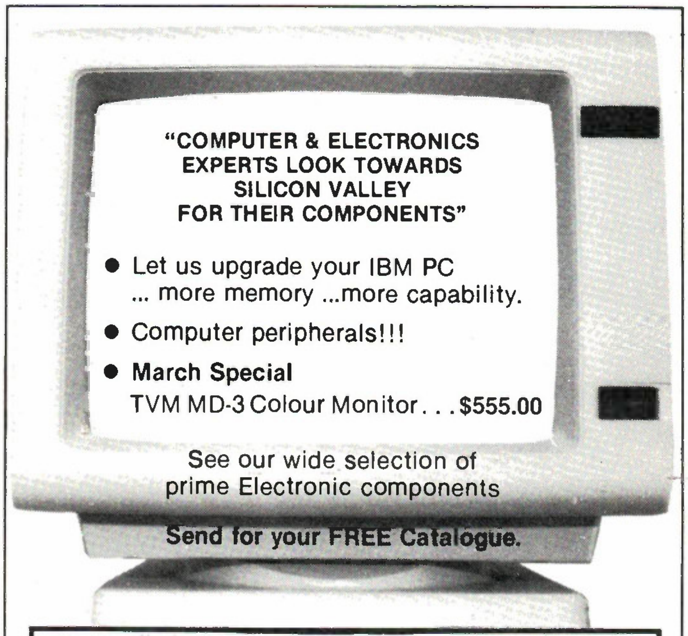

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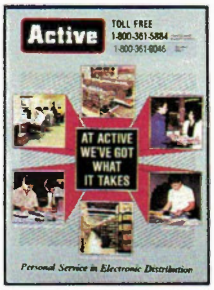

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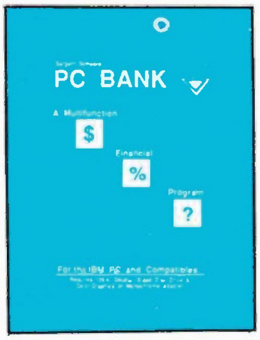

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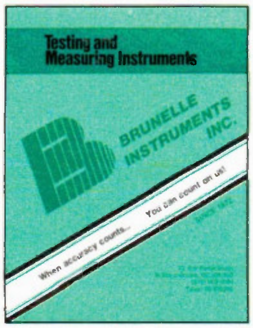

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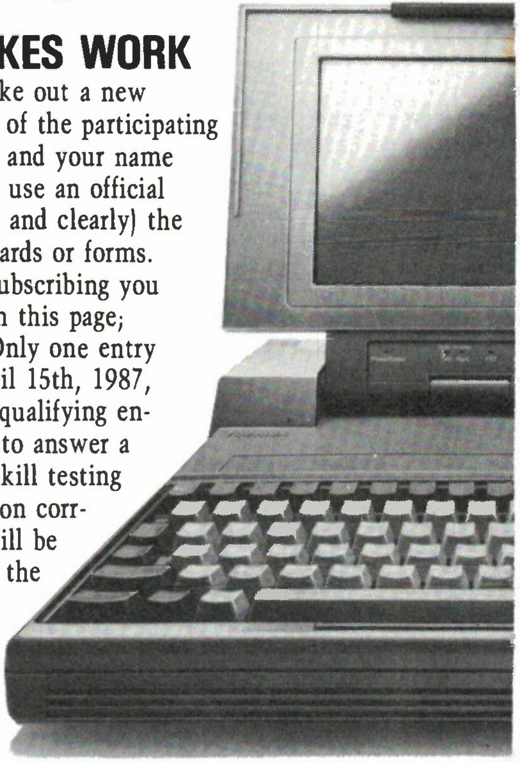

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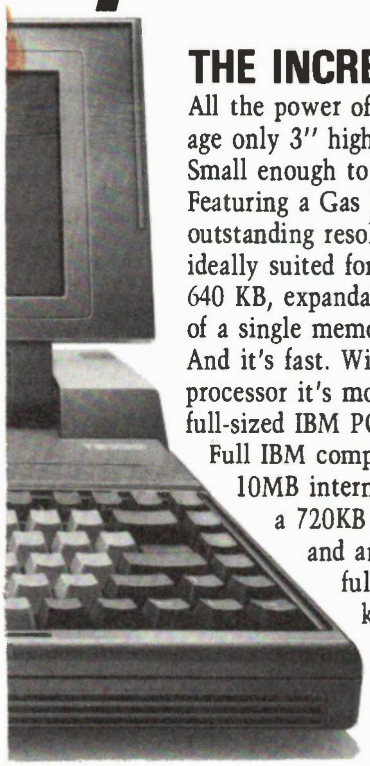

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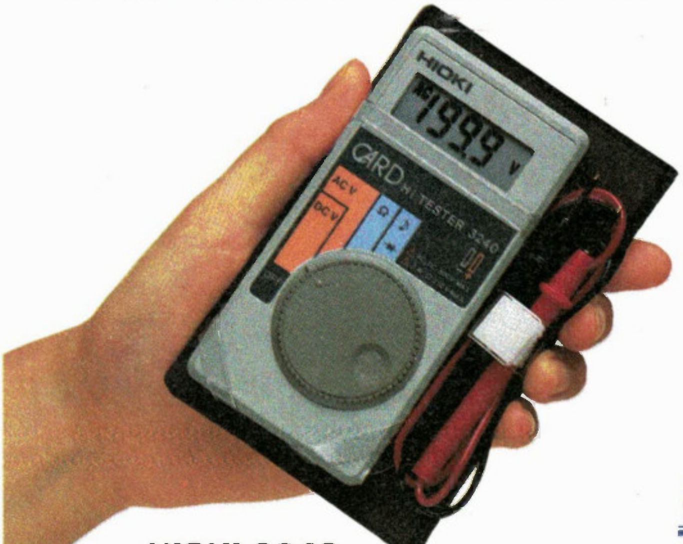

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