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Volume 13, Number 2 February 1989

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FOR YOUR INFORMATION

Correction

Gulp. Those of you reading Steve Rimmer's guide to the C programming language last month may have thought that huge amounts of text were missing. In fact, the order of two of the pages was inadvertently switched during the printing. To read it in the correct order, the pages would go 16-17-19-18-20.

Weather Satellite Sources

In answer to the unusually heavy response to the weather satellite photo article in last month's issue, we would like to add the following information. The author can be contacted for further information: Hank Brandli, 3165 Sharon Drive, Melbourne, Florida 32904-9533, (407) 724-5599. The low-noise preamp mentioned, the Vanguard 102-W, is available from Vanguard Labs, 196-23 Jamica Avenue, Hollis, NY 11412, (718) 468-2720. PC hardware and software information is available from Jim MacLean, 2112 S. Parsons Avenue, Melbourne, Florida 32901, (407) 727-3646.

Undersea Fibre Optics

AT&T has deployed TAT-8, the world's first undersea fibre optic cable. Stretching 3,148 miles from New Jersey to a branching repeater on Europe's continental shelf, the cable has the capacity to handle 40,000 simultaneous phone calls over its fur fibres (with two more fibres in reserve for reliability). 109 repeaters along the cable regenerate the digital audio, which is carried by a pulse train of infrared laser light at 295.6 megabits per second. The repeaters are powered from a 5,000 volt DC feed.

The first undersea cable was laid in 1856, though it failed after a few weeks service. Another telegraph cable was successfully laid between Ireland and Newfoundland in 1866. When it came to telephone service, though, the use of shortwave radio dominated until the 1950s. The development of the repeater made the analog long-distance cable possible, and in 1956 AT&T laid TAT-1, carrying 36 simultaneous calls between Scotland and Newfoundland.

TAT-9 will be in service in 1991, carrying 80,000 calls. A unique undersea branching multiplexer will allow the cable to come ashore at five different points in the US, Canada, the UK, France and Spain.

Soldering Equipment

Antex of England has appointed Cobra Sales of Downsview as the exclusive importer of their precision soldering irons, soldering stations, stands, etc. Their TCS soldering pencil, for instance, has a built-in temperature control (200-450°C) and a 50W element. Various tips are available, including IC tips that melt up to 16 pins simultaneously. Especially interesting is a soldering gun with jaws like a large pair of crimping pliers, used to solder plumbing pipe where a flame is not possible.

Circle No. 2 on Reader Service Card

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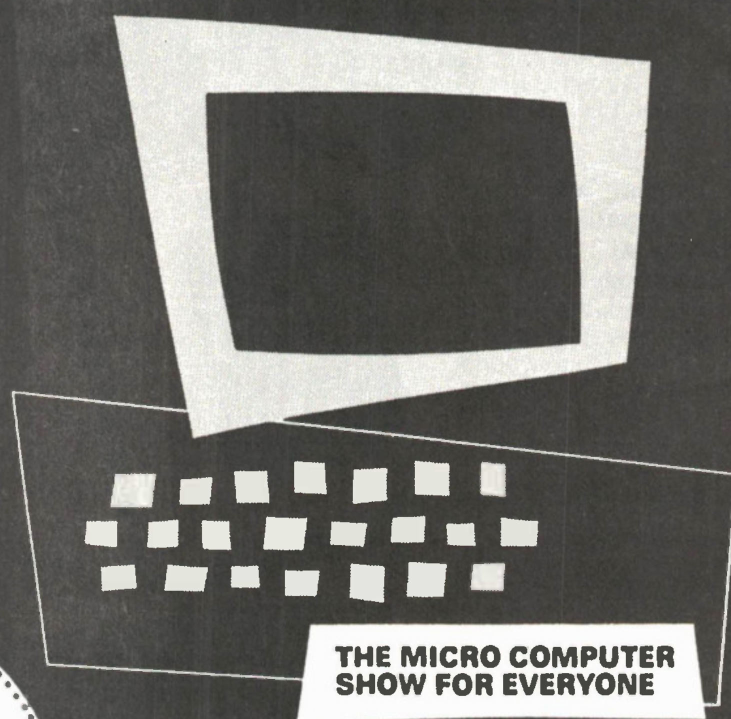

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Circle No. 3 on Reader Service Card

 Continued from page 4

Unix Study

The Unix operating system is rarely heard from in popular computing, which is dominated by Microsoft's MS-DOS. There's a general feeling that it's limited to scientific and engineering applications, but the Canadian Network of Unix Systems Users have commissioned a comprehensive study that shows that the highest use is for data processing and office automation. 31% of those surveyed use Unix for general computing, and 79% use it for specific limited functions (there was some overlap). Unix as a percentage of industry hardware revenue will increase from 6% in 1988 to 19% in 1992. For further information, you can contact the Unix user's group at (416) 259-8122.

Another Fast One

Continuing our monthly reports on the world's fastest semiconductor: this month it's Bell Labs and their bipolar transistor that can switch at 140 billion times a second (140GHz). That's 12 times faster than the commercial bipolars used in today's superconductors. The new transistors are made from indium phosphide and gallium indium arsenide using a new method of crystal-growing that minimizes collisions of the electrons with atoms in the structure. Researchers are evaluating the product potential of the new device, which would have obvious applications in high-speed logic or gigabit lightwave communications.

HP Workstation

Hewlett-Packard has introduced a new low-cost workstation using the Motorola 68030 CPU and 68882 math coprocessor, providing 4 MIPS (million instructions per second) for a price of $5,495 US. Other models in the 9000 Workstation Family line can provide up to 8 MIPS.

IBM Grant

IBM has granted $1,000,000 to Georgia Tech in Atlanta to support research projects in the field of electronics manufacturing. This continues the trend in both the US and Canada for commercial companies to work closely with universities in research and development.

AutoShade Upgrade

AutoShade, Autodesk's program that transforms AutoCAD drawings into full-color shaded renderings, now supports the 3D design capability offered by AutoCAD Release 10. It also includes VGA drivers, and files for hardcopy of shaded renderings are now compatible with desktop publishing applications via the Encapulated Postscript format.

Arctic Ozone

NASA and the National Oceanic and Atmospheric Administration (NOAA) have announced an investigation in early 1989 to better understand the nature of potential ozone depletion of the stratosphere over the Arctic. Scientists from NASA, NOAA and other organizations will carry out an airborne study similar to that done last year over the Antarctic. That study directly implicated manmade chlorofluorocarbons (CFCs) as a cause of the ozone hole and raised the question whether the same thing could be occurring in the Arctic.

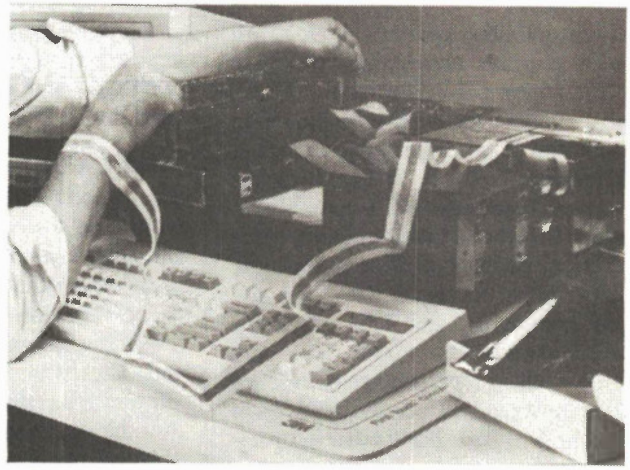
Flights will be stationed in Stavanger, Norway, with other similar tests based in Alaska and the NWT. Coordinated balloon experiments will be carried out by the Soviets and Germany. Airborne instruments will sample the stratosphere for many different chemical compounds. One of the aircraft used is the ER- 2, a highly modified U-2 high-altitude reconnaisance plane; it will fly at up to 65,000 feet.

A preliminary report on the findings should be ready by late August.

An AT for the Amiga

Commodore Business Machines has announced the availability of the 2286D Bridgeboard, a plug-in for the Amiga 2000 and 2500 computers, giving them an 80286 processor for AT compatibility. The board is recognized at power-on and allows the user to run IBM-compatible applications concurrently with Amiga software because of the Amiga's multi-tasking operating system. ■

NEW PRODUCTS



ESD Strap

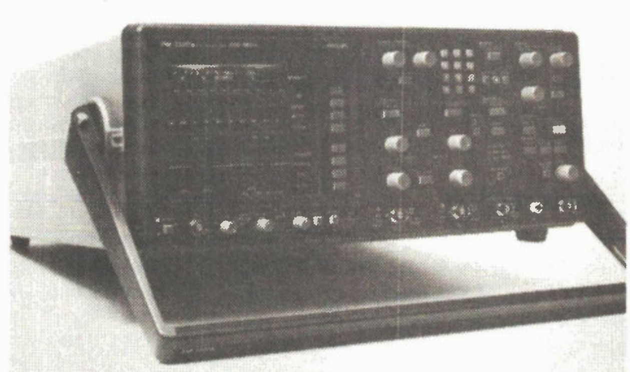
Low-cost static protection for electronic repair personnel and hobbyists is now available from 3M Canada Inc., Static and Electromagnetic Control Systems. A hypoallergenic conductive adhesive strip is attached to a porous, non-woven, insulative backing. A one-megohm resistor is part of the strap. When secured to a ground such as an equipment frame, using its self-sticking copper fopil, the strap allows movement within a four-foot radius.

Circle No. 5 on Reader Service Card

New Multimeter

The Brunelle Model 4090 Digital Multimeter features computer compatibility via an RS232 buffer, plus all the standard multimeter functions. When used with the Model 270 Buffer and software, and signal can be measured and output to a computer or printer. Various optional adapters allow measurement of temperature, humidity, light, RPM, etc. The software and hardware is compatible with the IBM PC/XT/AT.

Circle No. 6 on Reader Service Card



Hi-res Digital Scope

The Philips PM 3320A Digital Storage Oscilloscope from Fluke Electronics Canada Inc. is suited forcapturing single events with its 200MHz bandwidth, real-time sampling rate of 250MS/s and 10- bit resolution. Using random repetitive sampling, the full 200MHz of the dual-channel scope can be used for waveform digitizing and storage. Tow acquisition modes are available to capture signal details that exceed preset limits. The incoming signal is compared to one stored in memory and the new waveform is stored as soon as a difference appears, useful for unattended monitoring of signal lines. Up to 250 front-panel setups can be stored and recalled. Available from stock for $12,992 Canadian.

Circle No. 7 on Reader Service Card

Interfacing the PC

Part 2

Plumbing the further mysteries of I/O address decoding, it turns out that the world is really controlled by jumper settings.

STEVE RIMMER

In the first installment of this series, we had a look at the basic port addressing scheme of the 8088 microprocessor that drives the IBM PC and all its lineal – and oftentimes illegitimate – descendants. If you're still a bit dazed by it all, the contents of this article probably won't help you very much. We're going to dig a bit further into the whole writhing mess.

Regrettably, without a workable I/O decoding system fluttering about your head, all that comes later will be grass in the wind.

The basic I/O decoding circuitry that we checked out last month was workable, but only in the most rudimentary sense. In common with North American television and most Tory politicians, it ignored the real world to the best of its abilities. Plugged into just about any PC, it would probably have found itself instantly at odds with something.

This month, we're going to make it a bit more likeable – something that's relatively easy to do for a card, as it turns out. All it takes is a soldering iron. This is more that you can say for a Tory politician... although there are certainly those who would be willing to try the same approach on one just to see what happens.

Rabbits and Other Jumpers

If you flip back to the last episode in this drama, you'll recall that we devised an I/O decoder which would raise a line if any port in the range of 300H through 31FH were to be addressed by the processor. The only serious sweat about this is that it was fixed in this range, and no power in the known universe was likely to talk it out of its little hole in the wall.

In the original specification for the IBM PC, this range of port addresses was reserved for designing prototype cards. However, it should be realized that the people who designed this system were genuinely a bit short sighted. They figured that 64 kilobytes of memory, for example, would do for most souls, with 128 kilobytes for the greedy ones. As such, the original port address allocations of the system have become a bit blurred over time as designers realized that most of what they wanted to do with the system hadn't been allowed for.

Some of the original port addresses of the IBM PC *have* remained, of course. Things like disk drives exist in all machines, and, as such, their ports are invariably spoken for. Other devices, like hard drives, are sufficiently common that one would not want to design a card which infringed on their real estate. Of the remaining port ranges, it's largely impossible to realistically carve out any specific range of addresses for a custom peripheral card and blindly assume that it won't already be in use by some other card.

This all being the case, it's pretty well essential that in designing cards for the PC one make the port address range a bit flexible, such that the person using the card can find a free space in the port allocation of her or her particular system and plug in our card. This, of course, is why there are so many jumpers and DIP switches on cards. Ours will be no exception, of course.

To get started with all this, let's have a look at the "official" port allocation strategy of the PC.

000-00FDMA chip
020-021Interrupt controller
040-043 Timer chip
060-063 Parallel port chip
080-083 DMA controller
0A0-0AFNMI mask
0C0-0CFReserved
0E0-0EFReserved
100-1FF Not for rent
200-20FJoystick port
210-217 Expansion box
220-24F Reserved
278-27F Reserved
2F0-2F7Reserved
2F8-2FFCOM2 serial port
300-31FPrototype card
320-32FHard drive
378-37FPrinter
380-38CSDLC communications
3A0-3A9Binary synchronous communications
3B0-3BFMonochrome card
3C0-3CFReserved
3D0-3DFColour card
3E0-3F7Floppy controller
3F8-3FFCOM1 serial port

In the official IBM view of the universe, port addresses above 3FFH can't

New improved I/O decoder... now with the miracle ingredient PortSwitch

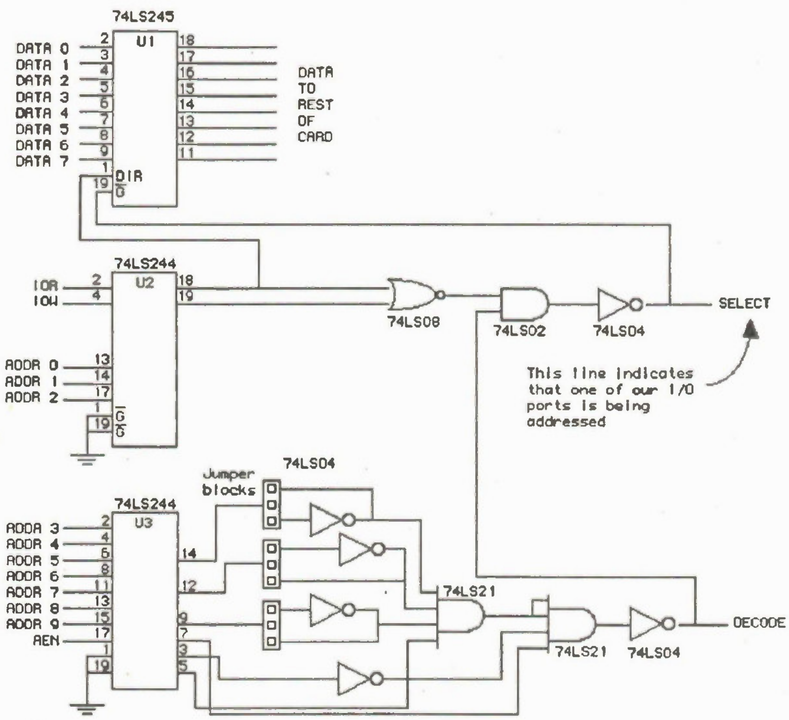


Figure one: The address decoder with modifications to allow for jumper selectable addresses.

be decoded because only address lines zero through nine are supposed to matter to the system when it's doing port I/O. In fact, as we've seen, one could build hardware to handle these extra addresses, although there are several good reasons why not to. The most notable of these is that most real IBM hardware... and clones thereof... do not look, for example, at address line ten. As such, if one attempts to address port 0400H, having designed a card which *can* decode this address, it will look like port 0200H to all the other cards in the system, that is, the ones which ignore line ten.

The low order port addresses, the ones below 200H, are better off left alone unless you specifically want to design a card that creates hardware interrupts. We will do this – but not just now. As such, the area we have to consider in creating this card is the one which ranges from 200H through 3FFH.

There are a number of devices in this list which may seem a bit unusual. For example, you may not have encountered an SDLC communications card. That's okay – they were never a real driving force in the PC universe. Likewise, if you were designing a local area network card, for example, you could probably assume that the sorts of machines that it would come to reside in would not have joystick ports in them.

If this seems a little funky... ya, well, it is. This is why it's important to make the port addressing of any cards we design for general distribution user selectable to some extent. It's impossible to know which bits of the unspoken for real estate other card designers will have snaffled, so you have to let the heads who use your cards decide for themselves.

You also have to find ways to explain to said heads how to ascertain what addresses *are* currently in use. Best of cosmic luck in this.

Even if you're just hacking copper for yourself, it's not a great deal of extra work to get this together, and it can save you some hassles later on, should you subsequently add more fiberglass to your system and find that some of it covets the address space you've set up for your home made interfaces.

Joy Sticks

In order to decode the address space from 300H through 31FH, as we got into last month, we have to see that address lines eight and nine are high and that lines five through seven are low. The lines zero through four constitute the low order part of the address, and don't matter at this stage of the decoding.

You can see the circuitry which does this in the schematic we used last month, or the one for this month, as nothing has really changed in this respect. The 74LS04 at the bottom of the diagram takes care of the lines five through seven. Lines eight and nine go directly to the second 74LS21 and gate. Thus, if all of lines five through seven are low and line nine is high, all of the inputs to the first quad AND gate will be high because of the 74LS04 inverters, and the output of the gate will be high. If line eight is high as well, all the inputs to the second quad AND gate will be high and its output will be high, indicating that we have decoded an address in the range we're interested in.

Clear as a Toronto sky in smog season, I know.

Now, in order to shift the address range around a little bit, let's consider jumpering out one of the inverters that connects the address lines five through seven to the first quad AND gate. Let's lose the one that handles line seven. This line decides whether the address range in question starts at 300H or 380H. As things are, it must be low for the address to fall in the area we're up for decoding. However, with the inverter removed, it would have to go high. As such, with this inverter gone our decoded address range for this card is suddenly 380H through 39FH.

Ah hah!

This is a particularly handy little port address, as it's where the aforementioned and seethingly mythical SDLC communications adapter is supposed to go. It's prime hunting ground for custom cards.

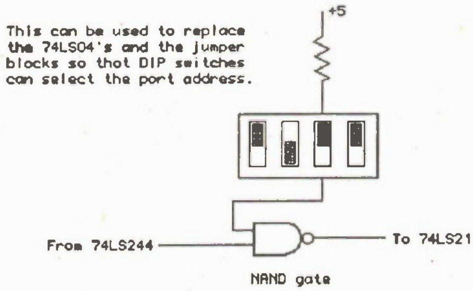


Figure two: using a NAND gate instead of inverters and jumpers. This takes a bit of extra hardware, but it makes the addresses easier to set for the end user of the card. The NAND gates replace the inverters

If we jumper the inverter in line six, we can switch the range up to 340H through 35FH, which the chart doesn't have anything much to tell us about.

How about jumpering both of them, you cry. Well, yes, this would give us address decoding in the range of 3C0H through 3DFH. The lower half of this range is marked as being reserved, whatever that means, and I'd certainly be willing to trample on it. The upper half, however, overlaps the port addresses for the 6845 CRTC chip that makes the colour card go. This is harmless if you have a Hercules card in your computer, but it could be a tad nasty otherwise.

Now, this range might be useful if we were designing a card which really only wanted to be able to use a maximum of sixteen ports. This is actually a fairly probably occurrence, in which case putting the base of the address range at 3C0H would be quite acceptable.

Jumpering out the three inverters on the card does, of course, only allow us to shift the addresses around in the range of 300H through 3E0H. It ignores the juicy looking space down at 0200H, where the aforementioned game controller and expansion box port ranges dwell. In order to be able to address these areas, we'd have to put a jumperable inverter between pin seven of the 74LS244 that buffers the high order address lines and the second quad AND gate. This would allow us to switch the base of the address range being decoded between 300H and 200H.

In designing actual hardware to allow for the selective jumpering of these inverters, we can set the whole ugly mess up with DIP switches and NAND gates, the preferable way, or we can use three pin header blocks, such that jumper caps fit over two of the three pins to decide how the connection is to be made. I've used jumper blocks in the schematic here to keep things reasonably easy to understand, but you can see how the NAND gate approach works, too.

It may seem that having a variable port address system like this would make writing the software that ultimately speaks to the ports in our card a bit of a nightmare. It doesn't. The 8088 allows for floating port ranges very nicely. It should be kept in mind that no matter where in the absolute address range of the machine the ports actually wind up, all the ports on our card will bear the same relationship to each other. For example, the 8250 serial chip that drives the COM ports on a PC has the following register port addresses when it lives in the address range for the primary serial port.

3F8HData buffer and LSB divisor
3F9HInterrupt enable MSB divisor
3FAHInterrupt identification
3FBHLine control
3FCHModem control
3FDHLine status
3FEHModem status

Don't worry about what these actually do. However, this is a pretty typical example of register use, and therefore port use, in a peripheral card. More to the point, if this serial port suddenly becomes COM2, all the addresses shift downwards to start at 2F8H instead of 3F8H.

In software, we would address this problem as follows. Rather than writing code to access specific ports, we would define a word variable like this

```
PORTBASEDW03F8H
```

and use it to deal with the ports. To read the line status port of this card, for example, we would

```
MOVDX,PORTBASE;GET THE PORT BASE
ADDDX,0005H;ADD THE OFFSET
INAL,DX;GET THE BYTE
```

The number five that we add to the base port address is the difference between the port base and the line status register, that is, five locations. No matter where the card turns up, this will remain constant. As such, if we move the card we need only adjust the value of PORTBASE accordingly.

Ports of Call

I think we've decoded the high order part of the port address question into groveling, helpless submission. It will not rise again. In the next part of this series, we'll look at those five lines that we keep saying don't actually matter. They do, in fact, just not all that much.

By the end of the next part of this engrossing narrative, you'll be able to narrow things down to a single port. It makes one stop and consider the incredible wonder of the universe in all its cosmic order, I know...

'Til then... ■

THE SCIENTISTS TELL ME

DAVID P. DEMPSTER

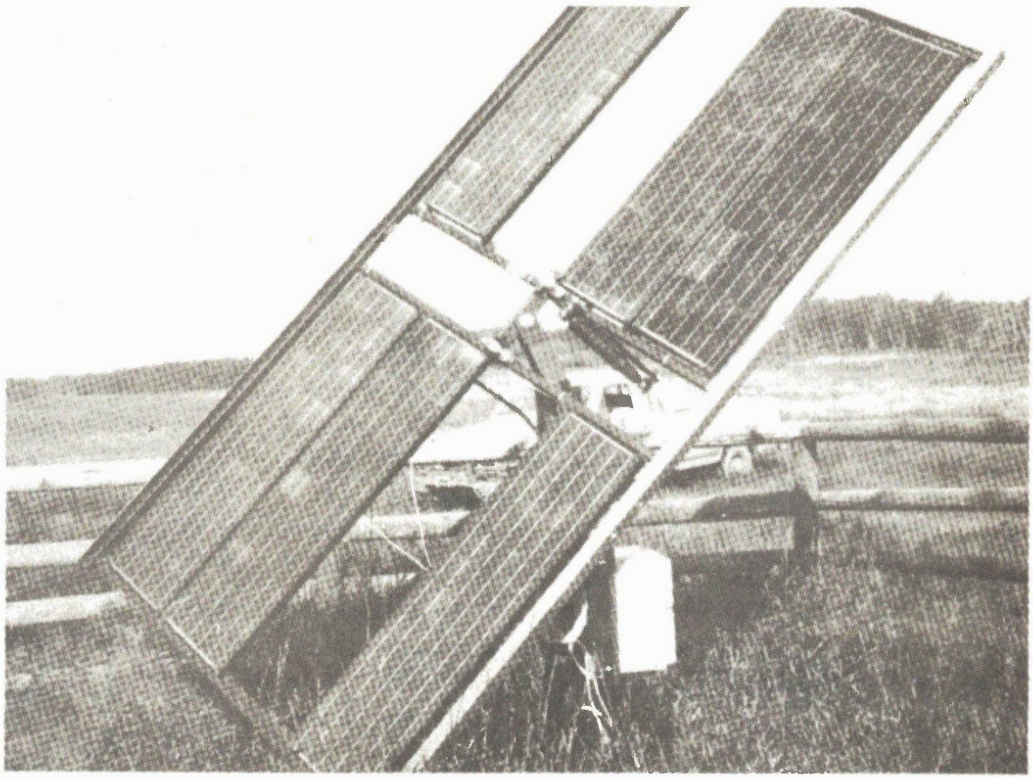


Fig. 1. Solar panels in Montrose Community Pasture near Saskatoon. The panels track the sun's progress through the day.

Solar Powered Pumps for the Prairies

Goodbye wind — hello sun. That's the message that Agriculture Canada engineers are giving to prairie farmers these days.

All during last summer the sun beat down on the prairies almost without let-up. It didn't take long for the earth to become parched, crops to shrivel, and livestock to become thirsty. It was bad enough to see crops burn out, it was even more frustrating to scramble for water supplies for cattle. But with all the trouble caused by the sun, that same sun was also the source of power to supply water to a couple of parched prairie farms.

In the past five years, the Prairie Farm Rehabilitation Administration (PFRA) of Agriculture Canada, has been operating two solar pumps in the Swift Current and Saskatoon areas of Saskatoon. The units which stand about a metre off the ground, are simplicity plus — a battery of cells in a glazed panel on a single post. The post rotates to face the sun which activates the solar cells in the panel to produce electricity. The power generated then runs a pump in an adjoining well which pushes water up to a trough for livestock consumption.

PFRA wasn't happy with the existing system used throughout the prairies — windmills. They are costly to maintain, demanding annual expenditures to keep them operating. Initial costs of windmills are somewhat less than the solar units, $5,000 vs $6,000 to $8,000 respectively.

"Quite a few farmers are using windmills in areas that are far from hydro lines," says Ron Lien, a technical standards engineer with the agency. PFRA started looking for various alternatives to conventional windmills when replacements parts started to be in short supply in the 1970s. And based on PFRA's experience over the last five years, he sees solar pumps as being a realistic alternative.

The solar pumps are easier to install and easier to maintain. So far, the two units in operation have needed no significant repair. If repairs are required, components are simple to fix and it is done at ground level, not up on the top of a tower, as it could be with windmills.

Windmills must be checked frequently because in periods of low wind and hot weather the troughs tend to run dry, just when farmers are having to deal with thirsty cattle.

Based on PFRA experience, it would appear solar pumps could have a good future on the prairies — minimizing maintenance problems and guaranteeing a source of water, because with them, the troughs seldom run dry.

What of the future? Says Lien, "The PFRA work with solar pumps is attracting the attention of private industry. Several firms have expressed interest in producing and marketing the pumps to farmers. And if they take off, no doubt the market for them could expand beyond the prairies.

3-D Image Data Files from National Research Council

The National Research Council of Canada has recently produced a series of three-dimensional image data files which are available on magnetic tape or disks. This bank of more than 200 3-D images have been designed for use by computer scientists for a variety of research activities — robot vision, graphics, animation, metrology, the medical field, anthropometry, image processing and understanding, 3-D portraiture, inspection vehicle guidance, automatic assembly, and automation.

Each image consists of 256 lines, with each line being made up of 256 points or picture elements. Range resolution is in the order of 0.04 mm and the dimensions of the picture element varies from 0.5 mm to 2.0 mm depending on the subject recorded. A variety of familiar objects are included — industrial objects, tools, utensils, blocks, fruits and vegetables, toys, human faces, plus many others. The three dimensional images can be the same object to form a model; creating a library of object models; and developing interactive procedures to measure, manipulate, and edit 3-D information.

What makes it all so interesting is the quality of the images, quality which has been achieved by a camera based on a laser scanner developed and patented by NRC. The system uses a unique method of high-speed data collection and is capable of scanning 200,000 points in one second. NRC has been successful in transferring the technology to industry. Firms licensed to market the NRC development are Servo-Robot of Boucherville, Quebec, and Hymarc Engineering Ltd. Ottawa, Ontario.

Servo-Robot offers two systems, The Saturn System and the Jupiter System, the former a three-dimensional laser vision for high speed measurements and robot control in the factory, the latter a compact, high speed, high range, 3-D laser ranger finder designed for applications requiring a compact and light weight optical head with a large field of view.

Hymarc Engineering Ltd. has incorporated the technology in their Hyscan-60, a 3-D machine vision system for digitizing rapidly and accurately, complex shapes. The resulting data can then be used as input to a CAD/CAM system. Their scanner is said to be suitable for use in many applications and on a variety of materials including metals, plastics, wood and cloth.

Data of the 214 images in the free NRC catalogue may be purchased for $900 on tape and $1500 on disk. Individual images on disk only, are $35 each. Further information about this data bank may be obtained from Mr. N. Rioux, National Research Council of Canada, Division of Electrical Engineering, Laboratory for Intelligent Systems, Photonics and Sensors Section, Ottawa, ON K1A 0R6. (613) 993-

7902. The free catalogue is obtainable from The Editorial Officer, Room 301, Division of Electrical Engineering, National Research Council of Canada, Ottawa, ON K1A 0R6, (613) 993-1880.

Controlling Computers with an Eye-Tracking Device

All eyes are focused on the future for a Texas A&M University project that uses an eye-tracking device to control machines including computers and robots.

The system's biggest advantage is speed, it is much faster than traditional control schemes because eyes move almost as fast as thoughts, says Dr. Charles Shea, a researchers in the university's Human Performance Laboratory. "The applications of eye tracking systems seem limitless," she said. "The Air Force is currently monitoring eye position in the newest experimental aircraft with hopes someday of incorporating the eyes into the controls scheme. Perhaps some day, not too far off in the future, pilots will be making rapid maneuvers based on the movement of their eyes, just like we saw in "Star Wars.".

What are some of these future applications envisaged by Shea. He suggests that eye-tracking systems could benefit wheel-chair use by quadriplegics, microsurgery telephone dialing, reading and air traffic control situations, for a start.

Research on computers to use eye position information as a way to select control functions has been going on in the Human Performance Lab for the past two years, said Shea. Although other facilities across the country are studying eye-tracking devices, few are looking at it from an applications standpoint, he said.

They have found that subjects can efficiently — and much more rapidly — give commands to a computer by using eye position.

The two major components of eye-tracking systems are a signal processing unit accompanied with spectacle frames and a computer graphics monitor.

The eyeglass frames are equipped with infrared emitting diodes and phototransistors and the basic theory of operation involves electro-optical sensing. The light intensity detected by the phototransistors is dependent on the positioning of the eye.

The system uses photoelectric sensing and processing techniques to determine both the magnitude and direction of eye movement.

Results of Shea's experiments show that after a decision is made, it takes only 20-30 milliseconds for the eyes to make command selections, while giving computer commands via a keyboard or computer "mouse" takes much longer.

"Eyes are an unexplored resource we can use to control our environment. Eye-tracking devices are simply a resource — a special device to enable us to do just that," he stated.

Good News at last about Acid Rain

Scientists from Norway and Sweden have concluded that lakes and streams will recover at least in part from the chemical changes caused by acid rain.

The scientists wrote in the August 25 issue of Nature that their "acid-exclusion experiment shows that chemical changes caused by acid deposition are largely reversible." The researchers based their conclusions on experiments conducted for the past four years under the Reducing Acidification in Norway (RAIN) project.

In the acid-exclusion experiment, the scientists studied a site in southern Norway that had been exposed to acid rain. They covered the site with a roof, shielding it from further acidic precipitation.

The scientists filtered the precipitation that fell on the roof before distributing it to the water. They wrote in the Nature article that runoff has "begun to recover to preacidification chemical composition."

Can water and soil recover completely from the effects of acid rain? The scientists hope the Norwegian experiment — which agrees with previously conducted research in Canada, United States and Scotland — will provide the answer to that question in the future. ■

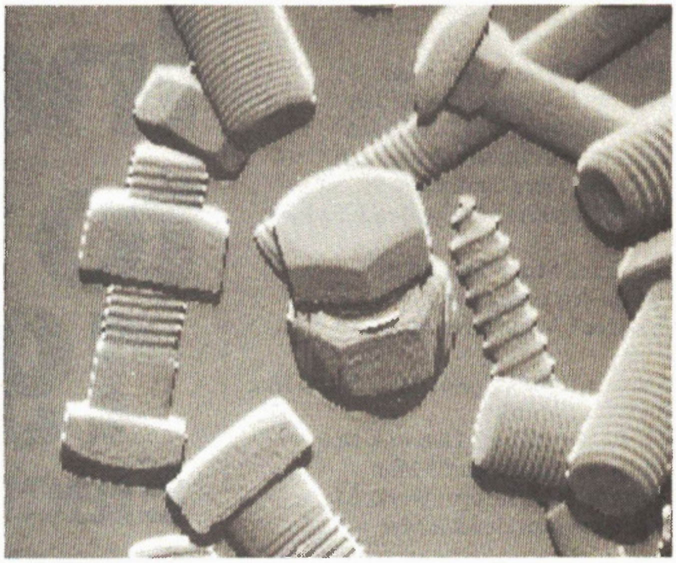


Fig. 2. A three-dimensional image which was taken at the National Research Council of Canada laboratories employing a three-dimensional camera based on a synchronized laser scanner recently developed at the Division of Electrical Engineering.

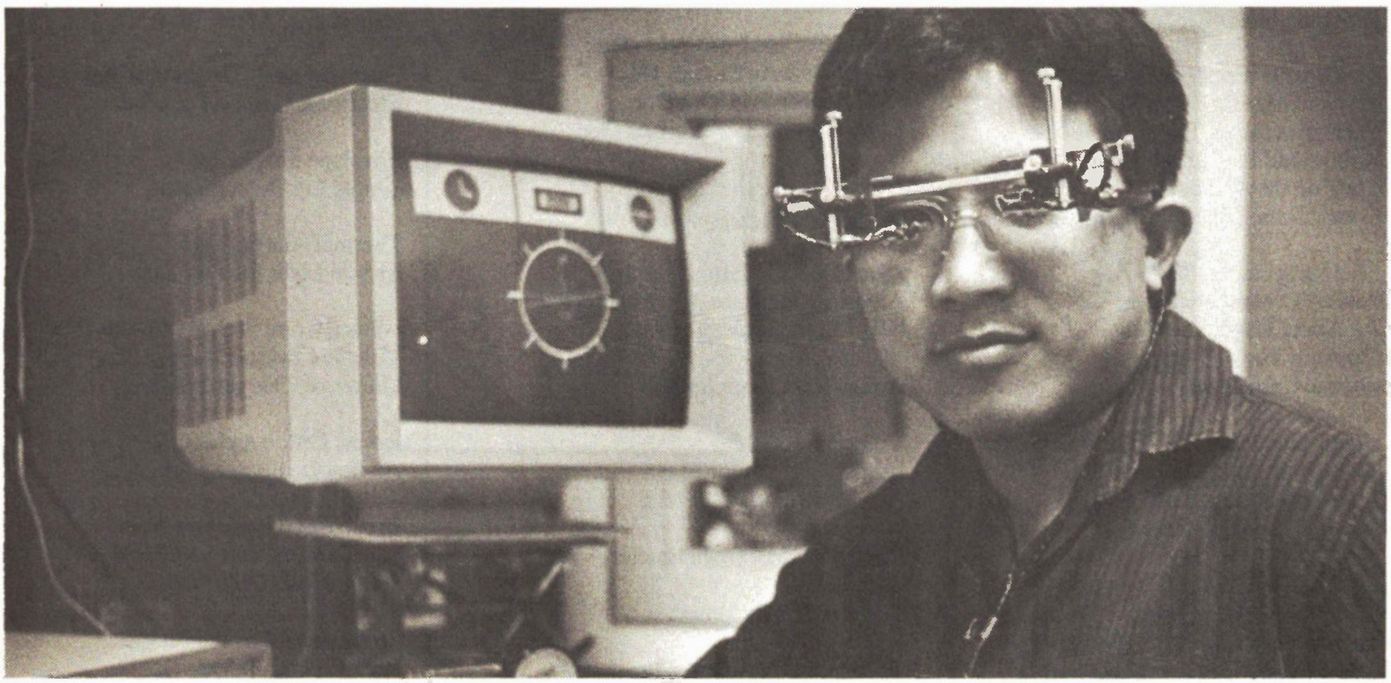


Fig. 3. An eyeful — Bernard Zee, an electrical engineering graduate student at Texas A&M University from College Station, models the eyeglasses used in an eye-tracking device used to control machines including computer and robots.

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If you own a PC, XT, or AT compatible microcomputer, you'll probably have heard about the power and economy of low cost public domain software and shareware. However, if you've ever tried to make sense of the thousands of cryptic programs available in the public domain, you might well have abandoned all hope of any of it ever being of much use to you.

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BROWSE lets you scroll forwards and backwards through a text file just like you can in a word processor... without having to wait for one to boot up.

CARDFILE is a memory resident address book you can pop up from within any application. It'll even dial your phone for you.

DCACHE is a "disk cache". Install it in your machine and just about any program which uses your hard drive frequently will speed itself up noticeably.

DELZ is a very important security tool. The DOS DEL command doesn't completely destroy the contents of a file you delete, and potentially sensitive files can be brought back without your knowing it. This program quickly destroys all trace of a deleted file.

DIRNOTES allows you to affix notes and comments to any file on your hard drive... great for remembering what they are a few months later.

DOSEDIT is a must for every PC. If you type a command incorrectly under normal DOS you'll have to retype it. With DOSEDIT installed, you can call back previous commands, edit them and use them again. Saves buckets of frustration.

FREE quickly tells you how much free space is available on any floppy or hard drive.

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NPAD is a small, memory resident note pad you can pop up from within any application to jot things down on.

POP-CAL is a calendar which can be popped up from within any application. It will show you a correct calendar page from any month of any year from 1582 onwards.

RENDIR allows you to rename subdirectories as you currently rename files.

RN is a great little utility which will show you a map of the subdirectories of your hard drive and allow you change directories simply by pointing to the area you wish to log into.

SETUP sends control codes to your printer. It allows you to change fonts and effects with having to remember scores of obtuse escape sequences.

SNIPPER lets you copy the contents of any text screen into other applications. For example, you can extract part of a spreadsheet and pop it into a report being prepared on your word processor.

SWEEP lets you execute any command you like in every sub directory of your hard drive.

TSR MANAGER is a collection of utilities which will keep your pop up utilities, resident programs and other TSR's from rising up to consume you. Among other things, it lets you load in pop up programs and blow them away later on. It also includes several utilities which will help you identify TSR conflict problems.

VTREE is another of those essential little programs. It draws a map of the subdirectories of your hard drive.

CONFIG allows you to change the way your CONFIG.SYS behaves when your system boots up. For example, you can exclude specific drivers or commands to free up memory. This is extremely handy if you have a tape streamer, a LAN and a couple of other memory pigs in your system.

READRITE allows you to analyze how readable your writing is... as you write it. It pops up from within your favourite word processor and produces a readability index of the screen contents.

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The Techie's Guide to C Programming

Part two, in which Doctor Max O'Blivion locates an ancient map which promises of vast treasure and many parenthetical digressions. Danger lurks everywhere.

STEVE RIMMER

A lot of very zen-like things have been said about programming in C language. I doubt that the greater part of them were original thoughts at the time – zen-like things rarely are. They're simply adapted from previously uttered zen-like things said about related subjects. This, to a large extent, further enhances the zen-like nature of their uttering, somehow suggesting the universality of all human experiences. After all, if you can say roughly the same thing about C language programming and ox gelding there has to be some sort of intelligent design to the universe.

This is how quite a few of those clever sounding slogans for coffee mugs and tote bags come to pass, methinks.

My favourite of these zen-like utterances, which I think I mentioned last month, is the all but immortal "real men don't use Pascal". Add to this that no one over the age of four programs in BASIC and that only people who like pain enjoy assembler and there's little left. We'll discount the yuppie languages like Forth, Ada, COBOL, SnoBOL, Fortran, BLINK, Yawn, gROUCH and Queeg for the moment.

As the gods have clearly indicated that C is *their* preferred way of dealing with computers, one can do little else but get on with it. As such, in this feature we're going to look at a few new aspects of the language and learn a bit more about compilers.

How To Kill Cats Quickly

The structure of C programs can be a bit elusive until your brain attaches itself to the nature of the language. It's helpful to remember that everything under C ultimately represents some sort of value, with the largest part of what you find in the average program representing an integer.

This program will echo everything you type on your keyboard to the screen. Let's see how it works.

```
main( )
{
while(putch(getch( )));
}
```

Anyone with an ounce of common sense, or a millilitre of common sense if you've caved in and gone metric, will see that this works by black magic, and that there's little sense in any further discussion. Fortunately, few people willing to invest several thousand dollars in a television set that only displays letters can be said to be that sensible, so we'll press on.

It will be helpful to start by knowing that *putch*, as we saw last month, will take the character passed to it and print it to the screen of your computer. Thus, if we said *putch(65)*, the letter *A* would appear on the screen, the number sixty five being the ASCII code for the letter *A*. Under C, by the way, we could also say *putch('A')*. A single character in single quotes will be interpreted by C as working out to a numeric value, rather than as a string.

Note that we can only pass *putch* numeric values – ASCII codes – not strings. It prints one character at a time.

The *getch* function is another thing which is built into C. When you call *getch* your program will wait until a key is pressed on your keyboard and it will "return" the ASCII code when *getch* returns. This may be a bit confusing.

This program calls *getch*.

```
main( )
{
getch( );
}
```

In this case, *getch* waits for a key press and the program ends and returns to DOS. The actual value of the key hit gets thrown away, as there's nothing to catch it.

In this case, something more happens.

```
main( )
{
int i;

i=getch( );
}
```

This program assigns the value returned by *getch* to the integer variable *i*. However, nothing happens to *i* in this program either.

In theory, every function under C returns something. Much of the time this returned value is of no use to us, and we ignore it. In the case of *getch*, we may or may not use it for anything, depending on whether we're using *getch* to wait for a key press or actually to see which key has been belted.

Let's expand the program a bit further.

```
main( )
{
int i;

i=getch( );
putch(i);
}
```

This program will get a keyboard character and print it to the screen. It waits for a key press with *getch*, assigns the keyboard character to *i* and then uses *putch* to send it to the tube.

We can write this another way.

```
main( )
{
putch(getch( ));
}
```

Daring souls who've been awake for a few hours might well ask where the integer went. It's still there, sort of. It's just hiding in the depths of C.

In order to properly understand this latest example, we have to know before hand that presented with a set of nested functions like this, C will always resolve the innermost one first. In this case, it will execute *getch* first, derive its returned value... a character code... and then execute *putch* with the returned value of *getch* passed to it. The program itself will create a place to store the returned value of *getch* in the interim. Variables that appear and disappear for these sorts of purposes are called "temporaries", and, as we'll see a bit later in this series, we can often use them to make C do very clever things.

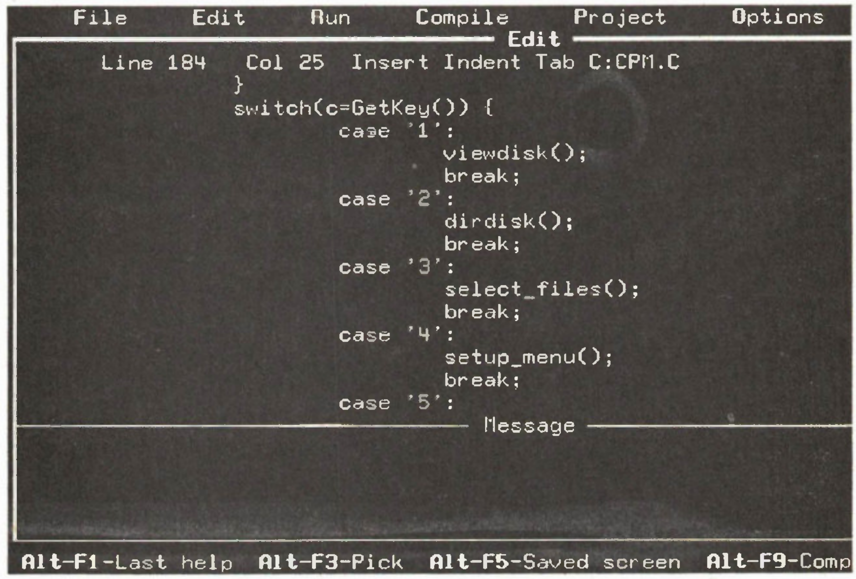

Figure 1. This is an example of a switch statement... or part of one... in a real C program being developed in Turbo C. The GetKey( ) function is an expanded version of getch, discussed in this article.

As we noted last month, the *while* statement under C will execute something repeatedly until the condition it's testing becomes false, that is, until it is zero. Thus, this line will execute forever

```
while(1);
```

and should probably be avoided unless you just happen to like rebooting your computer.

This line... as seen in the first example we looked at, actually... will also execute forever.

```
while(putch(getch( )));
```

but at least it'll do something. This will cause *getch* and *putch* to be called repeatedly, echoing what you type to your tube. Actually, you can break out of this loop on a PC by hitting control break.

As it turns out, this isn't really a perfect dumb typewriter program. For example, if you hit *Enter*... a carriage return... the cursor will go back to the beginning of the current line, not down to the start of the next one, as is usually the case when one hits *Enter*. The reason for this is that C... and your PC... interpret a carriage return literally. The cursor simply returns to the start of the current line. We're used to hitting *Enter* and having DOS or whatever we're typing into issue both a carriage return and a line feed.

Alien Swamp Monsters

Let's change our program a bit. This is how little, elegantly simple programs quickly swell into huge, multi-headed alien swamp monsters that engulf whole mid-Western American towns. What fun...

```
main( )
{
int i;

while((i=getch( ))) {
putch(i);
if(i= =13) putch(10);
}
}
```

There's a lot of new stuff happening here. First off, as you'll notice, we're back using a variable once more. Again, we're testing the returned value from *getch* for the validity which drives our *while* loop — not all that sensible, as you can't actually type character zero at the keyboard to end the loop, but never mind that for now.

The line after the first *putch* is an example of an *if* statement in C. This says

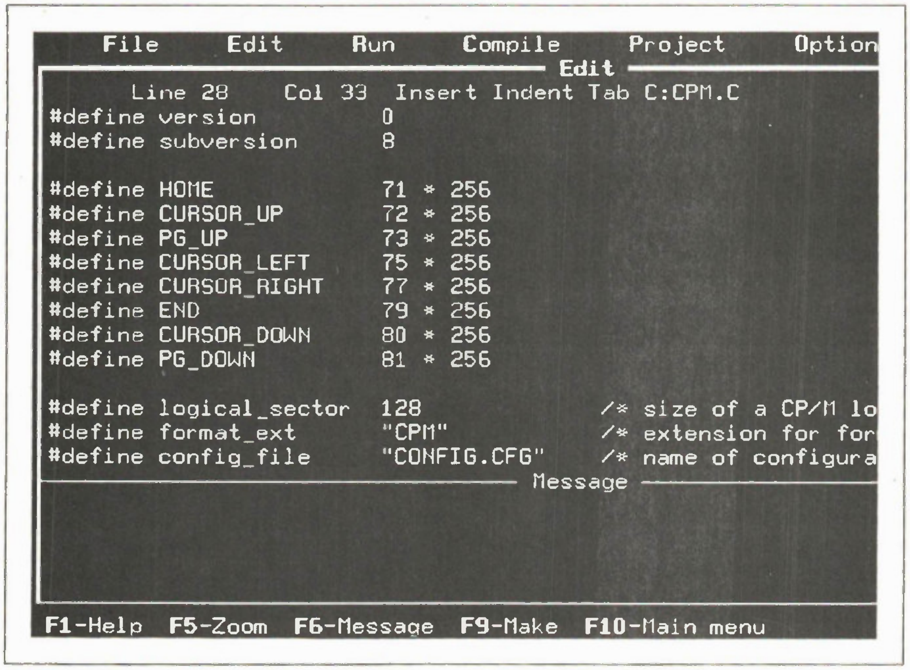

Figure 2. Here are some actual uses of the #define directive in a C program. Note that they define not only numeric values, but strings as well. This program, in its entirety, translates CP/M diskettes into PC ones.

that if the value of *i* is thirteen, the program is to print character ten as well. If we bear in mind that the ASCII code for a carriage return is thirteen and that of a line feed is ten, the purpose of this line becomes pretty obvious. It causes every carriage return to be followed up by a line feed.

However, the way we test the value of *i* may seem a bit odd. In BASIC, equal signs can be used in two ways. We might say A=21 to assign one thing to another thing. We also might say IF A=21 GOSUB 1000 to test the value of a thing. Under C, we differentiate between these two uses.

If we say ***a*=*21*** under C, this can only mean that the variable ***a*** is being assigned the value twenty one. If we wish to test the value of *a*, we must use two equal signs, as in *if(a==21)*. This makes C happy... don't argue with it.

Smart compilers, knowing the propensity of the human digit to miss keys whilst typing more rapidly than the human brain can properly think, check to make sure that these two uses are not interchanged. For example, if we say *while(i=getch( ))*, a good compiler will complain, as this is ambiguous at best. What we want to do, in fact, as we've seen in the example above, is to assign *i* the return value of *getch* and then test the value of *i* to see if it's true. However, this could also mean that the *while* statement is to regard things as being true so long as the value of *i* is the same as that of the return value from *getch*, which is very clearly not what we want to do.

For this reason, the contents of the tested part of the *while* loop above is enclosed in an additional set of parentheses to force C to evaluate it first and remove the ambiguity.

We might improve this line, actually, and we'll see how the two uses of the equal sign are properly employed. If we change the line with the *while* loop to

```
while((i=getch( ))!=27) {
```

we will have modified to program to allow for an escape clause — quite literally. This means that the *while* loop should assign *i* the value of *getch* and keep looping so long as *i* does not equal twenty seven. This is the value returned when you hit the escape key. As such, hitting *Esc* will end the program.

The exclamation point is something different as well. When we wish to see if one thing equals another, we use two equal signs. We when wish to see if one thing does not equal another, we use an exclamation point and an equal sign.

There's another problem with this program. We can't backspace. We also can't deal with tabs. We need more *if* clauses. This is going to start getting a little messy.

Having to program many possible reactions to the value of something, depending on the value, is something which happens quite commonly. As such, C provides us with a very elegant... and somewhat daunting... construct called the *switch* statement. This allows us to do away with a lot of *ifs*, as well as tightening up our code a bit in the bargain.

Let's rehash the program once more.

```
main( )
{
int i;

while((i=getch( ))!=27) {
switch(i) {
case 8:
putch(8);
putch(32);
putch(8);
break;
case 9:
printf("    ");
break;
case 13:
putch(13);
putch(10);
break;
default:
putch(i);
break;
}
}
}
```

I said it was daunting. With each iteration through the *while* loop, the *switch* will evaluate the contents of *i*. If it matches one of the three specific cases we've set up — eight is a backspace character, nine is a tab and thirteen is, as we've seen, a carriage return, it will do whatever is in those cases. Otherwise, it will execute the *default* case, which is simply to print the character to the screen.

The word *default* here is a specific case defined by C. You have to have it called *default* in order for it to behave as a catch all for numbers that don't conform to any of the other, specific cases.

Each case starts with the *case:* statement, naturally enough, and ends with a *break;*. The *break* tells C that the case is done with, and that it should skip ahead to the end of the switch immediately. If you leave the break statement off, C will execute the contents of the next case in the

Continued on page 58

NEW

ALMOST FREE SOFTWARE VOLUME 44

If it's getting dark and cold around your digs right now, you probably need this collection of almost free software. Pop it into your disk drive and you'll be able to mix yourself up a Depth Charge... or a Flying Scotsman... or a Chelsea Sidecar... three of the many drinks contained in our electronic bartender. While you're getting warmed up, you can go quietly mad playing Son of Tetris. When you can't think anymore, you'll be able to warp out of your dimension watching our electronic pyrotechnics.

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BCOPY is one of the cleverest copying programs around. It hides in the background while it's working, so that immediately after issuing a copy command your DOS prompt returns and you're ready for whatever's next. A great little time saver.

BDS is a slick pop up electronic engineer's calculator. It handles things like wavelength, capacitance, radio equations and so on.

CALCQF will analyze your system and figure out how much you can speed things up by changing the refresh rate of your memory... without crashing your machine. Then it will generate a small COM file to include in your AUTOEXEC file.

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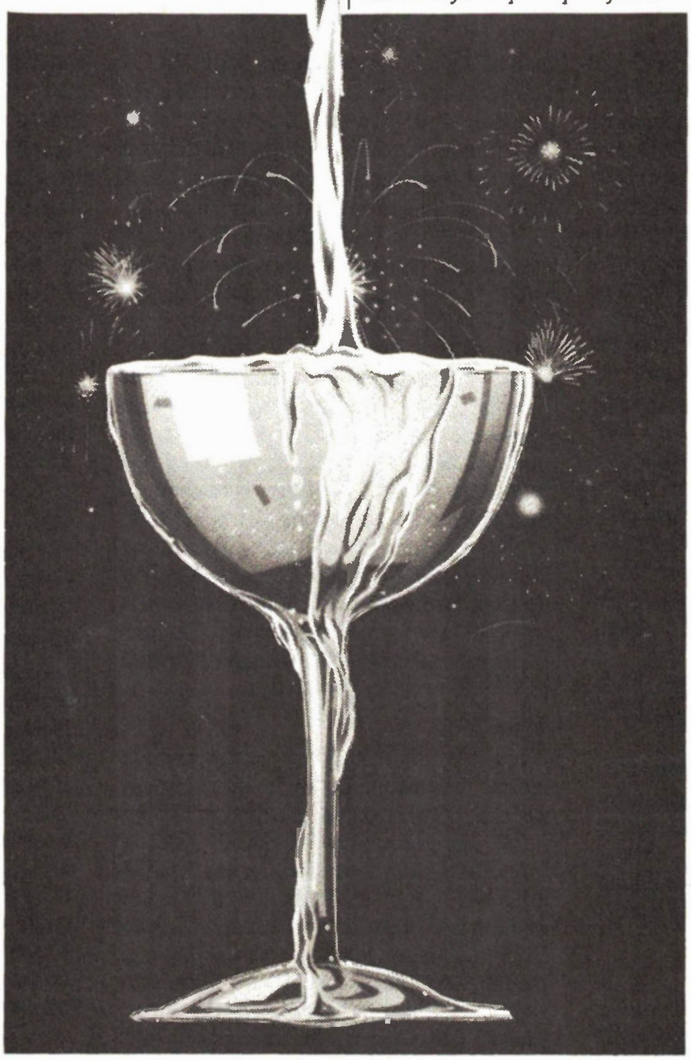
NJFRERAM will show you how much free memory you have from moment to moment up in the upper right corner of your screen. Great for spreadsheet users, amongst others.



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SOT is the son of Tetris, the addictive game from the Soviet Union. This one is even more devious.

STYLIST is an essential tool for any Ventura Publisher user. It allows you to edit, manipulate and print out any style sheet.

TONTO is a SideKick-like program with a host of features, including a clock/calendar for any year since the middle of the sixteenth century, an ASCII chart and a printer setup program.

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A hot 386 and novel marketing plan bring you leading-edge computing economically.

BILL MARKWICK

When you're working with a program that does a lot of calculating or video image painting, such as CAD or desktop publishing or spreadsheets, you've probably looked longingly at the 80386 machines on the market. Today's complex programs can make the PC, XT or even the AT look like a turtle. The hidden-line- removal function of AutoCAD, for instance, makes them look like a turtle that's been bound and gagged.

The 80386 is Intel's answer to the demand for more speed and flexibility in personal computing; with a 32-bit bus structure, a clock speed of 16 to 25 megahertz (depending on price) and the ability to address huge amounts of memory, it's capable of running behemoth programs (or several) at speeds that don't require you to play Solitaire during loading and calculating.

Of course, there's the Number One axiom of all leading-edge technology: *it's gonna cost ya.*

Dell Computer Corporation, originally from Texas, set out to build a high-quality line of 286 and 386 computers that could be compared favorably to the best on the market, and at the same time do something about keeping the price down. They've certainly succeeded on both counts.

Direct to Your Door

Dell's marketing intent was to eliminate the expensive chain of dealers by selling directly to you. The comprehensive list of options lets you choose the computer of your dreams from the many possibilities: the base model is an AT-compatible 80286 at 12.5 or 20MHz, with 80386 models at 20 and 25MHz. The drives available are 3.5" or 5.25" floppies, plus hard drives of 40, 90, 150 and 322MB. The base memory on the 386 machines is 1MB, expandable to 16MB with memory modules in increments of 1, 2, 4 or 8MB.

All machines have a VGA video board that's compatible with CGA software, and the monitors available are monochrome, monochrome VGA, colour VGA and VGA Colour Plus (which has a finer dot pitch for a sharper image). VGA drivers are included for popular software.

Other options include a Microsoft-compatible mouse, an internal modem, and tape drive backups for the hard disk.

Getting stuck with a hardware or software problem can be a nightmare for some computer owners, and Dell promises "the best customer and technical telephone support in the personal computer industry". Should the problem go beyond the expertise of the technician on the other end of the phone, you don't have to ship your computer back to Richmond Hill or Texas. On-site servicing is handled through Honeywell Bull, which has a network of service offices across Canada. Dell systems come with a 12-month on-site service contract as standard.

The 310

When we asked Dell for a computer to review, they must have had spies dig up my wish list, because they sent a System 310. It's a 386 20MHz motherboard with 1MB of RAM as standard, two serial ports, 1 parallel port, 1 3.5" 1.44MB drive, 101-key keyboard, a 200W power supply, Phoenix BIOS, six 16-bit expansion slots and two 8-bit slots. All this was standard. Then they went to town: the monitor was the super-sharp VGA Colour Plus, there were both 3.5" and 5.25" floppy drives, the hard disk held 150MB, and the motherboard contained an 80387 math coprocessor and 4MB of RAM in total. A mouse plugged into COM1.

The software Dell offers with the systems consists of MS-DOS 3.3 or 4.0 (both enhanced Dell versions), or Microsoft OS/2. *Windows/386* is also available. The review model had all of the above except DOS 4.0.

When it comes to prices, we asked for and received a thorough price list just in time for it to become obsolete; the Free Trade agreement was whizzed through at a speed never before seen in government work except maybe for collecting taxes, and computers made in the US were the first to be exempted from duty. As a result, prices quoted here were revised and accurate when we went to press, but don't be surprised if there are minor changes here and there.

The base price for the computer and keyboard, with one diskette drive and no hard drive, was $4299. With the 150MB drive and Colour Plus monitor, the basic system becomes $8249. Software such as OS/2, enhanced DOS, etc., is optional. If you comparison shop, I think you'll find this a substantial saving over comparable computers such as Compaq or IBM PS2.

Unpacking

Setting up was straightforward and takes minutes. Loading the software onto the hard disk is simplified by the enhanced DOS, which has a Dell utility to do the formatting and partitioning for you. There are quite a few enhancements with DOS, including a disk cache to store frequently-used disk accesses, and Cruise Control from Revolution Software, which gives very good control of the cursor speed while preventing overshoot. There is also a diagnostic disk that lets you check just about every function in the computer.

The Dell 310 is fairly large and heavy, unlike their 200-series, but then it holds a lot (and does a lot). It boots up quickly and quietly; our model held both MS-DOS 3.3 and OS/2, and the computer lets you choose which you want by pressing ESC for DOS. If you don't press anything, the default is OS/2.

I loaded in all the software I could think of and spent a pleasant few days watching things run the way they were meant to. Xerox Ventura desktop publishing software seemed to fill screen after screen instantly; the 386 finally gives you the power to compute as fast as you can go instead of waiting around for the video section to repaint the image.

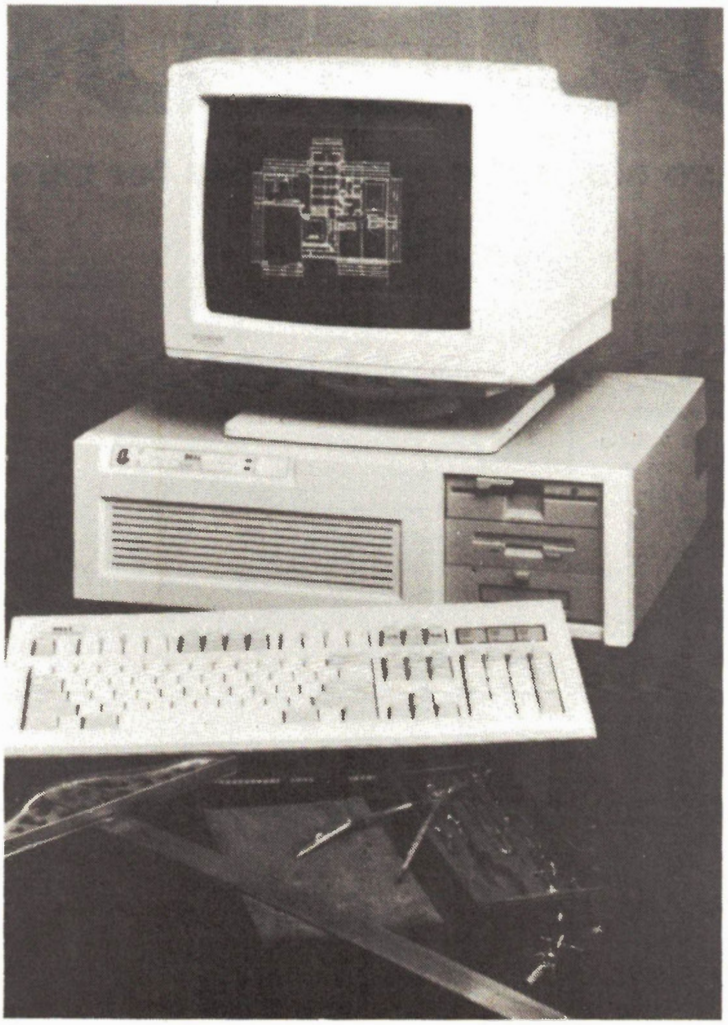
AutoCAD, that cumbersome sloth of a program (powerful though it may be) comes to life with the Dell 310. I ran Release 9, which requires the horrendously expensive math coprocessor ($999.95). At last the fear of the dreaded Regeneration is over. The AutoCAD drawing of St. Paul's cathedral, for example, regenerated in five seconds compared to 30 on my 8MHz 8086. Only the hidden line removal could slow it down: five minutes to produce St. Paul's in hidden-line 3D, compared to enough time to grow a beard with a PC compatible. Incidentally, the Dell mouse, which is made by Logitech and is compatible with the Microsoft driver, is very fast in action, but absolutely precise; it needed only a six-inch square on the desk for perfect results with all programs that used it.

Those of you who are addicted to the Microsoft/Sublogic Flight Simulator have no idea at all what awaits you when you throttle up with a 386, EGA or VGA monitor, and Version 3.0. This is the undisputed King of Simulators. The scenery is sharp and clear instead of jagged wiggling lines, and it unrolls in front of you with movie-film smoothness. The instrument panel is razor-sharp and the colors are beautiful (try a dusk flight over Chicago or the Golden Gate). The Learjet is smooth as silk, instead of lurching out of control from overshoot as it does on slower machines. The Atari and Amiga versions don't even come close.

The much-heralded OS/2, introduced by Microsoft as a replacement for MS-DOS, is like an enormously powerful sportscar for which you can't find the keys. There's no software for it yet – it's a Catch-22 situation in the beginning: you have to produce the system first in hopes that people will write programs for it, but software firms might want to wait until it's popular, which it won't be with no software... Actually, the power of OS/2's multitasking, with each application (including MS-DOS) getting a "computer" of its own, should prove irresistible. 1989 is said to be the year when we'll start seeing applications.

Just to say I tried it, and to get a taste of its power, I ran MS-DOS as an application under OS/2. The Crtl-Esc keys let me toggle back and forth between the OS/2 prompt and the DOS program.

Microsoft *Windows386* is a cross between DOS commands and the icon system used by the Macintosh. It lets you load several programs at the same time, and DOS commands are selected from pulldown menus by using the mouse. It's very convenient and tremendously powerful, but very difficult to set up for the novice. Once you spend some time learning how to configure the files to keep it happy, it greatly simplifies working with large numbers of files and directories (something you'll soon have with a 150MB disk).



Benchmarks

I've always been leery of benchmarks. The speed of a computer is so dependent on so many different things, such as bus structure, video scrolling, memory access, math performance, etc., that benchmark programs often give misleading numbers, depending on what task they have the computer do. For example, Norton's SI, long a standard, gives a rating of 24.2, implying that the 310 is 24 times faster than a PC. From timing various bits of complex software, I'd say that ten times is a more realistic figure. Still, SI at least gives a figure that can be used to compare similar systems, and the 310 is the same as the Compaq Deskpro 386/20 and faster than the IBM Model 80/20. It's also faster than either of these with memory tests (PC Labs test) and CPU performance (4.72 million instructions per second, or MIPS – Power Meter test).

The Zenotest software I use to test video speed gave a result of 18, certainly the fastest of any I've tested so far. The Zeno program can move the video BIOS instructions from slow ROM to faster RAM, giving a speed increase of three times, but the Dell's scrolling is practically instantaneous as it is. Type DIR and try to read the files as they fly by.

Conclusion

The 310 proved to be flawless in operation. It's superbly fast (ask them about the Dell System 325 if it's not quite fast enough for you – it runs at 25MHz) and hugely versatile when it comes to expansion. The ship-direct marketing means a considerable saving over the competition (and very high quality competition it is). Despite the fact that folk wisdom holds that computers are obsolete as soon as they're off the drawing board, I think it's safe to say that the Dell 310 will keep you satisfied for years.

Incidentally, computer manufacturers may not be aware of a clause in the Free Trade agreement. Somewhere in the fine print, it says that they're required to supply journalists with a free 386 system sometime during 1989. I'll just hang on to this Dell 310 to save them the trouble of shipping me one... ■

For further information, contact Dell Computer Corporation, 2 East Beaver Creek Road, Richmond Hill, Ontario L4B 2N3, (416) 881-3513, or toll-free 1-800-387-5752, or FAX (416) 881-3513.

Simple Codelock

A simple, secure electronic lock release for cars or other uses.

JERRY PENNER

It seems that it's a whole lot easier to lock your keys into your car these days. Automobiles with power locks seem to invite you to do so with open(?) arms. Well, I don't like the way my locksmith snickers and I hate to see anyone get rich from my misfortunes. What I needed was a simple electronic codelock that wouldn't take up too much room or money, or destroy the appearance of my vehicle, but

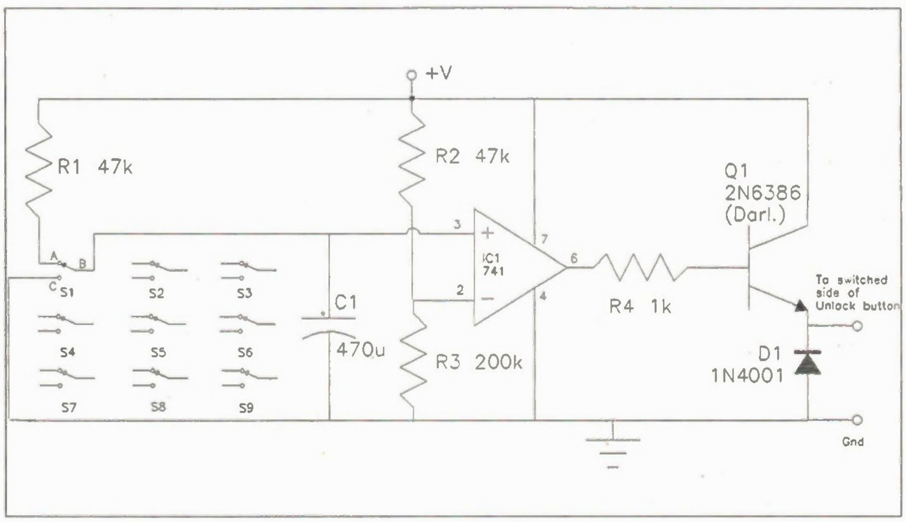


Fig. 1. The schematic of the codelock circuit.

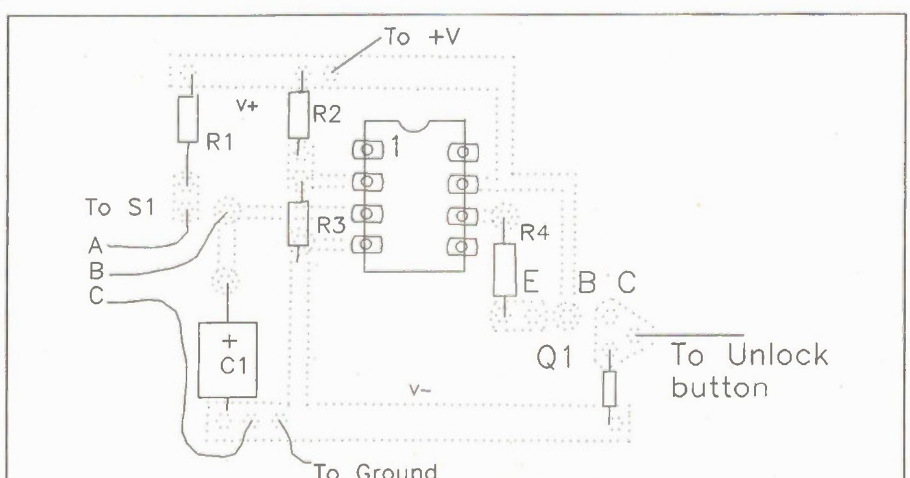


Fig. 2. The parts location, shown enlarged, component side.

PARTS LIST

Resistors

All .25W, 5%

R1 .... 47k
R2 .... 47k
R3 .... 200k
R4 .... 1k

Capacitors

C1 47uF 20V electro.

Semiconductors

D1.......... 1N4001 rectifier diode
IC1 .... 741 opamp
Q1 2N6386 NPN 40V 8A Darlington transistor

Switches

S1.......SPDT momentary switch

Miscellaneous

Wire, project box, nine momentary switches or keypad would maintain an adequate amount of security. The circuit described here fits the bill perfectly and can be used in a host of other security applications.

How It Works

The circuit in Fig. 1 compares an RC divider network to a resistor network. When S1 is depressed, C1 charges through R1 and sets the output of IC1 high when the voltage across C1 exceeds the voltage across R3. This takes about 1.5 RC time constants and with the values given comes to about 30 seconds. The timing is unaffected by supply voltage since both the RC divider and the resistor divider reference from +V. This means that as long as the supply voltage is sufficient to operate the op amp, the length of time S1 must remain activated will remain constant. The output of IC1 controls Q1, which parallels the controlled side of the 'UNLOCK' button in the car. The security of the system is based upon the fact that

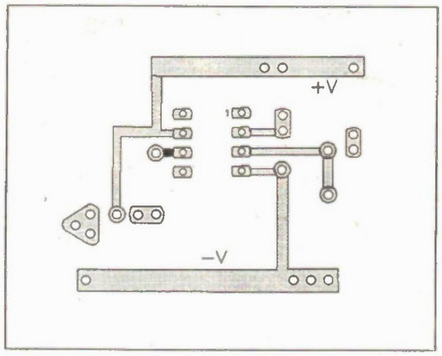


Fig. 3. The printed circuit board, foil side.

anyone seeing a matrix of nine switches will assume it is the front end of sequential-push codelock. Simply pushing any button will do nothing. Pushing the active button for less than the proper time will produce no result, since C1 will discharge when S1 is released. Pushing the active button many times will produce no result for the same reason. Since the circuit activates on time rather than sequence, hiding the active button in an unlikely place will provide protection against unauthorized entry as well.

Construction

Construction may be by the method of your choice, but either PC board or perfboard is recommended to keep everything neat. See Fig. 2 for the component layout. Be sure of the wiring of S1 or else the lock may activate itself about 30 seconds after power is applied. Remember that if S1 is going to be exposed to the elements, a weatherproof switch should be used and the connections siliconed.

Getting In

So go ahead, lock your keys in your car; it doesn't matter anymore. It will take you less than a minute to get into your vehicle and you don't have to pull out your hair or your wallet to do it. ■

The Norton Difference

A guide to the underused Norton differencing op amp.

RAY MARSTON

Most popular op amps (Fig. 1a) give an output proportional to the difference between their two input terminal voltages and are thus known as voltage-differencing amplifiers or VDAs. There is however a type of op amp which gives an output voltage proportional to the difference between the *currents° applied to its two input pins. These devices are known as current-differencing amplifiers or CDAs. Figure 1b shows the standard symbol of the CDA, also known as a Norton op amp.*

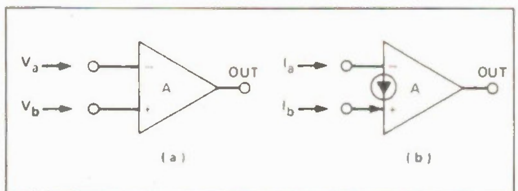


Fig. 1 (a) A conventional op amp. (b) A Norton op

The two best known Norton op amps are the LM3900 and the LM359. The LM3900 is a low-cost medium performance IC that houses four identical op amps in a 14-pin PIL package (Fig. 2) and can operate from a single-ended 4–36V power supply. Each of its op amps has a unity-gain bandwidth of 2.5MHz with an open-loop gain of about 70dB, and gives a large output voltage swing. This IC is particularly useful in DC and low frequency applications where several op amp stage are needed in single-ended supply circuits.

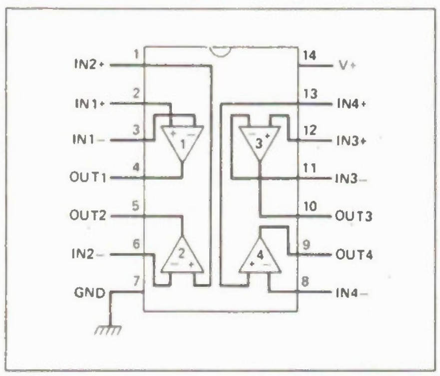


Fig. 2 Connections of the LM3900 quad Norton op amp.

On the other hand, the LM359 is a very fast dual Norton amplifier in which each op amp has a unity-gain bandwidth of 30MHz with an open-loop gain of about 72dB, and in which most of the op amp parameters are externally programmable. This IC is particularly useful in video and high frequency amplifier/filter applications.

The LM3900 and LM359 operate in a very different way to conventional op amps and require the use of special biasing techniques. We will first take a look at the LM3900 and next move on the faster LM359.

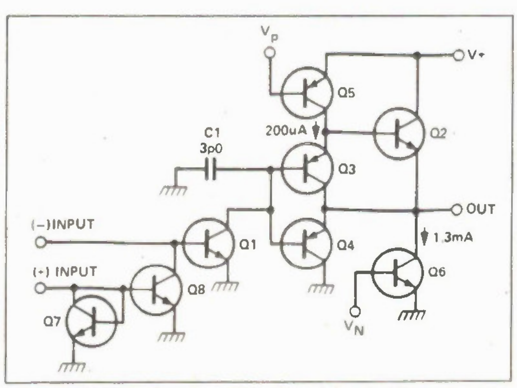


Fig. 3 Circuit of each of the four identical op amp stages of the LM3900.

Inside The Box

The LM3900 incorporates four identical current- differencing op amps, each having the circuit shown in Fig. 3. To aid understanding of the complete circuit, Fig. 4 shows six simple stages in the development of the final design.

Figure 4a shows a basic inverting amplifier circuit. Q1 is a common emitter amplifier with a high-impedance (constant-current) collector load, and gives a high-gain inverting action. Q2 is an emitter load. The high frequency response of the complete amplifiers is rolled off by C1, to enhance circuit stability.

Note that the output of this circuit can swing to within a few hundred mV of both zero and the positive supply rail voltage, and that its overall current gain equals the product of the two transistor current gains.

Figure 4b shows how the current gain of the above circuit can be increased with little loss of available output voltage swing, by adding PNP transistor Q3. The output of this circuit can typically source up to 10mA (via Q2) but can sink only 1.3mA (via Q2's constant-current generator).

Figure 4c increases the sink current by wiring Q4 so that in over-drive conditions it gives class-B operation.

Figure 4d shows transistors Q5 and Q6 used as constant-current generators

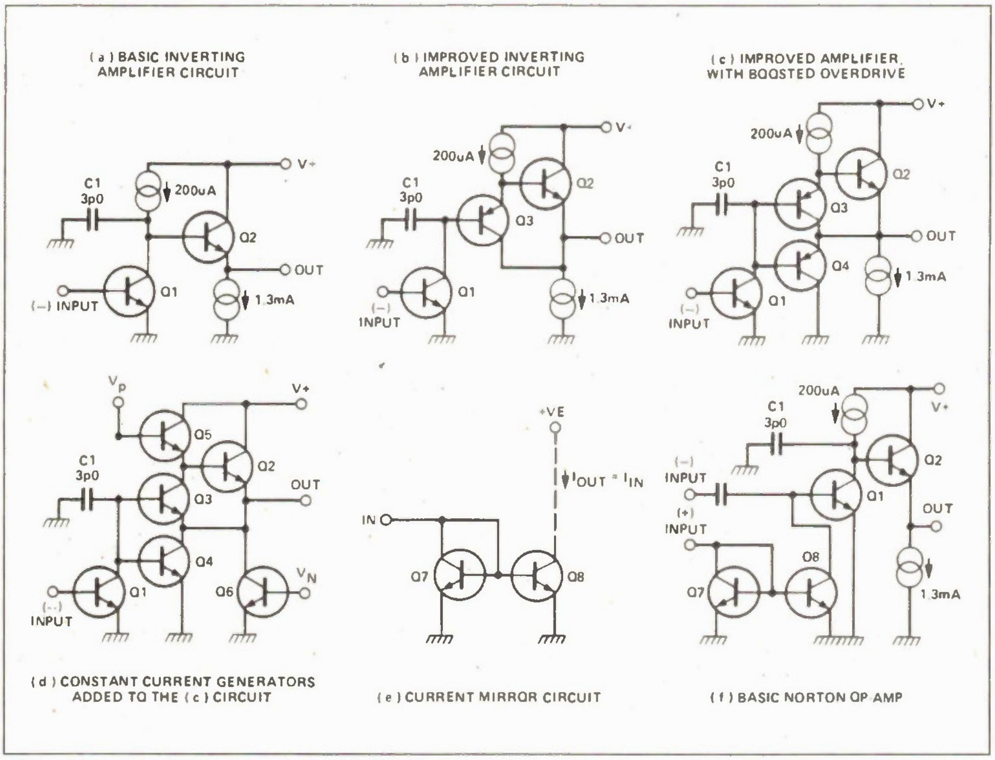


Fig. 4 Development of the LM3900 op amp circuit.

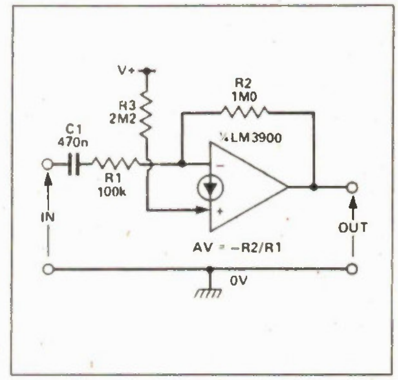


Fig. 6 Inverting AC amplifier with supply-line biasing.

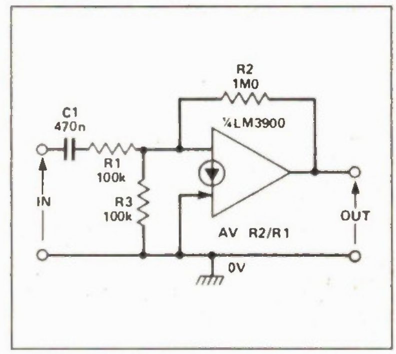


Fig. 7 Inverting AC amplifier with N x Vbe biasing.

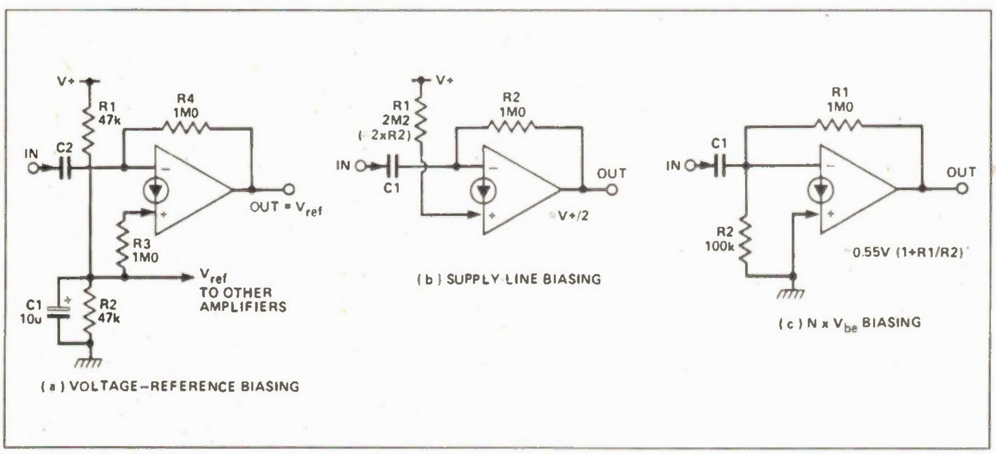


Fig. 5 Methods of biasing LM3900 op amps for linear operation.

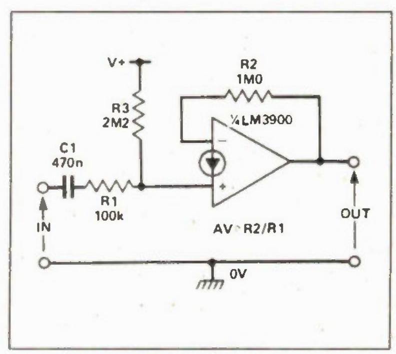


Fig. 8 Non-inverting amplifier.

(biased via a network that is built into the LM3900 IC).

Current Mirrors

The Figure 4-d circuit forms the basis of each of the LM3900 amplifier stages, but gives an inverting action. The non-inverting LM3900 requires the assistance of the current mirror circuit of Figure 4e, which is made up of two matched and integrated transistors and simply draws an output current that is almost identical to the input drive current.

The input current is fed to the bases of both Q7 and Q8. Let's say both have current gains of x 100, and both are drawing base currents of 5uA. In this case both collector currents are 500uA plus both base currents. The input and output currents of the circuit are thus almost identical (within a few percent), irrespective of the input current magnitude.

Figure 4f shows the current mirror circuit connected to the basic Fig. 4a circuit to give the current-differencing action of the Norton amplifier. The mirror circuit is driven via the non- inverting input terminal, and the mirror current is drawn from the inverting input terminal, also connected directly to the base of Q1 amplifier stage. Consequently, the base current of Q1 equals 1- — 1+. This is the difference between the two input currents. The complete amplifier (back in Fig. 3) thus gives the current-differencing op amp action already mentioned.

Note that since both input terminals of the op amp are connected to transistor base-emitter junctions, both inputs act (in voltage terms) as virtual-ground points. Consequently, these CDA circuits can be made to act like conventional voltage-differencing op amps by wiring high-value resistors in series with their input terminals, so that the input currents and directly proportional to the input V/R values. When this technique is used, there is no upper limit to the available input common-mode voltage range of the LM3900 op amp.

Biasing Techniques

The basic amplifier stages of the LM3900 have high current gains, and the output of the amplifier starts to swing down through the half-supply point when the input bias current of Q1 starts to rise above 30nA or so. This input current is normally equal to the difference between the two input terminal currents, which should normally be restricted to the range of 0.5uA to 500uA (ideally about 10uA).

In linear applications an op amp is normally biased so that its output takes up a quiescent value of half-supply volts to accommodate maximum undistorted signal swings, and Fig. 5a shows how the LM3900 can be biased to meet this condition.

R1, R2 and C1 generate a decoupled half-supply reference voltage, which applies a reference current to the non-inverting terminal via R3, and a negative feedback current is applied from the op amp output to the inverting terminal via R4. The basic action is such that the op amp output automatically adjust to such a value that the two input currents equalize and hence reduce the internal Q1 base current to near-zero (about 30uA) – in Fig. 5a this occurs when V out(Bill check the size) equals to V ref. (check the size). In practice, the single reference voltage source can be used to apply biasing for several op amp stages.

A variation of this biasing system is shown in Fig. 5b. The non- inverting terminal is biased from the positive supply rail via R1, which has a value approximately double that of R2, causing the output to bias at a quiescent value of half-supply volts. A minor defect of this biasing technique is that it allows supply line ripple to break through to the output, with gain of 0.5.

Note that in Figs 5a and 5b, the input signal is shown connected to the inverting terminal of the amplifier, but in practice the signal can be connected to either input.

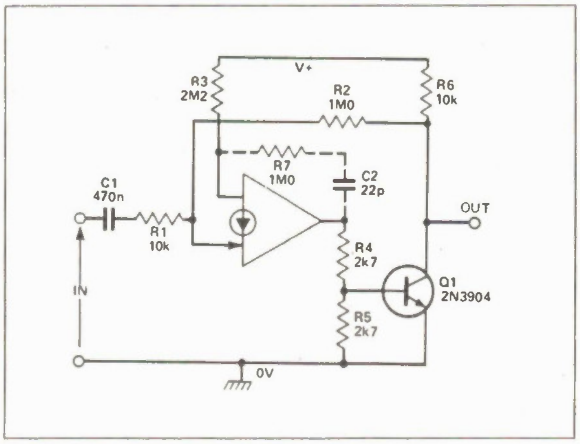


Fig. 9 Wideband (200 kHx) high-gain (x100) amplifier.

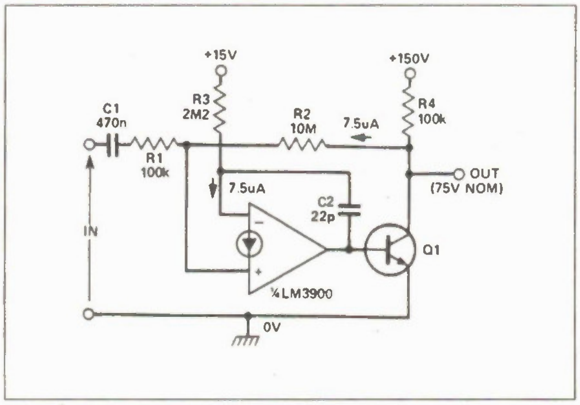


Fig. 10 High-voltage amplifier with x 100 gain.

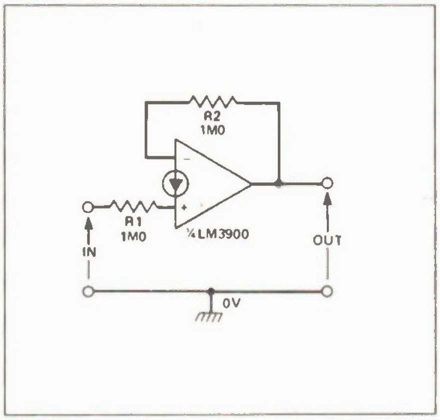


Fig. 11 DC voltage-following buffer.

Figure 5c shows an alternative biasing technique that can be used when the op amp is to operate only as an inverting amplifier. In this case the non-inverting terminal is disabled, and feedback potential divider R1, R2 is applied between the output and the inverting terminal. Consequently, since the inverting terminal acts as a transistor base-emitter junction (V be. about 0.55V at 10uA bias), the output automatically takes up a quiescent value of V be X (1+R1(R2). This is about 6V with the component values shown.

Linear Amplifier Circuits

Six ways of using the LM3900's op amps as linear amplifiers are shown in Fig 6 to 11. In Figure 6, R2 and R3 bias the output to a a quiescent half-supply value, and the input signal is fed to the inverting terminal via R1. The voltage gain is determined by the R1, R2 ratio – this acts as a X 10 inverting amplifier.

Figure 7 shows an alternative X 10 inverting amplifier, in which biasing of the type in Fig. 5c is used and the gain is determined by the R1, R2 ratio.

Figure 8 shows a non-inverting amplifier with a gain of approximately ten. Supply-rail biasing is again used, but the input signal is applied to the non-inverting pin via R1.

The LM3900 op amps are fairly slow devices with slew rate of only 0.5V us,(check symbol) and thus very limited useful bandwiths. Figure 9 increases the useful bandwith by connecting an external common emitter transistor to the output and transposing the input connections of the standard amplifier. This makes a X 100 'compound' amplifier with as 200kHz bandwidth.

Because of its very high overall gain, this circuit may be unstable if care is not taken in layout R7 and C2 can be used to slightly reduce the bandwidth and enhance stability if required.

Figure 10 shows the same circuit modified to give a peak-to-peak output voltage swing of 150V (or whatever voltage is used to power Q1). Note that the output voltage of this circuit has a quiescent value of 75V, causing 7.5uA to be fed to the non- inverting terminal of the op amp via R2. To give correct biasing R3 (powered from the 15V supply rail of the op amp must also apply 7.5uA to the inverting pin of the op amp, as shown.

Finally, Figure 11 shows how to connect an LM3900 op amp as a unity-gain non-inverting amp-lifter or voltage following buffer. The input is connected to the non-inverting terminal via R1 (giving the non-inverting action) and R1 and R2 have equal values thus giving unity gain (note that the circuit would give a gain of X 2 if R1 were half the value of R2). ■

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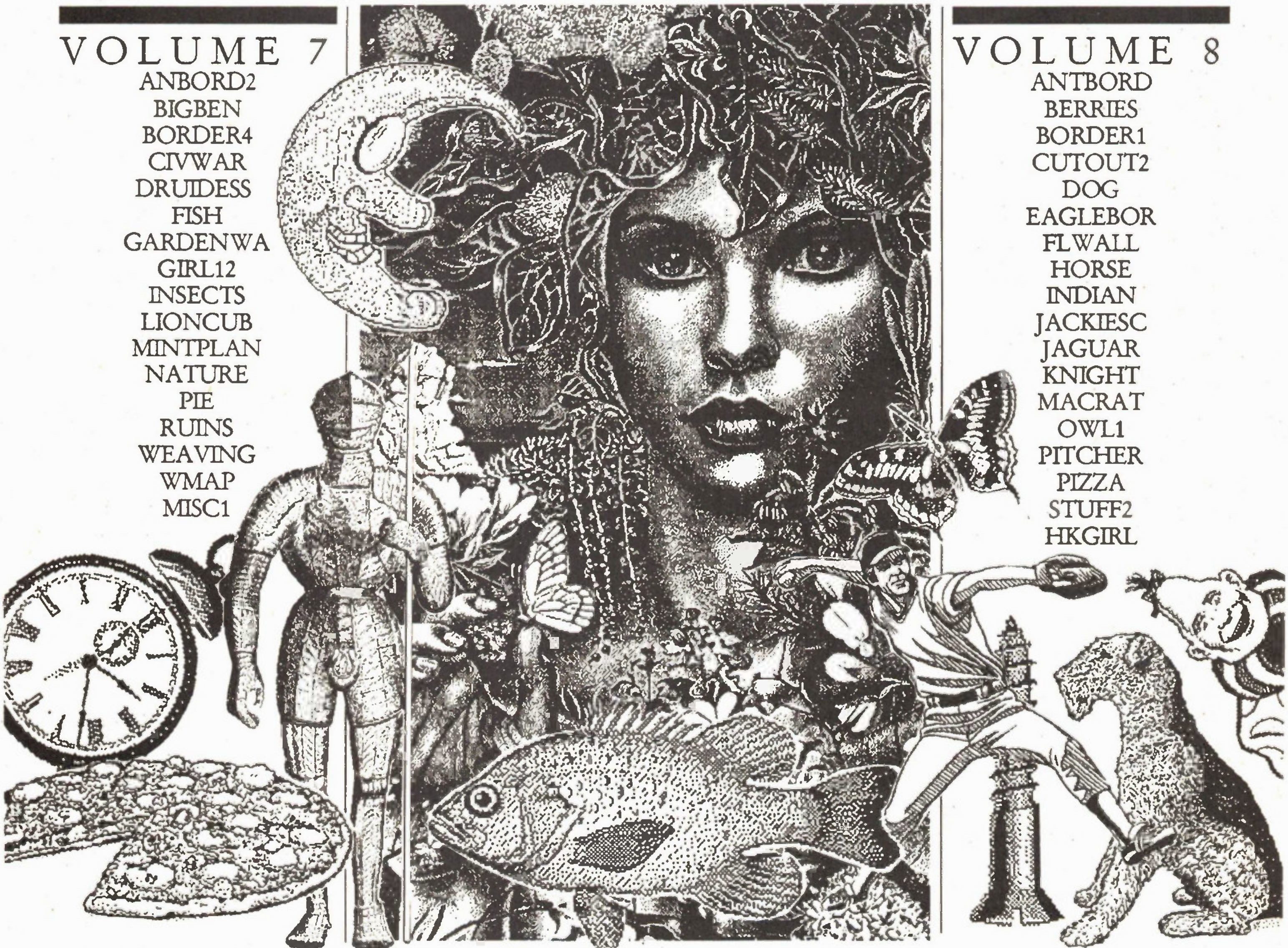

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BP239: GETTING THE MOST FROM YOUR MULTIMETER *$9.00*
This book is aimed at beginners and those of limited experience of electronics. Using the simple component and circuit testing techniques in this book the reader should be able to confidently tackle servicing of most electronic projects.

BP53: PRACTICAL ELECTRONIC CALCULATIONS AND FORMULAE *$11.75*
A book that bridges the gap between complicated technical theory and the "cut and try" method. A good reference book.

BP174: MORE ADVANCED ELECTRONIC MUSIC PROJECTS *$12.00*
Complementing Book PB74, "Electronic Music Projects", BP174 provides more advanced projects, such as a flanger, a phaser, mini-chorus and ring modulators, percussion synths, etc. Each project has an Introduction circuit diagram and constructional notes.

BP113: 30 SOLDERLESS BREADBOARD PROJECTS - BOOK 2 *$9.00*
R.A. Penfold
A companion to BP107. Describes a variety of projects that can be built on plug-in breadboards using CMOS logic IC's. Each project contains a schematics, parts list and operational notes.

BP92: ELECTRONICS SIMPLIFIED - CRYSTAL SET CONSTRUCTION *$5.25*
This is a book written especially for those who wish to participate in the intricacies of electronics.

BP192: MORE ADVANCED POWER SUPPLY PROJECTS *$8.00*
Robert Penfold.
A companion to BP76, this book covers switched mode supplies, precision regulators, tracking regulators, computer- controlled supplies, etc.

BP222: SOLID STATE SHORT WIVE RECEIVER FOR BEGINNERS *$7.80*
R.A. Penfold
In this book, R.A. Penfold has designed and developed several modern solid state short wave receiver circuits that will give a fairly high level of performance, despite the fact that they use only relatively few and inexpensive components.

BP197: INTRODUCTION TO THE AMSTRAD PCs *$20.00*
The Amstrad PC is an MS-DOS computer for general and business use. This book explains all you need to know to start computing.

BP150: AN INTRO TO PROGRAMMING THE SINCLAIR QL *$7.80*
Helps the reader make the best use of the Sinclair QL's almost unlimited range of features. Complements the manufacturer's handbook.

BP48: ELECTRONIC PROJECTS FOR BEGINNERS *$7.80*
F.G. Rayer, T. Eng. (CEI), Assoc.IERE
Another book written by the very experienced author - Mr. F.G. Rayer - an in it the newcomer to electronics will find a wide range of easily made projects. Also, there are a considerable number of actual components and wiring layouts, to aid the beginner.

BP135: SECRETS OF THE COMMODORE 64 *$5.85*
This book is intended as a beginner's guide to the Commodore 64.

BP155: INTERNATIONAL RADIO STATIONS GUIDE *$9.00*
An invaluable aid in helping all those who have a radio receiver to obtain the maximum entertainment value and enjoyment from their sets.

BP130: MICRO INTERFACING CIRCUITS — BOOK 1 *$9.00*
Aimed at those who have some previous knowledge of electronics, but not necessarily an extensive one, the basis of the book is to help the individual understand the principles of interfacing circuits to microprocessor equipment.

BP131: MICRO INTERFACING CIRCUITS — BOOK 2 *$9.00*
Intended to carry on from Book 1, this book deals with practical applications beyond the parallel and serial interface. "Real world" interfacing such as sound and speech generators, temperature, optical sensors, and motor controls are discussed using practical circuit descriptions.

BP51: ELECTRONIC MUSIC AND CREATIVE TAPE RECORDING *$5.85*
This book sets out to show how Electronic Music can be made at home with the simplest and most inexpensive equipment.

BP74: ELECTRONIC MUSIC PROJECTS *$10.00*
R.A. Penfold
Although one of the more recent branches of amateur electronics, electronic music has now become extremely popular and there are many projects which fall into this category. The purpose of this book is to provide the constructor with a number of practical circuits for the less complex items of electronic music equipment, including such things as a Fuzz Box, Waa-Waa Pedal, Sustain Unit, Reverberation and Phaser Units, Tremelo Generator, etc.

BP110: HOW TO GET YOUR ELECTRONIC PROJECTS WORKING *$7.80*
R.A. Penfold
We have all built circuits from magazines and books only to find that they did not work correctly, or at all, when first switched on. The aim of this book is to help the reader overcome these problems by indicating how and where to start looking for many of the common faults that can occur when building up projects.

BP86: AN INTRODUCTION TO BASIC PROGRAMMING TECHNIQUES *$5.85*
This book is based on the author's own experience in learning BASIC and also in helping others, mostly beginners to programming, to understand the language.

BP234: TRANSISTOR SELECTOR GUIDE *$15.00*
Listings of British, European and eastern transistor characteristics make it easy to find replacements by part number or by specifications. Devices are also grouped by voltage, current, power, etc., includes surface-mount conversions.

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BP101: HOW TO IDENTIFY UNMARKED IC's *$1.95*
An unusual and fascinating chart that is highly recommended to all those interested in electronics and which will hopefully pay for itself many times over, by enabling the rEader to use IC's that might otherwise have been scrapped.

BP121: HOW TO DESIGN AND MAKE YOUR OWN PCBs *$5.85*
The purpose of this book is to familiarize the reader with both simple and more sophisticated methods of producing printed circuit boards. The book emphasizes the practical aspects of printed circuit board designs and construction.

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This book describes how to build 25 amateur band aerials. The designs start with the simple dipole and proceed to beam, triangle and even a mini-rhombic.

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Shows how home computers can easily be applied to the control of model railroads and other quite sophisticated control. A variety of projects are discussed as well as circuits for train position sensing, signal and electric points control, etc.

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The aim of this book is to enable the reader to simply and inexpensively construct and examine the operation of a number of basic computer circuit elements and it is hoped gain a fuller understanding of how the mysterious computer "chip" works.

BP185: ELECTRONIC SYNTHESIZER CONSTRUCTION *$9.00*
With this book a relative beginner should be able to build, with a minimum of difficulty and at a reasonably low cost, a worthwhile monophonic synthesizer and also learn a great deal about electronic music synthesis in the process.

BP115: THE PRE-COMPUTER BOOK *$5.85*
Aimed at the absolute beginner with no knowledge of computing, this entirely non-technical discussion of computer bits and pieces and programming is written mainly for those who do not possess a microcomputer but either intend to one day own one or simply wish to know something about them.

BP72: A MICROPROCESSOR PRIMER *$5.25*
In an attempt to give painless approach to computing, this inexpensive book will start by designing a simple computer and then the short-comings of this simple machine will be discussed and the reader is shown how these can be overcome. Includes a glossary of microprocessor terms.

BP42: 50 SIMPLE L.E.D. CIRCUITS *$5.85*
Contains 50 interesting and useful circuits and applications, covering many different branches of electronics, using one of the most inexpensive and freely available components.

BP85: INTERNATIONAL TRANSISTOR EQUIVALENTS GUIDE *$9.00*
This book is designed to help the user find possible substitutes for a popular user-oriented selection of modem transistors and includes devices produced by over 100 manufacturers.

BP140: DIGITAL IC EQUIVALENTS AND PIN CONNECTIONS *$15.00*
Shows equivalents and pin connections of a popular user-oriented selection of Digital Integrated Circuits. Includes European, American and Japanese devices.

BP100: AN INTRODUCTION TO VIDEO *$5.85*
This book is for the person who has just, or is about to buy or rent video equipment but is"nt sure what it's all about.

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The powerful sinclair QL microcomputer has some outstanding capabilities in terms of its internal structure. With a 32-bit architecture, the QL has a large address range, advanced instructions which include multiplication and division.These features give the budding machine code programmer a good start at advanced programming methods. This book assumes no previous knowledge of either the 68008 or machine code programming.

BP93: ELECTRONIC TIMER PROJECTS *$7.80*
Windscreen wiper delay, darkroom timer and metronome projects are included. some of the more complex circuits are made up from simpler sub-circuits which are dealt with individually.

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Adrian Michaels
Find equivalents and cross-references for both popular and unusual integrated circuits. Shows details of functions, manufacturer, country of origin, pinouts, etc... includes National, Motorola, Fairchild, Harris, Intersil, Philips, ADC, AMD, SGS, Teledyne, and many other European, American and Japanese brands.

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This book covers many aspects of electronics where a knowledge and familiarity of the appropriate formulae is essential for a fuller understanding of the subject. An essential addition to the library of all those interested in electronics be they amateur, professional or student.

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This book deals mainly with TTL type chips such as the 7400 series. Simple projects and a complete practical construction of a Logic Test Circuit Set are in cluded as well as details for a more complicated Digital Counter Timer project.

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Divided into six parts, this book covers such areas of mobile "disco" as: Basic Electricity, Audio, Ancillary Equipment, Cables and Plugs, Loudspeakers, and Lighting. All the information has been subdivided for quick and easy reference.

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BP59: SECOND BOOK OF CMOS IC PROJECTS *$7.80*
This book carries on from its predecessor and provides a further selection of useful circuits, mainly of a simple nature. The book is well within the capabilities of the beginner and more advanced constructor.

BP88: HOW TO USE OP-AMPS *$11.80*
E.A. Parr
A designer's guide covering several op-amps, serving as a source book of circuits and a reference book for design calculations. The approach has been made a non-mathematical as possible.

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BP37: 50 PROJECTS USING RELAYS, SCR's & TRIACS *$7.80*
F.G. Rayer, T. Eng., (CEI), Assoc. IERE.
Relays, bi-directional triodes (TRIACs), and silicon controlled rectifiers (SCRSs), have a wide range of applications in electronics today. This book gives tried and practical working circuits which should present the minimum of difficulty for the enthusiast to construct. In most of the circuits there is a wide latitude in component values and types, allowing easy modification and ready adaptation of them to individual needs.

BP95: MODEL RAILWAY PROJECTS *$7.80*
Electronic projects for model railways are fairly recent and have made possible an amazing degree of realism. The projects covered included controllers, signals and sound effects: stripboard layouts are provided for each project.

BP84: DIGITAL IC PROJECTS *$7.80*
F.G. Rayer, T. Eng. (CEI), Assoc. IERE.
This book contains both simple and more advanced projects and it is hoped that these will be found of help to the reader developing a knowledge of the workings of digital circuits. To help the newcomer to the hobby the author has included a number of board layouts and wiring diagrams. Also the more ambitious projects can be built and tested section by section and this should help avoid or correct faults that could otherwise be troublesome.

BP44: IC 555 PROJECTS *$10.00*
E.A. Parr, B.Sc., C. Eng., M.I.E.E.
Every so often a device appears that is so useful that one wonders how life went on before it. The 555 timer is such a device included in this book are Basic and General Circuits, Motor Car and Model Railway Circuits, Alarms and Noise Makers as well as a section on the 556, 558 and 559 timers.

BP94: ELECTRONIC PROJECTS FOR CARS AND BOATS *$7.80*
R.A. Penfold
Projects, fifteen in all, which use a 12V supply are the basis of this book. Included are projects on Windscreen Wiper Control, Courtesy Light Delay, Battery Monitor, Cassette Power Supply, Lights Timer, Vehicle Immobiliser, Gas and Smoke Alarm, and more.

BP49: POPULAR ELECTRONIC PROJECTS *$10.00*
R.A. Penfold
Includes a collection of the most popular types of circuits and projects which, we feel sure, will provide a number of designs to interest most electronics constructors. The projects selected cover a very wide range and are divided into four basic types. Radio Projects, Audio Projects, Household Projects and Test Equipment.

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Twenty useful projects which can all be built on a 24 X 10 hole matrix board with copper strips. Includes Door-buzzer, Low-voltage Alarm, AM Radio, signal Generator, Projector Timer, Guitar Headphone Amp. and more.

BP103: MULTI-CIRCUIT BOARD PROJECTS *$7.80*
R.A. Penfold
This book allows the reader to build 21 fairly simple electronic projects, all of which may be constructed on the same printed circuit board. Wherever possible, the same components have been used in each design so that with a relatively small number of components and hence low cost, it is possible to make any one of the projects or by re-using the components and P.C.B. all of the projects.

BP98: POPULAR

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BP195: AN INTRODUCTION TO SATELLITE TELEVISION *$15.00*
For the absolute beginner or anyone thinking about purchasing a satellite TV system, the story is told as simply as such a complex one can be.

BP106: MODERN OP-AMP PROJECTS *$7.80*
R.A. Penfold
features a wide range of constructional projects which make use of op-amps including low-noise, low distortion, ultra-high input impedance, high slew-rate and high output current types.

BP107: 30 SOLDERLESS BREADBOARD PROJECTS - BOOK 1 *$9.00*
R.A. Penfold
A "Solderless Breadboard" is simply a special board on which electronic circuits can be built and tested. The components used are just plugged in and unplugged as desired. The 30 projects featured in this book have been specially designed to be built on a "Verobloc" breadboard. Wherever possible the components used are common to several projects, hence with only a modest number of reasonably inexpensive components it is possible to build, in turn, every project shown.

BP127: HOW TO DESIGN ELECTRONIC PROJECTS *$9.00*
Although information on stand circuits blocks is available, there is less information on combining these circuit parts together. This title does just that. Practical examples are used and each is analysed to show what each does and how to apply this to other designs.

BP122: AUDIO AMPLIFIER CONSTRUCTION *$6.75*
A wide circuits is given, from low noise microphone and tape head preamps to a 100W MOSFET type. There is also the circuit for 12V bridge amp giving 18W. Circuit board or stripboard layout are included. Most of the circuits are well within the capabilities of even those with limited experience.

BP179: ELECTRONIC CIRCUITS FOR THE COMPUTER CONTROL OF ROBOTS *$12.00*
The main stumbling block for most would-be robot builders is the electronics to interface the computer to the motors, and the sensors which provide feedback from the robot to the computer. The purpose of this book is to explain and provide some relatively simple electronic circuits which bridge the gap.

BP108: INTERNATIONALDIODE EQUIVALENTS GUIDE *$7.00*
Cross-references European, American and Japanese diode part numbers. Besides rectifier diodes, it includes Zeners, LEDs, Diacs, Triacs, SCRs, OCIs, photodiodes, and display diodes.

BP118: PRACTICAL ELECTRONIC BUILDING BLOCKS — BOOK 2 *$7.60*
R.A. Penfold
This sequel to BP117 is written to help the reader create and experiment with his own circuits by combining standard type circuit building blocks. Circuits concerned with generating signals were covered in Book 1, this one deals with processing signals. Amplifiers and filters account for most of the book but comparators, Schmitt triggers and other circuits are covered.

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TECH TIPS

Circuits for the experienced constructor

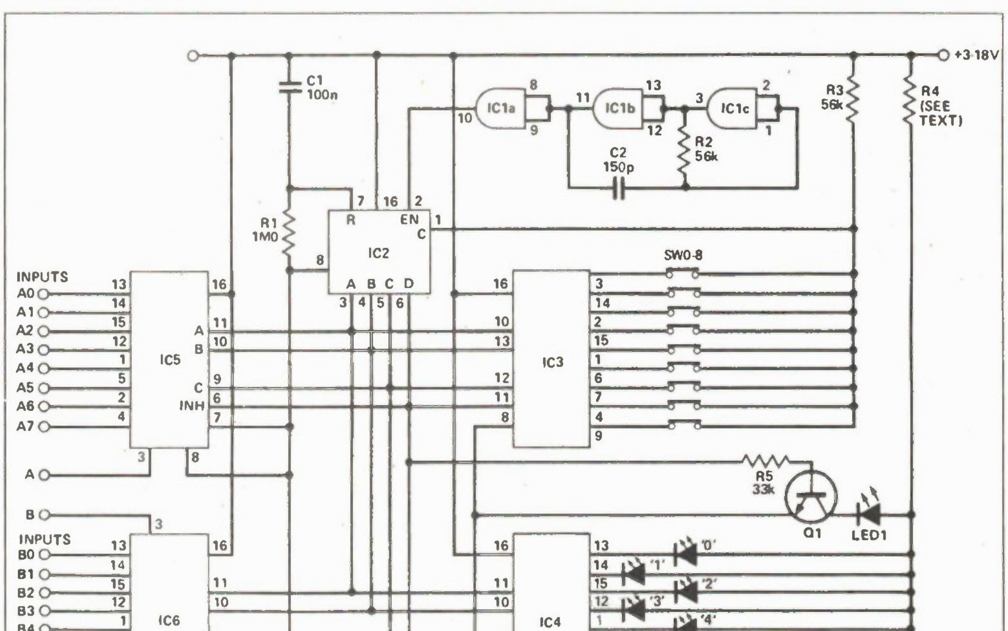
8-Way Stereo Selector

This circuit provides noiseless remote selection and routing of eight audio signals, either stereo or balanced pair mono, using simple non-locking push-switches.

The BCD counter IC2 is disabled from counting IC1's 1MHz clock rate by the wired high on pin 1. A momentary closure of SW2, say, is sufficient and the switching action is effectively debounced. The code 0010 is now present on all the ICs so that LED 2 on IC4 is now lit and inputs A2 and B2 are connected to the outputs of IC5 and IC6.

SW8 selects BCD 1000 inhibiting the 4051s and providing an 'off facility. ICs 5 and 6 may, of course, be remote from the selection and indicating circuitry — advantageously sited with respect to the audio signal paths.

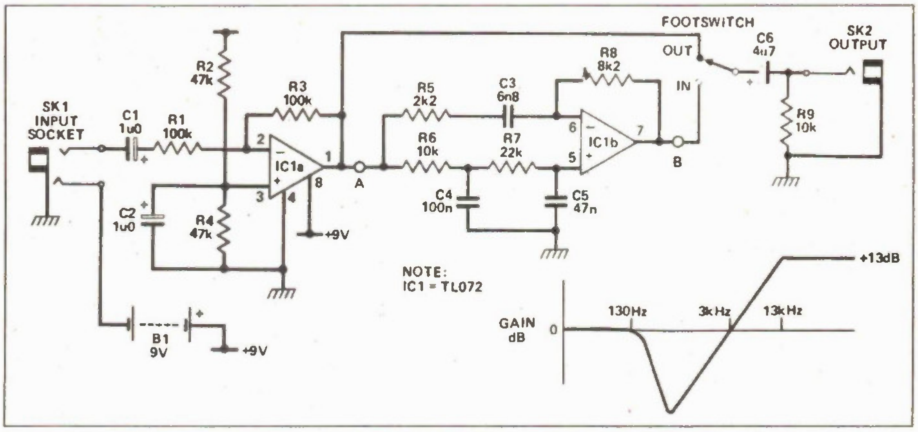
The power requirement is only about 1/2mA above the required by the LEDs. Select R3 to suit the supply voltage assuming 25mA for the LED (so 140R for 6V. 260R or 9V, 380R for 12V, 500R for 15V and so on).



Guitar Preshaper

Some upmarket bass and guitar amps are fitted with a preset tone circuit to give an instant clean modern sound without the tedious EQ setting. In this circuit IC1b filters high and low frequencies, then recombines them to produce a frequency response approximately as shown. This produces a clean bright sound for either 6-string guitar or bass.

The circuit can be built as a footpedal powered from a 9V battery (no power LED is included to extend battery life).

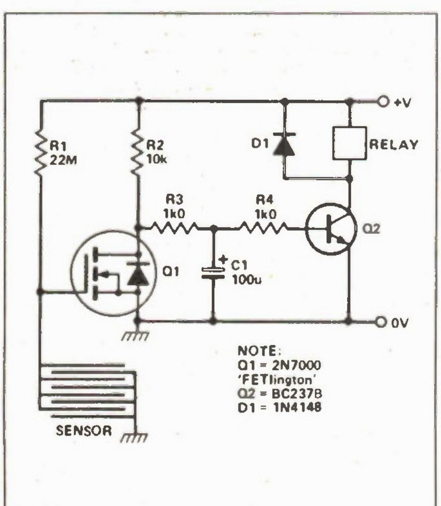


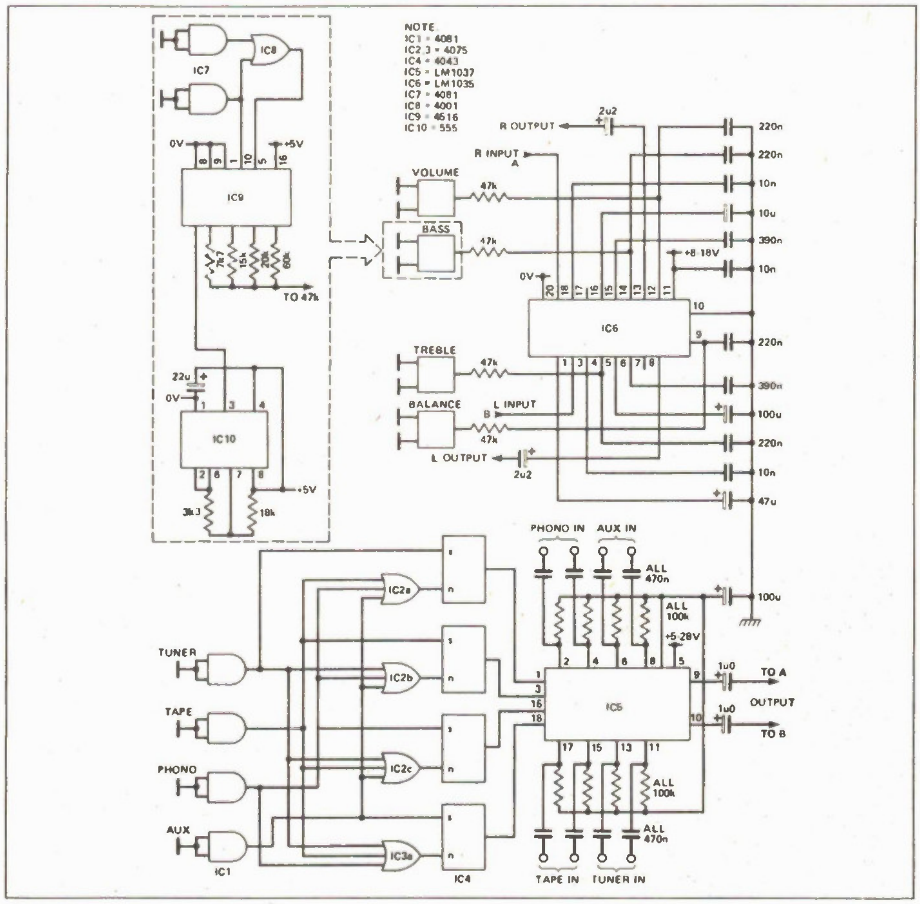
Cheap Touch Switch

This circuit, originally designed as the switch of an alarm system for a disabled person, takes advantage of the high input impedance of the 2N7000 'FETlington.' The high value resistor R1 pulls the gate of Q1 to the positive rail. If the operator's finger is placed across the sensor contacts, the gate voltage falls close to zero. This switches Q1 off.

Q2 acts to invert the signal from Q1 and so the relay is normally de-energised. R3 and R4 provide the correct voltage at the base of Q2. C1 adds some delay to overcome any 'contact' bounce from the sensor.

The type of transistor used for Q2 is not critical and nor is the supply rail voltage. R1 may be reduced to 10M to reduce sensitivity. With a value of 22M it was found the switch could be activated by breathing on the sensor! For the prototype a small piece of stripboard was used for the sensor.





Touch Controlled Pre-amp

A touch controlled pre-amp with touch plate selection of inputs and volume, bass, treble and balance can be easily constructed with the help of the LM1037 and 1035 audio control ICs. The touch plate sensors rely on the tied inputs of the AND gates (IC1, 11, 21, 31, 41) floating low and being taken high by a touch on the plate.

IC2, 3 form a latching arrangement so that each touch on an input selector plate will set the relevant flip-flops and reset the others.

The four flip-flop outputs are used to switch on a pair of inputs to IC5 through to IC6. This uses the DC voltage from the four identical volume bass, treble and balance circuits to filter and attenuate the stereo channels.

The DC control voltage is obtained by weighting the 4-bit output from up/down counter IC13 (23, 33 and 43). The counter is clocked by the 555 timer in astable mode and enabled to count up or down by IC11 and IC12.

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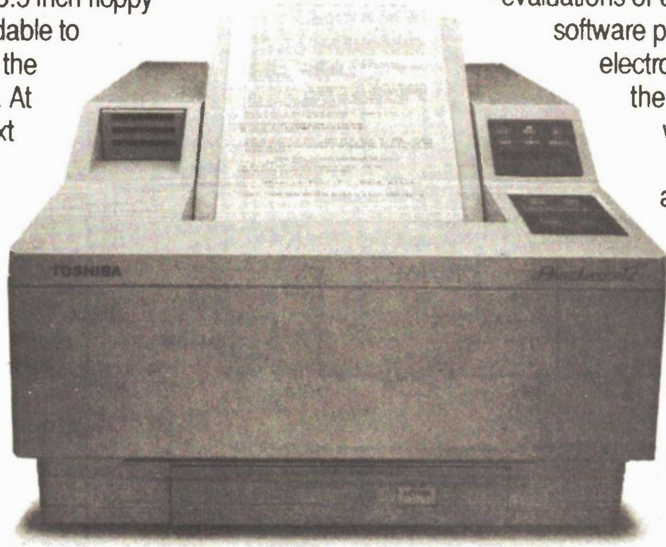

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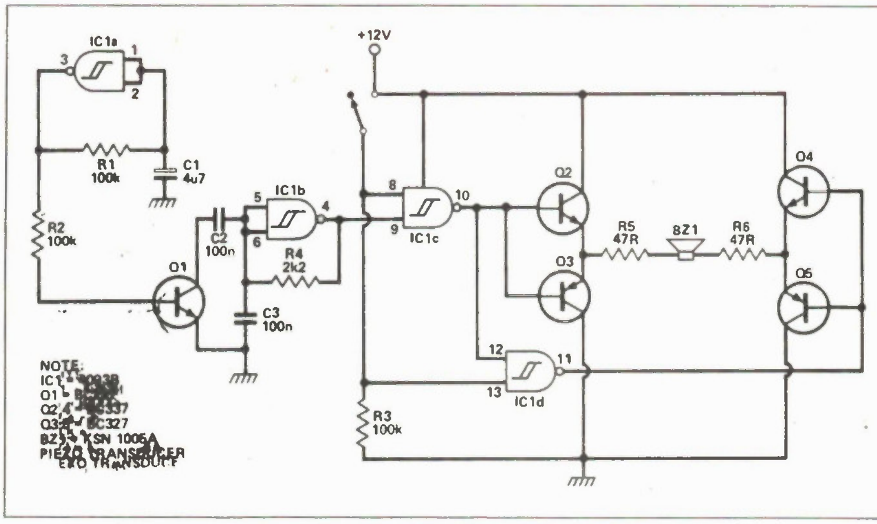
Low Current Siren

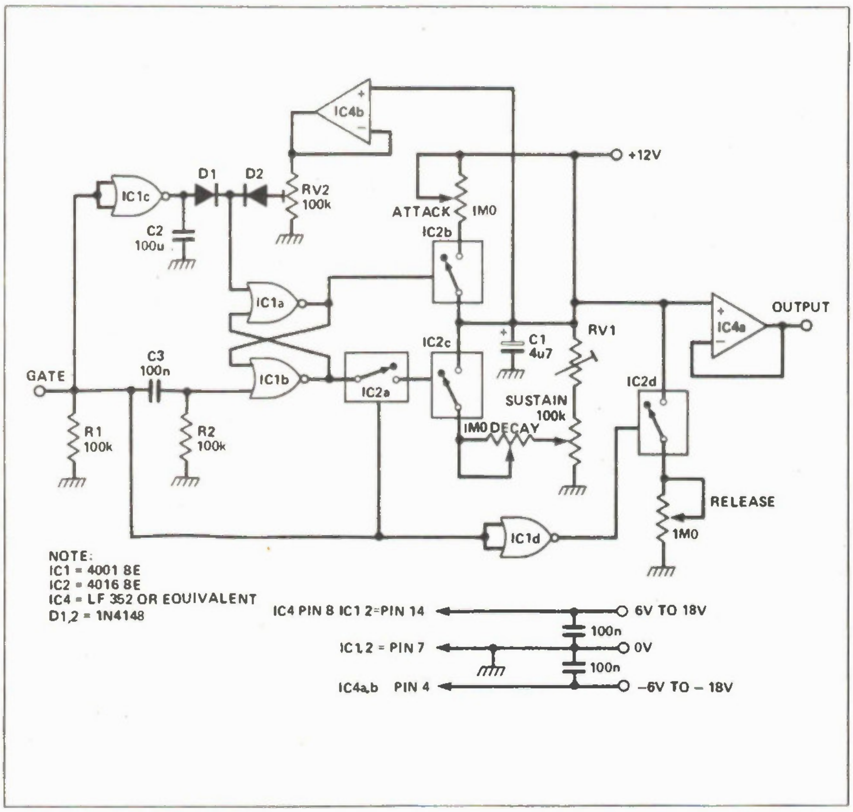


This efficient circuit provides an output of 10V RMS (approx 103dB at 1m) at a current consumption of only 30mA.

Low frequency oscillator IC1a varies the frequency of audio oscillator IC1b by switching in and out C2. The rapidly varying audio signal is gated by IC1c to output amplifier stage Q2, 3 and an inverted signal is passed to Q4, 5.

The piezo transducer is connected between the stages with 20V peak- to-peak across it.

Resistors R5 and R6 serve to limit the current and stabilize the output stages.



Super Woofer

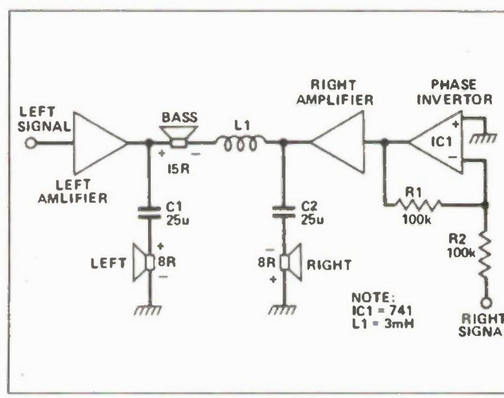
This circuit enables a single centrally placed woofer to be added to a stereo system. This gives a cost effective bass enhancer which still preserves the stereo picture via the original speakers.

The right channel is driven in antiphase and the right hand speaker is reverse connected to restore the phase.

C1 and C2 as shown give a crossover at about 800Hz – other values could be tried.

The single bass speaker is bridge connected across the antiphase outputs via inductor L1. This has the incidental advantage of cancelling out in-phase hum and vertical turntable rumble.

Note that for a system playing records only, the inverting IC circuit could be removed by reversing one half of the stereo cartridge.



Envelope Generator

This envelope generator was designed to boost the performance of my ancient monophonic synthesizer which came equipped with only one. This way I can control either the VCA or VCF with each generator. It's a no-frills ADSR generator and it's small and cheap.

C1 charges at a rate set by the attack pot when the gate goes high (at the start of a note). At a certain voltage (set by RV2), the flip-flop of IC1a, b resets and C1 discharges at a rate set by the decay pot until it reaches the voltage set by the sustain pot. When the gate is removed (note off) C1 discharges through the release pot.

RV1 sets the maximum sustain level which should be set to match the voltage controlled device. IC4 buffers the voltage across C1 for the output.

I used this circuit with a Moog Rogue with excellent results.

The circuits shown are from readers, and while we make every effort to reproduce them accurately, E&TT cannot be responsible for circuit operation.

Pioneer's Surround Sound AV Receiver

TIMOTHY B. PALMER-BENSON

The VSX-9300S is one of the most interesting and sophisticated A/V products I've ever come across and in view of what it can do, its $1,200 suggested list price gives you quite a bargain. In a sense, Pioneer is tackling the last frontier in home audio with the VSX-9300S: the rebirth of surround sound in a new and improved format. This unit gives you the very best of this new technology: Dolby Pro-Logic Surround Sound, with adjustable digital delay as well as Simulated and Stadium Sound, a real 125 watts RMS power per channel with low distortion and 30 watts per channel on the rear. With this and a host of other features, the unit has all that most people will ever need when it comes to bringing the theatre into their homes.

There are facilities for connecting and processing video signals from two VCRs, two-way dubbing, a video disc player input, a split-screen video enhancer (for comparing enhancement with the original) and a VCR audio noise filter (see fig.1). The unit can remember five acoustic control environments and comes with a Smart Remote (an infrared control box that can be taught the control codes of other equipment). For those who like to be lulled to sleep, there's even a timer that will turn the power off after 60 or 30 minutes.

Controls

A newcomer to the VSX-9300 is faced with a myriad of controls. Microprocessors offer an inexpensive way of operating a lot of functions and some Japanese designers go overboard with them. Nevertheless, I find that when sensibly used, these controls make consumer equipment much easier to operate and in the case of Pioneer, I take my hat off to the ergonomics of the design. The VSX-9300's station ID display is an example of this. As you preset one of up to 20-stations, you can also assign it a four character ID and store it in the unit's non- volatile memory. This concept is taken still further with what Pioneer calls a "Hyper Intelligent Tuning System" — HITS for short — that lets you scan all the named stations beginning with the four character IDs already

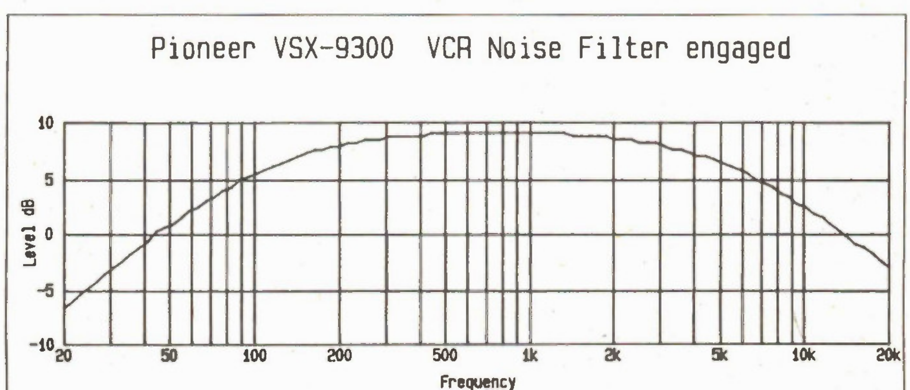


Fig. 1. The Pioneer VSX-9300 with the VCR noise filter engaged.

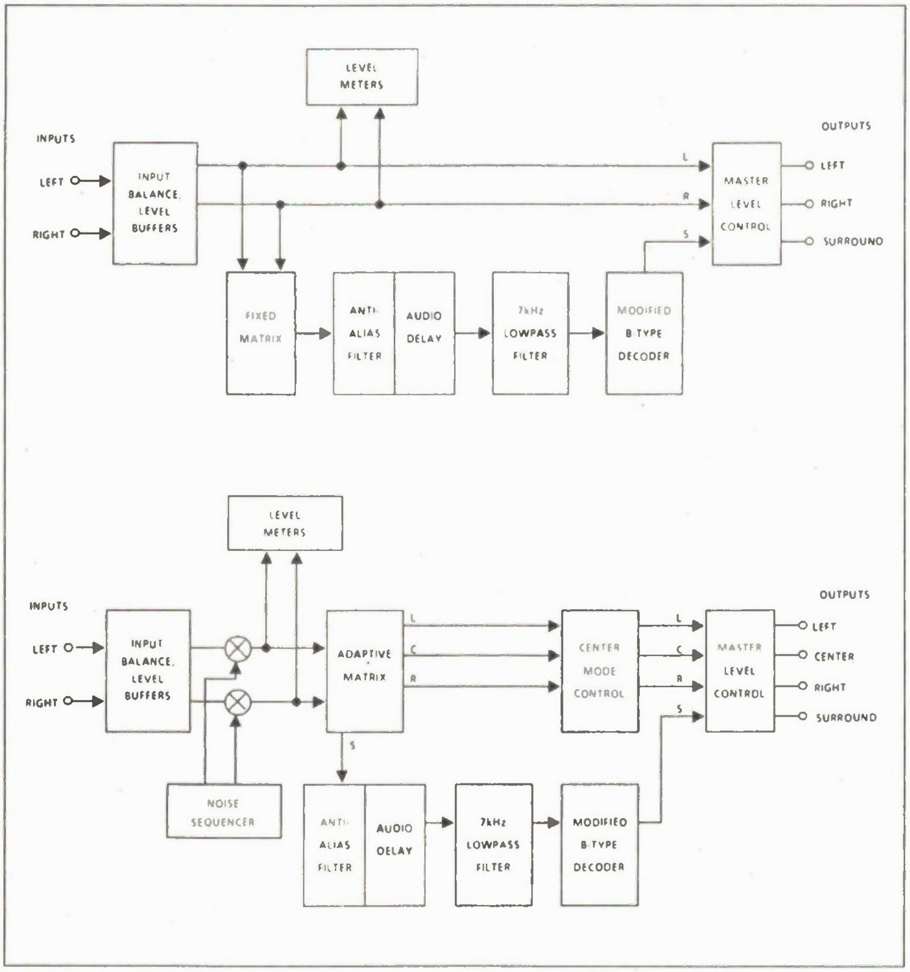


Fig. 2. The Dolby surround decoder block diagram (top) and the Dolby Pro Logic surround decoder block diagram (bottom).

entered.

Decoding

Unquestionably, the VSX-9300's biggest drawing card is the Dolby Pro-Logic Surround Sound circuitry licensed from Dolby Labs. Dolby Pro-Logic decodes motion picture soundtracks in a manner similar to that used in movie theatres equipped with Dolby Stereo. All movies that bear the Dolby Stereo logo, including those available on VHS and Beta tapes, contain surround channels of audio which have been combined into regular two channel stereo using Dolby encoding. An adaptive matrix, part of the Dolby Pro-Logic circuitry, recovers the surround sound information by continually analyzing the two channel stereo information and producing so called "steering vectors" that indicate in which direction the dominate signal was encoded and the relative degree of that dominance. The steering vector is then used to control a variable matrix which feeds each output with an appropriately weighted sum of the two input signals. The procedure results in proper location of sounds in a 360 degree listening environment. An additional benefit is a "steered" centre channel which puts dialogue on the screen. Pro-Logic is said to be especially effective in ensuring that listeners both on and off "axis" benefit from the surround sound effect. Separation is nominally 25dB between left centre and right centre, and 25dB between left, right front and surround. This is a substantial improvement over the passive Dolby surround decoder which gives only 3dB of separation.

All Dolby Surround decoding systems include Dolby B type noise reduction, a time delay for the rear or side speakers and 7kHz bandwidth limiting. The normal delay is 20 milliseconds but with the Pioneer, 15 and 30 millisecond delay is also available (the delay is accomplished via digital circuitry). Delay is used because it helps the ear establish directionality. Bandwidth limiting is used to mask the effect of any phase errors in the encoding and decoding process since high frequency errors are more noticeable.

Note that the block diagram of the Dolby Pro Logic Surround decoder (fig.2) as it appears in the VSX-9300S does not show that the receiver has additional circuitry for Stadium and Simulated surround sound. The "Noise Sequencer" shown in this diagram is used to adjust volume on each channel (this can be done from the listening/viewing position with the remote control). The sequencer generates band-limited noise that is gated alternately to left, centre, right front and surround channels. The noise appears for two seconds in each channel as soon as Pro Logic is engaged and one has selected "Test".

Outputs

Dolby has also included in its licensing agreement with manufacturers a bass splitting function for home use. Dolby surround sound systems in movie theatres use a full frequency range centre channel to help locate dialogue on the screen as well as left and right speakers. In private homes this is not considered so important because the left and right speakers are likely to be closer together, so Dolby includes three additional settings. The normal set-

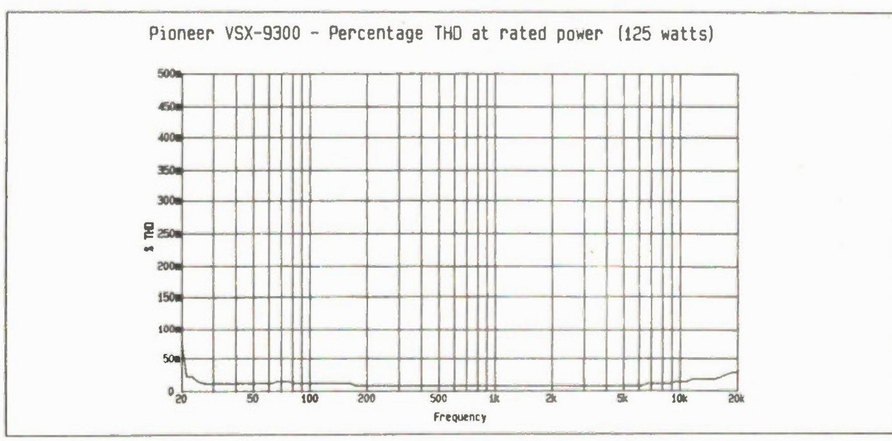


Fig. 3. Percentage of Total Harmonic Distortion at rated power (125W).

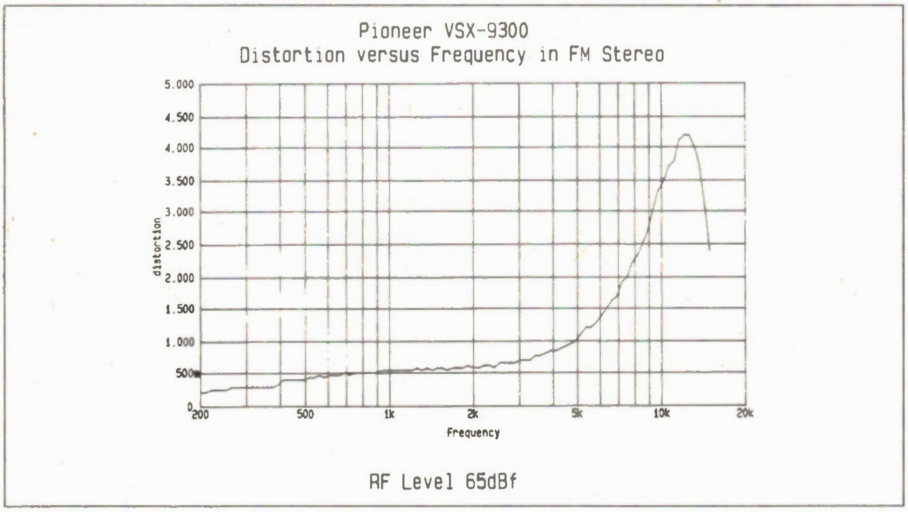


Fig. 4. Distortion versus frequency in FM stereo.

ting separates bass information below 100 Hz and distributes it equally to the left and right channels. What's left, which is anything above 100Hz, is available for a small centre channel amplifier and speaker, such as the ones in a TV set. The wide setting provides full frequency range output to the centre channel. The third setting, or what is referred to as "Phantom", distributes the entire centre channel signal to the front left and right channel speakers.

The VSX-9300S uses a single power supply for both the front and surround channels. There is no centre channel amplification, just a line output that is approximately 4dB higher than the left and right front line outputs.

Specs

I found my unit capable of generating 135 watts of continuous power into two 8 ohm loads in both front channels with no more than 0.03% THD. This signal level was achieved with the volume control wide open and only 158-millivolts applied to the CD input. The receiver is rated at 125 watts per channel with no more than 0.005% THD into 8 ohms; however, I was unable to confirm this extremely low distortion figure (see fig.3). I was pleased to note that the VSX-9300S maintained its rated power output with low distortion even with an AC line voltage of 110 volts. Dynamic headroom as per the IHF standard measured 1.67dB, a little less than claimed.

Signal-to-noise via the CD and VCR inputs, compared to a 500-mv input to achieve a 1-watt output, measured 77dB, A weighted, also somewhat less than specified. I fear my measurement result was caused either by power grounding or by the lack of adequate shielding or grounding of the motorized volume control. At any rate, I detected what appeared to be microprocessor noise leaking into the signal path at medium and high volume levels. Pioneer's own S/N spec is 98dB.

FM performance is acceptable. Some people may be fooled by the fact that the FM tuner section will burst into life with several stations in urban areas without an antenna connected. Unfortunately, this an indication of poor shielding which could affect the tuner's specified 80dB IF interference ratio and which did affect my measurements. Usable sensitivity measured 22dBf in mono (IHF), stereo separation was 36dB at 1kHz, and the S/N for a mono signal was 42dB. THD measured 0.5% in stereo at 1kHz and was substantially higher at 6kHz as can be seen in fig.4. Noise in the phono section was down 65dB. Phono equalization (fig.5) was reasonably accurate with 0.5dB error in the mid bass.

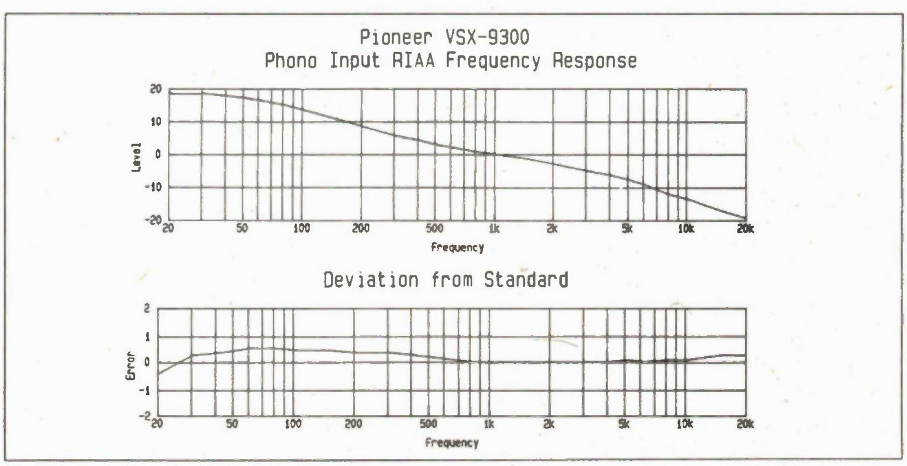


Fig. 5. Phono input RIAA response (top) and deviation from the standard (bottom).

Although some of these measurements don't indicate spectacular performance, one most remember the price of this unit and that it is primarily intended to create a movie theatre in the home. In this area it excels, with impressive separation figures in the Pro-Logic mode. Table 1 shows what this Pro-Logic surround sound receiver can do.

While these figures are impressive, it is the sound field that this unit is capable of producing that impressed me the most. I've heard this unit used with a 50-inch projection TV and a laser disc player as well as with smaller TVs. Believe me, with the right soundtrack, the sound bowls you over. The VSX-9300S has enough power to make the visual and audio experience of a movie like Top Gun truly memorable. In the video realm, I found the video enhancer particularly useful and really appreciated the ability to make copy either from VCR 1 to VCR 2 or viceversa. ■

Table 1. Separation measurements; test signal 1kHz, 400mv.

Fr. Left to Fr. Right 51dB
Fr. Right to Fr. Left 54dB
Fr. Left to Fr. Centre 29dB
Fr. Right to Fr. Centre 31dB
Fr. Left to Left Surround 43dB
Fr. Right to Left Surround 44dB
Fr. Centre to Fr. Left 22dB
Surround to Fr. Left 20dB
Fr. Centre to Fr. Right 37dB
Surround to Fr. Right 38dB
Fr. Centre to Left Surround 47dB
Surround to Right Fr. 38dB
Fr. Centre to Right Surround 47dB
Surround to Centre 32dB

Looking Back

In which a former editor of this publication drags himself to the keyboard and reminisces tearfully about the glorious past, interjecting the odd lie and half truth to keep things interesting.

STEVE RIMMER

It all started in a 10,000 watt radio station. Well, sort of. I recall sitting in the control booth with my feet up on the mixing board and something really obscure rattling in the speakers – Golden Earring or Captain Beefheart or Blue Cheer – one of those bands that made your ears bleed if you went to sleep with headphones on. It was one of those days when you think of what it'll be like in a year from now, playing the same records and wondering the same things.

It occurred to me at this juncture in time that it'd be a good idea to think about getting a proper job. I was staring debt that bordered on indentured servitude square in the face, and only one of us was enjoying the prospect. The allure of radio had long since dissipated.

I was perusing a copy of one of the magazines I wrote freelance stuff for when I noticed that they wanted an editorial assistant. The idea sparked my imagination. It would be interesting to work in a place with a horizontal ceiling. Journalism seemed to be one of those professions which shares with radio a lack of pressing demands on one's wardrobe. It seemed like a regular paycheck without the need to wear a suit.

The record prepared to end. I put a tape on and tried to decide how many lies I could tell on a resume without its being obvious.

Within a week I was trying to figure out how to get a Consumer's Distributing desk on top of the boss's station wagon so I could have a real flat space to work at as assistant editor for ETI. Things were unquestionably looking up.

International Blue Velvet

Electronics Today International, as it was called at the time, was a very different sort of magazine when I started working for it. The company was a lot smaller, for one thing. I think there were about eight people there when I showed up. With the exception of Halvor Moorshead, who actually started the company and owns the whole party, I'm the last one of that crowd still to be associated with the company it has become.

The company had just finished its first expansion when I arrived, propitiously, two days after all the moving had been completed and the heavy lifting was over with. The new offices were spacious, with everyone having a desk and a room to put it in. Within the year they'd be cramped again, and within a year after that the company was to become split over two buildings. Things were growing.

The former assistant editor of Electronics Today, John Van Lierde, was leaving to go back to school. I was to spend three months as the editorial assistant on the magazine, and then step up to his job.

Working for a small publishing company is rarely boring. Halvor liked to say that a lot. Because the company couldn't afford to have all sorts of specialized people on staff, the assistant editor was expected to be quite a few of them. This included handling things like photography, writing, designing projects, lifting boxes of magazines and building trade show booths.

One of the perennial problems at the time, one which has not really gone away to this day, was figuring out what to stick on the covers. Occasionally this would work itself out because something in the magazine would engender an obvious stock photograph. Most of the time, though, we had to take the pictures ourselves. We had this camera, sort of, an aging Bronica which had more loose pieces than tight ones. It tended to come springing apart at odd times, occasionally launching bits of itself into space when you attempted to wind the film on. Some of the unusual cropping that showed up on the ETI covers of the day were not so much inspired photography as compensation for light leaks.

One of the more original covers had to do with soldering. The idea was to have a soldering iron that seemed to be burning through the cover, exposing the first few pages beneath. The effect was coming along nicely when the cover it was burning through caught fire before the camera.

When I arrived at ETI, the magazine was being typeset on an IBM composer, which is a sort of glorified Selectric typewriter. Shortly after this, we acquired a Compugraphic EditWriter, a *real* typesetting machine. It actually had memory, about eight kilobytes of it, and a monitor rather than a roll of paper. It was so... post-Victorian.

Still a year or two from actually having a working word processor of my own, I used to stay late just to be able to write on the Compugraphic rather than using an electric typewriter. The thought of doing anything meaningful on it is frightening now, but at the time it was so unspeakably high tech.

About eleven minutes after the warranty on the Compugraphic expired, it did too. Service men came and service men went, but the Compugraphic remained obdurate. It worked about half the time, and emitted long strips of uniformly black galley film for the other half. It was over a month before we realized what the problem was. Cindy, the girl who actually set the type, had a fetching smile and equally fetching curves. The service men showed up but they just stood there, transfixed, and never got anything done. Cindy thought it was the funniest thing she'd seen in ages.

After a long time Compugraphic admitted that they couldn't fix the machine. Halvor and I took turns sitting in the typesetting room with an oscilloscope, a pile of schematics which turned out to be for the wrong machine and a desoldering bulb. After a long time we managed to replace most of the bad memory in the thing, and it limped reluctantly into the future. Halvor promised me that one day we would take the Compugraphic out into the parking lot and blow it to hell. This thought sustained me in my darker days.

The most popular project of the entire time I was working there was the amazing 400 watt amplifier. It used a whole bucketful of output transistors, a power transformer that came with its own pickup truck and a heatsink which caused a modest aluminum shortage every time someone tried to build one, but it certainly could pump out 400 watts. There were three or four places around town selling kits for the things, and they could barely keep all the parts in stock.

A lot of souls built these things who shouldn't have. People would try them out with ten watt car speakers and discover, amidst a lot of burning paper and smoking alnico five, that a four hundred watt amplifier can put out better than ten watts of hum and background noise if you aren't careful. My favourite four hundred watt amplifier tale is about a fellow who called and wanted to know if he could build two and bridge them to get one and a bit kilowatts out of them. Headphones of the gods, to be sure.

Flasks and Beakers

A part of ETI was scientific, rather than electronic. In months wherein nothing much was happening electronically, the purely scientific bits sort of swelled up and overwhelmed the magazine. One of the most notable of these was the dreaded Shroud of Turin issue. It wasn't really planned that way, but the other features in the magazine were solid, workable and not really cover material. There was, however, this really interesting bit about the shroud that was supposed to have been using to bury Christ in.

The problem with the shroud article was that if it had been just a bit longer it could have been a book. Not knowing a whole lot about the shroud, and, as such, not knowing what could be edited out of the thing, I was at a bit of a loss over how to reduce the thing beyond simply removing its voluminous padding. As such, it ran a little long.

About two month ago, someone actually got to carbon date the ol' shroud. It turns out, after all the fuss that's been devoted to it, to have been a medieval fake. Nice try, though.

People liked to think of ETI as having a monstrous project laboratory with at least a dozen lab coated technicians running around spouting differential calculus at anyone who would listen. This wasn't exactly the case. When John Van Lierde left and I moved up a notch, there was this free desk in my office. It became the project lab. Prior to this, I think the project lab had been the kitchen table in John's apartment.

We were a bit shy of equipment, too. Most of it was mine. The oscilloscope used only the best 1950s vintage vacuum tubes, and I rarely attempted to design anything which required looking at non-sinusoidal waveforms much above twenty kilohertz during this period; the limited frequency response of this aging box tended to make everything above the audio spectrum into sine waves, and damned small ones at that. By comparison, the signal generator could only do unclipped sine waves above about five kilohertz, and then only if it was lying on its side. I had a capacitor meter which always said that the capacitors it was testing had shorted, which it turned out they always had, as it was putting about three hundred volts across them.

Despite these little traumas, we did some pretty decent projects. I now have a 60MHz dual trace scope, a working capacitor meter, and the same signal generator, actually... I keep meaning to get a new one. However, it's amazing how little fabulous test equipment really affects what you do. Electronics is very much more ingenuity and very much less expensive tools than most people would imagine.

When I started working there, ETI was being pasted up by a lone artist, Sarah Jane Newman. She worked faster than the human eye could follow. One day Halvor stuck his finger on something she was slicing away at and she very nearly removed it. She maintained that he bled non-repro blue.

While we had an intercom of sorts, Sarah never liked it very much. She communicated with typesetting by shouting. The place had an echo. She had a fairly thick accent. The typesetting machine had a pretty loud fan. Communication was not always what it might have been.

The summer after I started, Halvor decided that the company required a second production artist, and he elected to import one. He'd known a fellow named Terry Fletcher back in Britain, and he paid to have him move over here and come to work for ETI. Terry was... unique. The magazine quickly became riddled with little cartoon characters he liked to draw. The schematics he rendered started to sport baroque looking curls and ogives. He liked to shout at Cindy too. Cindy liked to throw things at Terry. That end of the building was a little dangerous close to press day.

Terry and his family moved into a sort of monstrous old house with a five degree list to starboard down near the lake. After a winter of trying to make sense of it, they decided that it would be an asset to have a housekeeper. They sent for the daughter of a neighbour of theirs back in Britain, who came to spend the summer. I recall being told that she was a really nice girl from a good family, and that it would be appreciated by all concerned if I could stay away from her so they wouldn't have to explain to her parents why she was returning in greater numbers than she arrived.

We got married about a year after that. I haven't seen Terry in a long time, but I doubt he's wholly forgiven me. I'm fairly certain Meg's parents haven't forgiven him.

Big Bang

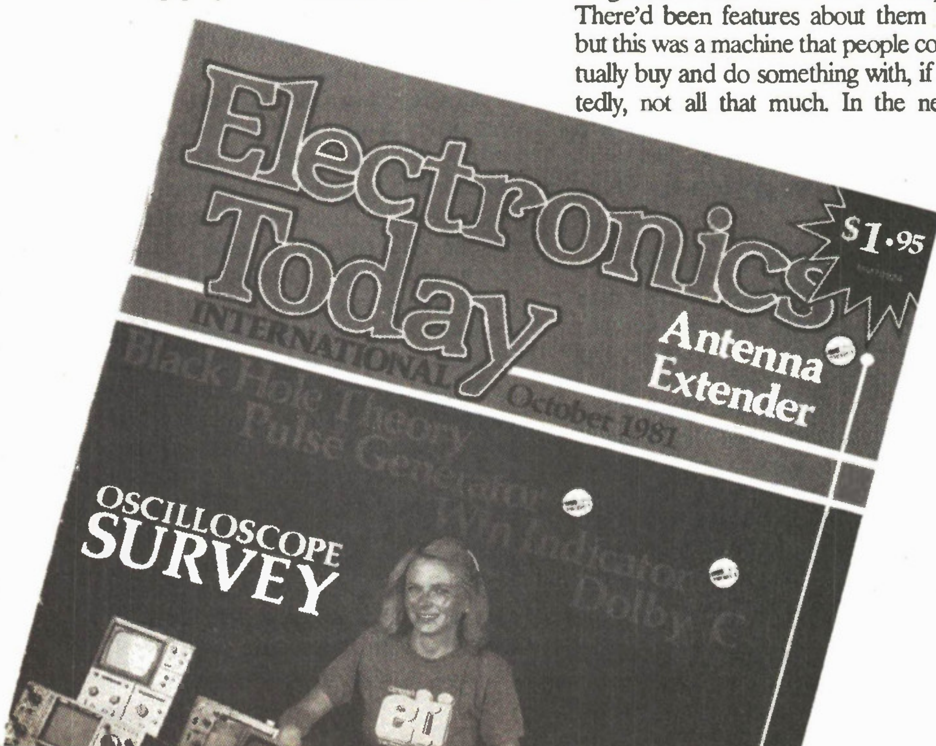
Testing projects continued to be a challenge. Halvor arranged for us to get a better scope, which was like something handed down from on high. As the Compugraphic was not ready for detonation at the time, I dropped a brick through the cathode ray tube of the old scope as a substitute. More than satisfying, this.

Great projects are not simply handed to you. It's more of an affliction. Take the amazing movement alarm project. It was a 110 decibel horn in a plastic box with a trembler switch. If you tried to move the box, the horn went off. In order to reset it... well, that was a problem. The trembler was a little sensitive in the early prototype. In fact, just pushing the reset button was enough to set it off. It became obvious that the box had to be dismantled and the batteries removed before everyone went deaf. Suddenly, without any warning, an alien space craft appeared overhead and beamed up all the Phillips screwdrivers... at least, that was my explanation. The horn blared on.

Fortunately, you can't run a 110 decibel horn from a nine volt battery for very long, and it petered out after a while. The lawyer down the hall inexplicably moved to larger quarters a while after that.

One day someone from Commodore called. I'd thought they made office furniture and calculators, but they had this computer and they asked if we were interested in having a look at it. I had nothing going at the time, so I agreed to write it up for the next issue. The next edition of ETI sold as few magazines every did before or will again.

This was really the beginning of the magazine's interest in microcomputers. There'd been features about them before, but this was a machine that people could actually buy and do something with, if admittedly, not all that much. In the next few months we ran more computer reviews, all received with similar acclamation. Within the year, Halvor had asked me to pass the assistant editor's position for ETI over to someone else and start something called Computing Now.



One of my last functions for ETI was to hire my replacement. Halvor suggested that if I put an ad in the paper I'd probably get about a zillion calls and, for this reason, it would be handy to dream up six simple questions to weed out the people who knew nothing about electronics. The six questions went something like this.

1. What's the value of a resistor with the colours yellow, purple, yellow on it?

2. If you have a transformer with a thousand windings in the primary and ten thousand windings in the secondary, how many volts will come out of it if you put ten volts in?

3. What does AM stand for when used in conjunction with radio reception?

4. Roughly how many ohms of DC resistance would you expect to see across an eight ohm speaker coil?

5. If you have identified the base and the emitter of a transistor, what leads are left?

6. What is the end of a silicon diode with a stripe around it usually called?

We decided initially that we wouldn't consider anyone who couldn't get all these right. Three days into the hiring, when no one had even come close, we decided that we'd at least interview anyone who could manage four of the six – as soon as someone called who could do this. Toward the end, we were down to giving serious consideration to anyone who could get the resistor question and make an intelligent guess at any of the others.

Then one guy called and breezed through the whole works. Bill Markwick came to work as editor of ETI, and, through several magazine name changes and shifts of locale, is still at it.

Closing the Book

There are a lot of people and incidents from this period that I haven't mentioned. I could cite a lack of space, but, in truth, few of them would be interesting out of context. You had to be there.

There's nothing like the inspired chaos of working for a small, dynamic publishing company. If the editions of ETI which we produced during that time lacked polish in a few places, they were unquestionably never dull. Like the job of editing them and making them come to pass, they were always rushing off and doing something different. ■

MARKET PLACE

Versatile Alarm Circuit

A simple but comprehensive home burglar alarm.

PAUL CHAPPELL

Here's a burglar alarm that can use keyswitches, the usual continuity loop, and an anti-tamper loop. Figure 1 shows the component overlay for the project and Fig. 2a shows the circuit.

Figure 3 shows how to build the completed circuit into a suitable box — a die-cast aluminum box is a good choice — and how to connect up the power supply and relay. The PCB can be held in place with double-sided adhesive pads or tape, or you can drill a hole in the board and use a nut, bolt and spacer. A single bolt will be quite enough — there's nothing heavy on the board. The relay can lie on its back, glued in place, with the contacts facing upwards. The smoothing capacitor C7 can be fixed with a double-sided adhesive pad or with a capacitor clip.

The transformer show has two secondary windings; if you're using a 12V centre-tapped type, you can just tape the centre-tap wire out of the way. For the rectifiers D4-D7 you can either use individual 1N4000-series devices or an encapsulated bridge rectifier — whatever you've got in your parts box.

The very first switch in the anti-tamper loop is a microswitch to protect the control box itself. If anybody removes the lid, the switch will open and sound the alarm. This is one of the many ways the alarm protects itself. The anti-tamper loop prevents any interference with the wiring. Cutting the alarm wires will sound the bell, removing the plug or cutting the power cord will activate the alarm — and it still finds time to protect all the doors and windows in your house, to check up on pressure mats and infrared sensors, and to do all the other things a burglar alarm should.

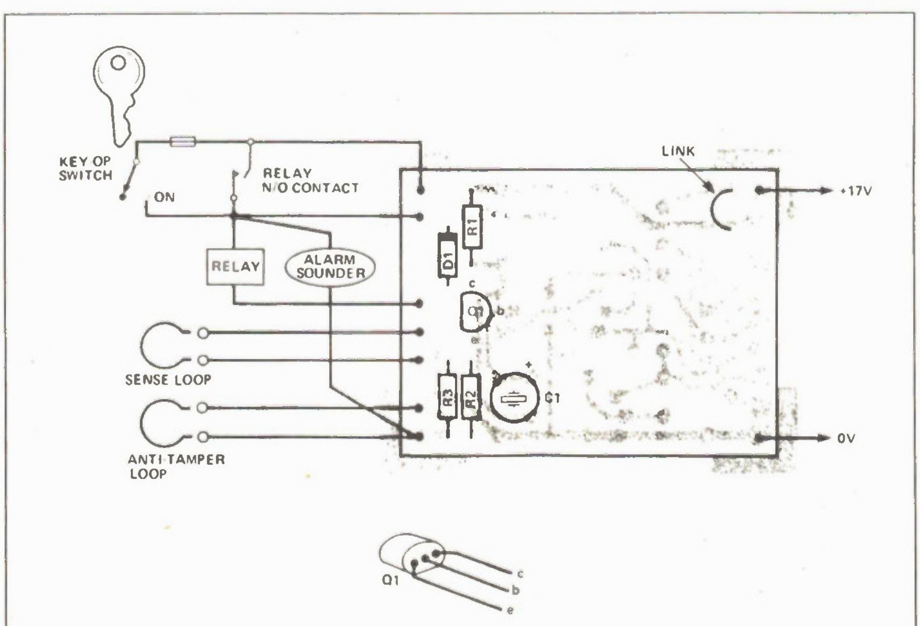


Fig. 1 Component overlay for the free Burglar Buster PCB.

Entry And Exit Delay

With so many features, it's hard to imagine what could be added to the basic alarm to fill up the rest of the PCB. But there is one feature you'll find on almost all commercial alarm controllers that the circuit so far doesn't have: entry and exit delay.

With the basic alarm system, the key operated switch to turn the circuit on and off

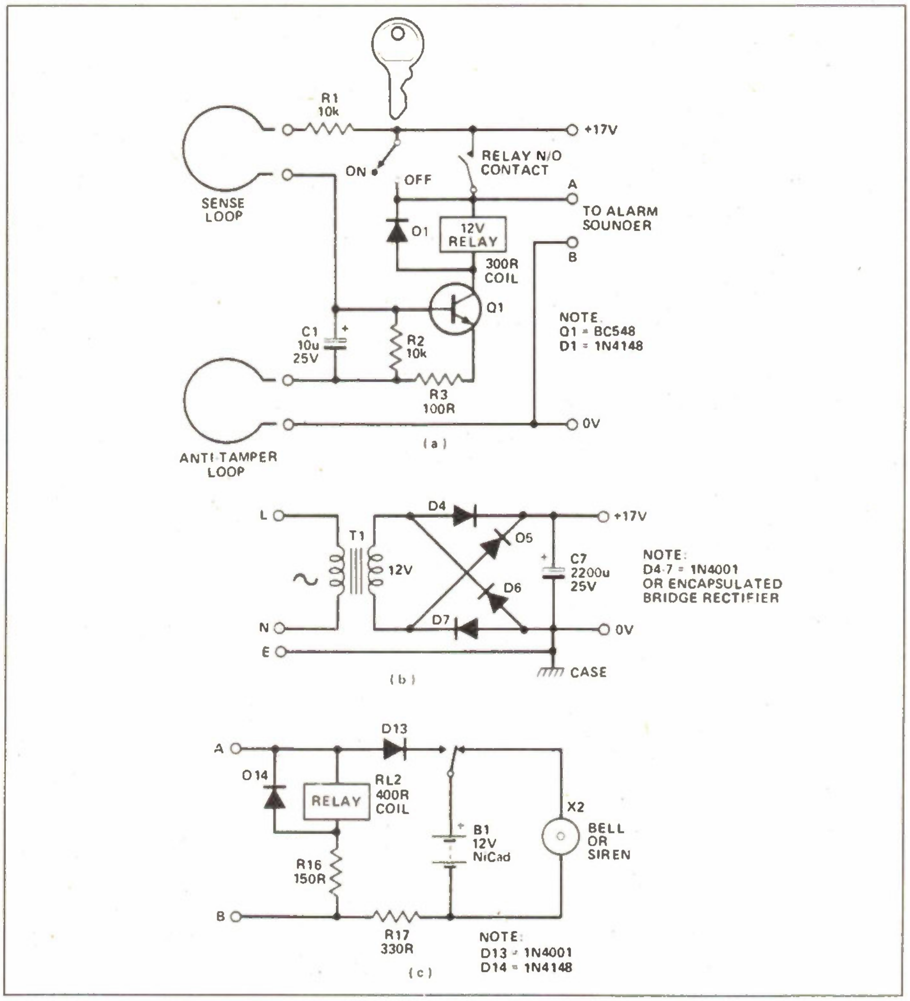


Fig. 2 The circuit diagram of the Burglar Buster (a) The main control box. (b) A suitable power supply (c) A simple alarm sounder.

must be outside the house. When you leave, you turn on the alarm from outside. When you return, you turn it back off again before entering the house. The key-op switch being outside the protection of the alarm system, is a point where the circuit can be attacked.

With entry and exit delay, the idea is to wire the front door in a separate loop to all the other doors and windows. When you turn on the alarm, the main loop is activated at once but the front door contact remains inactive for, say, thirty seconds. This gives you time to get out of the house and, as long as the door is closed within the delay period, the alarm won't ring. This time there's nothing outside the house to be interfered with so the alarm system is much safer.

When you return home, there's another delay to give you time to get back in but now it's not enough just to shut the front door — a burglar could manage that easily enough. The only thing that will stop the alarm from being activated is if it's turned off with the key within the thirty seconds.

The circuit is shown in Fig. 4a. When you turn on the alarm, power is applied to the board, and C4, which will have no voltage across it initially, begins to charge via R6 Q5 and Q4. Transistor Q4 is held on by the charging current and in turn holds on Q3.

If the front door is closed it will prevent C2 from charging. If the front door is open, C2 will charge via R1 and Q2 and after about thirty seconds the current in the main loop will no longer hold Q1 in conduction so that the alarm will sound. Closing the front door during this period will discharge C2 via D2 and the loop will derive its current from Q3 and Q4.

In the meantime C4 is still charging. After about forty seconds the current falls below the value needed to maintain Q4's b-e voltage across R5 and at the same time provide current for Q4. At this point the charging continues via R5 but Q4 now relies on Q3 for its base current. Transistor Q3 is quite happy to provide the base current as long as nobody opens the front door. As soon as this happens, Q3 and Q4 both drop out and since Q5 is no longer supplying them with any priming current they won't switch on again even if the door is closed. Now the only way to stop the alarm from ringing after C2's charge period is to use the key. Otherwise the circuit ticks on remorselessly.

The power supply and relay circuit for this version of the alarm is shown in

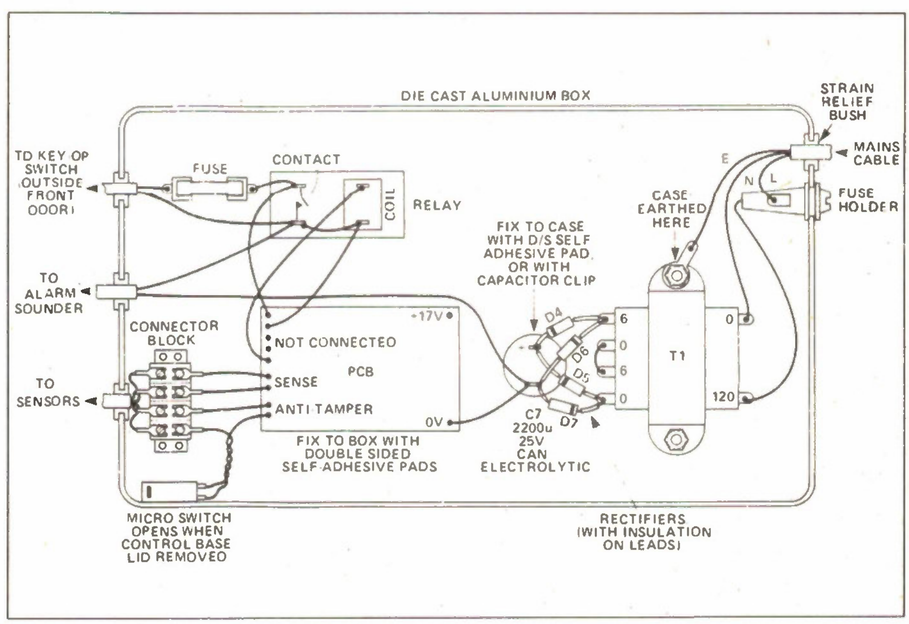


Fig. 3 Installation and off-board wiring.

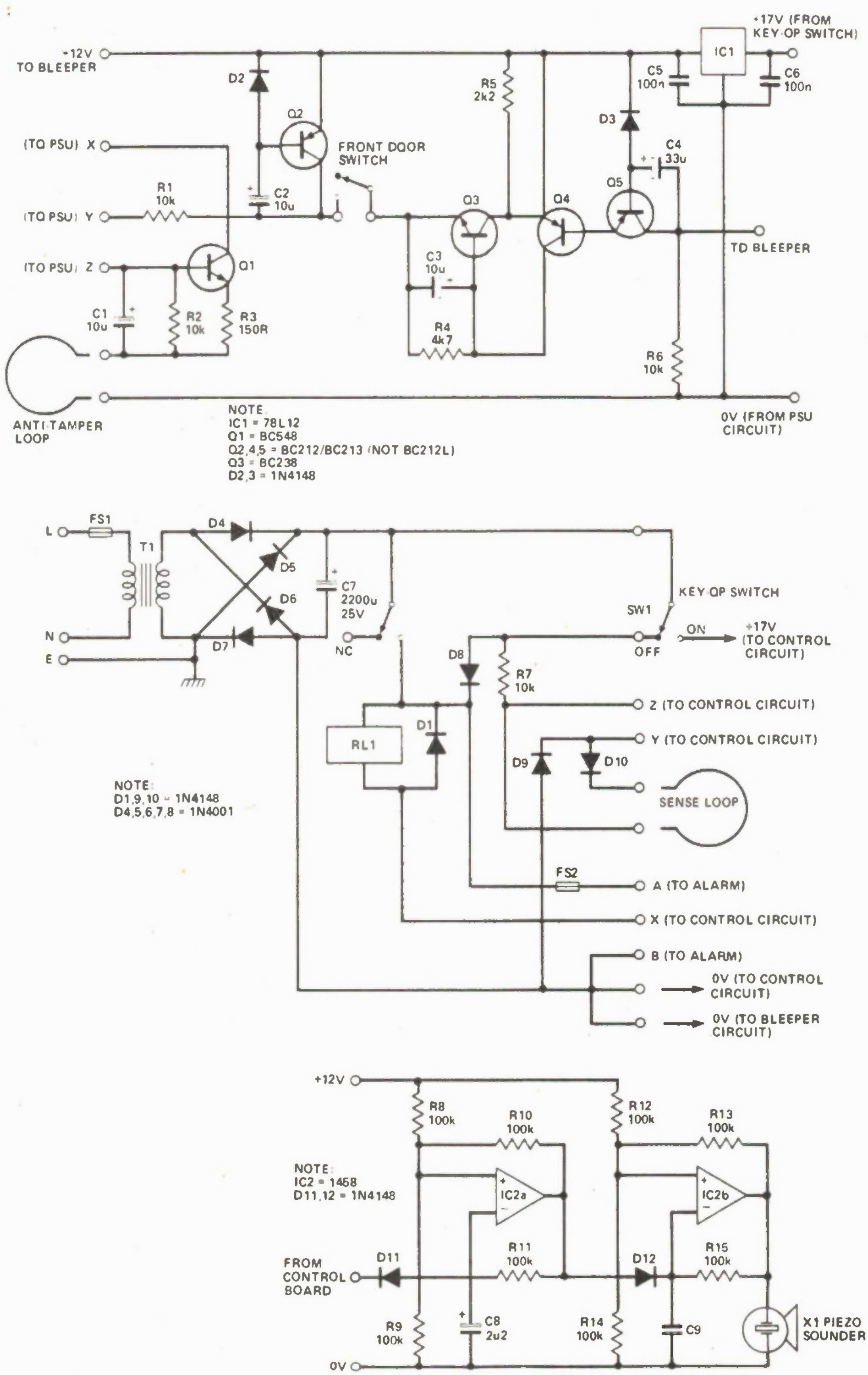


Fig. 4 (a) The expanded control circuit. (b) The expanded PSU and relay circuit. (c) A warning circuit for timed entry and exit.

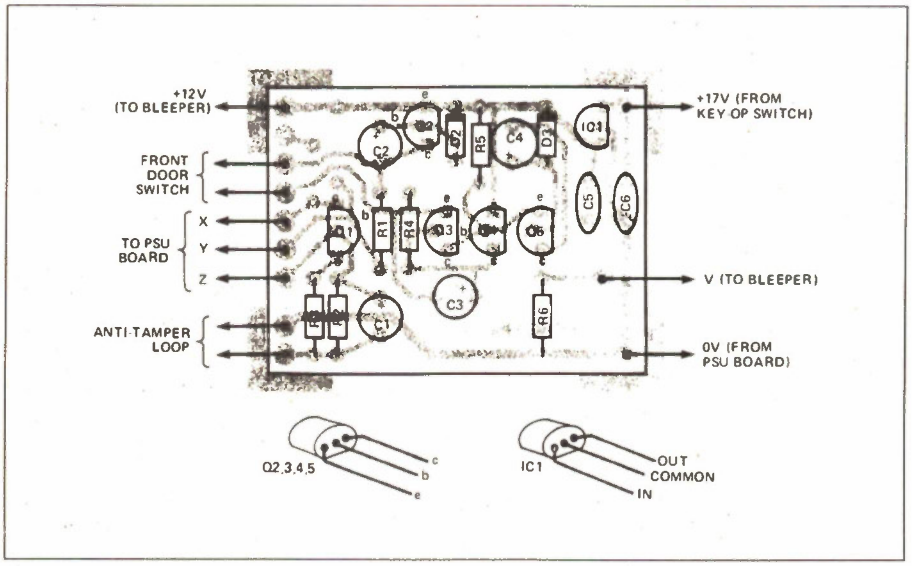


Fig. 5 Component overlay for the expanded alarm controller.

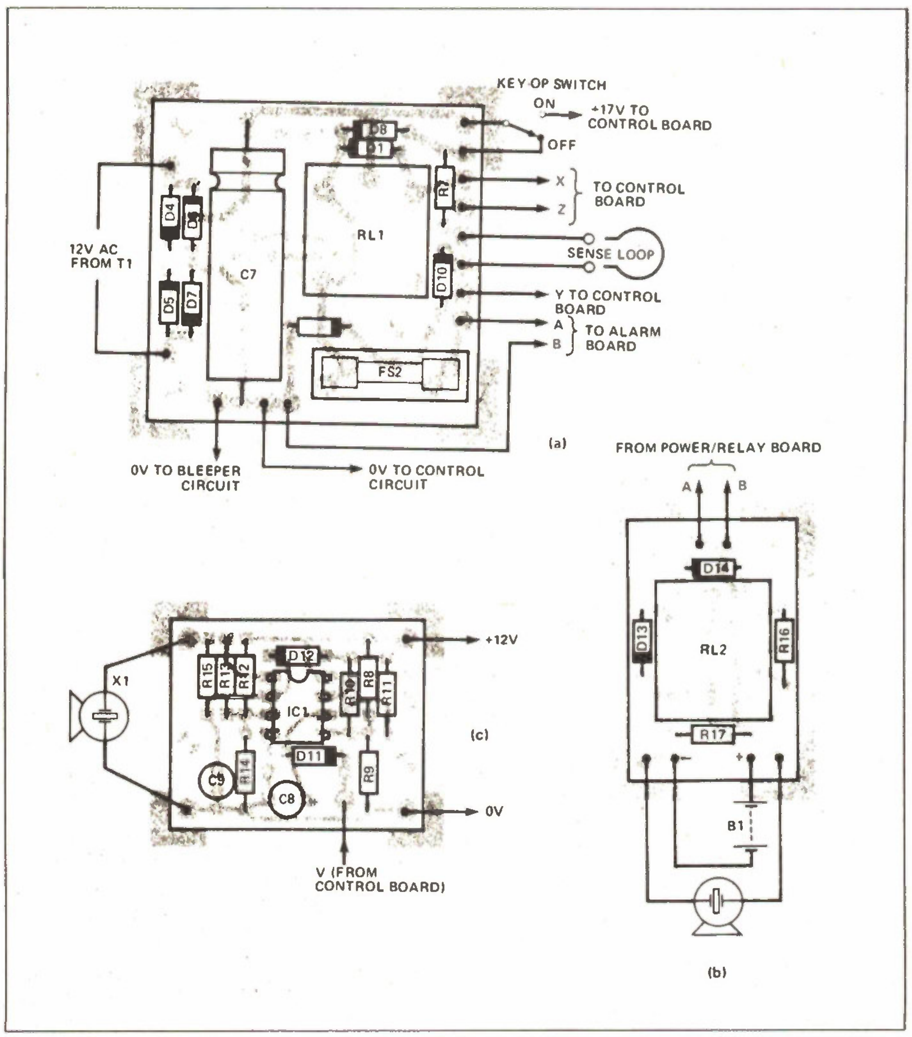


Fig. 6 Component overlays for the expanded Burglar Buster. (a) The power and relay board. (b) The bleeper board. (c) The alarm board.

PARTS LIST

Resistors

(all 1/4W 5%)
R1, 2, 6, 7 10k
R3 100R (150)
R4 4k7
R5 2k2
R8-15 100k
R16 150R
R17 330R

Capacitors

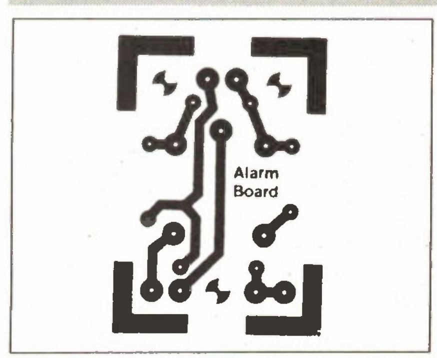
C1, 2,3 10u elect
C4 33u elect
C5, 6 100n
C7 2200u elect
C8 2u2 elect (or tant)
C9 4n7

Semiconductors

IC1 78L12
IC2 1458
Q1,3 2N3904
Q2, 4, 5 2N3906
D1-3, 9-12, 14 1N4148
D4-8, 13 1N4001

Miscellaneous

RL1, 2 Relays, 12V 300-400R coil
X1 Piezo sounder
X2 12V siren or bell
T1 transformer, 6VA, 12V secondary
FS1 250mA slow-blow fuse
FS2 250mA fast-blow fuse
SW1 key operated switch
B1 12V or 2 x 6V NiCad battery
Case for control unit, case for sounder unit, panel fuse holder. Fuse clips, connector block, micro switch, strain relief bushes, hardware for mounting transformer and PCBs. Power cable. Connecting wire, door switches, window foils and other accessories to suit your installation.



The alarm board PCB.

Fig. 4b. Diode D1 is now mounted on the PSU board to reduce the number of interconnections between the two PCBs. The timing circuit are reset when the key-op switch removes power from the control board. Capacitor C3 discharges through R6 and D3 (in much less than forty seconds since Q5 is no longer in action to multiply up the timing period) and C2 discharges via D2 on the control board and D9 on the PSU board. Components R7 and D10 allow Q1 to work independently of the rest of the circuit – you can change the off position on the switch to a 'standby' function by leaving out D8 so that any interference with the anti-tamper loop will still trigger the alarm when the main loop is disabled.

Figure 4c shows a useful addition to the alarm. It's quite unnerving to turn the circuit on and know that at any moment the alarm might sound, without knowing quite when. The bleeper of Fig. 4c begins to sound as soon as the alarm is turned on. When it stops sounding, you've got about ten seconds left before the alarm deafens you.

The alarm sounder itself is shown in Fig. 2c. This circuit (for use with the basic or expanded versions of the alarm) is built into its own box and mounted so that it can be heard from outside the house. If you put the circuit itself outside, remember to use a weatherproof box. Spraying the circuit with a protective waterproofing compound wouldn't hurt, either.

Component overlays for all these circuits are shown in Figs 5 and 6. None of the circuit boards should give you the slightest trouble. If you are 'expanding' the basic version of the control board, note that R1 is soldered in a different position and that R16 is now 150R to suit the specified relay. Apart from that, try to bend the component leads carefully and not too close to the body (the component's body, not yours.), remember to melt the solder over the joint and not over the iron, don't cook the transistors and IC for too long and everything should be fine.

Once you've assembled all the boards you'll want to connect them all together and build them into some sort of box. Figure 7 shows the way to do it. The best place for the bleeper board is on the back of the piezo sounder – use double-sided tape to hold it in place. The alarm board and the power and relay board both have relays on – double-sided tape might not be quite strong enough to hold them, so both have screw holes. Apart from that Fig. 7 more or less explains itself.

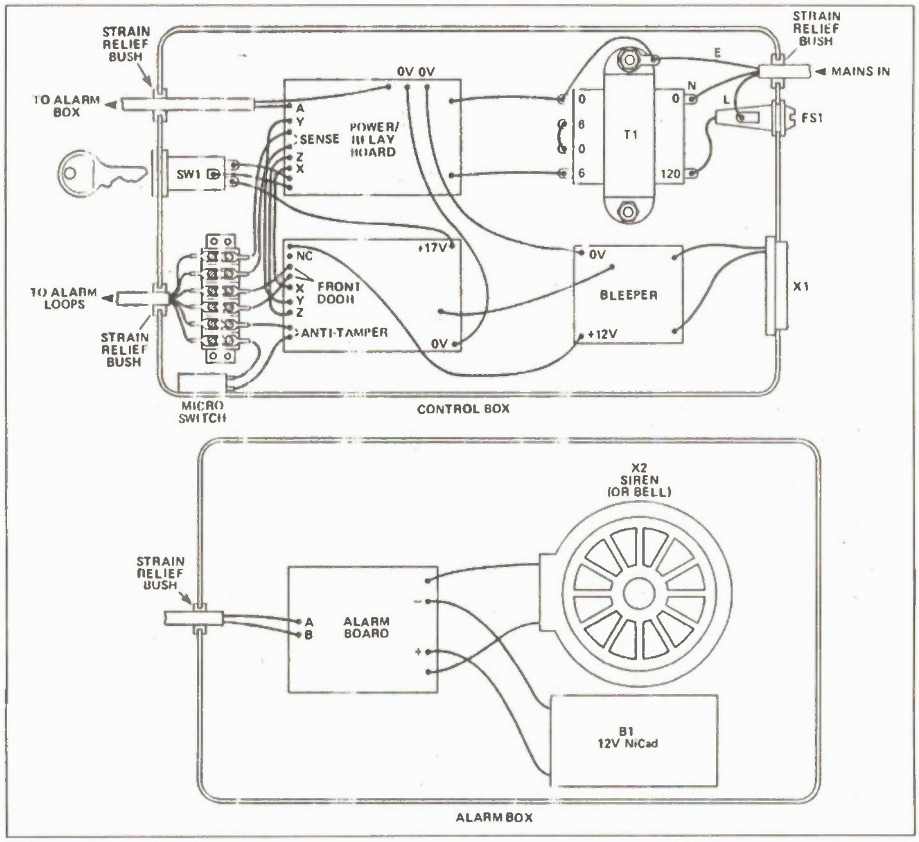
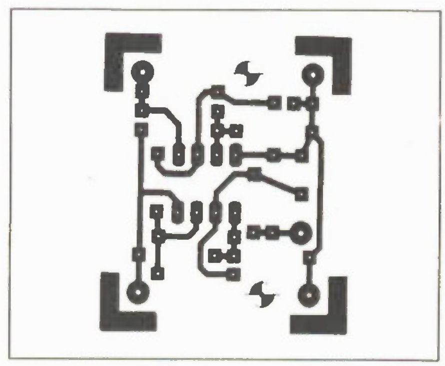
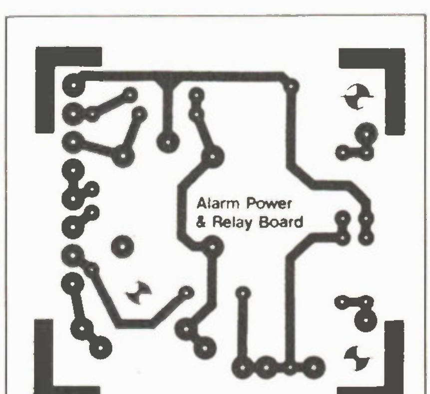


Fig. 7 Installation and off-board wiring of (a) the alarm control box and (b) the alarm sounder box.

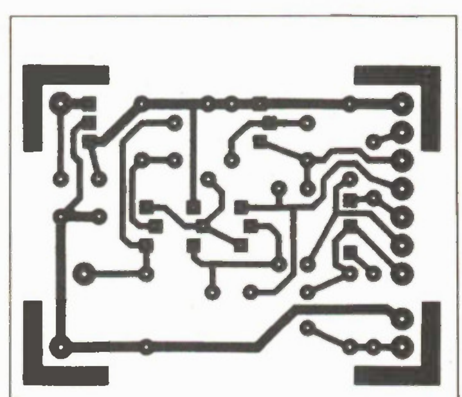
Once the alarm has been assembled, the sense and anti-tamper loops are connected as described last month. Just about any commercial alarm equipment can be used with the project – window tapes, door switches, pressure mats, body heat sensors, infrared beams and so on. For a low cost alarm system, wiring up the doors and windows will give most of the protection you could ever need, with perhaps a few pressure mats to give a surprise to anyone who might be clever enough to penetrate the external defences. ■



The alarm bleeper PCB.



The alarm power and relay PCB.



The main PCB, foil side.

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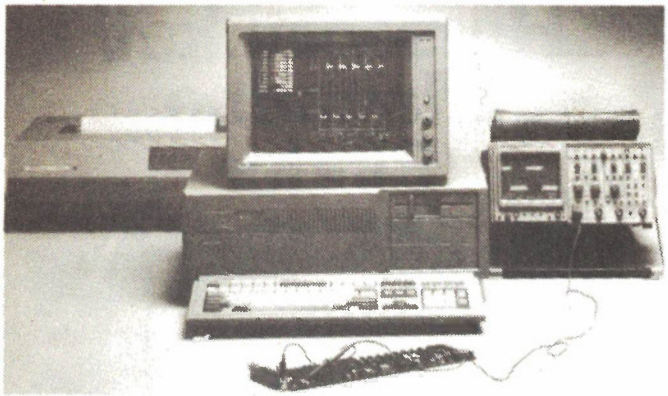

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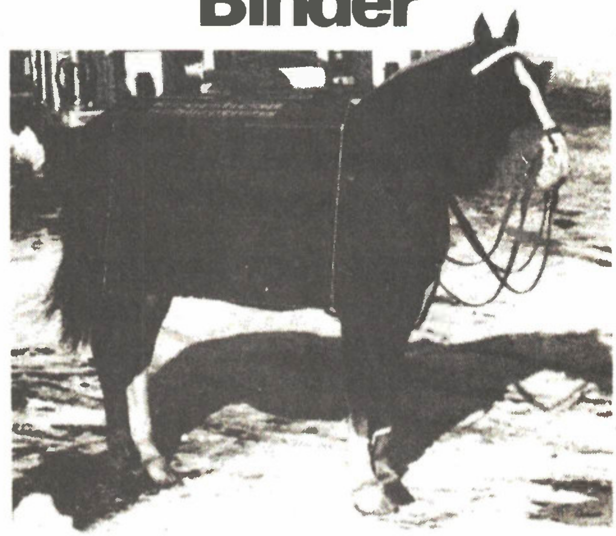

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How Stepping Motors Work

Precise control of rotating shafts is possible with these unique motors.

DR. H. VIRANI

Electric step motors are ideally suited for driving the lead screws of numerically controlled machines. The quantized stepping motion is readily specified in digital form; hence the motors are simply controlled by computers.

A typical positioning system comprises a lead screw or rack and pinion driven by an electric motor. The expense of a DC motor, together with its associated position measuring system and controller, has caused many manufacturers to adopt step motor drives. These drives allow simple control and can give reliable adjustment-free operation in a properly designed system. However, it is worth noting that at least one major computer manufacturer has switched from step motors to DC motors because of "mechanical adjustment problems". When the position is determined numerically, it is quantized. The quantization error is usually (but not always) set to be less than the backlash and pitch errors in the mechanical system. For an electric step motor, the position quantum is typically one step, although this may be less if micro-stepping is used. Step sizes typically range from 0.36 to 30 degrees (1000 to 12 steps per revolution) but may be as small as 0.0014 degrees in microstepping applications.

In a numerically controlled machine, the position is determined by a computer and the position quantum is normally set equal to the movement produced by a single motor step. This provides a direct correspondence between the positioning system and the position number within the computer. Thus it is possible to implement a very simple position control system by using a micro computer and a step motor. Such a system is shown in Fig. 1, for a three phase reluctance step motor.

In the next section, the various types of step motors are briefly described. This is followed by a brief outline of the types of electronic drive circuits used for step motors.

Step Motors

There are three types of electric step motors: the variable reluctance (VR) step motor, the permanent magnet (PM) step motor, and the hybrid step motor. These are described in order. A VR step motor is shown schematically in Fig. 2.

It operates by attracting the nearest pair of rotor lugs to the stator pole pair which is magnetized. The rotor moves so as to align the lugs with the active pole pair. Further active phase (which supplied the current to the active coil) is turned off and the next phase is activated. The new active phase establishes a new magnetic field displaced from the original field and the rotor moves to realign its salient poles with the new stator field. The process continues as further steps are taken.

The VR step motor will operate with phase currents in either direction. Thus a minimum of three phase is required to establish reliable rotation characteristics. The three phases may supply three sets of coil wound on a single laminated stack as shown in Fig. 2. This configuration is known as a single stack VR step motor and it is commonly used in small low cost motors.

Alternatively, each phase may be wound on its own stack of laminations which is keyed into a housing. Up to seven stacks can be keyed into the housing at appropriate angles. This would be known as a seven stack VR step motor. Multistack VR motors typically use a common rotor. The mutual coupling between phase of a multistack VR motor is much less than for a single stack VR step motor.

The PM step motor has a cylindrical rotor which has alternating north and south permanent magnetic poles distributed around the circumference of the rotor. At least two phases are attached to the stator coils with the same number of magnetic pole pairs on the stator. The magnetization of these stator poles can be

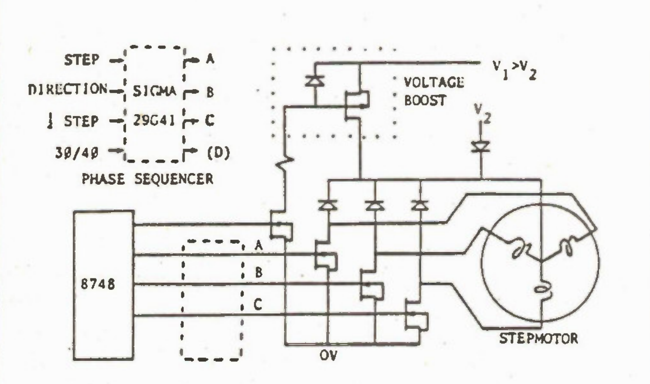

Fig. 1.

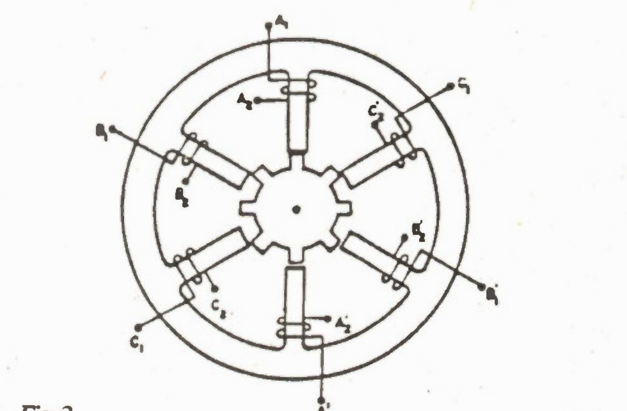

Fig. 2.

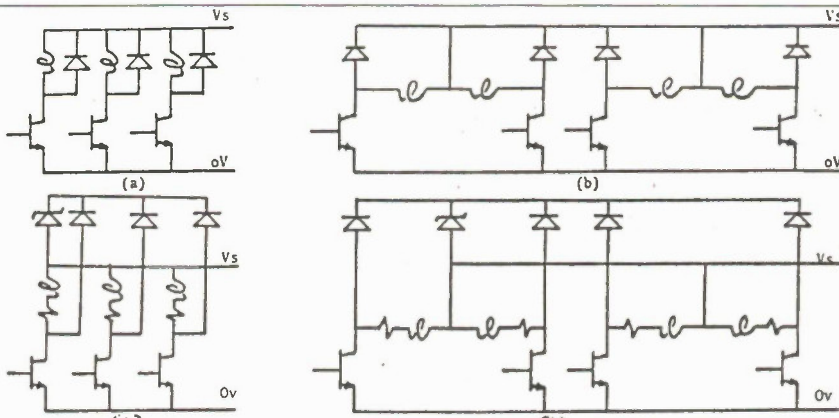

Fig. 3a and b (top) Simple switched drives for VR (left) and hybrid or PM motors (left).
Fig. 4a and b (bottom) Drives for bifilar-wound motors.

moved one step by reversing the current in one phase. The rotor then moves by one step to realign its magnetic poles with the opposite magnetic poles on the stator. The permanent magnets on the rotor generate a large back emf at high step rates. This precludes the simple switched drive circuit in high speed positioning systems.

Some PM step motor systems include velocity feedback coils and are quite suitable for microstepping applications. The hybrid step motor combines features of both VR and step motors.

A pair of offset salient rotors are on the same shaft. The rotors are separated by an axially aligned permanent magnet; the drive schematic for such a bifilar-wound step motor is shown in Fig. 3b.

Drive Circuits

A simple switch unipole drive for variable reluctance motors is shown in Fig. 3a, and a drive for bifilar wound PM or hybrid motors is shown in Fig. 3b. These simple drives could use either micro switches or transistor switches and are adequate for low speed positioning. Note the use of clamp diodes to carry the free wheeling coil current and to limit the voltage of the switching device during switch off. However, torque fails rapidly as the speed increases because of the time taken to establish the full phase current in a coil.

At high speeds, the full phase current is not attained, so the magnetic field and hence the torque is reduced. The phase current increases

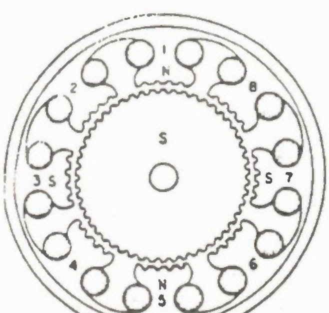

Fig. 5. The Vernier stepping motor has a large number of poles for up to 500 steps/rev.

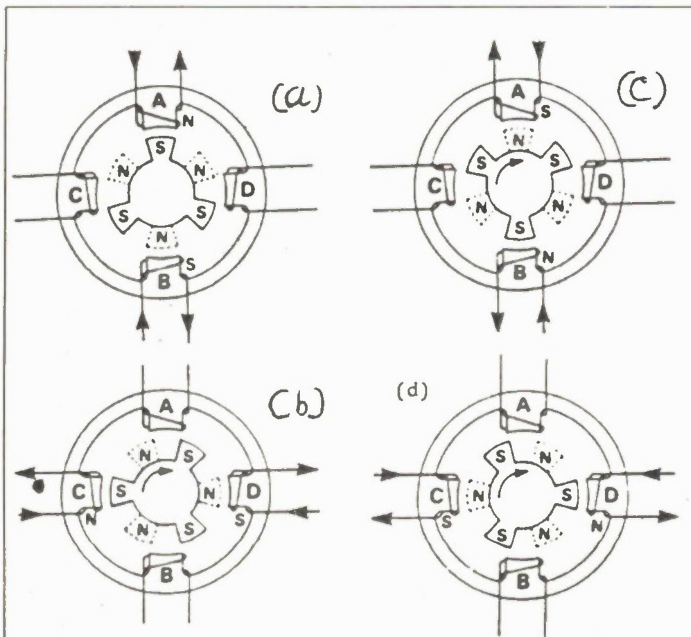

Fig. 6. Operation of the Vernier motor.

from zero and exponentially approaches the rated value. The time constant for the exponential rise is L/R where L is the inductance of the coils attached to the phase and R is the total phase resistance. For the simple drive circuits shown in Fig. 3, R is the resistance of the coils. The current risetime constant can be reduced by increasing the phase resistance as shown in Fig. 4a and 4b.

The supply voltage is increased so that the same maximum phase current is attained. There is another current reducing effect present in PM and hybrid motors at higher speeds. The permanent magnets on the rotor generate a back EMF which increases with speed. This decreases the effective voltage across the coils which results in reduced torque. Thus the increased supply voltage decreases this effect and is a great advantage for these motors.

Voltages up to 240V DC are used.

When a phase is switched off, the two rotors form a north and south pole pair. Operation of the motor is shown schematically in Fig. 6. The most commonly used form is the Vernier hybrid motor which yields up to 500 full steps/rev. This large number is obtained by having a large equivalent number of salient poles on both the rotor and stator. Each coil on the stator activates several equivalent salient poles as shown in Fig. 5.

For the configuration shown in Fig. 5, there are 48 equivalent stator salient poles

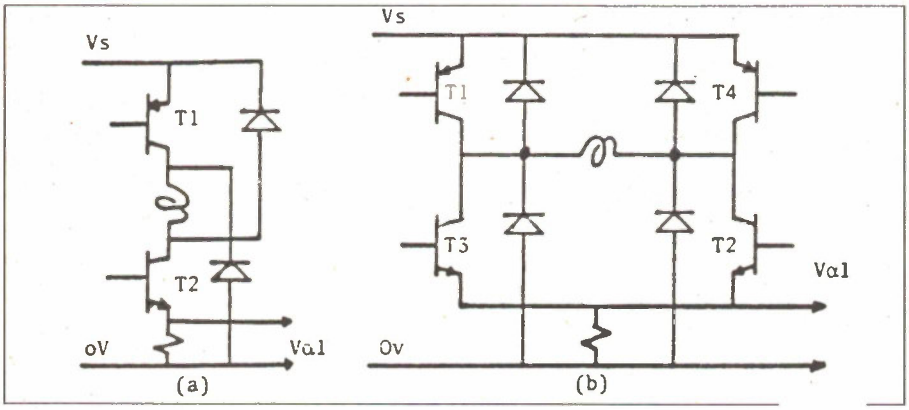

Fig. 7(a) A single-ended drive circuit with suppression (freewheel) diodes, and (b) a bridge circuit which doubles the voltage applied to the load.

on four pole pairs (2/phase) and 50 rotor salient poles which gives 200 full steps/rev. Torque is increased by axially extending the stator coils and adding more pairs of magnetized salient rotors along the rotor shaft.

The motion of the hybrid step motor is dependent on the magnitude and direction of the magnetic field in the air gap. Hence a PM or hybrid step motor will often have two windings on a pole so that a magnetic field can be established in either direction by using one or other of the two coils. This continues to circulate through the freewheel diodes which protect the transistor switches against destructive breakdown voltages.

The phase current gradually decays to zero as does the magnetic field produced by the "off" phase. This decaying field contributes a new "on" phase.

The time for which the negative torque component acts is reduced by including active suppression of the "off" phase current by means of Zener diode (or equivalent). This increases the reverse voltage across the phase when it is turned off. Suppression voltage limits are set by the high voltage limit of the switching device less the supply voltage.

A bridge circuit such as that shown in Fig. 7 doubles the effective voltage applied to a coil.

However, it does require four switching devices per phase for the common two phase hybrid step motor. This may be reduced to two devices if a split power supply is used, but this doubles the high voltage requirements of the devices. For a three phase PM step motor, the windings can be connected in star or delta and only two devices per phase are connected.

The bridge circuit shown also includes a current sensing resistor so that the drive current can be controlled to produce a constant current output. This is effective at all but the highest step rates when the motor's back emf approaches the supply voltage.

An additional advantage of constant current drives is that the torque can be increased 40%, and the complicated timing needed to overcome current lag and decay problems can be largely ignored. However, these constant current drives do introduce considerable RFI and the additional current harmonics may induce resonance in the motor.

Resonance

The slow stepping response of a VR step motor is shown in Fig. 8a, and it illustrates the underdamped second order response of the system.

Notice in Fig. 8b, that the motor has reversed because of forward motion response. It is found that unreliable operation occurs over a band of step rates centred on those at which resonance occurs, *ie,* at the natural frequency and its integral subharmonics. In some motors, limit cycle resonance occurs at twice the natural frequency step rate, and parametric oscillations at four times that rate.

Reliable Operation

In all cases, resonance effects are reduced by increasing the amount of energy dissipated during each step. Increases in the friction load, changes in gearing, back lash reduction or drive voltage changes can all affect resonance of the step motor. These can also adversely affect the maximum speed. A viscous Lanchester damper has the advantages of damping only the acceleration. Hence it does not reduce the top speed but does reduce resonance. However the device does require periodic adjustment and can be difficult to set correctly.

The above suggestions can cure many resonance problems but other requirements may preclude their use. The use of feedback can eliminate resonance. Essentially off phases are operated at less than 1% of rated current by a constant current chopper drive circuit and the on phase is operated at 100%. The current rise time for an off phase is proportional to the inductance in that phase, and hence to the rotor position. Thus the feedback information is obtained within the electronic drive circuitry and the motor is completely standard. This approach is well suited to multi-stack VR motors.

Conclusions

In many applications, a step motor is an open loop control system that gives excellent results, as both its position and velocity are predetermined. The addition of electronic rotor position detection provides actual position and velocity information which can be used to overcome resonance problems. The step motor may then run as a brushless DC motor, but it does not need the expensive position encoders and velocity tachometers required for DC motors. The step motor is ideal for numerically controlled systems and robots, as the motor is simple and the complexity is restricted to the drive circuity, which is remote from the machinery. ■

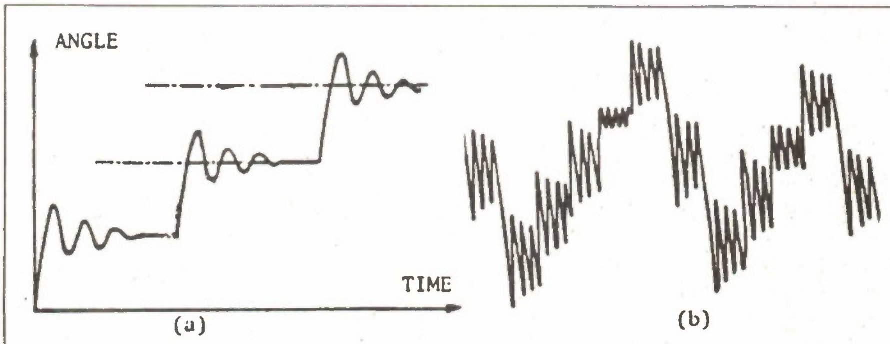

Fig. 8(a) The underdamped response of a VR motor. In (b) the motor has reversed because of forward motion response.

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Zero Crossing Power Controller

Control AC power and eliminate RFI with integral cycles

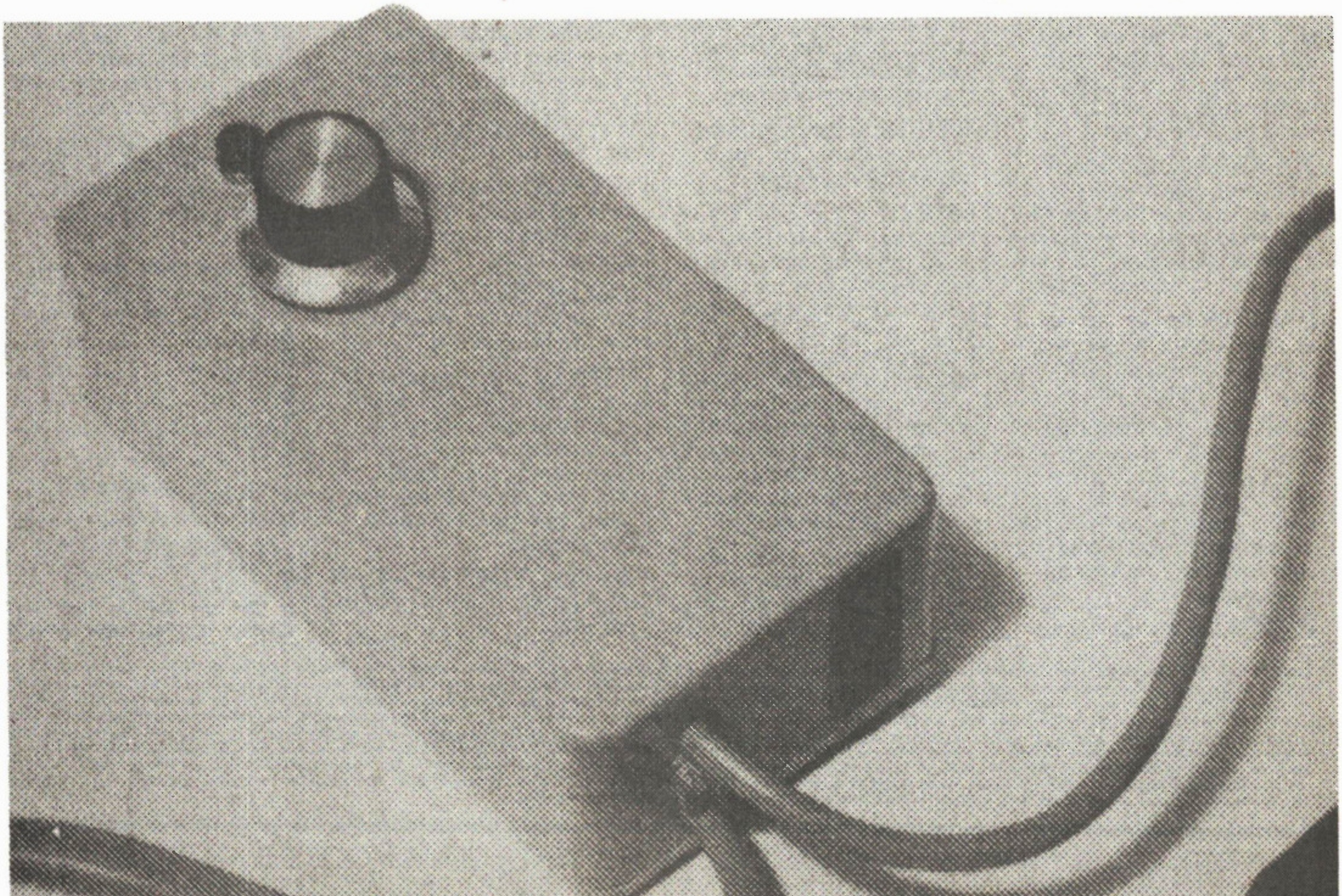
ANDY FLIND

The idea for this project arose when a new soldering iron was purchased for the author's workshop. The old iron was a 15 watt model, perfectly adequate for light electronic work, but sadly unequal to the occasional heavier task. It was decided that the replacement should be a 25 watt iron, especially as a very popular version just happened to be on "special offer" at the time.

The extra power is sometimes useful, but for lighter day-to-day work it soon proved to be an embarrassment. The bit (an iron-coated type) continually oxidized and refused to tin properly; eventually it turned blue and started to warp. Joints made with it took ages to solidify and displayed the typical appearance of overheating. In short, something had to be done.

Burst Fire

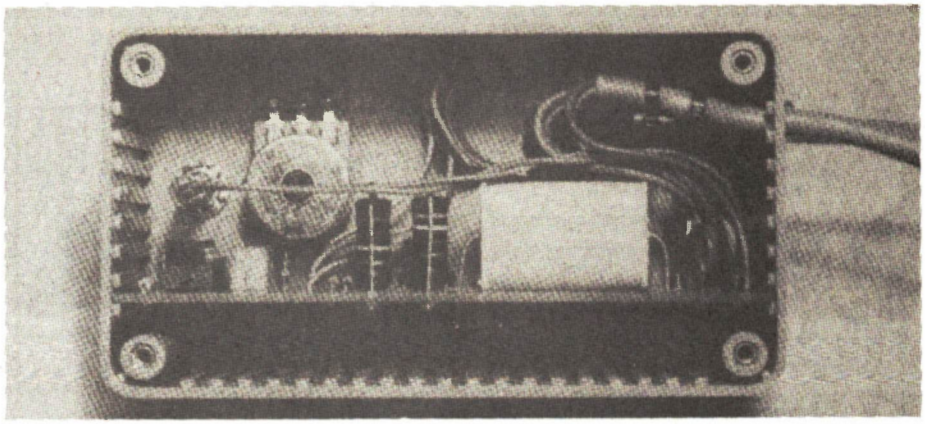
The usual method of controlling light loads is by variable phase control, as used in lamp dimmers. Even when well suppressed, though, these create a lot of radio frequency interference at close range, especially unwelcome where sensitive electronic equipment is being tested. As a soldering iron has a fair degree of thermal



inertia, some form of "burst fire" controller seemed the best solution, as these are inherently interference-free.

Since the mains supply alternates between positive and negative peak voltages at 60 hertz, it follows that it must pass through zero 120 times a second. If the load can be switched on and off at, or very close to, these zero points, the switching device will not make or break any heavy currents, so the interference generated will in consequence be negligible. Integral-cycle controllers using this method switch loads on and off at regular intervals, the switching taking place at zero crossings. The net power delivered depends on the ratio between the "on" and "off" times.

Switching "off" at the right moment is easy. If the drive is removed from a triac gate it will continue to conduct until the current passing through it falls to a low level, which of course coincides with the low voltage point (for a resistive load). Thus the correct "off" point is selected automatically. Switching on is slightly more difficult; the right point has to be sensed in some way and drive applied to the triac at that exact moment.



Custom chips are available for the job, but are not really suited to light loads. The reason for this is that they usually fire the triac with a very short pulse to the gate, then rely on the "on" condition being maintained by the load current. With a small load such as a 25W iron, this is likely to be insufficient at the point where the gate pulse ends; for such applications a

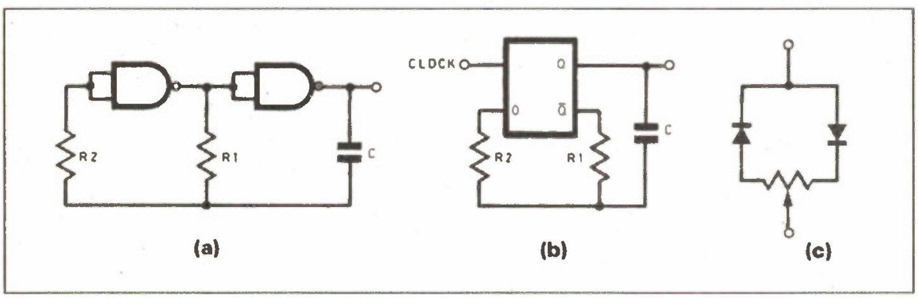


Fig. 1a. CMOS NAND gate oscillator. Fig. 1b Oscillator built with a "D" type flip-flop. Fig. 1c. Substitute for R1 to obtain variable mark to space output.

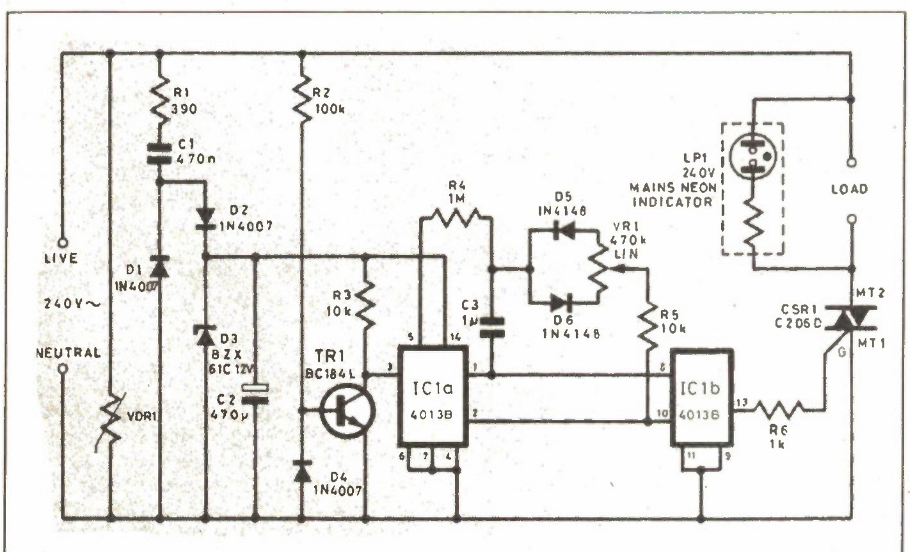


Fig 2. Complete circuit of the power controller.

PARTS LIST

Resistors

All 0.5W types except R1 and R2

R1 .... 180 1 watt
R2 .... 100k 1 watt
R3,5 .... 10k
R4 .... 1M
R6 .... 1k

Potentiometer

VR1 470k lin. carbon with nylon or plastic spindle

Capacitors

C1 .... 0.47u 250V
C2 .... 470u 25V electro.
C3 .... 1u polyester layer

Semiconductors

IC1 CMOS 4013B type D flip-flop
TR1 .... 2N3904 or equiv.
D1, D2, D4, ... 1N4003 or equiv.
D3 .... 12 volt 1W Zener
D5, D6 .... 1N4148 or 1N914
CSR1 .... C206D triac

Miscellaneous

VDR1 mains transient suppressor such as Int. Rectifier Z21L271 or Active Components #10441; PCB; box, 120 x 65 x 40mm; plastic control knob; 120VAC neon indicator (with integral resistor); 8- pin DIP socket; connecting wire, etc.

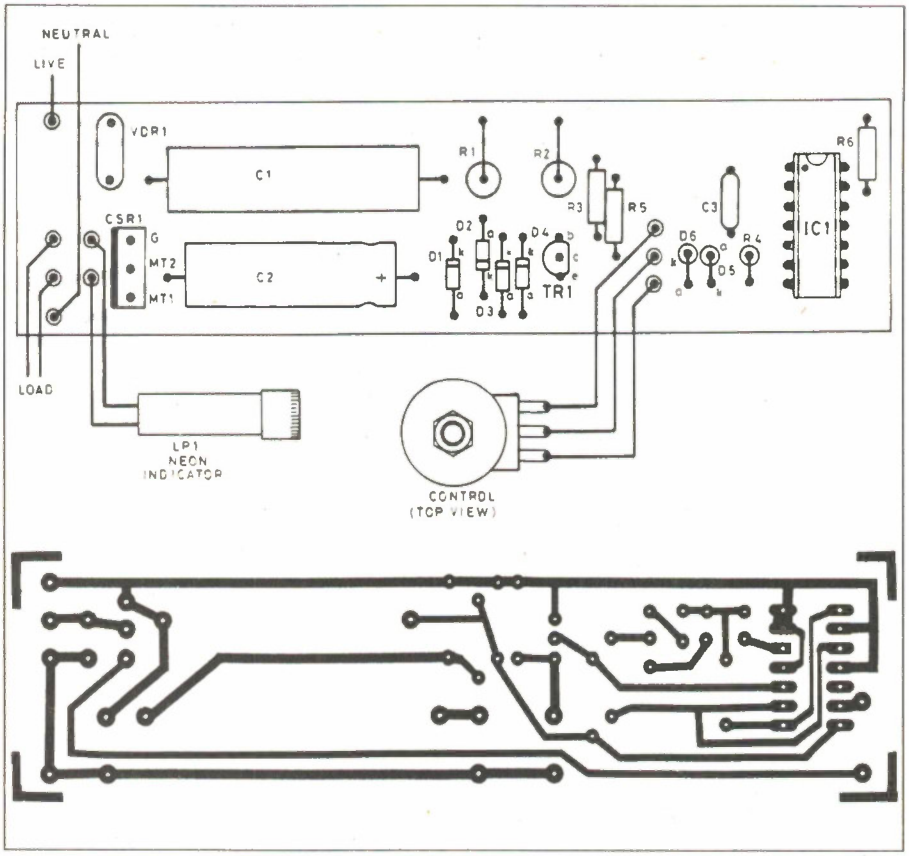


Fig. 3. Layout, wiring and PCB for the controller. The ground wires from the AC input and to the load should be connected together with a screw connector.

continuous gate drive is better. Fortunately it is possible to construct an extremely simple circuit around a "D" type flip-flop which will not only generate the required variable mark-space timing function, but can be synchronized to the zero crossings through its clock input.

A common oscillator circuit that can be built with the two inverting logic gates is shown in Fig. 1a. Positive feedback is applied right around the circuit via capacitor C and R2, ensuring clean and positive switching. However, after each switching action, negative feedback from R1 gradually pulls the input towards the opposite polarity until another change of state takes place. R2, by the way, prevents the gate's input protection from loading the timing circuit.

In Fig. 1b the same circuit is shown built, with a "D" type flip-flop. With this type of device, the "Q" output will assume the state present on the "D" input, whilst the "Q" output will take up the opposite state. We thus have an input and two opposing outputs, so an oscillator circuit can be constructed exactly as before. However, changes of input are only transferred to the outputs when the "clock" input changes state, so this can be used to synchronize output changes to another input signal.

As shown, the output will have equal "on" and "off" periods, but with some simple additions these can be altered as desired. If a linear pot is used for R1 with a couple of steering diodes, the output will have a constant frequency, but the ratio between high and low states will be directly proportional to the pot setting.

The Circuit

The full circuit appears in Fig. 2. A low voltage supply for the electronics is derived from the mains through a series capacitor, C1, together with diodes D1, D2 and Zener D3. C2 stores and smooths the output. With capacitive voltage droppers (C1), there is always a slight risk of catastrophic failure should the capacitor fail, but in the author's experience this is uncommon, especially where protection against high voltage transients (VDR1) is provided. Capacitors are much cheaper and easier to mount on PCBs than transformers.

To generate the clock signal, current flowing through R2 is passed through the transistor's base-emitter junction during positive half-cycles, turning it on. During the negative periods it flows through D4, and the transistor turns off. A logic signal synchronized to the mains can thus be taken from its collector. The IC used, a CMOS 4013B, actually contains two "D" type flip-flops. The first of these is used as described, the output switching at about 1Hz, with the on–off ratio being adjustable through VR1.

The flip-flops in the 4013 are also provided with "set" and "reset" inputs, which can be used to drive the outputs directly regardless of the "D" and the "clock" inputs. In the first stage these are not used so they are connected to ground. The second flip-flop is used simply as a follower to buffer the output before it drives the triac. Its "set" and "reset" inputs are driven from the "Q" and "Q" outputs of the first stage, and the unused "D" and "clock" inputs are grounded.

The triac is a C206D, chosen for this project as it is readily available and requires less gate current than most other types. The neon lamp is optional; it provides indication that the unit is operating correctly and if, like the author, you're in the habit of forgetting to switch off the iron after a long day at the bench, the flashing will serve as a useful reminder.

Construction

Construction of tis project is quite straightforward, so little needs to be said about it. Since live testing is difficult and a faulty component in some areas could result in a fair degree of destruction, it is a good idea to check some of the parts before insertion, in particular diodes D1 to D4. Zener D3 can be tested with a suitable voltage source, say a couple of nine volt batteries, and a series resistor of 1k or so (R6 will suffice for this), then measure the voltage across the diode – it should be

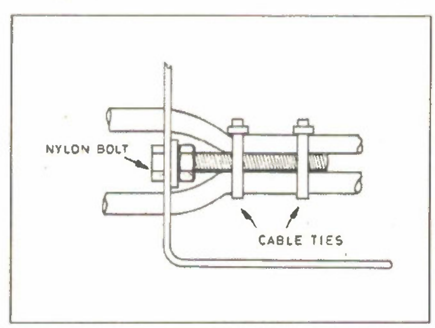


Fig. 4. Method of securing the AC power leads.

12V. Fig. 3 shows the positions of all the components; take care to ensure that the diodes are fitted the correct way round.

Testing

Testing, of course, must be carried out with due regard for the fact that all of the circuit will be connected directly to the mains and MUST therefore be treated as "live". It is suggested that a socket is used for IC1, and initially the unit should be plugged in without this IC. It is a good idea to connect the meter probes to the points indicated before plugging in, to eliminate the risk of making contact with live parts. Begin with the meter connected across the 47u capacitor C2, set to a range covering up to 250 volts DC. This will protect your meter if a fault is present.

Plug in, and if there is scarcely any reading, reduce the meter range until you can see the voltage on C2, which should be around 11.5 to 12 volts. If this seems correct, unplug and reconnect the meter between negative and the bottom end of R3 (collector of TR1), which should read around five volts when plugged in again. This is an average reading, indicating that TR1 is switching properly. Ignore any reading present when the unit is unplugged, which will be due to charge stored in C2. If all appears well, it remains only to insert IC1 and plug in again; the neon indicator should begin to flash at about 1Hz, and adjustment of VR1 should vary the flashes from so brief they're just visible to so long they're very nearly continuous.

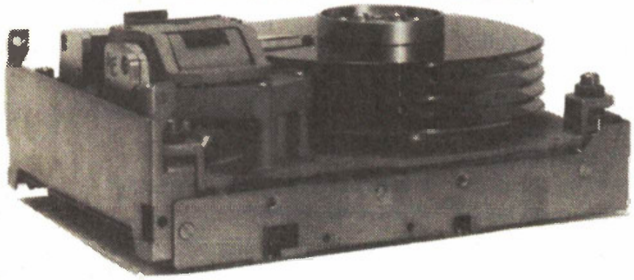
Final Assembly

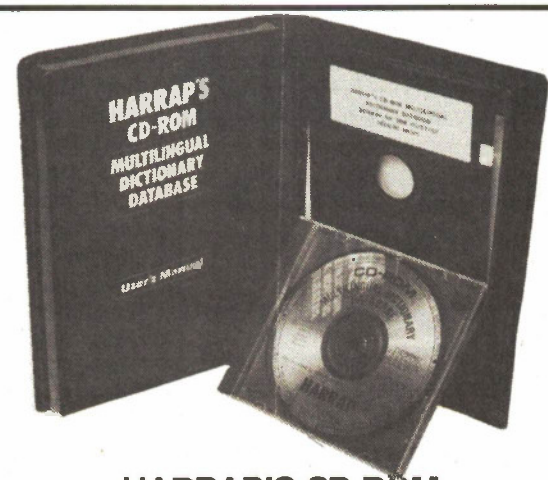
The layout of the unit in its case is shown in Fig. 4. the "cord- grip" arrangement is a little unusual; since the unit is rather compact, there isn't space for most of the available types of cable clamp. The solution is to place a nylon screw between the two cable entry holes and tie the cables firmly to it with a couple on nylon cable-ties. This provides a compact, cheap and effective fixing for both leads. No metal parts should be exposed on the outside of the case. A potentiometer with a nylon shaft and a plastic knob must be used.

In Use

Though designed to control a soldering iron, this simple unit could be used or adopted for a host of other applications. It can be employed anywhere a low-power interference-free controller is required, for instance with an electric blanket. The specified triac is rated at three amps, permitting safe use with loads up to about 250 watts (though a small heatsink may be required above a couple of hundred watts).

Alternatively it could be used to operate flashing displays of various kinds, disco lights, Christmas tree lights, and so forth. The flash rate can easily be altered or made variable just by changing the pot connections and the value of C3. Two pots would allow independent adjustment of the "on" and "off" periods. C3 of course must be non-polarized: in practice this means that larger values should be made from two electrolytics placed back- to-back. Low-leakage types such as tantalums are preferable for this. The prototype has been tested with two 10u tantalum beads giving a flash rate of around five seconds, with no problems at all. ■





Advertiser's Index

The Techie's Guide to C *Continued from page 18*

list when it finishes with the current one. This is actually useful sometimes.

You'll probably note that, strictly speaking, there is no *break* needed after the *default* case, as it's the last case in the list, and there's no where for C to fall through to if the *break* had been left off. This is true enough. In this case, C actually ignores the existence of the last *break* when it compiles the program. However, if we were to tack another case onto this *switch* some time in the future, we might forget to go back and add the necessary *break* to the *default* case. As such, it's a good rule to always end cases with *breaks*, whether they're really needed or not, unless there's a good reason to omit them.

The contents of the three cases should be pretty easy to work out. The case for eight, the backspace, prints a backspace, a space and another backspace, so it moves to the previous character, blows it away and then moves back into the now vacant position. The case for nine, the tab, just prints five spaces. You'll recall this use of *printf* from last month. Finally, the case for thirteen, the carriage return, should be pretty obvious.

Definition of Terms

Before we vanish into the swirling mists of eternity, let's consider a bit of compiler lore. This has nothing to do with the above example; it's just a useful thing to have your head around when you're writing programs.

One of the slickest features of C is its *#define* statement. This is properly called a "pre-processor directive", which is a term that means that the authors of the language liked big words. Like the *#include* directive we saw last month, this is something which happens before the compiler starts worrying about the contents of your program.

Here's a common use of *#define*

```
#define pi 3.1415926

main( )
{
printf("The value of pi is %f",pi);
}
```

The syntax for the *printf* statement is a little weird; don't sweat it right now. The important point is that the *#define* statement has associated the number 3.1415926 with the label *pi*.

This may seem like just another sort of variable. It's not. What actually happens here is that before it compiles the program the compiler goes through it and finds every occurrence of the label *pi*. It then mechanically replaces each one with the number 3.1415926. This results in a lot faster code than would have come to pass if we'd used a variable for *pi*.

If you had a program with lots of occurrences of *pi* in it, you would use a *#define* to initially establish what *pi* actually is. You might want to experiment and see what effect changing the precision of *pi*, the number of digits after the decimal point, has on the working of your program. In this case, all you need do is to change the number in the *#define*.

You can assign anything to a label in a define. For example,

```
#define name "Wombat McAngleiron"
```

tells C that *name* should be replaced with the string *Wombat McAngleiron*. Now, if you attempt to use *name* in your program in some place where a string would not be appropriate, C will most certainly complain.

Finally, you can even use this facility to meddle with function names. For example, if you print character seven to the screen, the speaker on your PC will beep. Thus, we might

```
#define beep( ) putch(7)
```

This will appear to create a function called *beep* which makes the speaker sound. This is slightly more efficient of space and speed in your program than would be creating a real function called *beep*.

Beam Me Up, Scotty

If you're not exactly illuminated about C language programming as yet, don't sweat it. It's a bit like listening to rock 'n roll... you have to let it wash over you for a while until the lyrics start to make sense. Unfortunately, depending on the rock 'n roll you check out, when they finally do make sense, the lyrics might turn out to be telling you to go eat live sheep. At least C language, when it finally does become clear to you in a flash of blinding insight, won't involve mutilating livestock.

Next month, we'll have a look at some specific PC compatible C language compilers. If you're just itching to be able to actually write some code, you'll want to get the next edition of ET&T to find out what's best to write it in.

Bye... ■

The Small-fry Mini-Amp

Not too hi and not too fi — but small, hot and not a lot of money.

KEITH BRINDLEY

We certainly can't call this project the ultimate in super- powered, high-fidelity amplifiers, but we can assure you that it's simple to build and it really couldn't be cheaper. A single chip design means that as few as eight components give an amplifier with 46dB of gain from a 9V power source. A single pot controls gain from zero to maximum.

The output power into an 8 ohm loudspeaker with a 9V power supply is up to around half a watt which, although it isn't eardrum- shattering volume, is more than enough for a simple guitar practice amplifier, or a personal stereo extension amp. Power op amps are useful as servo drivers or simple intercoms too.

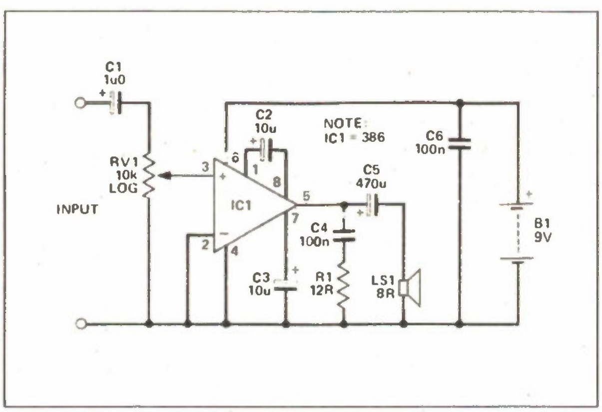


Fig. 1. The circuit diagram of the Mini-amp.

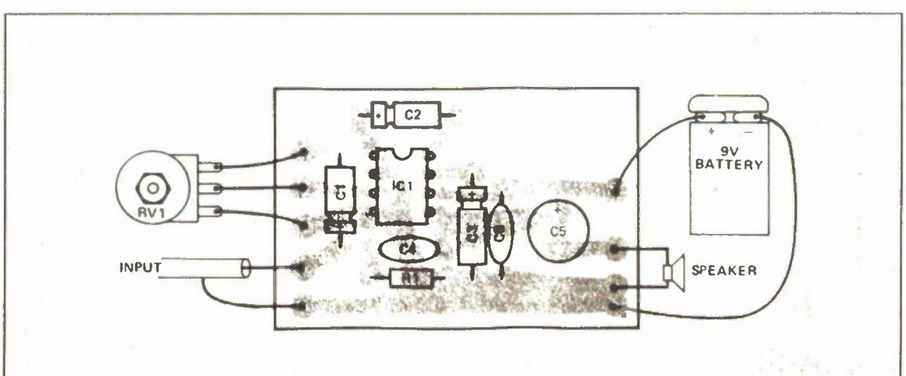


Fig. 2. The component overlay of the PCB.

Construction

The circuit of the Mini-amp is given in Fig. 1. You can choose between PCB and stripboard construction. Neither method involves any hazards; the usual precautions and procedures will let you build it safely. The PCB layout, component overlay and wiring diagrams are combined in Fig. 2, while those for stripboard are shown in Fig. 3.

If PCB construction is your choice, the only point to note is to leave insertion of the integrated circuit until last. This way there is less likelihood of damage from a slap-happy soldering iron. Preferably use an IC socket (although this isn't essential) and check that the chip is in the right way around. PCB pins for all input, output and power supply connections make life easy but again aren't essential. Watch for electrolytic capacitor polarization — make sure you get them facing the right way.

Stripboard construction is just as easy.

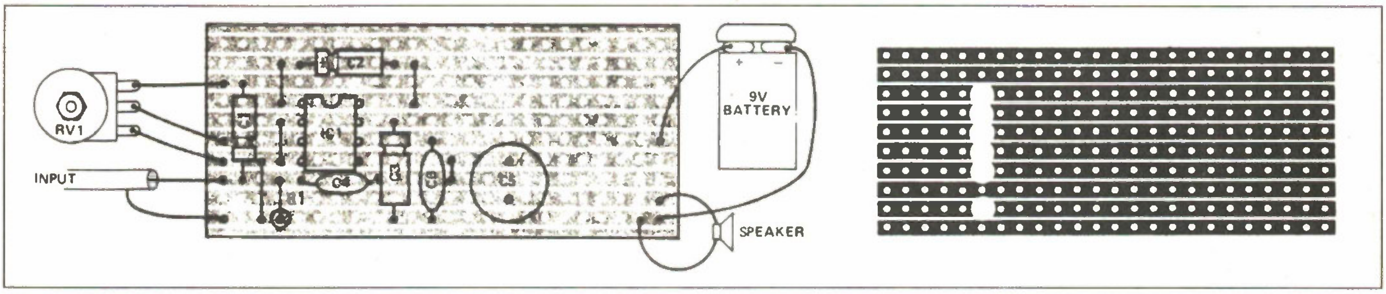


Fig. 3. The component overlay for the stripboard and the track cuts required.

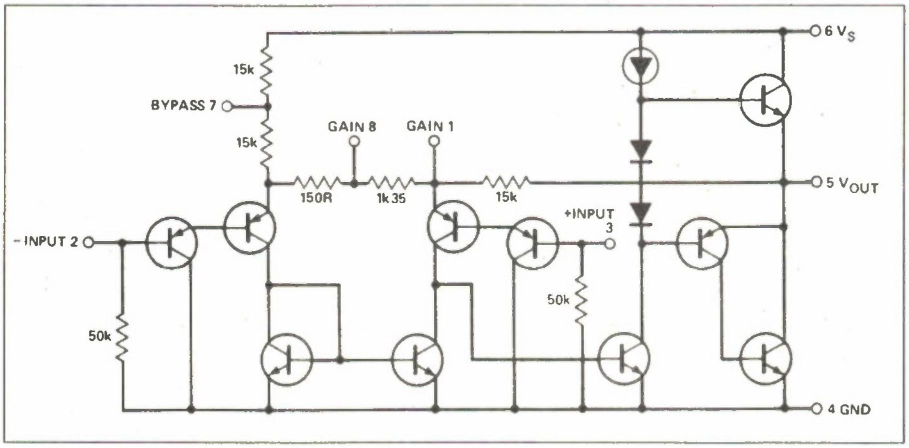


Fig. 4. The internal circuit of the 386 amplifier IC.

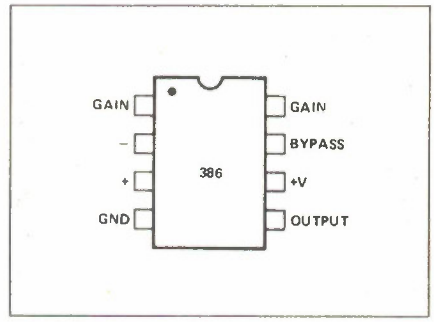
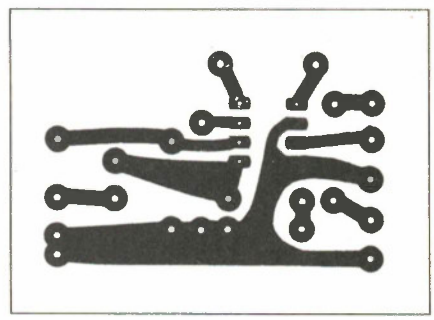


Fig. 4. Pinout of the 386.



The PCB for the Mini-amp.

Before components are inserted make all track breaks, shown in the underside view of the stripboard in Fig. 3. Then follow the same rules as for PCB construction.

Shielded cable must be used for the input connection; otherwise the amplifier's high gain will ensure heaps of hum and interference. Mount the potentiometer as close to the board as possible, or use shielded cable for these connections too. You'll see the potentiometer in the prototype amplifier is mounted directly to the PCB pins on the PCB. This is a good idea, as it keeps interference to a minimum and allows a method of fixing the board to the front panel of your choice.

Talking of housing, the vast numbers of possible uses makes suggesting a case fairly pointless. The board (PCB or stripboard) is small enough to allow housing inside the smallest of cases. If you intend fitting a loudspeaker into the same case, it'll be this that decides case size rather than the board.

Moving onto the loudspeaker, take care in your choice. Tiny and tinny radio speakers will make your project sound similar to a tiny and tinny radio and won't do your valuable time, confidence and pennies much justice either. So use as good a loudspeaker as you feel the need (and expense) for. There is an argument for not using an internal loudspeaker at all but rather one of your hi-fi system's loudspeakers.

How It Works

The circuit for the Small Fry Mini-amp (Fig. 1) tells most of the story. Integrated circuit IC1 is a 386 power amplifier which functions effectively as a power operational amplifier with ground referenced input. Pinout details are provided in Fig. 4. The IC can operate from voltages from 4V through to 12V. Its quiescent current drain with a power supply of 9V is only around 4mA. Internal circuit of the chip is shown in fig. 5.

In the Small Fry the IC is connected in a fairly simple non- inverting amplifier configuration. Gain of the IC is set by the connection between pins 1 and 8. No connection between them sets the gain internally to 26dB (20 times). As shown, with a 10u capacitor bypassing the internal 1.35k resistor, the gain is set to its maximum of 46dB (200 times). A variable resistor in series with the capacitor allows gains in between these limits to be selected.

Pin 7 of the integrated circuit allows a supply bypass connection to be made internally, a fact which can greatly improve the circuit's power supply rejection ratio at lower frequencies. Capacitor C4 and resistor R1 form a Zobel network, which prevents instability at high frequencies due to reactance in certain types of load. ■

PARTS LIST

Resistors

All .25W 5%
R1 .... 12R
RV1 .... 10k log potentiometer

Capacitors

C1 .... 1u 10V electro.
C2, ... 3 10u 10V electro.
C4, ... 6 100n
C5 .... 470u 10V electro.

Semiconductors

IC1 .... LM386

Miscellaneous

LS1 8R loudspeaker, B1 9V battery and clip, PCB or stripboard PCB pins. 8-pin DIP socket.

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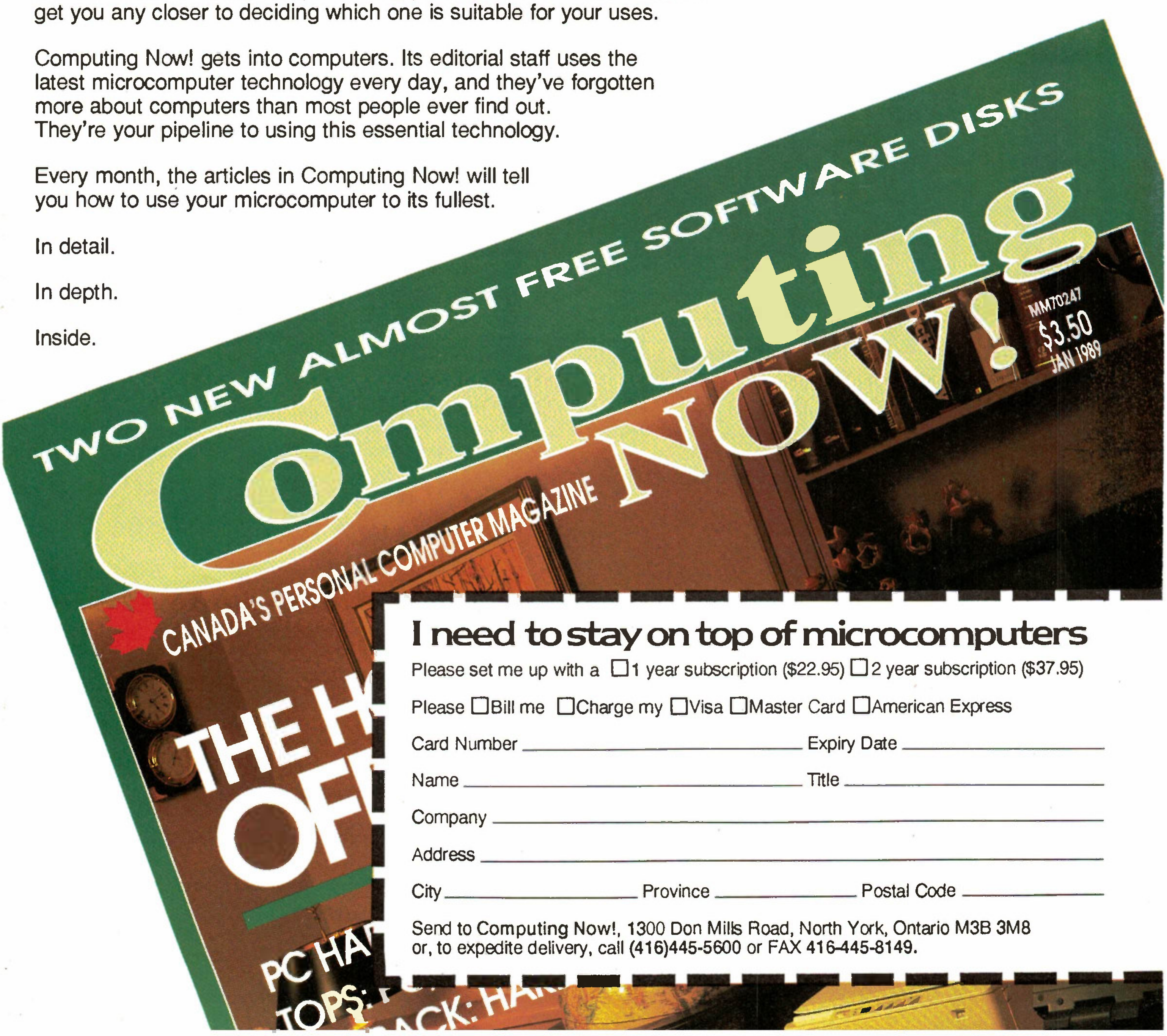

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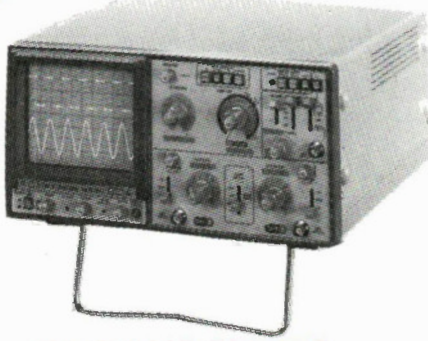

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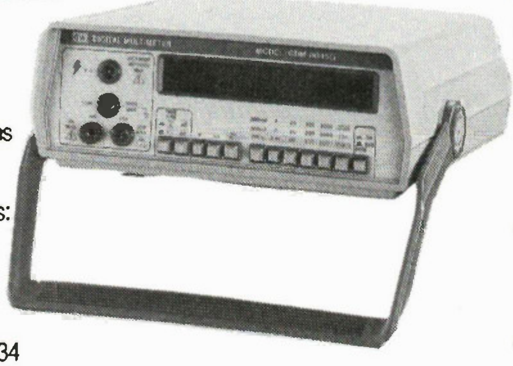

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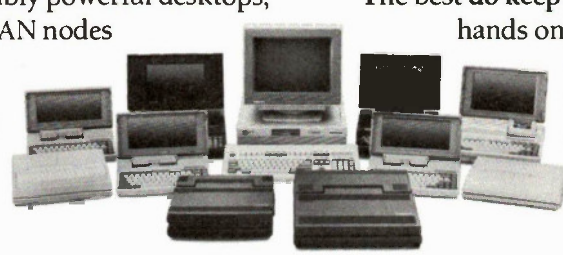

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