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June 1984

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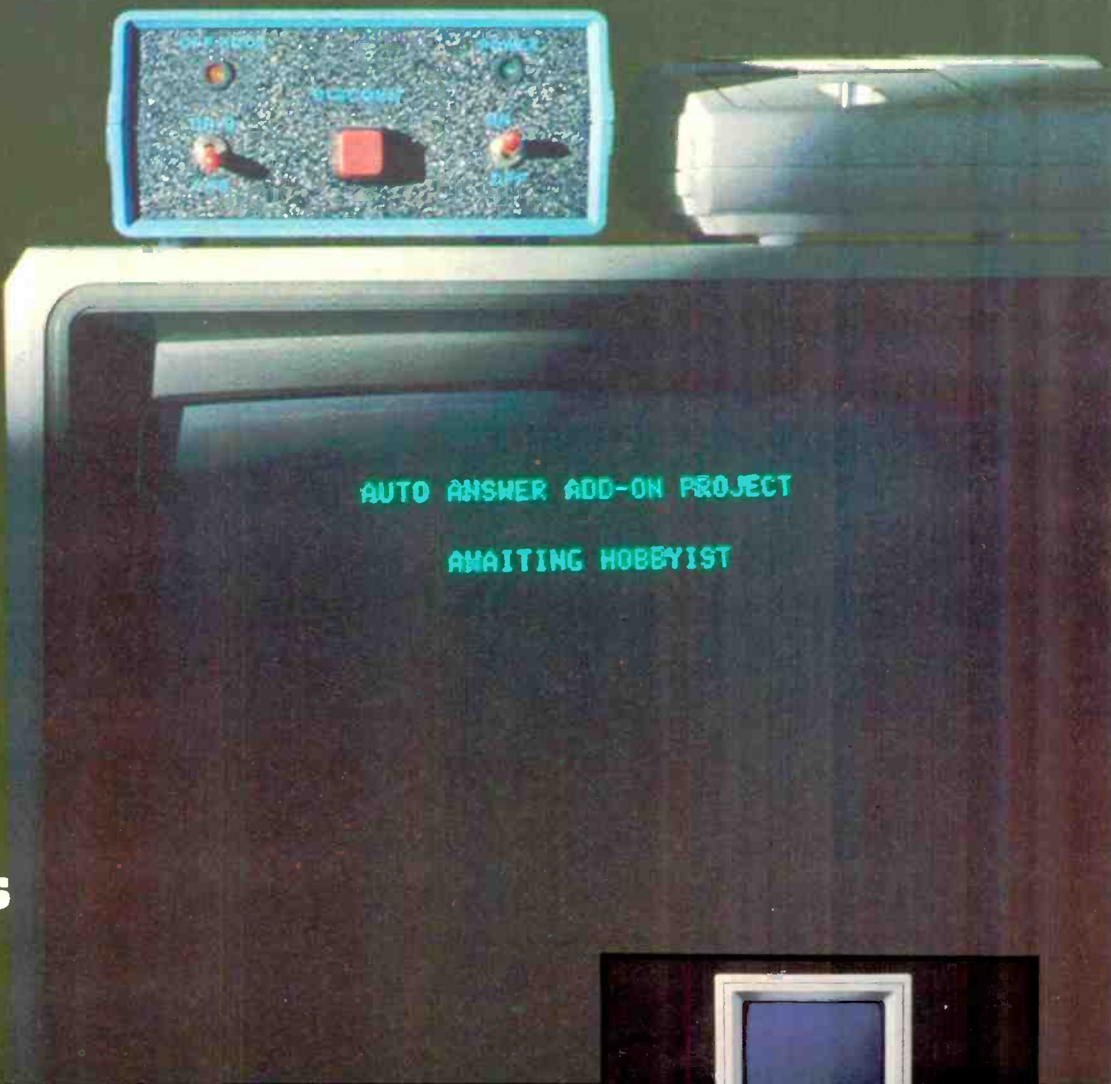

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Electronics Today INTERNATIONAL

Audit Bureau of Circulation

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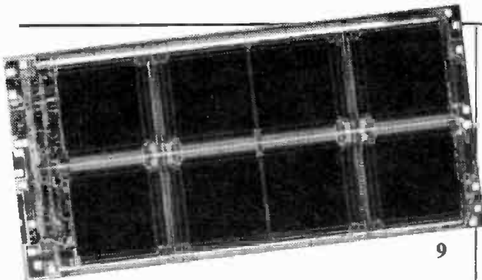
Vol. 8. No. 6 ISSN 07038984



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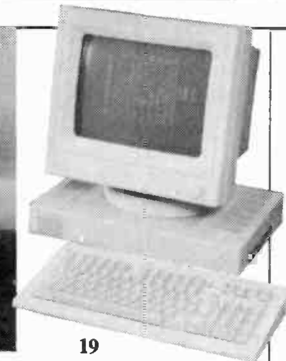

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Electronics Today is Published by:
Moorshead Publications
Editorial and Advertising Offices
Suite 601, 25 Overlea Boulevard,
Toronto, Ontario, M4H 1B1
Telephone (416) 423-3262

Editor:	**William Markwick**
Editorial Assistant:	**Edward Zapletal**
Director of Production:	**Erik Blomkwist**
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Publisher: H.W. Moorshead; **Executive Vice-President:** V.K. Marskell; **General Manager:** S. Harrison; **Controller:** B. Shankman; **Accounts:** P. Dunphy; **Reader Services:** C. Wyatt, S. Halladay, H. Brooks, K. Adams; **Advertising Services:** C. Zyvitski, **Dealer Services:** A. Nagels.

Newsstand Distribution:
Master Media, Oakville, Ontario

Subscriptions
$19.95 (one year), $34.95 (two years). For US add $3.00 per year, other countries add $5.00 per year. Please specify if subscription is new or a renewal.

Postal Information
Second Class Mail Registration No. 3955. Mailing address for subscription orders, undeliverable copies and change of address notice is:
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Component Notation and Units
We normally specify components using an international standard. Many readers will be unfamiliar with this but it's simple, less likely to lead to error and will be widely used everywhere sooner or later. ETI has opted for sooner!
Firstly decimal points are dropped and substituted with the multiplier: thus 4.7uF is written 4u7. Capacitors also use the multiplier nano (one nanofarad is 1000pF). Thus 0.1 uF is 100nF, 5600pF is 5n6. Other examples are 5.6pF = 5p6 and 0.5pF = 0p5.
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ETI magazine does NOT supply PCBs or kits but we do issue manufacturing permits for companies to manufacture boards and kits to our designs, Contact the following companies when ordering boards.

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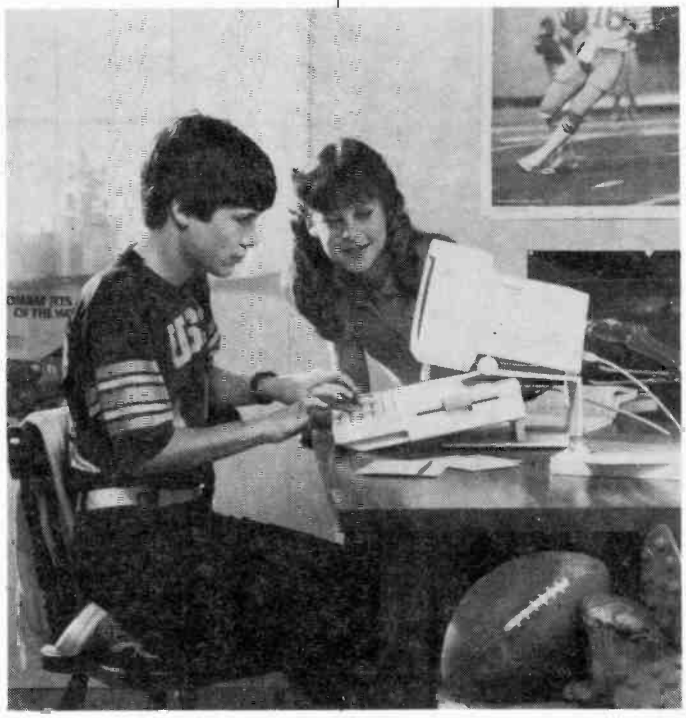
A New Apple



The Apple IIc, a 7½ pound computer, compatible with more than 10,000 productivity, education and entertainment applications, has been introduced by Apple Canada Inc. Aimed primarily at the serious home computer market, the IIc is also appropriate for business or educational applications. The new computer is a miniaturized transportable addition to the popular Apple II line of personal computers. The IIc has 128 kilobytes of built-in memory, which is ample for a wide variety of personal-productivity applications, such as word processing, tax planning and home budgeting. Because of the existing base of educational software for the Apple II product line, the IIc is also appropriate for home educational applications. In addition, the new computer runs a variety of entertainment programs. For only $1,895, the IIc includes the central processor, keyboard and disk drive in one unit. A disk-based owner's manual/computer-literacy course teaches those unfamiliar with computers what they can do with the IIc and how to do it. The course helps users learn about the IIc while actually using the computer. Once the IIc is hooked up to a television set or separate monitor, the user has everything necessary to get started.

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Motorola has introduced its first SMARTpower™ II device, which combines the best qualities of high speed CMOS logic and high-current TMOS vertical power structuring on a single chip. The MPC2005, an overvoltage and temperature protection circuit, is the first Motorola device to utilize this new technology. Previous Motorola SMARTpower™ efforts combined CMOS and bipolar characteristics. Capable of discharging capacitors with peak currents of 150 amps, the MPC2005 can operate at up to 15 amps of continuous anode current. When voltage exceeds 6.2 V or the junction temperature rises over 125°C, the device will trip and remove the voltage from the system. A single device can replace three resistors, an SCR, and an IC.

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Macintosh Manual

Howard W. Sams and Co., Inc., a Subsidiary of ITT Corporation, has released one of the industry's first books which thoroughly describes Apple Computer Inc.'s new Macintosh microcomputer for both new users and prospective buyers. *Introducing the Apple© Macintosh™* (ISBN 0-672-22361-9) is a comprehensive look at this new machine. The 189-page, illustrated volume will be available in bookstores throughout the country. Written by Edward S. Connolly and Philip Lieberman, experts in the fields of system integration, operation and microcomputer design, *Introducing the Apple Macintosh* thoroughly explains all there is to know about the Macintosh. Both Connolly and Lieberman worked closely with Apple in their research for the book, enabling them to include accurate information on all the hardware and software elements of the Macintosh.

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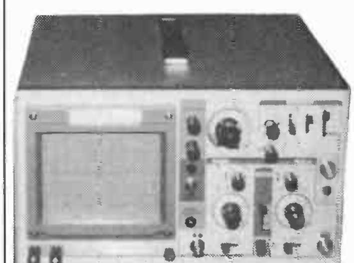

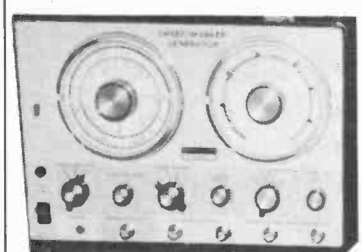

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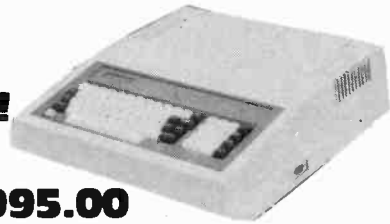

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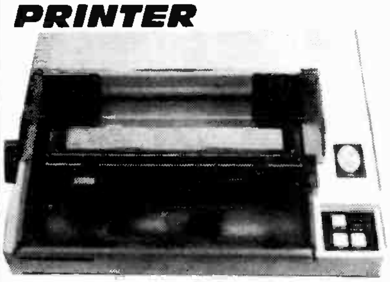

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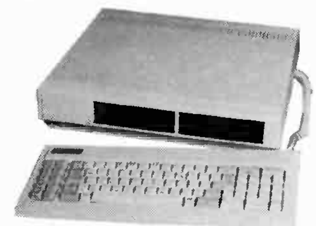

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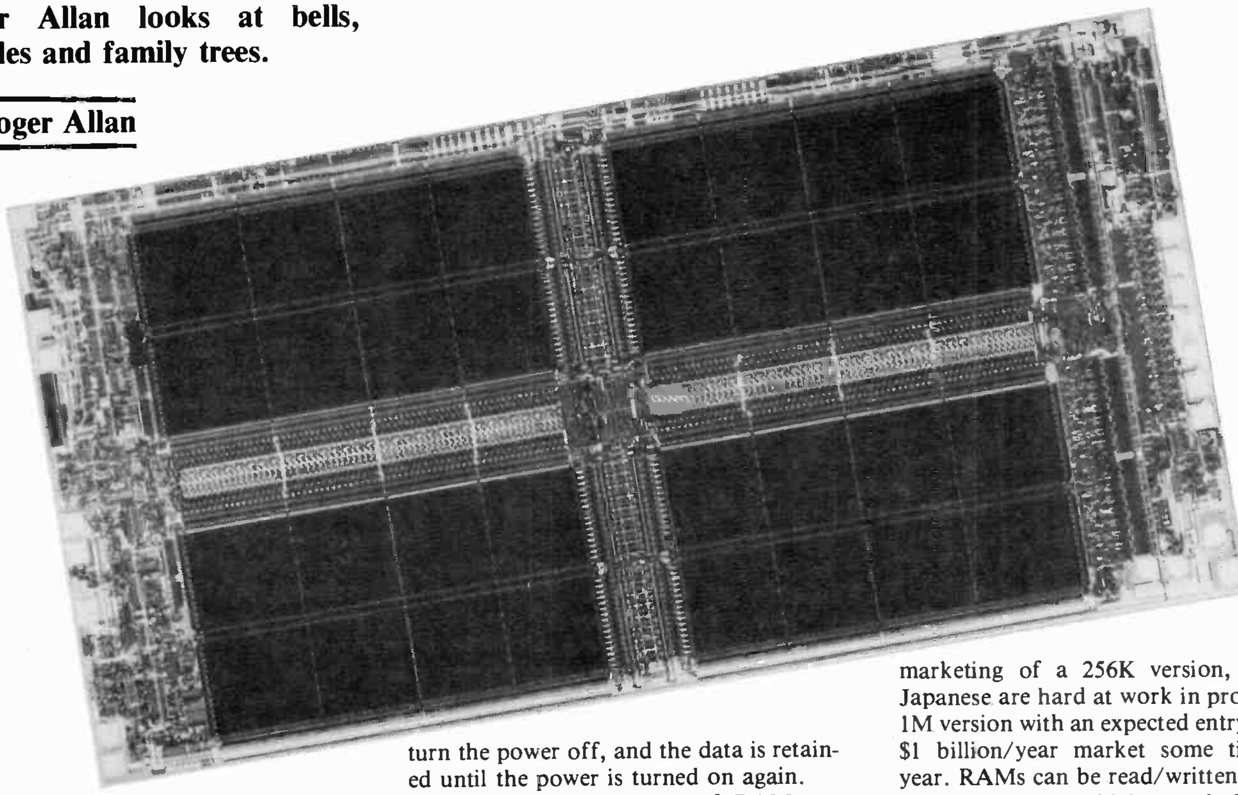
Circle No. 20 on Reader Service Card

Genealogy of the Chip

Roger Allan looks at bells, whistles and family trees.

by Roger Allan



EXAMINING THE background of integrated circuit chips is a bit like engaging in family genealogy — the deeper one delves, the more the branches and rootlets appear to have relevance. When the rootlets become intertwined, matters can momentarily become somewhat complicated. The next few years, if researchers' predictions are correct, will see the advent of whole new orders and classes of IC memories — whether direct or indirect products of the Japanese Fifth Generation Computer, or from such companies as Motorola, Harris, Xicor, Intel, United Technologies — the list seems endless. As such, a quick overview of what there is, what it can do, and where it is leading us seems appropriate.

In a magazine of this type, it is all but trite to mention RAMs and ROMs — one is almost expected to know what they mean before opening the cover. But in the interest of completeness, and as the Red King said to Alice, "begin at the beginning, proceed to the end, and then stop."

Random Access Memories (RAMs) lose their data when power is removed, that is, they are volatile. Read Only Memories (ROMs) are non-volatile — turn the power off, and the data is retained until the power is turned on again.

There are two types of RAMs — dynamic and static. Dynamic RAMs are the most widely used of memory chips in computers. They are very simple — each cell, which determines the 1 or 0 in binary code, consists of a single transistor and a single capacitor. The transistor pumps electrical charge into and out of the capacitor — that is, they read and write the cells into 1's or 0's. The capacitor stores the charge, providing the memory. If the capacitor is charged, when read it will produce a 1, if uncharged, when read it will produce a 0. They are called dynamic because they need to be refreshed. That is, the charge held in the capacitor leaks off in a very short period of time, milliseconds at most. As such, between normal data reading and writing operations, this type of RAM must be read out, amplified, and re-written back into the cell. This refreshing program requires an additional circuit, and hence more power input. For a small device, such as a microcomputer, this additional circuitry burdens the total system. However, in large mainframe computers, a single refresh circuit is all that is required. To date, dynamic RAMs customarily involve 64K of memory, though this year we will see the mass marketing of a 256K version, and the Japanese are hard at work in producing a 1M version with an expected entry into the $1 billion/year market some time next year. RAMs can be read/written ('accessed') at the same high speed. They are mainly used as the prime data storage memories for micro-, mini-and mainframe computers, as they are very cheap to produce and quite reliable.

The second type of Random Access Memory is the static RAM. The advantage of this type is that while volatile, they do not need refreshing. The disadvantage is that they are rather complicated — unlike dynamic RAMs which require only a single transistor and a single capacitor per cell, static RAMs require six components — two voltage adjusting resistors, and four transistors per cell. The two transistors are cross-wired into a 'latch'. Each of these two latch transistors is in turn connected to a resistor and another transistor conforming a cell. The configuration is such that when one of the latch transistors is on, it generates sufficiently high voltage levels that the other latch transistor is automatically turned off. As such, the cell is either powered or unpowered, producing the 1 or 0 of binary code. The largest device of this type to date is a 64K memory, which involves some 400,000 transistors, resistors and peripheral circuitry components. The peripheral circuitry performs signal-conditioning and interfacing functions.

Static RAMs are currently used for low-power versions of portable computers, high speed versions of mini-computers, and microcomputers utilizing small amounts of read/write memory storage. They cost two to four times as much as dynamic RAMS of comparable memory.

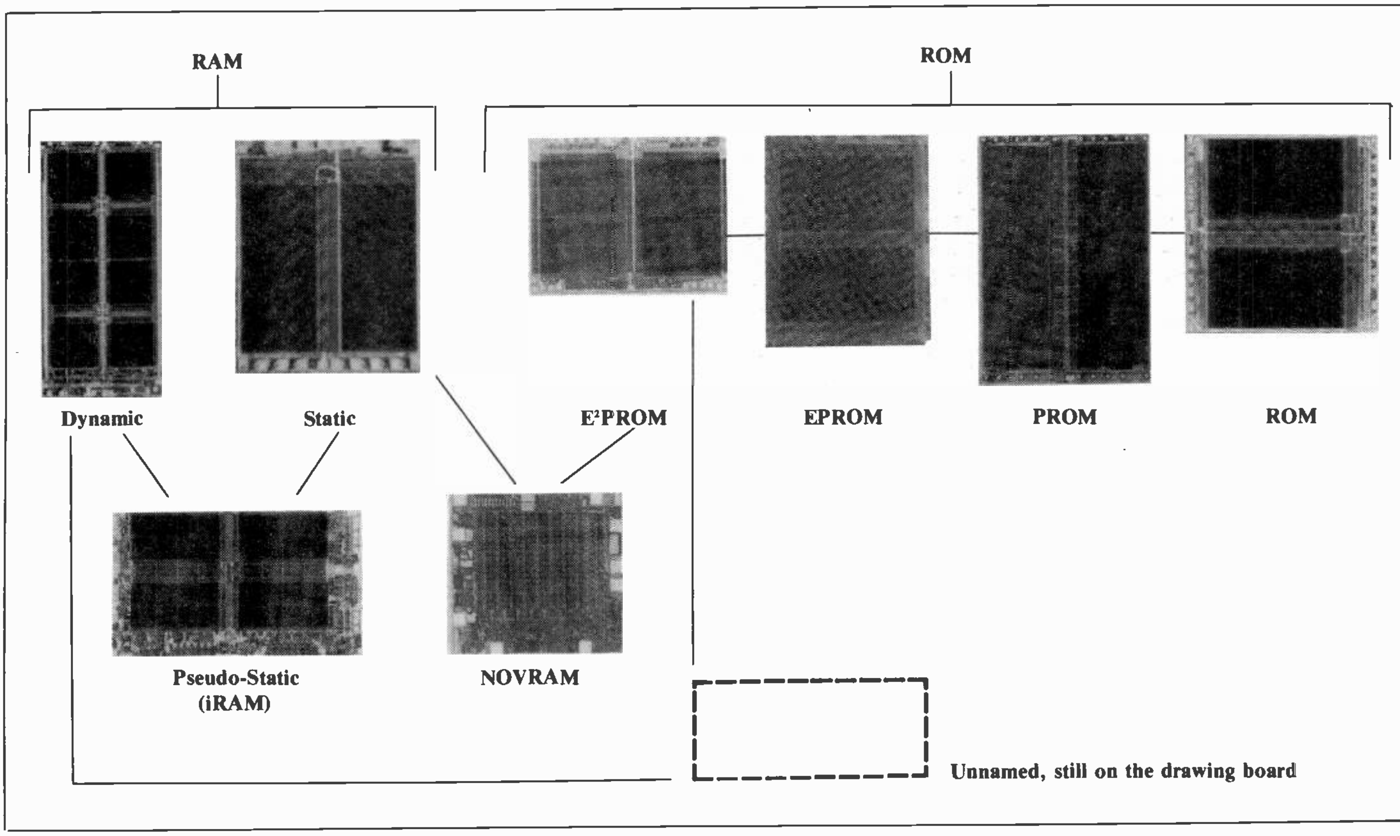
While all RAMs are volatile, all Read Only Memories (ROMs) are non-volatile. They have a further difference in that the speed with which their memories can be written, is far slower than the speed with which they can be read (usually — the rootlets are now becoming intertwined). There are a number of types, predicated on their writing mechanisms.

The simplest is just called a ROM, though more technically, it should be called a mask ROM. When the ROM is being designed and manufactured, a lithographic mask, specific to the final memory content program is drawn. As such, a ROM can only contain one memory program or set of data. It's memory cannot be erased, nor can it be modified. Costing somewhat less than a dynamic RAM, a ROM is customarily used for program storage, storage for character sets in displays and printers and function programs in pocket calculators, etc. While each cell consists of only one transistor, recent research has expanded ROM's capabilities. To do this each cell, in the newer versions, consists of four transistors, each with a different current carrying capability. The reading process consists of determining what the current level is. As such, each cell in effect carries the memory equivalent of two binary bits of information (eg. two sets of 1s and 0s).

The second type of ROM is called a fuse Programmable Read Only Memory, or PROM. It is similar to a ROM in that once it is programmed, the memory cannot be changed. It differs in writing technique however, in that all PROMs manufactured are identical and contain no memory. Their internal geometry is similar to a ROM, with the addition of what is essentially a fuse. When the PROM is programmed, after manufacture and sequentially by individual cell, this minute fuse is blown if the cell is to contain a 1 and not blown if the cell is to contain a 0, thereby permanently storing the memory on the chip. Costing about the same as a dynamic RAM, it is not used much these days, except for experimental work in designing computers (where the housekeeping routines and internal software programs may have to be changed as development proceeds), some automobile applications, some military applications — in general, where a small number of non-volatile ROMs are needed, bypassing the set-up costs of the masks for ROMs. More recent designs align the fuse vertically rather than horizontally, thereby saving space and increasing density.

The third version of ROMs are the Erasable Programmable Read Only Memories or EPROMs — well known to those involved with computers, as they can be erased by exposing their internal circuitry to ultra-violet light. While EPROM's internal structure consists of only one transistor, they do require an additional electrode for erasure purposes, resulting in less density per chip. However, a new Intel EPROM structures it's internal geometry vertically, resulting in a density all but the same for a single transistor ROM.

The EPROM's internal construction is similar to a PROM minus the fuse. In this instance, when the EPROM is programmed, the electrical charge is captured by the individual cell, electrically altering its characteristics. When read, this change is detected and read as a 1; or if there is no change, then the program is read as a 0. While exposing the EPROM to ultra-violet light before re-programming is cumbersome (one has to take the IC physcially out of the computer for a start), they do have the advantage of being re-programmed. To date, the highest



The history of the Chip family

density has been achieved by Intel's 256K EPROM, though larger devices are in the design stage. Customarily, they are used for the same sort of purposes as the ROM, plus extensive usage in the design stages of computers when software debugging is a problem.

The fourth version of ROMs are the Electrically Erasable Read Only Memories, or E^2PROMs. Similar to EPROMs, E^2PROMs require an externally applied current charge to transform the charges trapped in the individual cells, as opposed to removing them, exposing them to ultra-violet light, and reprogramming them. The erasure process can be done internally and electrically. The difficulty with this type of ROM is that the electrical voltage required to transform the cell's configuration must be substantially higher than the 5 volts customarily used in computer memories. For years, the voltage had to be upwards of 20 volts, though more contemporary designs have lowered the level to 12.5 volts. As such, a separate power supply and appropriate circuitry is required, increasing the cost.

E^2PROMs have passed through a number of generations. The earliest ones were merely Electrically Alterable ROMs (EAROMs). They were/are reprogrammable only after an entire memory array (or at least one page of an array) was electrically erased. In other words, to make a single change in one cell, one had to wipe the entire memory clean and start all over. Second generation E^2PROMs required erasure of individual bytes before reprogramming serially. That is, one had to start with the first cell and work through until one reached the cell one wished to modify, change it, then go back to the beginning and re-program all cells up till the one you just modified. Third generation E^2PROMs automatically and internally erase a to-be-written byte as part of the write cycle, and they also contain much of the required voltage generating and pulse-shaping functions internally on the chip.

The fourth generation E^2PROMs have on-chip generation of all high-voltage and wave-shaping functions, in addition to their use of on-chip latches and self-timing features. Their byte-write requirements are identical to those of a static RAM except that the E^2PROM write cycle takes as long as 10 msec. Once a byte-write operation begins, the E^2PROMs are self-supporting, freeing the processor and all external circuitry for other tasks. Read timing of the E^2PROM is identical to that of a standard EPROM, RAM or ROM.

One of the more interesting characteristics of the E^2PROM is that an EPROM or ROM based system only needs an additional Write Enable line to each socket to provide retro-fitting of an E^2PROM. The E^2PROM's internal architecture is a two transistor floating latch arrangement with 64K versions currently marketed. Their main usage is for program or data updating, such as warehouse stocks or pricing lists.

Hybrids

Having covered the major generic forms of RAMs and ROMs, one now approaches the hybrids — IC memories which do not 'fit' the generic forms, pulling strengths and weaknesses from more than one generic type.

The first is a hybrid, crossing a dynamic RAM and a static RAM. It is called, not surprisingly, a pseudo-static RAM, though in its most popular version (a 64K chip manufactured by Intel, soon to be increased to 256K), it is known as an iRAM.

The major advantage of a dynamic RAM is its simplicity — it requires only a single transistor and a single capacitor, thereby permitting a high density configuration. Its major disadvantage is that its memory needs refreshing via an external circuit. The major advantage of a static RAM is that they do not need refreshing. Its major disadvantage is that it requires a complicated internal geometry consisting of four transistors and two resistors.

An iRAM cross-breeds the advantages of both, while minimizing the disadvantages of both. Its internal geometry consists of a single transistor per cell, permitting high density like that of a dynamic RAM. However, it also has an on-board refresh circuit which operates at the same voltage as the IC, but does not require an external circuit. In other words, during idle periods (that is, when the individual cell is either not being read nor written), the chip automatically refreshes itself. The question of when to refresh is answered by an on-board 'arbitration' circuit. As such, the iRAM combines a density almost equal to a dynamic RAM, with the refreshing ability of a static RAM. It is primarily used in medium-sized computer systems due to its relatively high cost.

The second form of hybrid comes under a variety of names — shadow RAM, non-volatile shadow RAM, etc. In its most complete form to date (in a 1K version manufactured by Xicor), it is known as NOVRAM.

A major advantage of static RAM is its fast read-write cycle; a major disadvantage is its volatility. The major advantage of an E²PROM is its nonvolatility and reprogramability, a major disadvantage is that it can be re-written only a finite number of times before wearing out (i.e., it only needs a single cell, among the tens of thousands that compose the IC, to fail to render the entire chip redundant).

Essentially, the NOVRAM consists of marrying a static RAM with an E²PROM, cell by cell — eg., the combination of two memory technologies on a single chip. In the NOVRAM, data gets read and written exactly as in a standard static RAM. In addition, the Store signal transfers each of the RAM's cell data into a shadowing E²PROM cell and the E²PROM's cell's stored data is reloaded into the RAM portion of the chip via a Recall signal. This device's most powerful feature is its ability to transfer the entire RAM contents into non-volatile storage in one operation (eg., in parallel, rather than in series). This operation takes less than 10 msec., and once data is stored in this fashion, only another Store operation can alter it even if the chip loses power. Generating Store in the event of a power failure therefore saves the entire RAM contents, subject only to the power remaining on the chip for 10 msec. In the event of a power failure, one has between 20 and 40 msec. to play with. An on-board circuit can detect this, and thereby automatically initiate the 'saving' operation. As such, the NOVRAM combines the speed of a static RAM with the non-volatility of an E²PROM, and since the E²PROM is not used very often (only when there is a power failure or when the machine is turned off), it increases the life expectancy of the chip.

The NOVRAM also contains another unique piece of circuitry. An E²PROM requires an external circuit producing some 12.5 volts to change a cell's content. This requires two currents into the IC — a 5 volt one for its general workings and a 12.5 volt one to change the individual cell's state. In the NOVRAM, an on-board circuit automatically generates the 12.5 volts from the 5 volt input with sufficient amperage to change the individual cell's state, but without requiring a separate external power circuit. In other words, everything is on one chip: a static RAM, an E²PROM and a voltage generator.

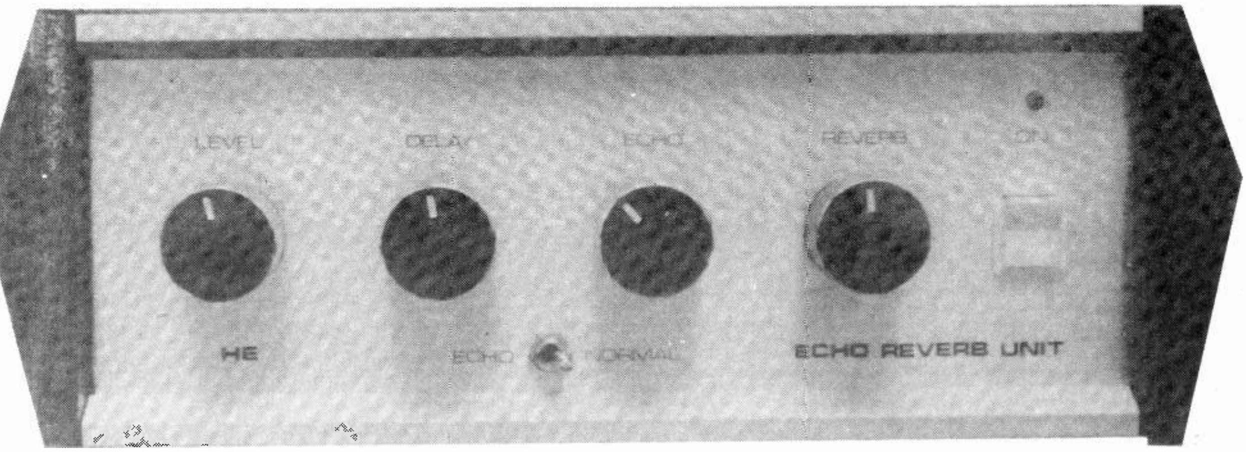
There is however, a disadvantage — size. Each double cell consists of six transistors and two resistors (for its static RAM portion) plus two transistors for the E²PROM portion of the double cell. With increased size comes decreased density.

And Finally . . .

The final hybrid may or may not exist, depending on who you talk to. Essentially, it consists of the marrying of a dynamic RAM (with its fast read/write cycle) and an E²PROM (with its non-volatility), the linkage between them being on a cell by cell basis. The advantage of such a device is that its density would be higher than the NOVRAM — dynamic RAMs only need two elements per cell (one transistor and one capacitor) rather than the static RAM's six (two resistors and four transistors). As such, this currently unnamed device would result in the speed of a dynamic RAM and the non-volatility of an E²PROM in a device consisting of only five elements per cell. There have been recent reports (erroneous) that such a device exists. However, upon investigation, one finds that such a device does not currently exist, but that the Mostek subsidiary of United Technologies in Texas is working on the fabrication problems involved. According to Tim Curran, of Mostek's Non-volatile Memory Group, while there is "no established program" to market such a device, Mostek is "doing the spade work" with respect to the fabrication problems involved.

Should such a device be built, it would be as close to a "perfect" IC memory as is currently envisionable. Should the technology then develop, and there is no real reason to believe that it won't be done sooner rather than later, the reality of marrying a pseudo-static RAM (with its automatic refresh circuits and high read/write speeds) and an E²PROM (with its non-volatility, power failure detection system and automatic 'save' all on-board) will have been achieved, possibly giving us the ultimate in IC memories. **ETI**

Echo-Reverb Unit



A superb project for creative musicians and audiophiles.

AN ECHO-REVERB unit is an accessory that can be added to virtually any existing audio or electronic music system and used to impart new life to existing sounds. In any audio system, the unit is simply interposed between the output of the preamp and the input of the main amplifier, so that the audio signals have to pass through the echo-reverb unit on their way to the main amplifier.

Some modestly-priced echo-reverb units use a crude mechanical spring-line to create the time-delayed echo-reverb and provide only a single, fixed delay time. Commercial (all electronic) echo-reverb units can be rather expensive, but provide fully-variable delay times. Many use clocked CCD (charge-coupled device) analogue ICs to implement the delays (see **How It Works**). The best commercial units use digital techniques to implement the delays, but these are extremely expensive!

We have used the analogue CCD technique to implement the time delays and the Echo-Reverb gives a performance that is at least as good as some commercial units using CCDs. The important thing about our unit, however, is that the design uses some clever techniques to reduce the hardware costs of its circuitry, while at the same time enhancing the overall performance and facilities.

Echo-Reverb

As the audio signals enter the echo-reverb unit they split into two paths which are reunited again near the output of the unit via a built-in-low-distortion audio mixer. One of these paths is a direct link from the input of the echo-reverb to the input of the mixer stage; the other path is via a variable signal-delay network. By varying the signal delay and then the mixture of direct and delayed signals, a variety of interesting effects can be obtained. Here are a few ideas to try:

(1). With equal levels of direct and delayed signals, and a few milliseconds of delay, a 'double-tracking' or 'mini-chorus' effect is obtained. This makes a single input sound like a pair of independent but time-synchronised outputs. Thus, a single violin can be made to sound like a duet and a duet is made to sound like a quartet.

(2) With a reduced level of delayed signal in the mix, and with a delay time of tens of milliseconds, a simple echo effect is obtained. The audio sounds as if it were being played in a softly furnished room where there is a single hard wall or reflective surface, facing the sound source. The apparent size of this room is directly proportional to the milliseconds delay time of the echo unit, and is fully variable up to 50 feet (50 mS delay).

A standard features of most echo units (including ours) is a Reverb facility. This allows a fraction of the output signal from the delay line to be fed back and added to the delay line *input*, so that you end up getting echoes of the echoes of echoes. By using only small amounts of feedback (often called 'Recirculation' or 'Regeneration' on commercial units), you get 'soft' reverb or, by adding lots of feedback you get 'hard' reverb. A variety of impressive effects can be obtained from the reverb facility, as follows:

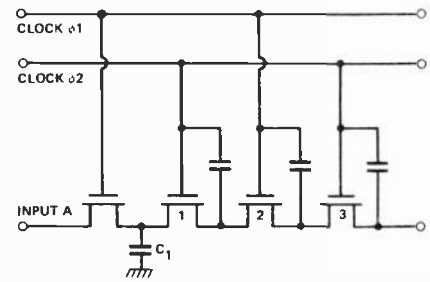
(3) When equal levels of mixing are used with maximum (50 mS) delay and maximum feedback, the sounds seem as if they are being played in a large hard-faced cave or chamber. The apparent dimensions of this 'chamber' can be varied via the delay-time control, while the apparent 'hardness' of the chamber can be varied by altering either the mixing or reverb level controls. Thus, the apparent sounds can be varied from those of a hard cave, to a small church, or down to a large but softly furnished lounge.

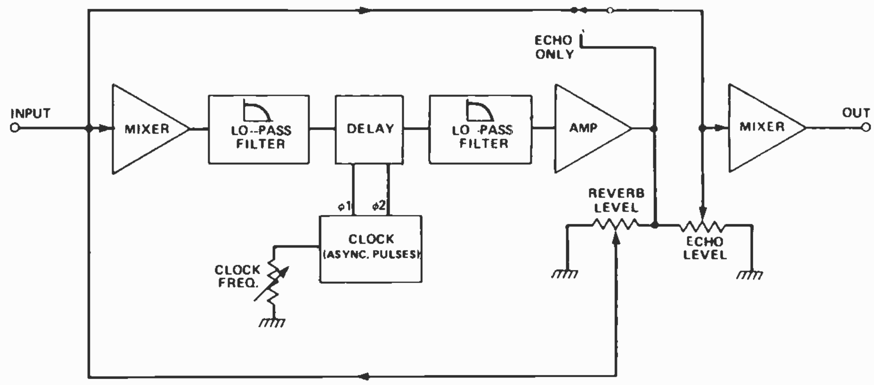
(4) When equal levels of mixing are used with short (a few mS) delays and a

HOW IT WORKS

THE STAGES for producing the various reverb effects from the Echo-Reverb, are shown in the block diagram. The main signal path comes from the ouput of the first mixer and through a 7 kHz low-pass filter. This filter is necessary to limit the audio band width to less than half the clock frequency, because the audio input is being *sampled* at the clock frequency (variable, to change the length of delay), and it is a fundamental principle of sampling that the sampling frequency must be at least twice the maximum input frequency. The filtered signal then passes through the delay line to a second low pass filter (at 15 kHz), which removes any clock signal residuals. This second filter includes a buffer amplifier to give the unit an overall gain of one. The output then splits into two paths; one is sent back to the input, to provide the reverb effect, the other goes to a final mixer via a switch. In the other position, the final mix can be varied from 'straight through' to full reverberation.

The delay circuitry comprises two charge coupled devices (CCD's) with 1024 delay stages. The diagram **right** shows an example of the internal structure of a MOS CCD IC. The principle may be compared to a line fo firemen passing buckets of water from one end to the other — hence the name 'buckets' are capacitors and the 'water' is an electric charge which is proportional to an instantaneous value of the input waveform — a sample. Each sample is stored briefly, then passed on to the next stage at the time of a clock pulse. Although each sample is stored for a very short time, at each stage, the time taken to 'clock' a sample from input to output can be as much as 50mS.





large amount of feedback, all audio signals sound as if they are being played inside a small-diameter hard-faced pipe or drum. The apparent dimensions of the 'pipe' are variable via the time-dealay controls and the apparent hardness of the 'pipe' is variable via the mixing or reverb controls.

The Circuit

The principle of the echo-reverb unit is described in How It Works. Audio signals enter the unit via RV1 and split into two paths which are re-united again, near the output, via a low-distortion audio mixer (IC7). One of these paths is virtually a direct link from the input of the unit (RV1 wiper) to one input of the IC7 mixer, via level control RV4. Thus, by varying the delay time and the setting of RV4, a range of different echo times and characteristics can be added to the original audio signals.

A fraction of the buffered output of the delay line can be tapped on via RV3 and fed back to the input of the delay line via the IC2 mixer stage. This produces echoes of echoes of echoes etc ('regeneration' or 'recirculation'), and is the standard characteristic of a reverb sound. The quality of the sound depends on the setting of RV3 (Reverb) and the delay time.

The delay line is formed by IC3 and IC4, a pair of series-connected TDA 1022 CCD (Charge-Coupled Device) "bucket-brigade" analogue ICs. They are clocked by a two-phase variable frequency oscillator formed by IC5, a 4046B phase-locked-loop chip. The TDA 1022s are 512-stage delay lines, so our circuit uses a total of 1024 CCD stages. The delay time available from these chips is:

$$D = \frac{P}{2} \times S$$

where P is the clock-cycle period and S is the total number of delay stages in the line. Our prototype is set up so that the clock periods are fully variable (via RV2) from a minimum of 2.5 uS (400 kHz) to a maximum of 60 uS (16.6 kHz), thus giving a delay range of 1.28 mS to 30.7 mS. In practice, however, the delay times can be extended to 50 mS by adjusting PR2 to give a maximum clock period of 97.6 uS (10.24 kHz) if some clock-signal breakthrough is acceptable on the output signal (see setting-up instructions, Max Delay Time).

When using CCD delay lines it is important that the clock frequency must be at least *double* the maximum audio signal frequency that will be used. The delay line output signal must be well filtered to cancel residual clock signals and the input to the delay line must be low-pass filtered, to avoid intermodulation problems by ensuring that the maximum input frequency is no higher than half the clock frequency. With these points in mind, the mixer IC2 with R7 and C7 are configured to give a 12

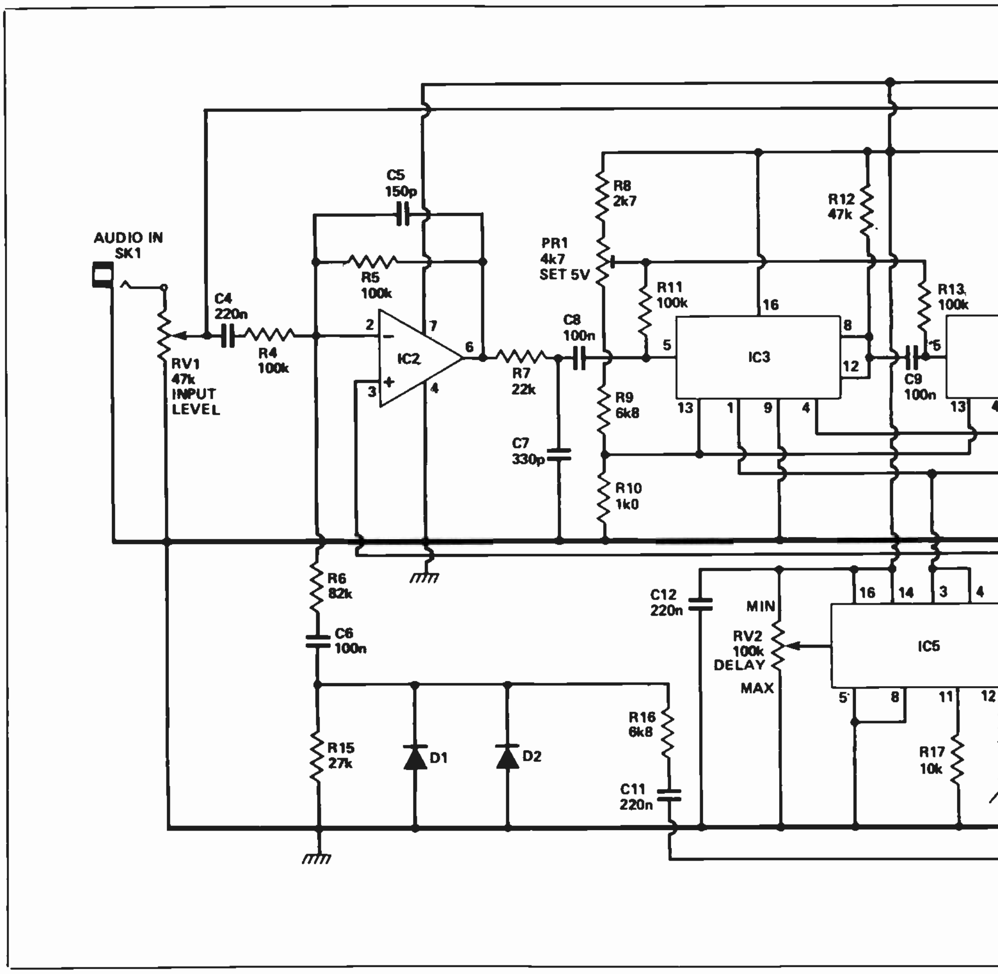


Figure 1. The complete Echo-Reverb circuit.

dB/octave slope, rolling off at 7 kHz at the front of the delay line. IC6 acts as a 12 dB/octave, 15 kHz low-pass filter at the output of the line.

Final points to note about the circuit are that D1 — D2 — R15 — R16 are configured to give a degree of self-limiting on the reverb signals. This protects the delay line against destructive reverb overloads. The entire circuit is powered from a regulated mains-derived 15 volt supply via IC1 **(Figure 3 above).**

Construction

Most of the circuitry for this project is built on a single PCB, and construction should, therefore present very few problems. Before you start, however, a word of warning: the circuit includes a high frequency clock generator which tends to produce a fair amount of RFI (Radio Frequency Interference). Consequently, you should build it into a metal box and take lots of care over RF shielding.

Begin construction by fitting the seven wire links and the PCB-mounting mains transformer. Then proceed with the assembly of the remaining components, taking the usual care to observe component polarities, etc. Use sockets to mount the two delay-line chips (IC3 and IC4) and IC5; handle the chips with care, when fitting them into place.

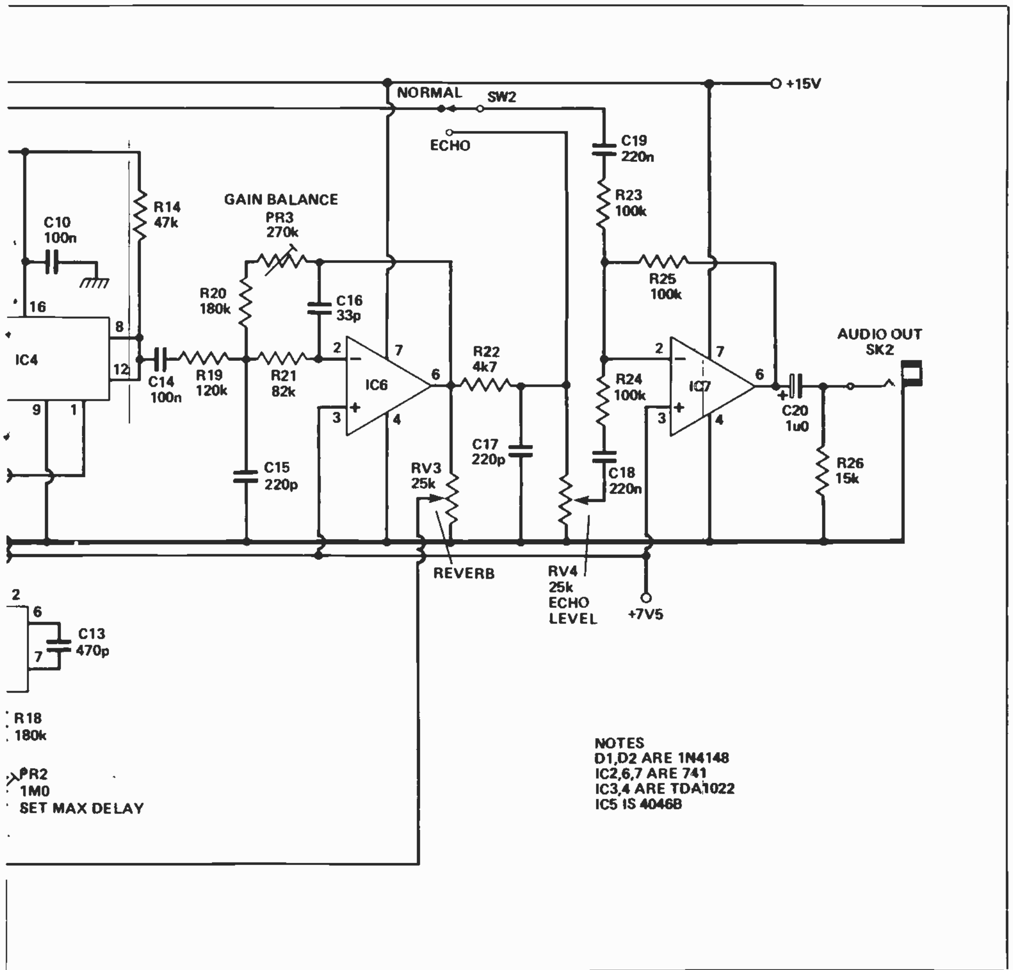
When the PCB is complete, temporarily wire the unit to all control pots, switches and sockets, then set-up the pre-sets.

Setting Up Procedure

The Echo-Reverb unit contains three pre-set pots which must be correctly adjusted to make the unit fit for use; once these have been set correctly initially, they require no further adjustment. The pre-sets (PR1, PR3 and PR2) control the delay line biasing, the delay line loop gain and the maximum delay time, respectively. The settin up procedure is as follows:

Delay Line Biasing: With no input signal present, set all three pre-sets to zero, set SW2 to Echo Only, RV4 (Echo Level) to maximum and RV2 (Delay) to mid value. Connect a DC volt-meter between the + 15 V line (+ ve) and the wiper of PR1 (-ve). Then adjust PR1 for a reading of precisely 5 volts. Remove the meter. Now connect an audio (voice or music) signal to the input and check that it can be played through the unit without excessive audible distortion (i.e., the sound never becomes harsh).

Delay Line Loop Gain: With RV2 (Delay)



via RV2 and the reverb can be varied with RV3.

The setting-up procedure is now complete and the unit can be cased and made ready for use, as already described.

set to mid-range but with RV3 (Reverb) and RV4 (Echo Level) set to zero, connect a voice-range (350 Hz — 3k5 Hz) input signal of about 1 V peak-to-peak and monitor the output signal. Switch SW2 between the Normal and Echo Only positions, adjusting PR3 so that equal output levels are obtained in both positions (this test can be done with test gear or simply 'by ear', using a tape or disc signal source). When this adjustment is complete, set SW2 to the Echo Only position. Pass a music/voice signal through the system and use RV2 to check the Reverb sound is satisfactory.

Max Delay Time: Set SW2 to Normal, RV3 (Reverb) to zero, RV4 (Echo Level) to maximum (wiper at zero volts). Adjust PR2 while monitoring the output of the unit and note that high-pitched tone (whistle) is produced when PR2 is turned beyond a certain point. Now pass a voice signal through the unit; note that the echo effect is obtained, then trim PR2 to find a compromise setting at which a good delay (echo) is obtained with minimum acceptable intrusion from the 'whistle' sound. Finally, check that the delay can be varied over a wide range (roughly 2 mS to 50 mS)

PARTS LIST

RESISTORS
(all ¼ W 5% carbon)

R1	1k5
R2, 3	1k2
R4, 5, 11, 13, 23, 24, 25	100k
R6, 21	82k
R7	22k
R8	2k7
R9 16	6k8
R10	1k0
R12, 14	47k
R15	27k
R17	10k
R18, 20	180k
R19	120k
R22	4k7
R26	15k

POTENTIOMETERS

RV1	47 linear carbon
RV2	100k linear carbon
RV3, 4	22k linear carbon
PR1	4k 7 miniature pre-set
PR2	1MO miniature pre-set
PR3	220k miniature pre-set

CAPACITORS

C1	1000u 40V electrolytic (axial)
C2	10u 35v tantalum
C3	680n polycarbonate
C4, 11, 12, 18, 19	220n polycarbonate
C5	150p ceramic
C6, 9, 14	100n
C7	330p polystyrene
C8, 10	100n polyester C280
C13	470p ceramic
C15, 17	220p ceramic
C16	33p ceramic
C20	1uO 35V tantalum

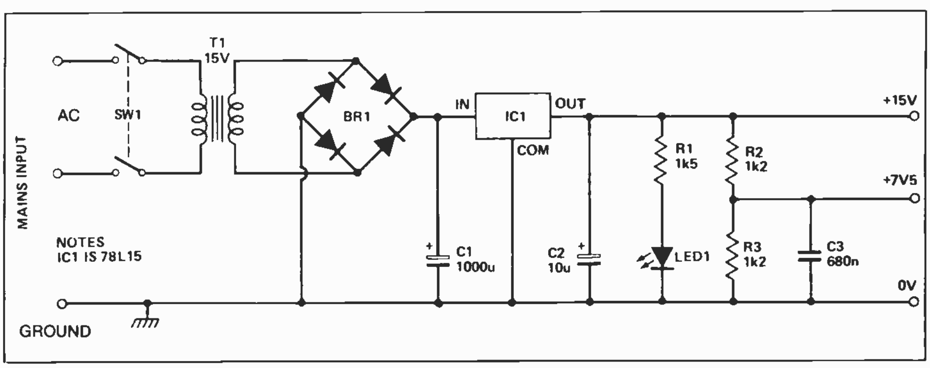
SEMICONDUCTORS

IC1	78L 15 voltage regulator
IC2, 6, 7	741 op-amp
IC3, 4	TDA1022 (Signetics) or DAC1022 (National) or TMS1022 (T1)
IC5	4046B CMOS phase locked loop
BR1	50V 1A bridge rectifier
D1, 2	1N4148 signal diode

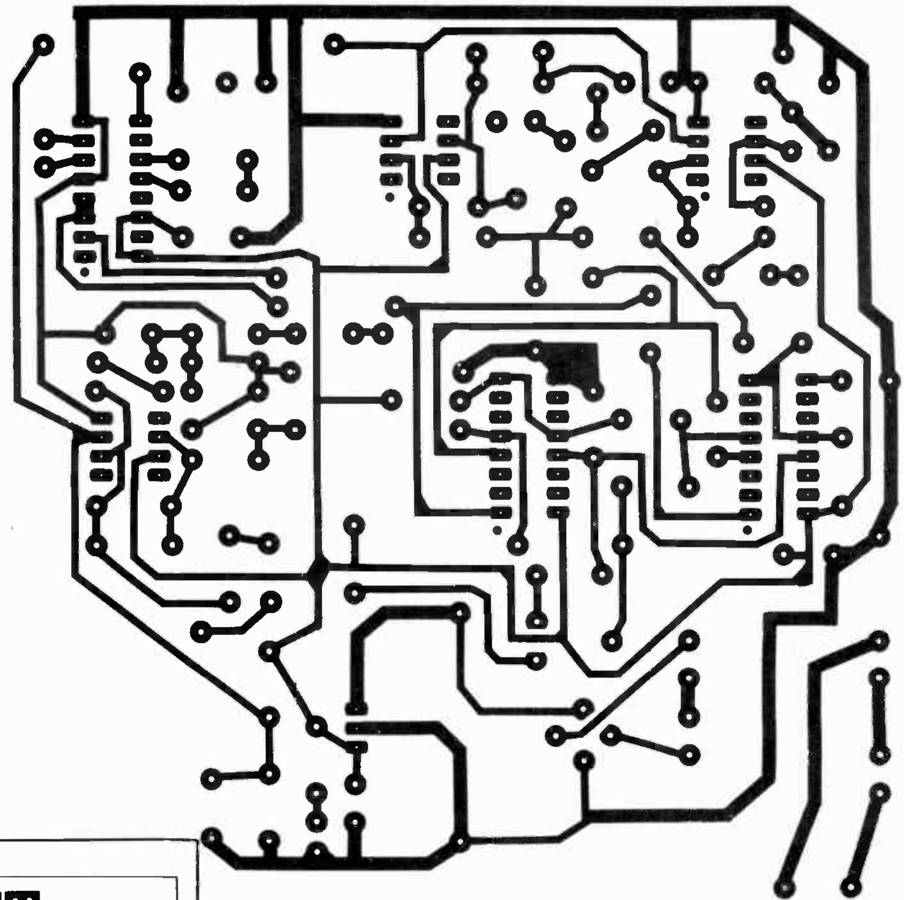
MISCELLANEOUS

T1	15 volt, 200 or 300 MA transformer
SWI	DPDT miniature rocker switch
SW2	SPDT miniature toggle switch
Sk1, 2	Phono Sockets

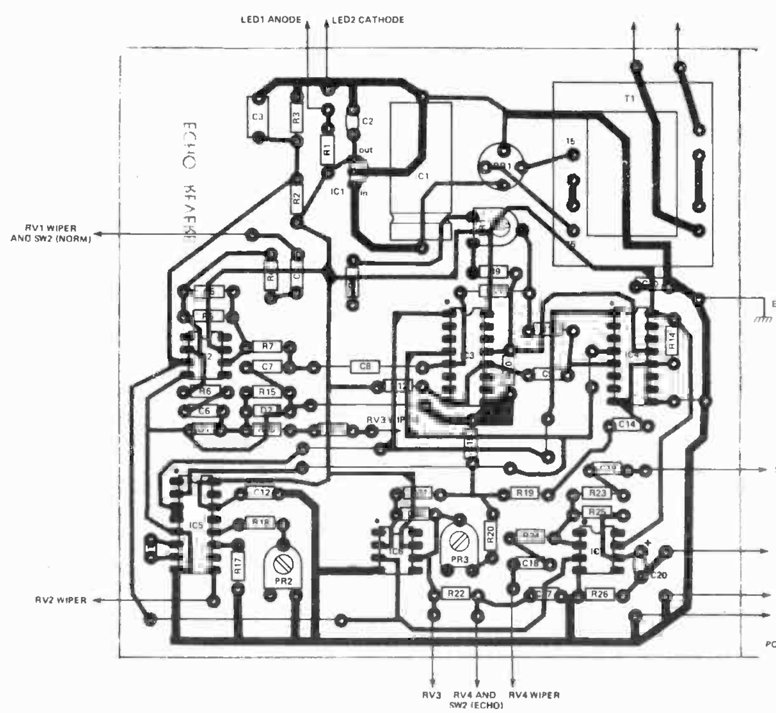
Case, PCB, bolts, knobs etc.



Circuit diagram of the regulated power supply.



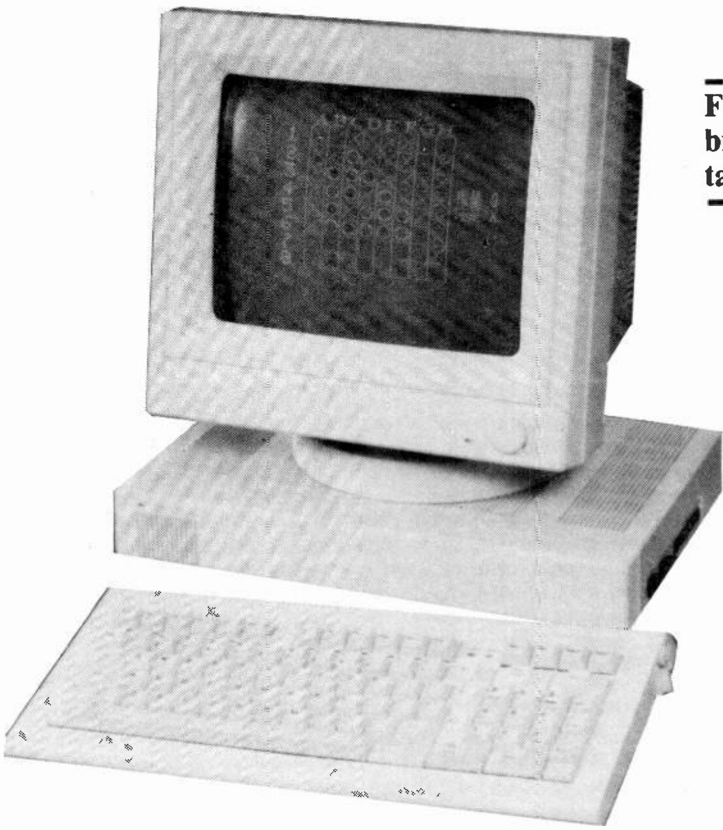
The printed circuit board.



The component location diagram. Transformer T1 may have to be located off the PCB and wires connected to the points labelled "15".

ETI

Multitech MPF-III



Fresh from the clone orchards in Taiwan, we bring you the MPF-III. Anthony DeBoer takes a look at the latest in imported fruit.

LOOK AT that keyboard, will you? Looks like we're reviewing another IBM compatible this month... Well, let's turn it on. Uh, sorry folks, it's an Apple clone. Well, I was close.

What we have here is the Multitech Micro-Professor III, Multitech's latest entry into the computing market, and quite a different machine from the MPF-1, that cute little bare-board computer that you may have seen. No, this time the good folks in Taiwan have brought you a full-sized micro, and a significant contender in the works--just-like-you-know-who market.

The Hard Facts

The main, essential part of the Multitech is a box-shaped box (well, they usually are, aren't they?) only about two and a half inches tall. Inside lurks most of the electronics. The keyboard is detachable, linked by a coiled cord. The Multitech video monitor sits on top or nearby or generally wherever you put it.

The Multitech doesn't really use real Apple peripheral cards. An 80-column card is built in, along with 64k of RAM, and Multitech offers specially-designed printer, serial, disk, and Z-80 cards to fit inside the low-profile case. Some of the literature also pictured a pair of slimline drives mounted in a box the same size as the main unit, although the disk connectors are standard and regular drives will also work with this computer.

Slot #2 is set up in the normal configuration, so you can plug in one normal card if you want to, but it sticks out of the right side of the machine, and, without proper support, looks like all it would take to snap it off in its socket is for the cat to pounce on it.

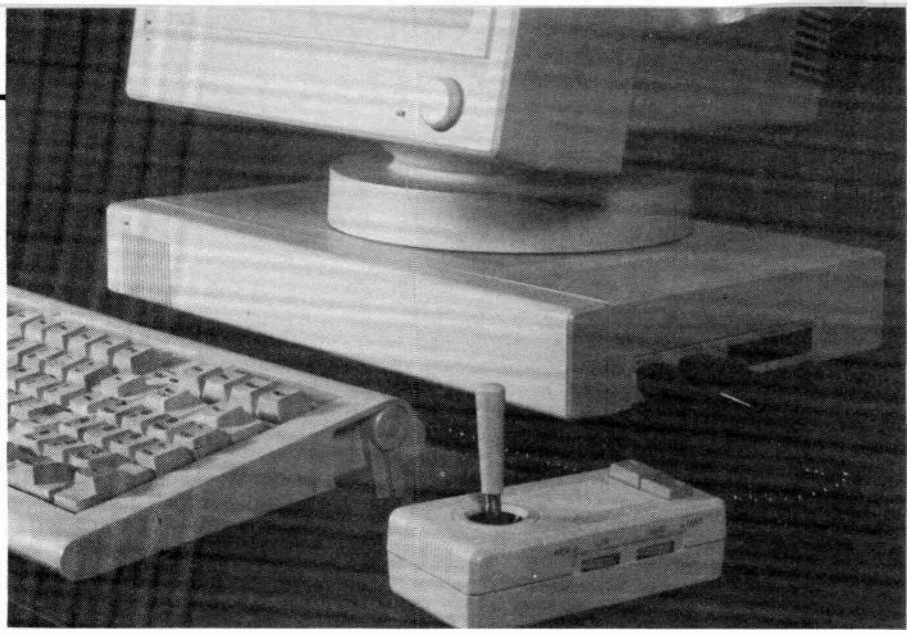
Next to the peripheral slot, on the right side of the machine, are a pair of nine-pin connectors for the keyboard and the joystick. Around back are the power cord, power switch, video connectors (TV and monitor), volume control (which needs a screwdriver, if you find it too loud), connectors for an external speaker, printer, disk drives, and the vestigial cassette in and out plugs.

The 80-column generator in the Multitech deserves mention. It's a treat for anyone who's ever had to stand up repeatedly to reach behind his or her computer to switch patch cords between the 40-column output and a normal 80-column card. Being built right in, the 80-column screen becomes much more integrated into how things work in and about the computer. Type PR#3 and the 80-column screen gets activated. ESC-4 and ESC-8 will switch you back and forth now. As with the iIe, you can go straight into graphics from 80-column, with the text window at the bottom of the screen still in 80 columns, which is something the good old Apple II never did.

There is one slight weirdness with the 80-column screen: you can't use it and the second graphics page at the same time. If you're in 80 columns and you run a program with a statement like HGR2 (or even POKE 49237,0) that accesses the second screen, for animation or whatever, you get a ?SYNTAX ERROR, of all things. Okay, so the manual does note that you only get one screen with 80 columns, but the first time you run up against that syntax error, it's guaranteed to send you around the bend trying to figure out what went wrong.

The keyboard should also be mentioned. To quote John, the office clone connoisseur, the keys are "like loose teeth". To be perfectly frank, they do jiggle and wiggle and go in a lot more directions than just up and down. The IBM-like design, with the backslash key where the shift key is supposed to go and the reverse-quote where the return key belongs, doesn't help either. At least they replaced that huge plus key at the right end with a smaller plus key and a return key.

The Multitech keyboard has twelve function keys, along with a break key (which gives out a control-C), a numeric keypad, and a few others. Unlike the original Apple, this one can generate the entire ASCII character set, including the tilde and the vertical-bar symbols. Like on the IBM, the keypad can also be used for cursor functions when you're editing program lines.



But it's still a bubblegum keyboard.

The Multitech video monitor is a fairly good piece of equipment, as such things go. The display is glare-free, and a duller shade of green than the Zenith monitors that everyone else seems to use. It sits on a nice round base, and will rotate and tilt as desired.

Multitechsoft?

In an almost commendable attempt not to violate any of Apple's copyrights, the folks at Multitech have rewritten Applesoft BASIC and the system monitor from the ground up. Part of this is good, because it lets them integrate the 80-column screen, the sound generator, and so on, but it does leave the system necessarily less than 100% Apple-compatible.

The big added feature in Multitech BASIC is sound. First off, you get the EFFECT command. Type EFFECT 0 : EFFECT 1 on a normal Apple and you get a syntax error. Try it here and you get the sound of a bomb dropping (or of all the air being squeezed out of a cat, your choice) followed by an explosion (presumably of the bomb or the cat, as the case may be). The other effects, 2 and 3, are supposed to be laser guns and ordinary mechanical machine guns respectively.

In case your musical tastes run more to real music than to sound effects, the Multitech also gives you something more melodic. The SOUND, PLAY, BASS, TEMPO, and INSTR statements let you feed songs through the computer's sound chip. SOUND and PLAY let you feed notes into the sound system, BASS lets you add a bit of bass (the results are suspiciously like those of the rhythm sections of those anyone-can-play-it electronic organs), TEMPO lets you adjust the note duration, and INSTR lets you choose between simulated piano, bell, xylophone, or organ.

The machine even has a rich, full-bodied control-G bleep that sounds like it comes through the computer's sound system as well.

Program editing changes here too. On the real Apple, you have to fool around with the I, J, K, and M keys to move around the screen. Here, however, with the IBM-style keyboard, there's a "NUM LOCK" key that lets the numeric keypad become cursor arrow keys and so on. What really makes editing program lines here easy are a few of the other keys here — an insert character key slides the rest of the line over to the right, making insertions less of a splice job than they used to be, a delete key does the opposite, and another key copies automatically to the end of the statement you're editing. Editing works in the 80-column mode only, which is not really a hassle, because given the choice, you'll probably want to use the 80-column screen to do programming on anyway.

Battle of the Clones

On the less bright side, this rewritten BASIC is slower than good old Applesoft. Two sample programs were run. The first simply counted from one to ten thousand, to test the speed of BASIC, and the second spat out four K of text to the screen. Both times, a more conventional clone (the Unitron) beat the Multitech.

The random number generator is probably the worst feature of this version of Applesoft. The "real" random generator generates a properly pseudo-random sequence of numbers, but the Multitech's generates a much poorer sequence. It repeats itself every few hundred times. This may not sound like much, but try running an Applesoft program, almost any program, that runs along and uses random numbers by the bushelfull. On a real Apple, or a blatant clone thereof, you get sufficiently random numbers, but the Multitech gives a repeating series. The practical upshot of this is that a program that draws random lines, for example, will start doing the same lines over and over and lock itself into a loop, rather than continuing to draw lines all over until the screen is full.

This rewritten version of Applesoft does bring up an interesting point: that of the legal battles surrounding the various clones on the market. Franklin lost a court case a while back, and now has to rewrite its BASIC and monitor and stop illegally copying Apple's. After winning that case and setting a legal precedent, Apple will probably now go after the smaller cloners.

Multitech seems to have seen this coming a while back already, though, and they already have a rewritten system. According to some of the documentation that came with the review machine, Apple is suing Multitech too, but Multitech is claiming that Apple has no case because all the software got rewritten.

But then Shakespeare noted quite a while back that a rose by any other name would smell as sweet. If it looks very much like an Apple and it smells very much like an Apple, then it is an Apple for most practical purposes (except, Multitech hopes, for legal purposes). On the other hand, all that glitters is not gold, and all that runs DOS might not necessarily be an Apple. 'Twill be interesting to see what comes of it.

CP/M?

Somewhere along the line an ETI tradition got started that we would use the name of the CP/M operating system as a sub-head once in every computer review. Well, here's this month's entry.

The Multitech's manufacturers, as one might expect, claim that it runs CP/M. Being an Apple-compatible machine, using a 6502 microprocessor, the Multitech, like the True Fruit, requires a Z-80 card before it will peacefully accept CP/M disks. As noted previously, Multitech offers a special card that fits inside their machine's case, but they do claim that a normal card will work in the slot on the side of the machine.

Among the documentation we got with the machine was a list of 151 pieces of popular Apple software that the Multitech would run and 19 that it wouldn't. Lots of CP/M software was on the first list and SpellStar somehow made the second one, but the fine print noted that they used their own Z-80 card (the one that fits inside the machine) for the tests. Since our review model didn't have this option, we tried a good old regular-type Z-80 card in the external slot. No dice. Fed a CP/M disk, the Multitech crashed like a ZX-81 flung off the CN Tower. It sprayed characters all over the screen and everything.

continued on page 22

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Almost as an afterthought, it must be mentioned that CP/M is not the only operating system the Multitech can run. There's something called DOS, too, that is actually designed to run on computers such as this one. Standard Apple DOS runs quite nicely on the Multitech, although there's a special Multitech DOS, in keeping with the rewritten BASIC and monitor. According to the docs, the big difference is that the function keys across the top of the keyboard become words like CATALOG and so on when you're running their DOS. Unfortunately, the review copy came on an unbootable disk (a hasty copy by the good folks that lent us the computer), so we had to settle for looking at the files, after booting normal DOS. There were the usual graphics demos, a sound demo, something similar to FID except for being written in BASIC, just the usual boring stuff, but to make up for it, there was a Chinese version of the board game Othello. Fun stuff, the prompts come up in genuine high-res Chinese letters, but unfortunately no one here reads Chinese. Well, now we know the Chinese for "It's your move, sucker". You learn something new every day.

Manual Labour

The manuals that came with the computer did the job they were supposed to. Well, they explained what the computer could do and how to get it to do it. They were written in Foreign Technical Manual English, a variant on the Queen's English in which quaint wordings and aleatoric spellings are used. Such manuals should, of course, be kept away from elderly English professors, in whom they are likely to cause coronaries. But if you're willing to forgive the style, they are as helpful as computer manuals ever are. The reasonably detailed tables of contents make up for the utter lack of an index, although it would still be nice to have one. They, like most other computer manuals, are not designed to teach you how to program — prior knowledge seems to be assumed — but they do cover the BASIC language and the computer itself quite well.

Conclusions

Being priced in the vicinity of $1300, the Multitech is somewhere in between the Real Apple and its other competitors. Although the extra features — the integrated 80-column software, the editing functions, the sound effects generator, and so on — are worth something, this computer may suffer from being in the middle of the market. Anyone wanting a computer and not wanting to pay very much will probably want a cheaper clone, and those computer connoiseurs who want the Real Thing will probably go those extra hundreds for an authentic //e.

The differences between this machine and the one Woz designed might also tip the balance in favour of either an Apple or one of the ones that feel no shame in copying it. As noted earlier, there are some subtle differences between the Apple system and Multitech's that will confuse a few pieces of software. In the vast majority of cases, there will be no problem, but those few cases where there is a problem will, according to Murphy's Law, inevitably crop up.

The final caveat that must be raised, as with all computers, is to try out the keyboard before trying out your Visa limit. That's where the interface between man and machine happens, and if you can't stand it, you won't be able to stand the rest of the computer very well either. IBM lovers will probably enjoy it, but the rest of humanity might not.

But it is still a respectable example of Far Eastern ingenuity. If you're looking for an Apple-compatible system with a few extra features, this might be the one for you.

Quick Reference

Multitech MPF-III

Mfg:	Multitech Industrial Corp.
Price:	$1300
CPU:	6502
RAM:	64k
Screen:	40x24, 80x24
Graphics:	280x192
Colour:	Yes
Sound:	Yes
Video:	TV and monitor

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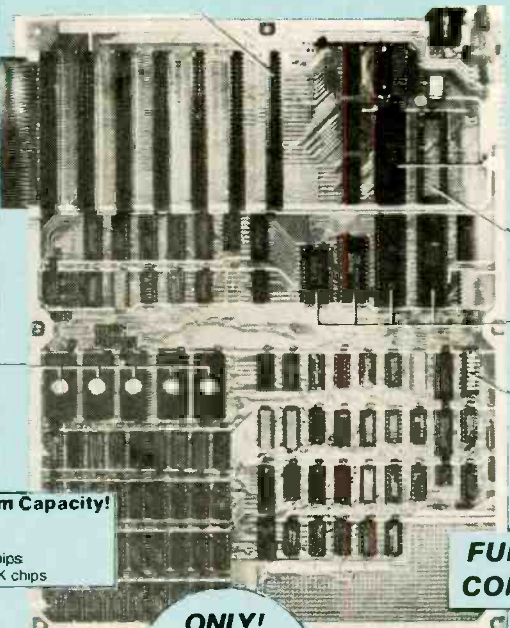

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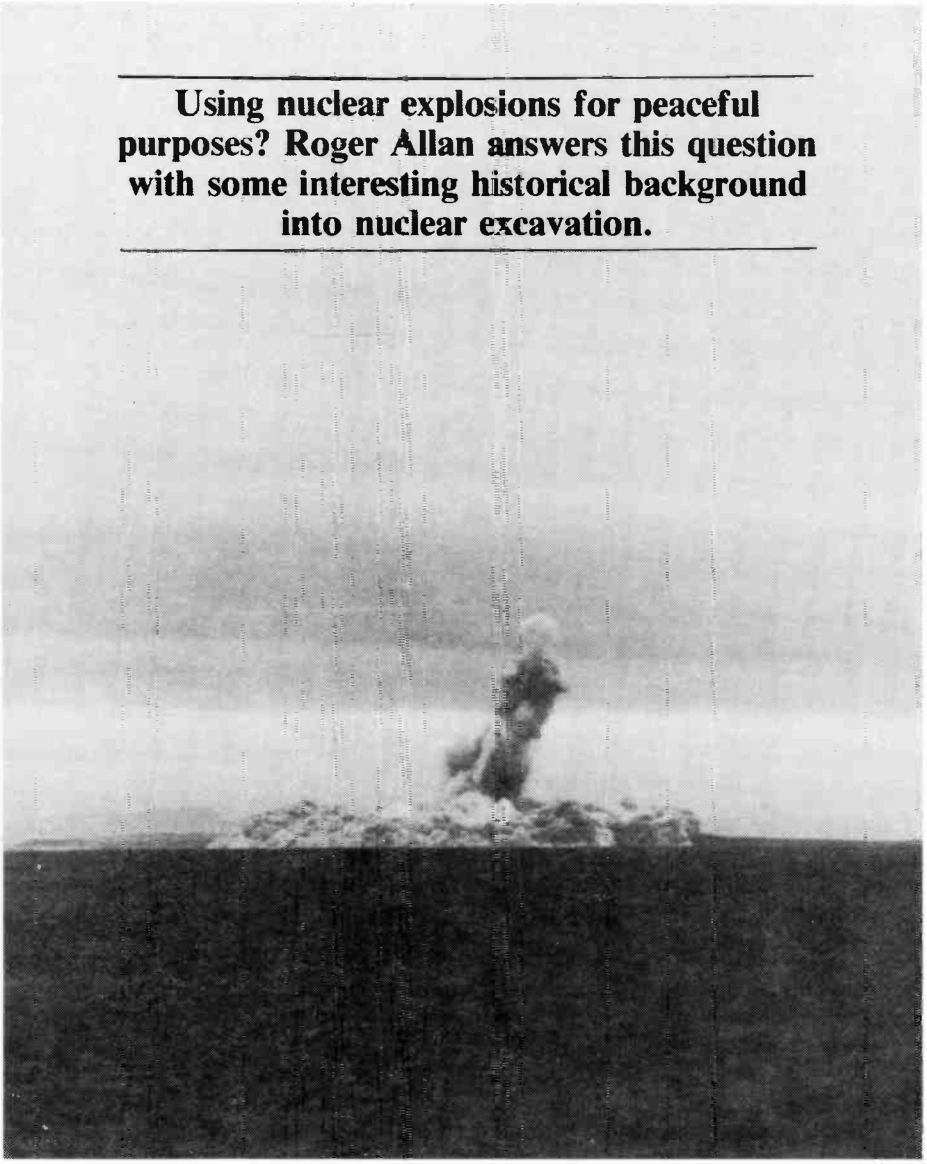

Using nuclear explosions for peaceful purposes? Roger Allan answers this question with some interesting historical background into nuclear excavation.

DESPITE THE enormous destructive forces that chemical explosives have added to the conduct of wars, it can be arguably demonstrated that explosives have been used for more good than evil. If one thinks about it for a moment, one finds that explosions of one variety or another permeate our entire lives — whether massively such as the construction of the Panama, Erie, Corinth or Suez canals, or microscopically such as the explosions in a cylinder head driving a car's piston engine.

Recognizing the advantages of explosions, coupled with the Suez Crisis in 1956, led Harold Brown, then director of the Lawrence Livermore Radiation Laboratory, to consider the possibility of using nuclear explosions to dig a sea-level canal across Israel, as well as one across the root of the Florida Penninsula. In the same year, Camille Rougeron, a French engineer, published his book *Les Applications de L'Explosion Thermonucleaire* a study on the peaceful applications of nuclear explosives.

Conjointly, their arguments were persuasive. The advent of the nuclear age, and U.S. testing of thermonuclear devices for military applications meant that sufficient data had been generated to permit economic feasibility studies to be cast. The figures produced seemed rather good — earth could be excavated for a few cents per cubic yard in some projects where conventional methods would cost 20¢ to $5 per cubic yard.

In the early part of the following year, a meeting of interested parties from the American Atomic Energy Commission (AEC) was convened to study the possibility of using thermonuclear devices for peaceful purposes. The *Proceedings* of this meeting, and subsequent ones, roughly at two year intervals, demonstrated that a number of avenues lay open to research and development, all at apparently cost effective prices.

The first consideration was for another Panama Canal, later known as the Isthmian Project. It was shown that using nuclear devices to do the cratering would result in a canal larger than the current one, not dependent on locks (they'd just blast through the mountains), would be more useful, require less maintenance, and militarily less vulnerable. If the route were between Sasardi and Marti in Panama (half way between the current canal and the Columbian border) its cost would be about $650 million (U.S./1964), while a canal between Atrato and Truando (fluctuating around the Panama-Columbian border) would cost about $1.25 billion (U.S./1964).

Another concern was for petroleum recovery. In particular, the Athabaska Tar Sands formation underlying 16,000 square miles of Alberta was investigated by the Richfield Oil Company in this regard. Calculations indicated that a 9-kiloton nuclear explosion would release enough heat so that several hundred thousand barrels of oil would be recoverable in a free-flowing state. Mining was also considered, with particular regard to the removal of overburden to prepare ore bodies either for mining by conventional methods or by the leaching-in-place of minerals — such as copper ore by sulphuric acid.

Studies by the U.S. Bureau of Mines showed that gas fields, from which little or no gas can be produced due to the low permeability of the host rock, could be 'freed up' by thermonuclear explosions. Essentially, the detonation would fracture large volumes of rock to the extent that economic recovery of gas might be possible.

In North Africa there are two massive depressions — the 8,000 square mile Qattar in west Egypt (only 35 miles

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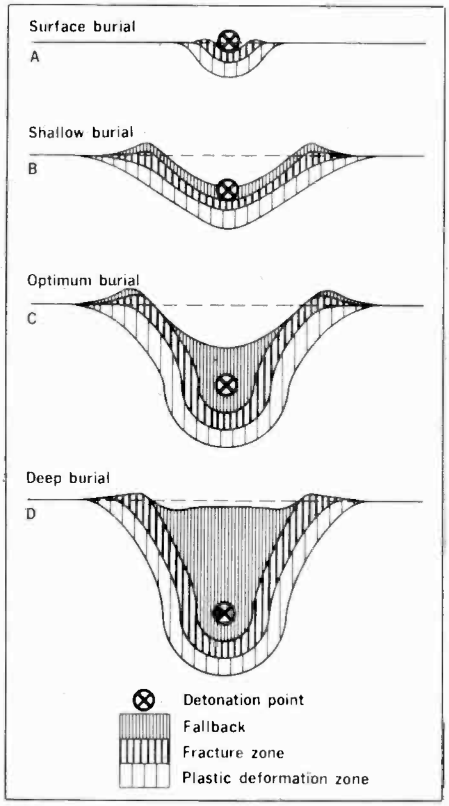
from the sea), and the 50,000 square mile Chotts Depression whose northern edge is just 20 miles from the Tunisian coast. It was thought that by creating large channels between the Mediterranean Sea and those depressions, that the inflow could power large hydroelectric stations. Natural evaporation from the new inland seas would reduce their level rapidly enough to assure a continuous inflow from the sea for many years.

Portions of Africa, Australia and South America have the reality of large mineral deposits located near the sea, but a coastline without harbours. It was felt that nuclear explosions would permit the cheap construction of harbours and thereby decrease the shipment costs of the minerals.

In the realm of water supply and its control and conservation, nuclear explosions were suggested to alter watersheds, interconnect aquifers, create or eliminate connections between surface and underground water supplies and where evaporation loss is high, create underground reservoirs.

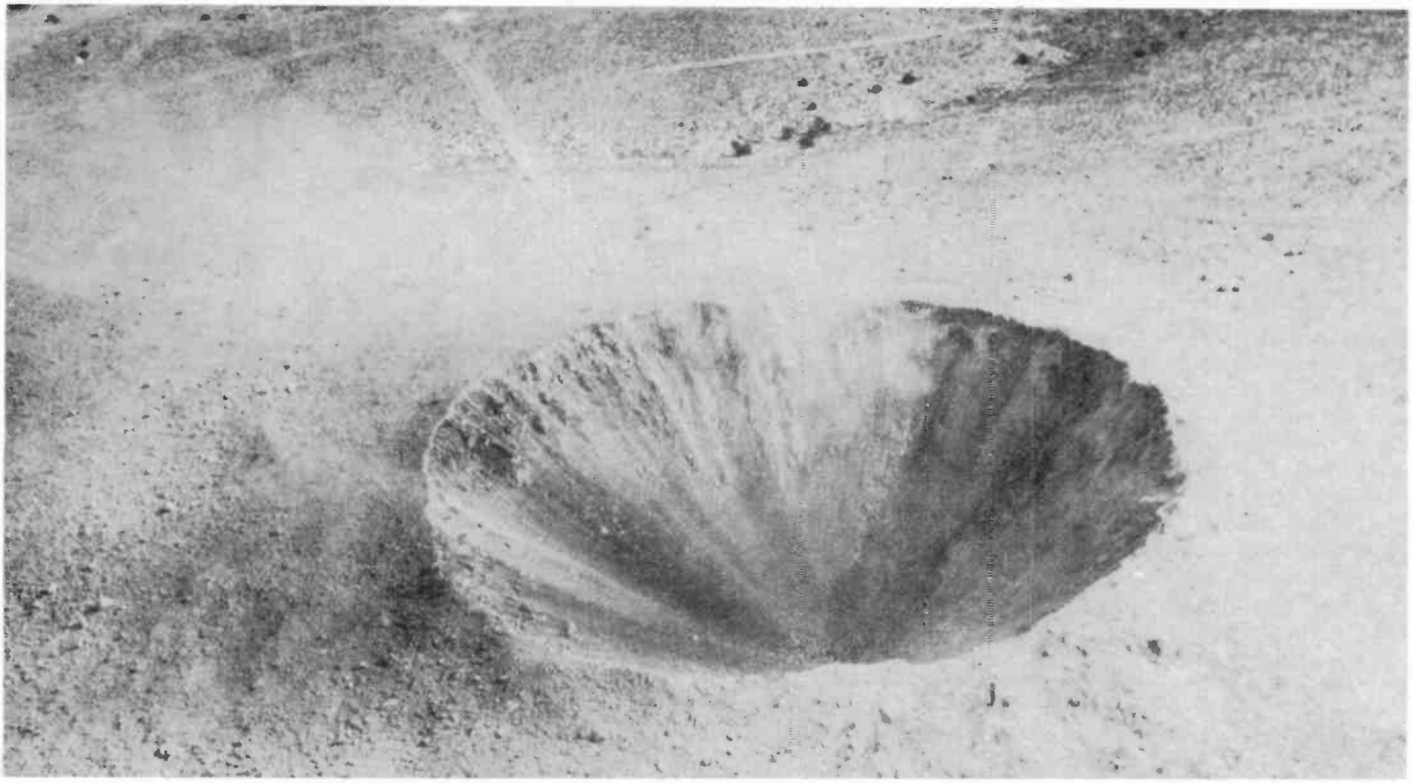
Relatively minor uses were suggested to bring down canyon walls to form dams, to aid in releasing natural geothermal heat to produce steam for desalting sea water or electric power, and for the *in situ* synthesis of chemicals in the ground — for example, calcium carbide might be produced from an explosion in a formation of coal and limestone, then by adding water, acetylene gas could be made.



In cratering explosions, the depth at which the explosion occurs is important. If it is too close to the surface (B), much of the energy escapes into the air and only a shallow crater results. If it is too deep (D), much rock is shattered and moved, but most of it fails to clear the crater rim and again only a shallow crater results.

With possibilities such as these, and recognizing that by the heady standards of the day, nuclear explosions were considered largely acceptable by both the government and general populace, the AEC in 1957 established *Operation Plowshare*. Composed of elements from the AEC's Division of Peaceful Nuclear Explosives, the Lawrence Livermore Laboratory and the Nuclear Cratering Group of the Army Corps of Engineers, *Plowshare* was to undertake the study of how 'best' nuclear explosions could be adapted to civilian purposes.

Although no nuclear test, designed specifically for *Plowshare* purposes, had been conducted by the time the U.S. voluntarily began a nuclear test moratorium in late 1958, more than 150 nuclear explosions of all types — atmospheric, surface and underground — had occurred prior to that time. They provided a data base of information for the *Plowshare* scientists. Analysis of data from these tests yielded information on such phenomena as cavity formation, diminuation of earth motion with distance, heat transfer to the surrounding materials, rock fracturing and containment of radioactivity. To help fill in the blanks, while fulfilling the U.S. obligations under the moratorium, between 1958 and 1961, the AEC conducted experiments with high explosives. More than 100 charges, ranging in size from 256 to 1,000,000 lbs. were set off at the AEC Nevada Test Site. One of the oddest things determined from these explosions,



The result of Project Cabriolet. A low-yield nuclear excavation experimental blast on January 26, 1968 produced this crater 125 feet deep and 400 feet in diameter. Photo courtesy of U.S. Department of Energy.

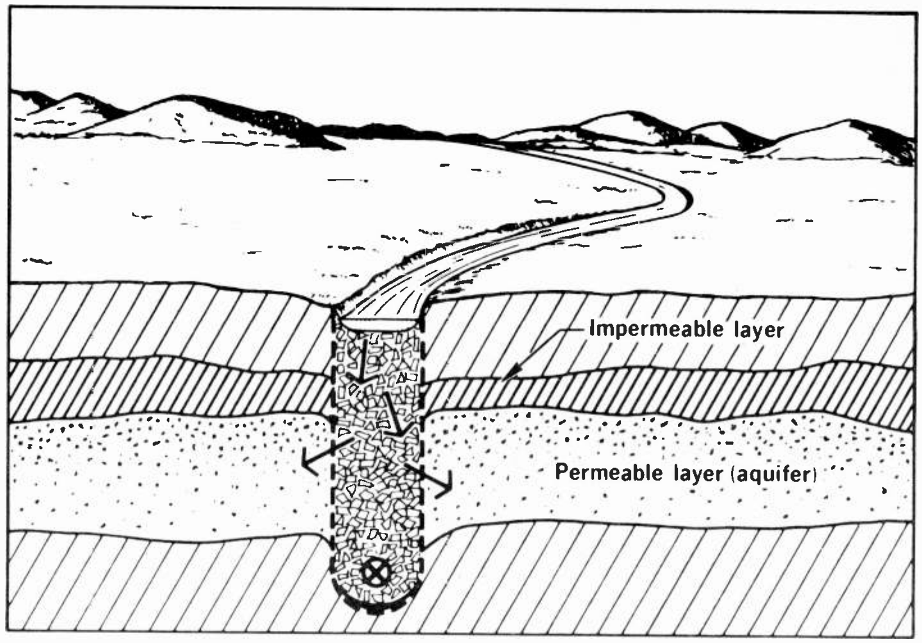
and subsequently verified when nuclear devices were used, was that when a number of charges are placed in a row and detonated simultaneously, an elongated ditch is formed with the usual 'lip' of thrown-out material along the sides, but little or none at the ends — creating, essentially, a perfect canal.

On December 10, 1961, following the end of the nuclear test moratorium, *Plowshare* became more active. A nuclear explosion with a yield of 3.1 kilotons was detonated in a salt formation 1,200 feet beneath the earth's surface at Carlsbad, New Mexico. Known as *Project Gnome,* the explosion produced an enormous cavity (134 by 196 by 75 feet), involving some 960,000 cubic feet of rock and melted salt. The purpose of the experiment was to study the possibility of recovering heat deposited in the salt formation by the explosion. The idea was the water would be pumped into the hot cavity after the explosion and the quality of the resulting steam measured. The experiment was a failure, as the heat was dispersed into a greater volume of rock than had been anticipated, and the heat recovery was not appreciable. Further, follow-up studies demonstrated that if steam had been produced, it would have been very salty and hence highly corrosive.

The following year, in July, *Project Sedan* was undertaken. This explosion involved a 100 kiloton cratering experiment. It was planned as the first of a series of thermonuclear explosions to develop techniques of nuclear excavation and to extend knowledge of cratering effects from explosions into the 100 kiloton range. The problem was that smaller explosions cannot necessarily be scaled up by bigger explosions. The explosion resulted in a crater some 1,200 feet in diameter and 320 feet deep, with a volume of some 6.5 million cubic yards — about the size of a small harbour.

In February of 1962, the AEC conducted the *Hardhat* experiment — the first attempt to provide information on the use of nuclear explosives to break and crush mineral deposits preparatory to extracting the ore by conventional techniques. It involved a 4.5 kiloton explosion at 950 feet. Following the detonation, a horizontal tunnel was driven through the rubble filled chimney and some 2,700 tons of broken rock were withdrawn in a simulated mining operation. Apparently, no hazardous amounts of radioactivity were encountered.

By 1964, the AEC had reached the point of being able to release a policy statement and project charges for *Plowshare* thermonuclear explosives for use by industry in conducting studies of economic and technical feasibility. For $350,000 (U.S./1964), one could purchase a bomb of 10 kilotons, and for a mere

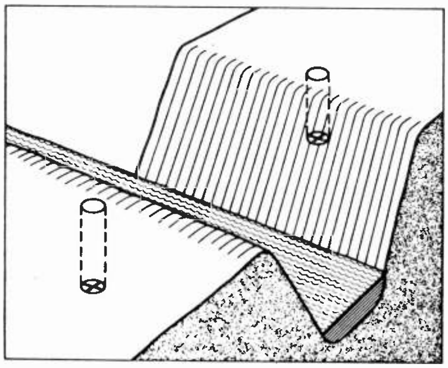


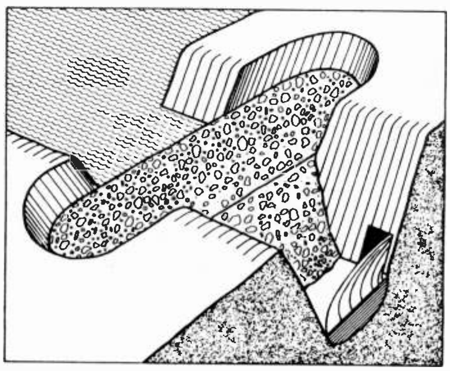
A nuclear explosion might be used to break through a barrier to permit run-off water to be used to recharge underground aquifers.

$600,000 (U.S./1964) one could obtain one's very own 2 megaton bomb. Concurrent with this policy statement and fee schedule, the U.S.S.R. announced that they too had a similar program, though they called it the "Nuclear Explosives for the National Economy" project. Bilateral talks immediately ensued, with the swapping of technical data, etc.

It is not the purpose of this article to dissect the entrails of *Plowshare* over its 16-year lifespan. But a few points are in order. There were some 40 plus tests, in-

dry rock and study the dispersion pattern of airborn radionucleotides under these conditions." It apparently was a success. The "Classified" test, at least according to what little information is available (nobody at the Department of Energy — the AEC's descendant — is talking much — apparently there was a liberal use of the 'Secret' rubber stamp all over everything), was a device which ranged somewhere between 20 and 200 kilotons. Known as *Project Flask*, it was detonated in May of 1970 to meet the "objective of improving





Mountain sides might be collapsed into valleys to make dams, with properly planned nuclear explosions.

volving thermonuclear devices and nitromethane compositions. They came under a variety of names — *Planquin, Pre-Schooner, Cabriolet, Simms, Switch,* et., with all of the explosions taking place at the AEC's Nevada Test Site.

The thermonuclear devices ranged from an 85 ton yield to "Classified." The 85 ton one was known as Project Sulky and detonated in December of 1964. It was designed to meet the "objective of exploring the cratering mechanics in hard,

nuclear explosives for excavation purposes." Most of the thermonuclear explosions detonated in the later 60s and early 70s are simply listed as having a 'low' or 'medium' yield — probably in the order of 2 to 5 kilotons.

As for the major, most economically viable (or at least so it seemed initially) project, the Isthmian Project, it quitely died. The Atlantic-Pacific Interoceanic Canal Study Commission presented its final report later in 1970 and stated that:

"although we are confident that some day nuclear explosions will be used in a wide variety of massive earth-moving projects, no current decision on U.S. canal policy should be made in the expectation that nuclear excavation technology will be available for canal construction." The report further recommended that: "the U.S. pursue development of the nuclear excavation technology but not postpone Isthmian Canal policy decisions because of the possible establishment of feasibility of nuclear excavation at some later date." In other words, it was a dead duck.

As for *Plowshare* itself, according to Prentice Dean, Historian at the Department of Energy, it wound down fairly quickly in the early 1970s. First came the *National Environmental Quality Act* of 1970 which put strings on the use of nuclear devices of all sorts. Then, due to inflation, it was found that the AEC couldn't really offer anything that was cost effective, within the parameters of the above Act. Environmental concerns by the general public and many in government with respect to nuclear devices, meant that proposed projects were increasingly greeted with scepticism. The death blow, if a single point in time must be elucidated, came in 1973 with a project to use thermonuclear devices for gas stimulation. The gas field was stimulated all right, but it also was highly radioactive.

To date, there has been no further research in the peaceful applications of thermonuclear devices, though the military, with its Nuclear Cratering Group continued studies of a miliary nature, the data from which can be applied to civilian cratering operations. The point being, that with the increasing loss of water for the central U.S. agricultural heartland — its aquifer is drying out rapidly due to prolonged misuse — and large scale diversion projects under study — how to bring water down from Canada — coupled with the viciously high costs of such projects using conventional methods — the prospect arises of using such devices to 'move the dirt' as it were. While it is extremely unlikely that such a project could get past the environmentalists and government lobby groups, the data exists to demonstrate that it can be done and how to do it.

ETI

A cannister containing the 26-kliloton explosive for Project Gasbuggy is lowered to a depth of 4240 feet and covered to within 50 feet of the surface with cement. Gasbuggy was an effort to determine the feasibility of recovering natural gas using nuclear explosive techniques. Photo courtesy of U.S. Department of Energy.

ELECTRONICS TODAY BOOKSHELF Page 57

Modem Auto-Answer

PROJECT

Auto-Tector. An auto-answer add-on for your Modem.

By K. Willmott

THE AUTO-TECTOR is a general purpose telephone line interface that is a capable of operating with any device that normally connects to the phone line such as a dumb modem, or any other limited feature modem. It's purpose is to detect an incoming ring signal on the line and connect the device on its equipment jack to the line until either the device or the calling party hangs up.

This is useful when a computer is operated remotely, with timesharing or bulletin board systems for example. With some additional logic, it could also function as the front end for a voice type answering machine.

When its digital interface is connected to a computer, the unit is also capable of auto-dialing and delayed answer modes. A status output informs the computer of when an off-hook is presented to the line; unfiltered pulses are brought out also so that the answer mode may be over-ridden.

All connections to the phone line are electrically isolated from the timing circuit and computer interface. Internal time constants ensure that the device will work reliably on a standard phone line.

Line Side Operation

Referring to fig. 1, bridge rectifier BR1, fed through C1, supplies a rectified voltage corresponding to A.C. fluctuations in line voltage. Zener diodes Z1 and Z2 ensure that only a large amplitude signal such as a ringing voltage (about 100Vrms) will produce enough current through limiting resistor R2 and opto-isolator I1. Incoming tip and ring are brought out to another jack so a phone can be attached to the line side which is never disconnected. Relay contacts K1 and K2 connect the equipment side to the line when operated by the timer.

Bridge rectifier BR2 rectifies the line current so that the line current detector comprising R3, D1-D4, and I2 is in the proper polarity regardless of line polarity. Diodes D1-D4 clamp the voltage across the series combination of R3 and I2 to about 2.6 volts so that the max current rating of I2 won't be exceeded. The max voltage drop across the detector will never be more than about 3.6 V. It is important that the voltage drop across the diodes be greater than the drop acrosss I2 so that R3 has a drop sufficient to supply current to I2. For example, if the diode drop is 2.6V, the isolator drop is 1.6 V, R3 is 180 ohms, then the current will be (2.6-1.6)/180 or 5.6 ma.

Timer/Digital interface

Refer to fig 2. The unit has two operating modes-**answer** and **originate.** With the answer/orig switch S3 closed the 555 timer-IC1 is continuously triggered and holds the connect relay KI operated. This closes contacts K1 in the line circuit to provide continuity to the modem from the line. The digital input signal ORIG going low will also put the circuit in the originate mode, after time delay T1.

In the answer mode the timer is triggered by pulses from the ring detection opto-isolator I1, and are buffered by a section of an open-collector buffer IC#3, these in turn are filtered by R9, R13 and C9 to remove the noise spikes that occur when (phone) line current is switched. The time constant T1 is set by the RC-diode network on pins 6 and 7 of IC1 and is approximately equal to:

$$0.6(1/(1/(R4 + R5) + 1/R6))c2$$

The reason for the delay is to hold the line until steady line current has been estabished. When this occurs (before IC1 times out), current in the output of line current detector, opto-isolator I2, holds the threshold pin (6) low and prevents the timer from finishing its cycle until (phone) line current is interrupted. Since this happens at the end of a call or within a timed period thereafter, the circuit will connect the modem upon receipt of a call and automatically release it when the caller hangs up. The holding current from pin 5 of IC2 is blocked from C2 by diode D5. This means that after holding current is established, C2 continues to charge to +5. through R5 + R6 so that the cycle will end immediately after holding current is released and not after another time period T1 caused by C2's reactance.

The output of the 555 IC is amplified by transistor Q1 in order to drive the coil of relay K1. Almost any 12 volt relay will do, as long as the current demand is not excessive and it is reasonably fast (about 20 ms. or less). Diodes D6 and D8 clamp the inductive surges on the coil of K1.

A 7405 hex open collector buffer, IC2, provides two digital inputs and two digital outputs which may be used to control the box's functions from a computer or other control device. The inputs ORIG and BRK are activated by either applying a low level from an open collector gate output or by grounding them with a switch. They simply duplicate the action of the front panel switches "originate" and "disconnect".

The output OFF HOOK reflects the state of the OFF HOOK LED and the output RING DET supplies rough unfiltered ring pulses. If the latter signal is used externally, it has to be debounced.

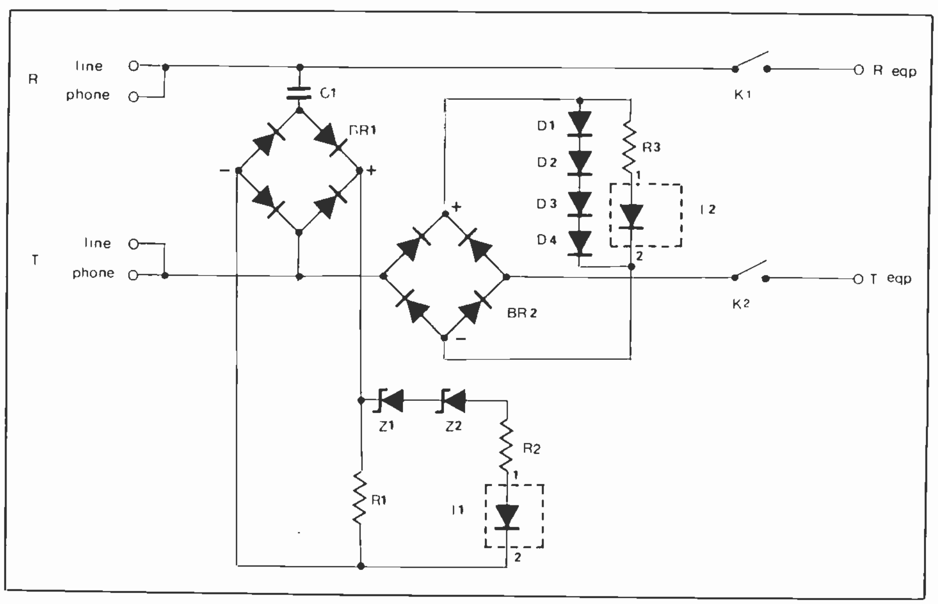


Fig 1. Line side schematic

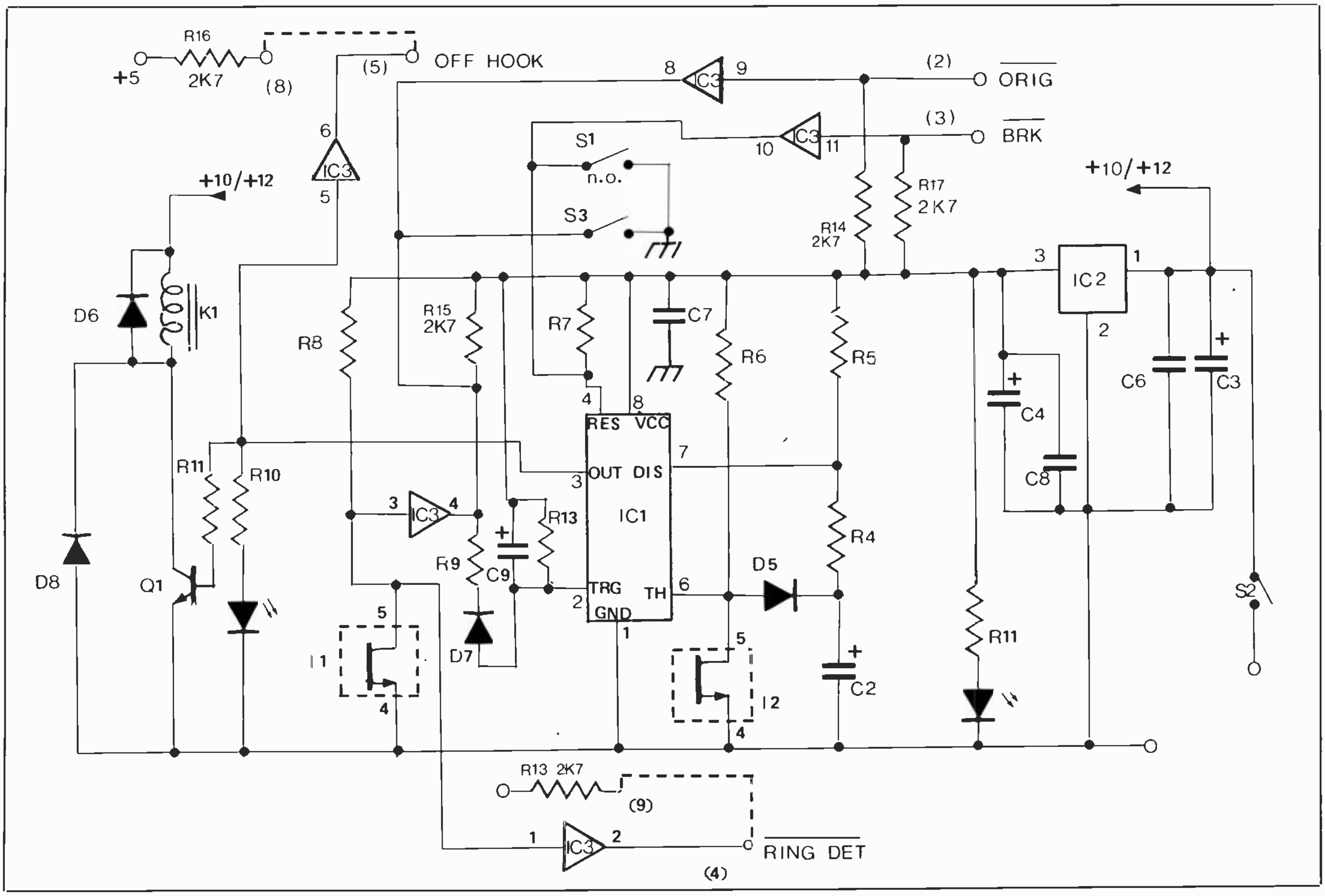


Fig. 2. Timer/Digital interface schematic diagram.

Using the Auto-Tector

To set up the unit refer to Fig. 3 rear view. This is the simplest configuration and has no connections to the digital interface on the DB-9 connector, J5. Plug your telephone into the "phone" jack, your modem into the "equipment" jack, and the telephone line from the phone company into the "line" jack. (if you don't have a modem for the test, another phone with its handset off hook will do). Plug the 12 volt adapter into the wall and its cord into the unit.

The "originate" position simply holds the answer relay closed so that you can make outgoing calls from your modem as you normally would. The off-hook indicator LED2 will be on to show that the modem is connected to the line.

When SW2 is in the "answer" position and the modem is set to answer, the unit will wait for a ringing signal on the line before connecting the modem (or other equipment).

It will then hold the call until whoever (or whatever) is calling hangs up. There may be a short delay of about 15 seconds between the time the caller hangs up and when the box hangs up. This is dependent on what kind of equipment is used in your telephone exchange. The call can be released anytime by pushing the "disconnect" momentary switch SW3.

Note that in the event that SW2 is switched from the "originate" to the "answer" position while a dial tone is on the line, the "disconnect" button SW3 has to be pushed to release the line.

When the Auto-Tector isn't powered up it has no effect on the phone line or any equipment you have plugged into the phone jack.

Construction

The project fits easily into a plastic test instrument case available in several electronic supply stores. The circuit board mounts to the four bushings that are provided for the purpose. The telephone jacks fit into slots cut in the back panel and holes should be drilled in the front and back panel to accept the switches plugs, and LEDs.

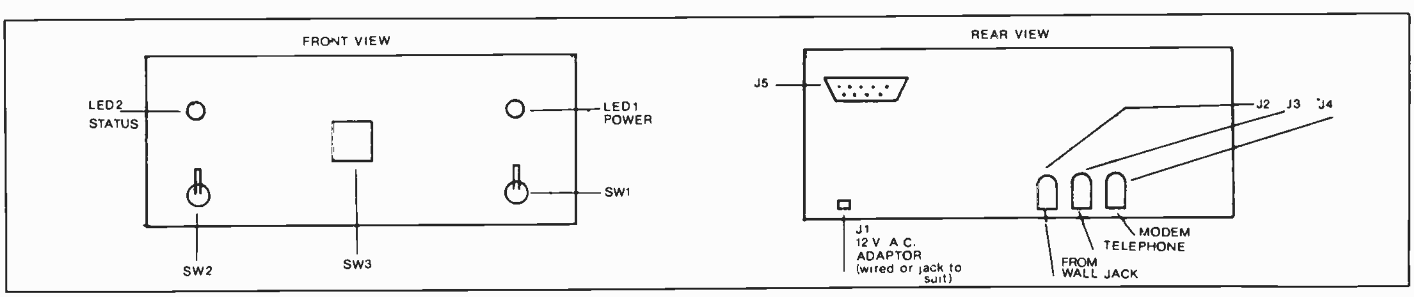
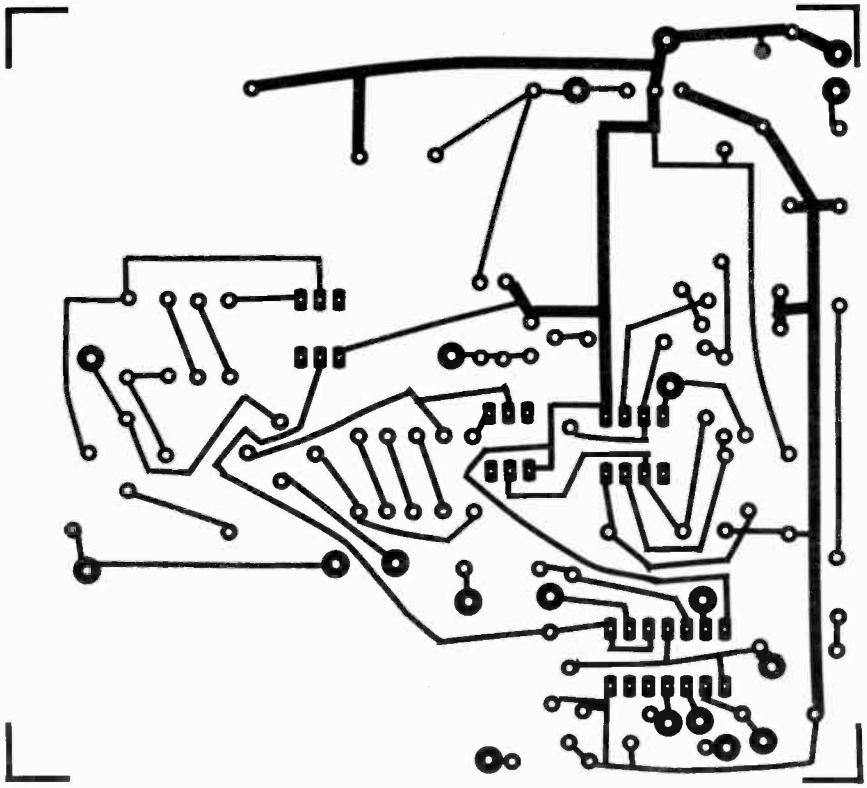
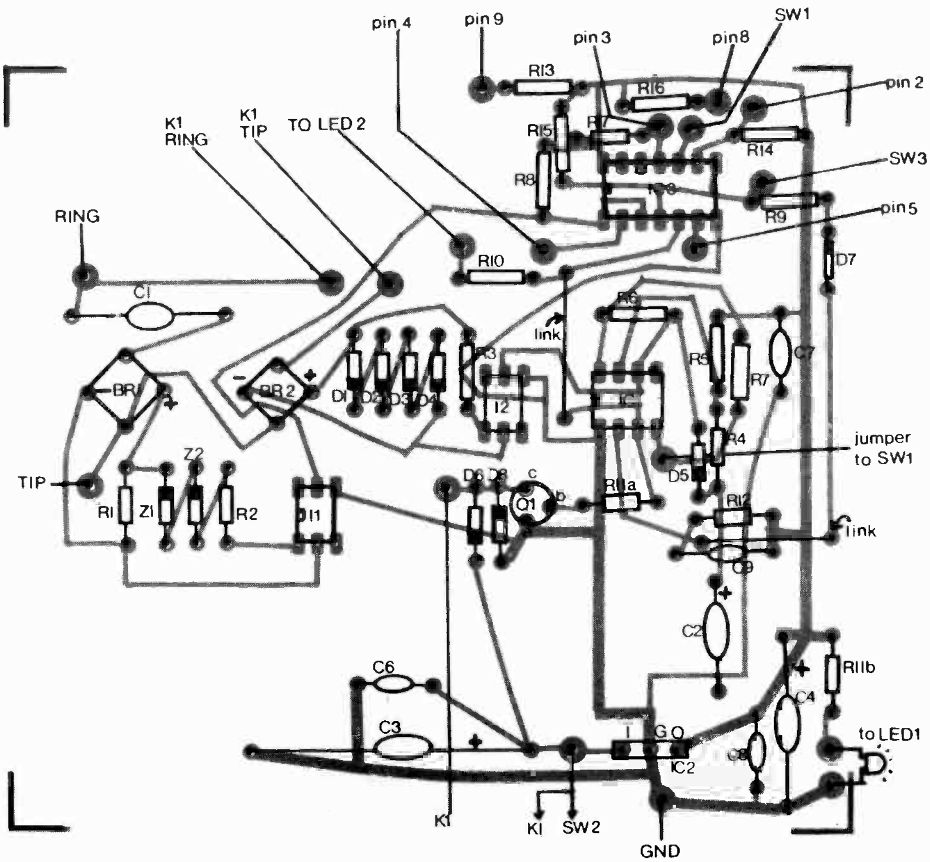


Fig. 3. Rear and front views of suggested Auto-tector panel layout.



P.C.B. for Auto-tector.



Parts overlay.

PARTS LIST

Resistors (all ¼ W 5% unless stated)

R1	51K @ ½ W
R2	22K @ ½ W
R3	180 @ ½ W
R4	1K
R5, R6	110K
R7	2K2
R8	150K
R9	5K6
R10	470R
R11, a, b	560R
R12	120K
R13, 14, 15, 16, 17	2K7

Capacitors

C1 0.68u @ 200V
C2 33u @ 10V tantalum electrolytic
C3 470u @ 15V
C4 2u2 tantalum
C5 0.1u low leakage
C6 0.1u @ 15V bypass
C7 0.1u @ 5V bypass
C8 0.01u bypass
C9 10u @ 10V tantalum

Semiconductors

IC1 555
IC2 7405
IC3 7407N
Q1 2N2222 general purpose NPN
I1, 24N35
D1, 2, 3, 4, 6, 8 1N4001
D5, 7, 9 1N914
Z1, 2 12V
LED 1, 2 any 0.125" Led
#1 green for power
#2 red for status
BR1, 2 8021 bridge rectifier

Miscellaneous

K1 12V @ 100 ma relay
J2, 3, 4 Standard female phone jacks, EIA type
J5 9 Pin DB-9 connector
SW1 Standard on/off toggle
SW2 Standard two-state toggle
SW3 Pushbutton momentary switch

ETI

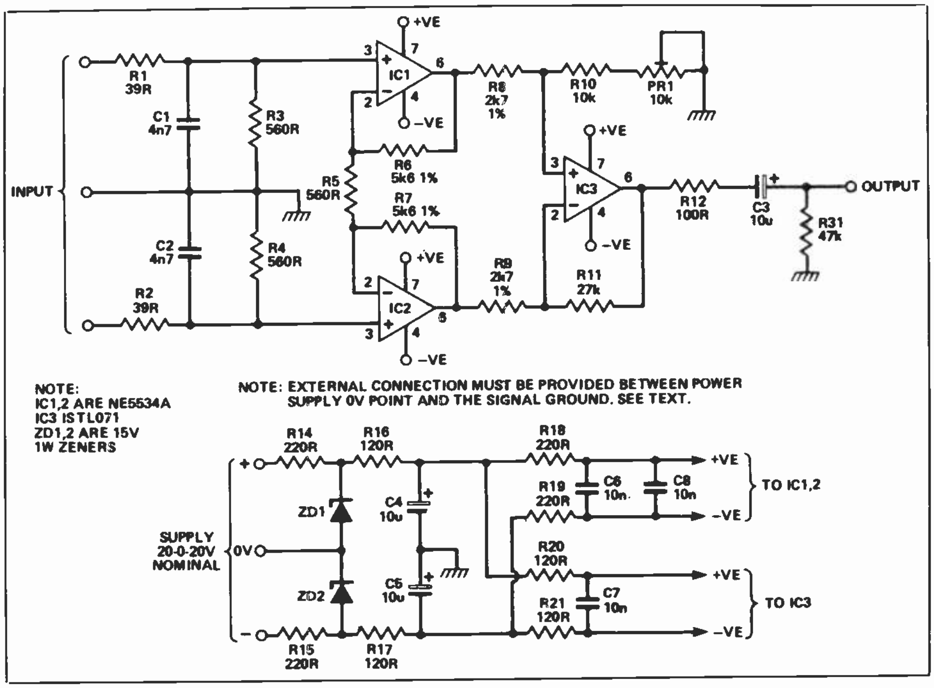
Circuit Supplement

A circuit for every occasion. From beginner to advanced, a whole bunch to keep you busy 'til next month.

BALANCED INPUT PREAMP

THE circuit is a relatively straightforward instrumentation amplifier. The main differential stage is formed by IC3, the TL071. This is a biFET op-amp with good common mode rejection ratio (CMRR) figures. This stage is buffered from the inputs by a pair of NE5534A op-amps that also provide additional gain and determine the overall noise performance of the preamp. The overall gain of the preamp is determined by the gain of the first and second stages. The gain of the second stage is determined by the ratio of R11 to R9, and is around 10. The gain of the first stage is approximately 20, giving an overall gain of about 200, or 46 dB. If you require a different gain to this, try to keep the ratios of gain in the first and second stages the same. The amount of gain provided here should be suitable for most microphones, providing around 100 mV output from a 0.5 mV input signal level.

The circuit is DC-coupled at the input. This assumes that the driving source will be transformer or capacitively coupled at the output, which should be a safe assumption. The input impedance of the stage is set by the two input resistors R3 and R4. To increase the input impedance, simply increase the value of these resistors.



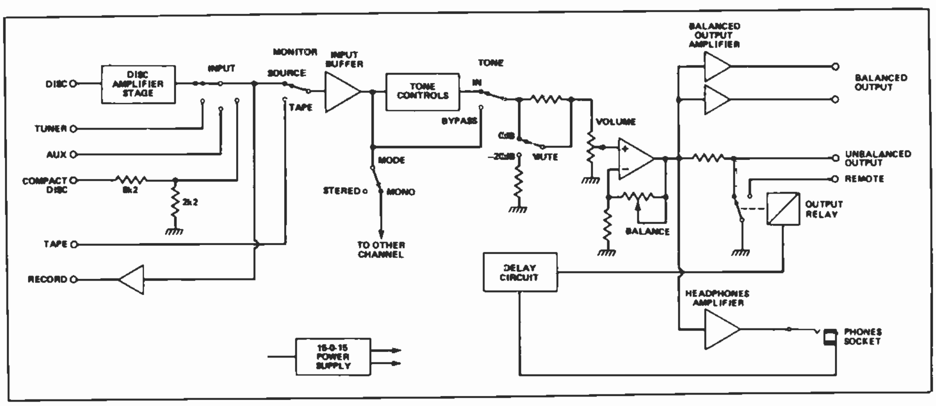
The RC networks consisting of R1-C1 and R2-C3 are high frequency filters to reduce the circuit's susceptibility to Rf interference.

The split power supply is provided either from two zener regulators or from a well-regulated and filtered DC source. The supply pins to each IC are decoupled by 1k0 resistors and 10n capacitors to prevent IC-to-IC interaction and possible feedback via the supply rails.

TONE CONTROL

THE type of tone control fitted to most hi-fi equipment is far from ideal, usually being much too dramatic in operation — for example, if it is required to lift frequencies below about 100 Hz, the effect is usually to lift by varying amounts, everything up to at least 1 kHz, and even higher.

The circuit shown is somewhat more sophisticated than usual, possessing in addition to the normal lift and cut controls, adjustment of the turnover frequencies of the two sections.



Circuit diagram of the tone control module.

ZERO CROSSING SWITCH

MOST of the functions of this switch are contained inside the IC, so let's take a look at the zero-voltage switch IC first.

Three zero-voltage switches are made by RCA — the CA3058, CA3059 and CA3079. They are all designed to control a thyristor in a variety of AC power switching applications for AC input voltages of 24,230, 230 and 277 V at 50, 60 and 400 Hz. Each incorporates four functional blocks as follows (refer to the block diagram here):

- Limited-Power Supply — permits operation directly from an AC line.
- Directional On/Off Sensing Amplifier — tests the condition of external sensor or command signals. Hysteresis or proportional-control capability may easily be implemented in this section.
- Zero-Crossing Detector — synchronizes the output pulses of the circuit at the time when the AC cycle is at zero voltage point; thereby eliminating radio-frequency interference (RFI) when used with resistive loads.
- Triac Gating Circuit — provides high-current pulses to the gate of the power controlling thyristor.

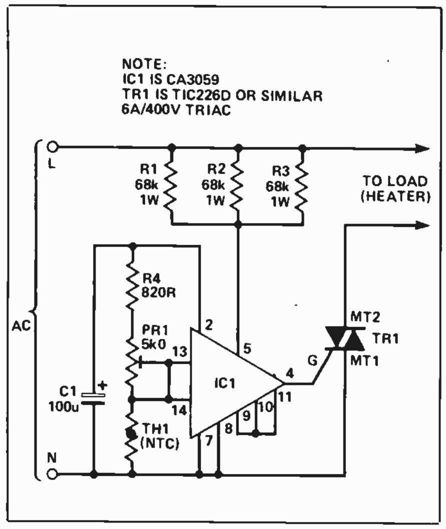
In addition, the CA3058 and CA3059 provide the following important auxiliary functions:

- A built-in protection circuit that may be actuated to remove drive from the triac if the sensor opens or shorts.
- High power DC comparator operation is provided by overriding the action of the zero-crossing detector. This is accomplished by connecting pin 12 to pin 7. Gate current to the thyristor is continuous when pin 13 is positive with respect to pin 9.

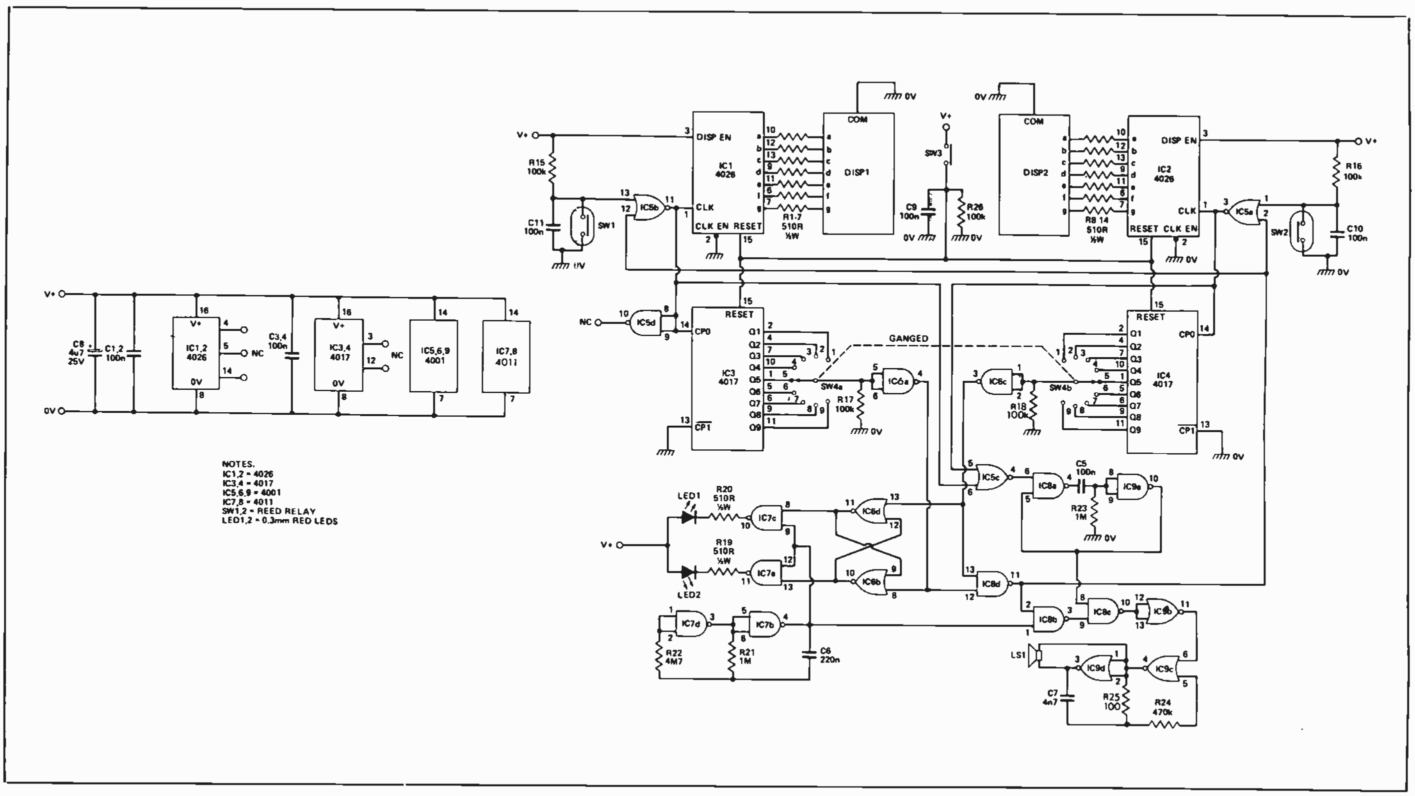
Because the CA3079 does not incorporate the built-in protection circuit, the CA3058 or CA3059 have been specified for this project. If the project is used to control a fish tank heater, one doesn't want to boil one's finny friends in the event of a thermistor failure!

Now we know what's inside the IC, how is it put to work in the circuit?

Initially, consider the triac to be turned off. Some current flows into pin 5 of the IC and this is limited by R1-3 and rectified within the IC to provide about 8 V DC for the operation of the circuit. Capacitor C1 smooths this supply. Inside the IC are a number of separate sub-circuits centered on a comparator ('On/Off Sensing Amp'). Connection of pins 9, 10 and 11 uses internal resistors to establish half supply rail (about 4 V) as one of the levels to be compared. When the voltage on pin 13 exceeds half rail potential, the comparator activates a circuit which turns the triac on at the next supply zero, and each subsequent zero until the voltage falls below half rail.



Clearly then, PR1/R4 must be selected so that they add up to the resistance of the sensing thermistor at the temperature for which it is desired to regulate. Thus, then the temperature reaches the preset point, the voltage across TH1 corresponds to half rail potential on pin 13.



SLOT CAR LAP COUNTER

The counter is operated via SW1 and SW2, using small magnets cemented to the underside of the cars. The supply voltage can be 9 V DC to 15 V DC unregulated.

COMPUTER OUTPUT DRIVER

FIRST of all, note that the component values shown on the circuit digaram are for the 2A output version. Other output current versions are possible, but basic circuit operation is the same.

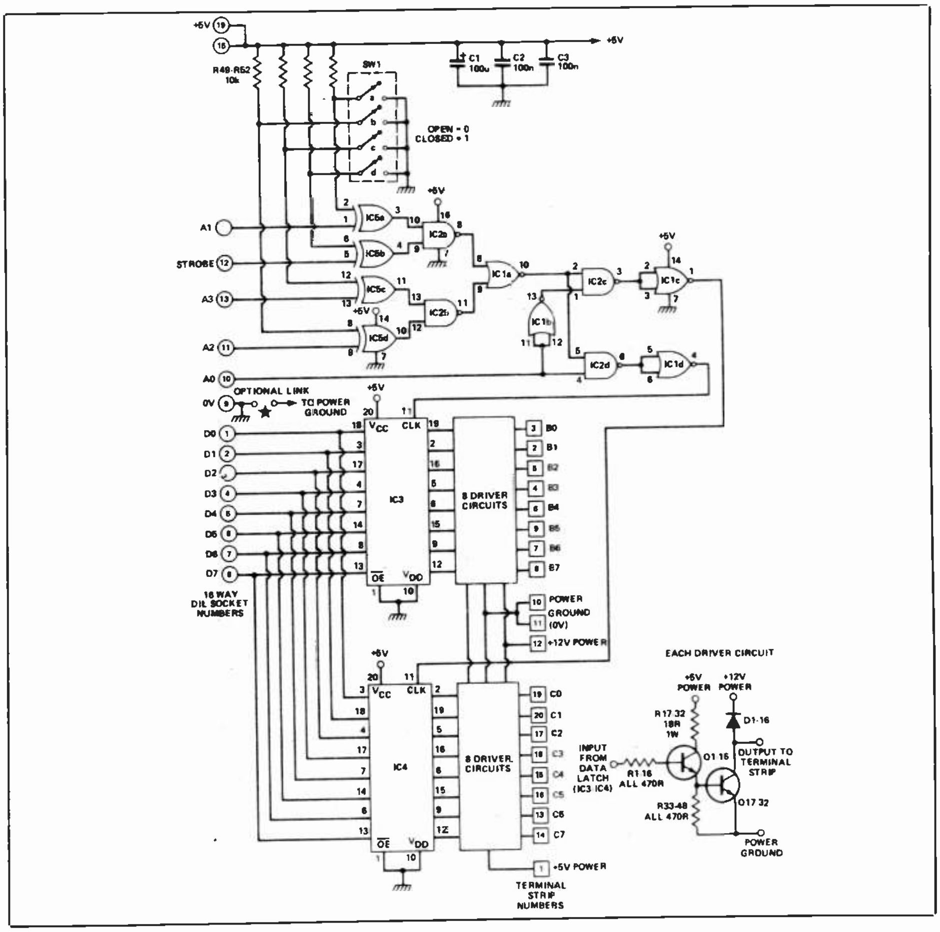
The host processor connects to the driver board via the 16-pin DIL socket. IC5 compares the logic levels present on the DIL socket pins 14(A1), 11(A2), 13(A3) and 12(STROBE) to the settings of SW1a-d respectively. When a match is found, pin 10 of IC1 goes high. The STROBE input should receive a pulse edge timed to coincide with a valid data bus (pins 1 to 8 of the DIL socket) and a valid address (pins 1 to 8 of the DIL socket) and a valid address (pins 11, 13, 14). Note that either a postive-going or a negative-going edge of the strobe pulse may be used, according to whether the setting of SW1d is closed or open, respectively.

The A0 input on pin 10 of the DIL socket determines which of the two onboard latches are being addressed. When pin 10 is low, IC4 is selected ('B outputs active'), if high, then IC3 ('C outputs active').

Each driver circuit buffers one of the 16 latch outputs and provides an open collector current sink of up to 3A.

To simplify the description of the driyer circuits, consider the one comprising R1, Q1, R17, R33, Q17 and D1. Diode D1 is a flywheel diode and protects transistor Q17 from excess back emf voltage when turning off inductive loads, such as a solenoid. When the latch output is low, Q1 is held off via R1 and Q17 is held off by R33. Resistor R33 speeds up the turn-off time of Q17 by providing a path to remove stored charge in the base-emitter junction.

When the latch output is high, about 5 mA of current flows into the base of Q1, thus turning it on. R17 sets the base current of Q17 and is chosen according to the output current requirement. Transistor Q17 must be saturated in order to reduce power dissipation and up to 300 mA of base current may be required for 3A loads.



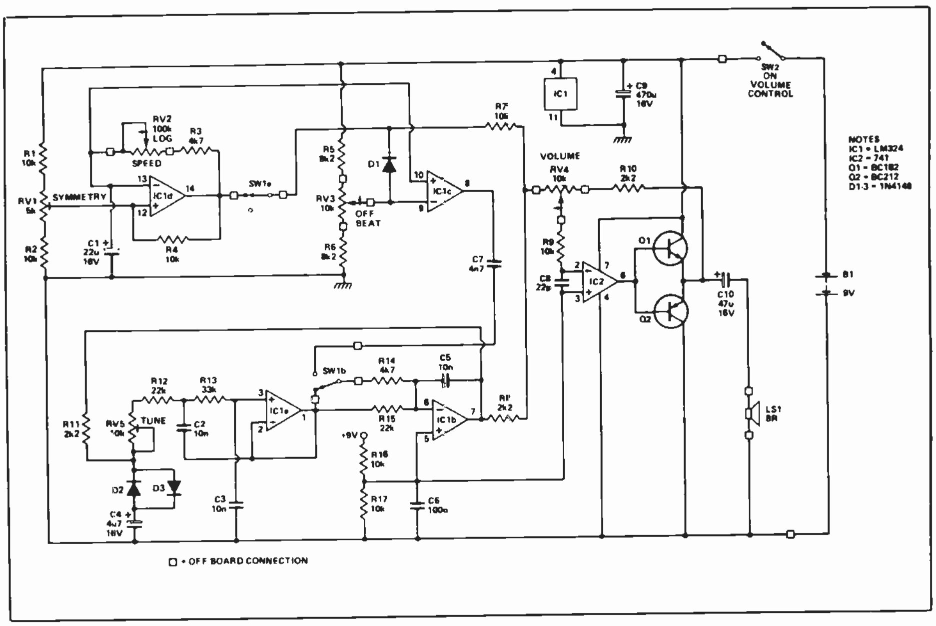
Circuit diagram for the ETI Computer Output Driver. Our artist drew the line (!) at reproducing 16 identical driver circuits, so we've shown just the one.

OFFBEAT METRONOME

THIS is a metronome with a difference. The initial requirement was for a simple metronome which would enable the musician or muscians to practise playing to an even rhythm, instead of succumbing to the inevitable temptation to play faster and faster until collapse from exhaustion ensues. The project became more ambitious when we decided to add a rhythm accent or offbeat to give a variety of rhythm 'feels' to play against.

The required variable offbeat was achieved by inserting another note between the regular beats, which can be adjusted to fall anywhere between the two beats, or in unison with one beat to give a stronger accent on that beat, or not to occur at all.

The final embellishment was the addition of a pure "A" tone for tuning purposes.



CHESS TIMER

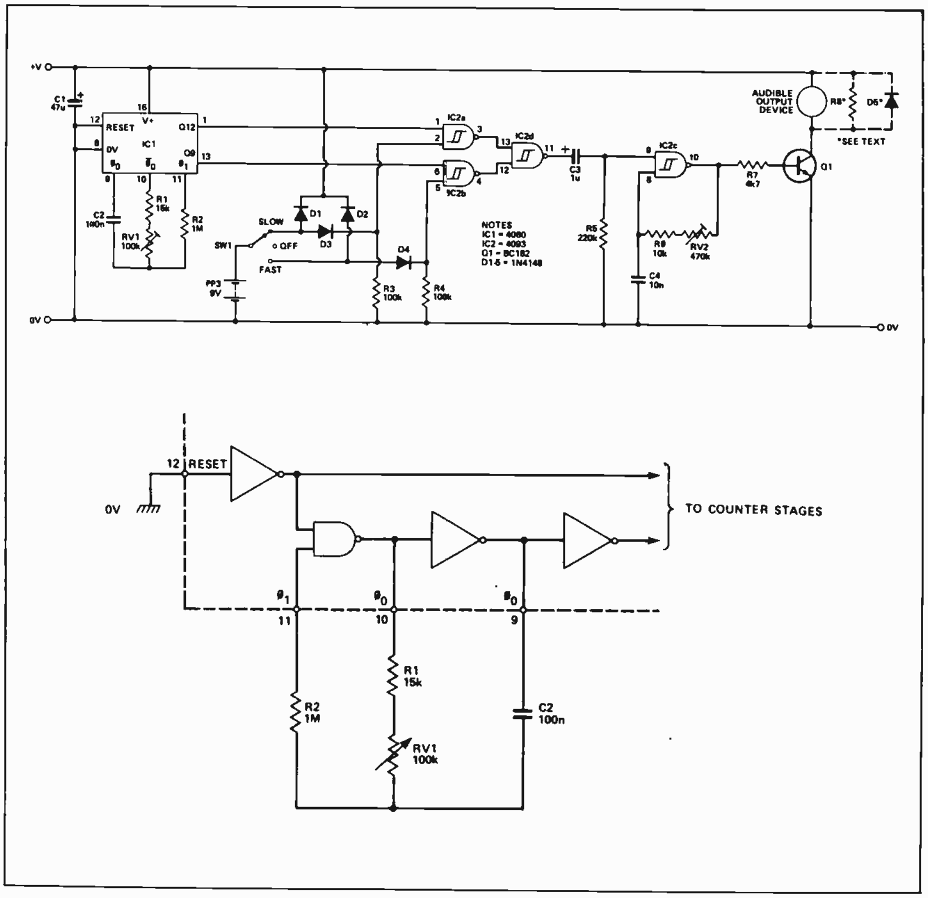
THE oscillator is a standard circuit, and the values of C2, R1, R2 and RV1 have been chosen to give an output frequency in the range 40-320 Hz. The rest of the 4060 is a 14-stage binary counter with the outputs from every stage being available — except for stages 1,2,3 and 11.

Since so many outputs are available, two speed ranges are provided by utilizing the Q9 and Q12 outputs. For the fast range, this gives intervals between 'buzzes' of approximately 1.5-12 seconds, and for the slow range of approximately 12-96 seconds.

Choosing to use different outputs of the 4060, one can of course have other ranges if one wished, Q10 giving half the speed between Q9 and Q12 is achieved by IC2a and IC2b.

Diodes D1, D2, D3 and D4 are included so that a single pole centre-off switch can act as both speed-range select and on/off. When the switch is in the slow position, power supply current flows through D1 and pin 2 of IC2a is taken to a high logic level via D3.

If a piezoelectric transducer is used, it may be necessary to fit R8, and this will have to be chosen by experiment to match the chosen transducer. The other possibility is to use a small loudspeaker, and under these circumstances, R8 will become diode D5, and will need to be fitted as shown.



The Chess Timer will sound between 1.5 and 96 seconds.

ALARM EXTENDER

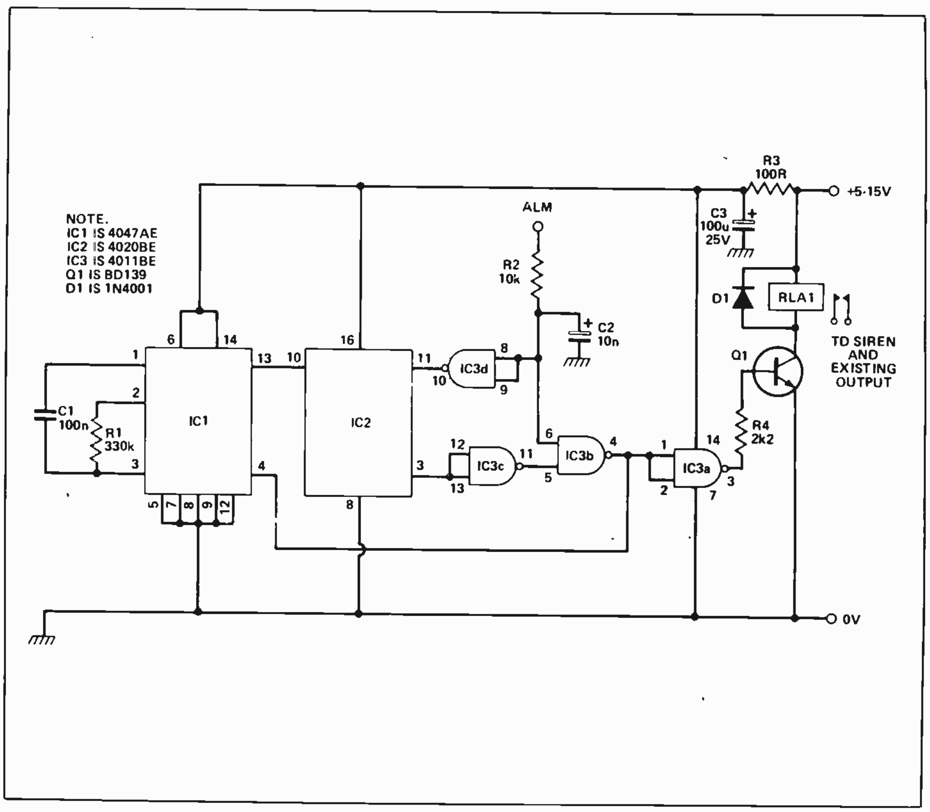
IC1 is a 4047, a CMOS multivibrator which can operate as a monostable, but which is here used as a bistable, its frequency being set by R1 and C1. IC2, a 4020, is a 14-stage ripple binary counter which counts the pulses generated by IC1. When the ALM input is low, IC3b pulls pin 4 of IC1 high, which prevents it oscillating; while IC3d holds pin 11 of IC2 high, thus holding its output low.

When ALM goes high, the relay is turned on via IC3b, IC3a, and Q1. IC1 and IC2 are enabled and IC1 starts supplying pulses at the rate of about 12 Hz (assuming the values of R1, C1 given) to IC2. After 16,384 pulses have been received, the Q14 output (pin 3) of IC2 goes high, turning off the relay and preventing further input pulses from reaching IC2.

The period can be adjusted by altering the values of C1 and R1, and is equal to:

36,045 R1 C1 seconds.

The output time can also be halved by using Q13 (pin 2) instead of Q14 on IC2.

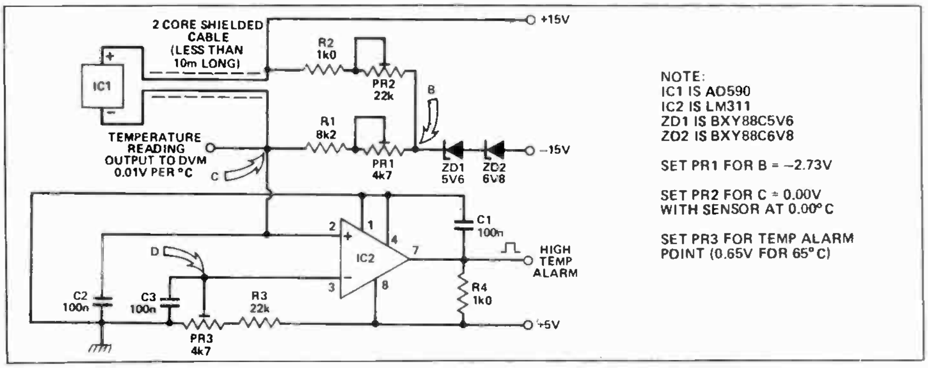


Circuit diagram of the alarm extender

COMPUTER TEMPERATURE CHECKER

ANALOG Devices' AD590 temperature sensor is used to provide an output in degrees Centigrade of the temperature inside the computer console. Zener diodes ZD1,2 and preset PR1 provide the conversion voltage of -2.732 V needed to change the degrees K to degrees C. PR2 is used to zero the AD590 sensor linear output at some point of its scale (-50__ to +150° C). I suggest the 0.00 V output should be set with the sensor in a beaker of a crushed melting ice. The sensor output is best displayed on a digital voltmeter (0.01 V per degree C) or on the specialized DVM chip (see previous circuit).

A voltage comparator (IC1) is used to compare the temperature sensor output with a value preset by PR3 and trigger the high temperature alarm when this value (65°C-70° C for most TTL and CMOS) is exceeded. This alarm output can be connected to a suitable optional alarm circuit.

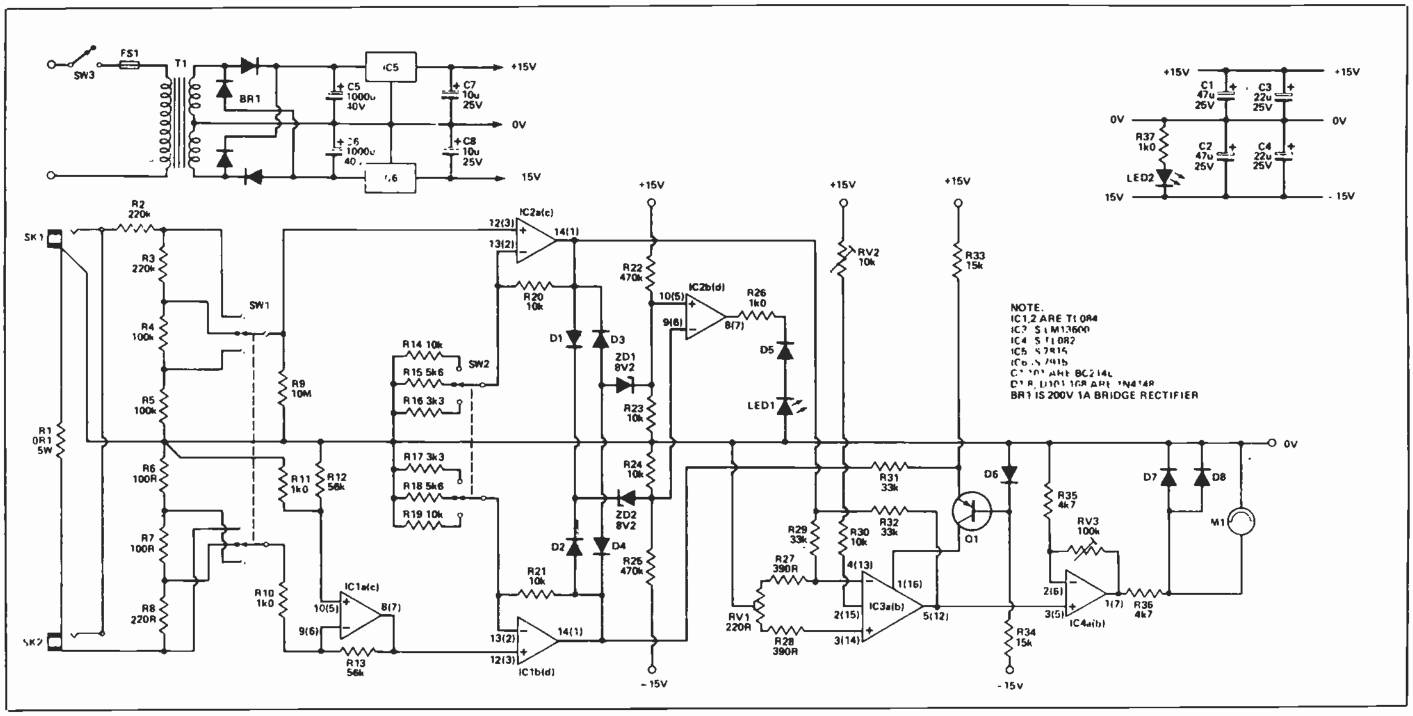


Circuit diagram for the temperature sensor and alarm.

AUDIO POWER METER

POWER is provided by a very simple dual rail supply derived from a centre tapped transformer and bridge rectifier. The output from this is smoothed by C5,6 and regulated to + and - 15 V by IC5,6. C7,8 remove any residual noise and improve transient performance.

The main part of the circuit is in two identical parts, so we shall only consider one of them. The signal whose power is to be measured enters SK1 and leaves SK2. En route it passes through R1 which develops a voltage across it proportional to the instantaneous current flowing. At the same time the voltage across the input is also sampled. Two sections of SW1 tap off portions of the voltage and current signals and pass them to IC2a and IC1a respectively. The resistors R2 to 8 are chosen to give the ranges indicated on the panel. IC1a amplifies the current signal by a factor of just under 60, while R11 and 12 enable a small amount of common-mode signal on the ground lines to be eliminated if desired. From IC1a, the current signal passes to IC1b which is a buffer whose gain can be set to approximately 2, 2.8, or 4. IC2a performs a similar job on the voltage signal except that when the gain of IC1b is 2 that of IC2a is 4 and vice versa. The diode network (D1 to 4 and ZD1,2) together with IC2b detect overload conditions. If the peak signal exceeds the zener voltage, then either the + input of IC2b



Circuit diagram of the audio power meter. Note that only one meter channel is shown (PSU section is common).

will be pulled low, or the - input pulled high. Either of these conditions will cause the output of IC2b to switch from the positive supply rail to the negative supply rail and illuminated LED1. R26 and D5 limit the current and prevent reverse voltage on the LED.

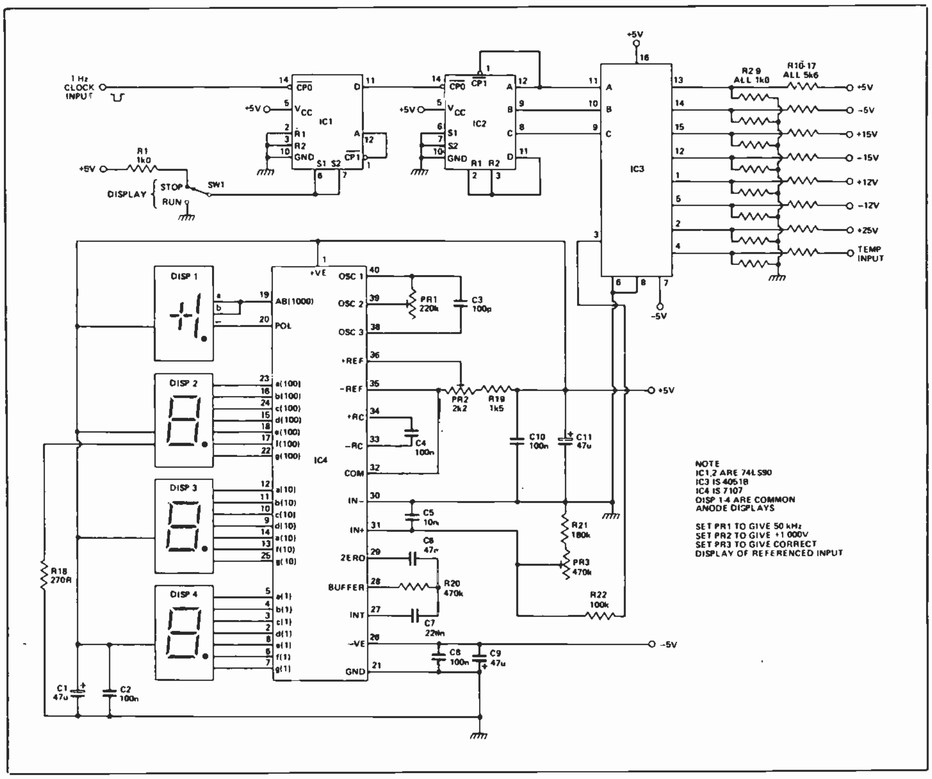
The next section is the multiplier and this is constructed around one half of an LM14600 transconductance amplifier. The part we use for this project has the property that its output current is proportional to the product of the input current and the bias current, and inversely proportional to the current through the linearizing diodes on the device. R34, D6 and Q11 form a simple virtual earth summing point for producing the bias current, which is a constant (via R33) plus a signal component (via R31). The other input to the device is via R29, which converts the voltage signal into a suitable current.

SUPPLY VOLT CHECKER

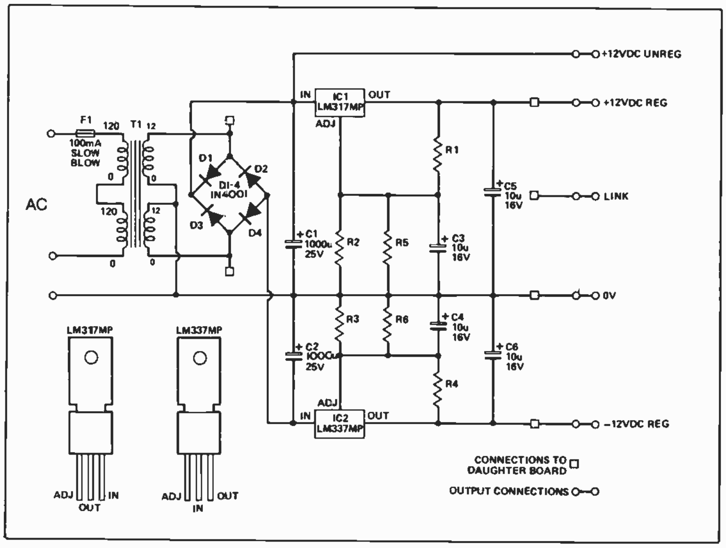
THIS simple scanning circuit is used to check the status of the multitude of DC supply lines in a typical computer/-peripherals system. A continuous clock input is divided by IC1 (more 7493s can be used if only fast clocks are available) and decoded by IC2.

The various supply voltages are divided down by the resistor networks R2-R9 and R10-R17 to provide safe levels for the analogue multiplexer IC3, a CMOS 4051B, which passes the selected supply line voltage to the standard DVM circuit. In this case the Intersil ICL 7107 single chip voltmeter is used together with four 7-segment LEDs to provide an accurate visual check on the DC supply lines.

The last input is used to display (in °C) the temperature reading taken by the following circuit.



AUDIO POWER SUPPLY MODULE



A general purpose 100 mA supply which can be set from 5 to 15 V DC.

Table 1

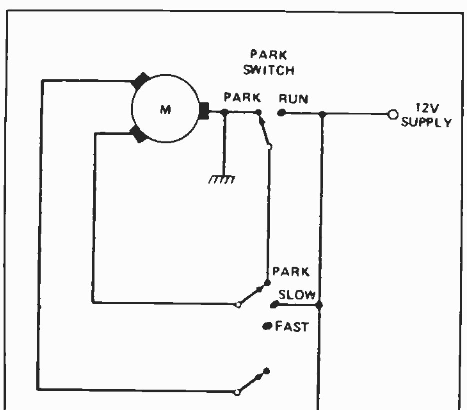
Transformer, 3 to 6 VA	R1, 4	R2, 3	R5, 6	Volts DC
0-6, 0-6	120R	390R	—	±5V
0-9, 0-9	120R	680R	—	±8V
0-12, 0-12	120R	1k2	10k	±12V
0-15, 0-15	100R	1k2	27k	±15V

Component values for output voltages from ±5V to ±15V

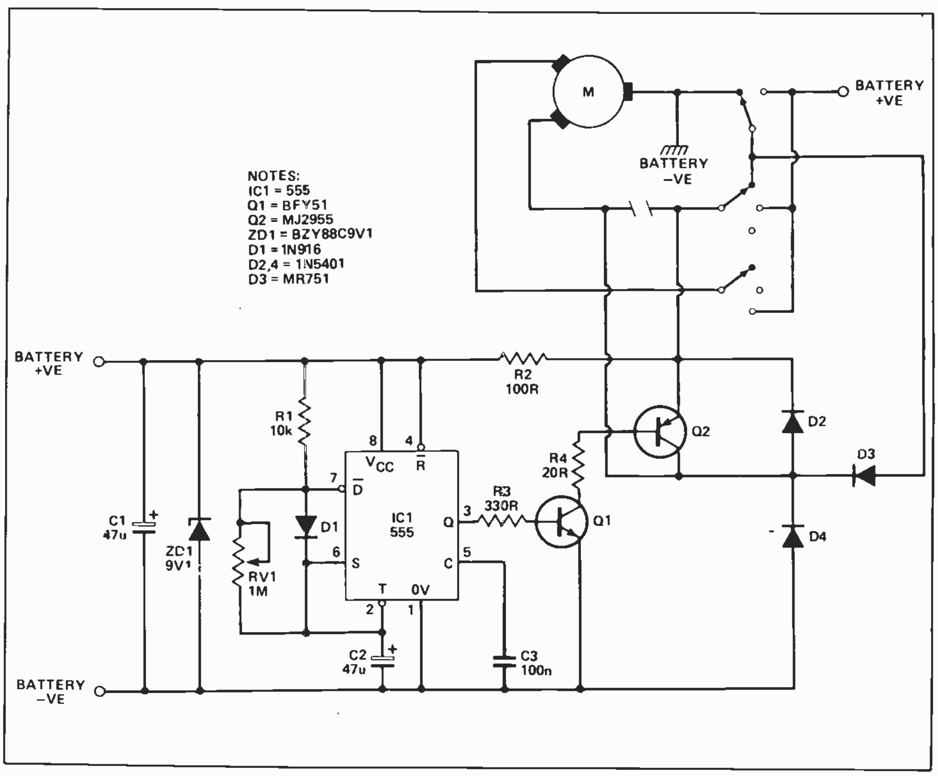
WIPER DELAY

THIS unit is suitable for all negative ground single or dual speed wipers. It is designed to replace the slow speed with a delayed-action wipe of between zero and 30 seconds. The delay is controlled with a potentiometer either on the dash or steering column, and the unit is switched on using the existing wiper switch. The fast and single shot functions (if fitted) are not affected by this current.

Connection of the unit is quite simple, involving only the breaking of the original slow-speed connection to the motor and making connections to each side of the break, to the park switch and a suitable ground. This is all shown in the circuit diagram.



The wiper control circuit shown is conventional on most makes. The Delay unit is installed in the 'slow speed' circuit, but slow wipe is still possible by turning the delay to zero.



The circuit uses a 555 timer in the astable mode to provide the delay function. The unit is connected into the slow speed wiper circuit at the points indicated by the breaks.

BENCH POWER SUPPLY

PARTS LIST

Resistors (all ¼W, 5%, unless otherwise stated)

R1,10	100R
R2	10R
R3,5,15,18, 19,22,29,30, 33,36	47R
R4,23,28, 31,32,41	1k0
R6	R33, 3W wirewound
R7,8	330R
R9,34,38	2k2
R11	100k
R12	10R, ½W
R13	47R, 1W
R14	1k0, 3W wirewound
R16	5k6
R17	220R
R20,35,37	1R8, 4W wirewound
R21	10k
R24,25,39	470R, ½W
R26	1k2
R27	1k5
R40	680R, ½W
R42	12k
RV1	100R
RV2	1k0
PR1,3,5,6, 7,9,10,11	470R horizontal skeleton preset
PR2	2k5 horizontal skeleton preset
PR4,8,12	10k vertical skeleton preset

Capacitors

C1	5000u 16V electrolytic
C1	100u 25 V electrolytic
C3,8,9,12, 13	10n 50 V ceramic
C4	1000u 25 V radial electrolytic
C5,11	1000u 40 V radial electrolytic
C6	470u 40 V radial electrolytic
C7	10u 63 V radial electrolytic
C10,14	220u 25 V radial electrolytic

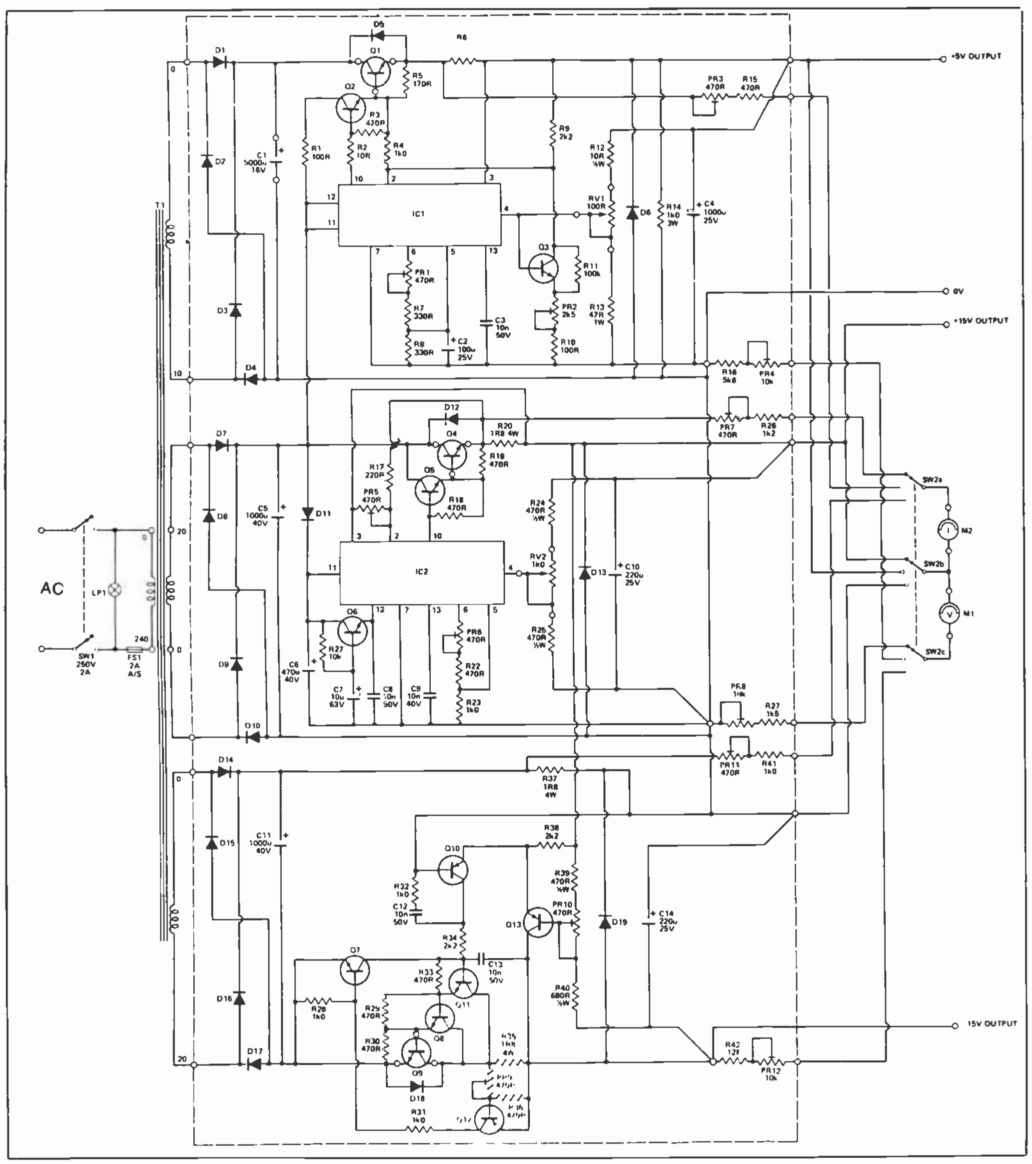
Semiconductors

IC1,2	MC1723
Q1,4,9	2N3232
Q2,5,8,11	2N3053
Q3,6,7	2N3904
Q10,12,13,	MM4002
D1,2,3,4,5, 6,12,13,18, 19	
D7,8,9,10, 14,15,16,17	1N5401
D11	1N4148

Miscellaneous

M1,2	1mA FSD meter
SW1	toggle, 2A
SW2	3 pole, 3 way rotary switch

PCB; IC sockets; M4 fibre washers; Heatsinks; insulated terminals; mains fuseholder and fuse; knobs; mains neon; Case, mains cable and strain-relief bush; solder tags; insulating kits for the power transistors; nuts, bolts, washers, etc.



Circuit diagram of the bench power supply unit. Separate 3 amp transformers can be used.

ETI

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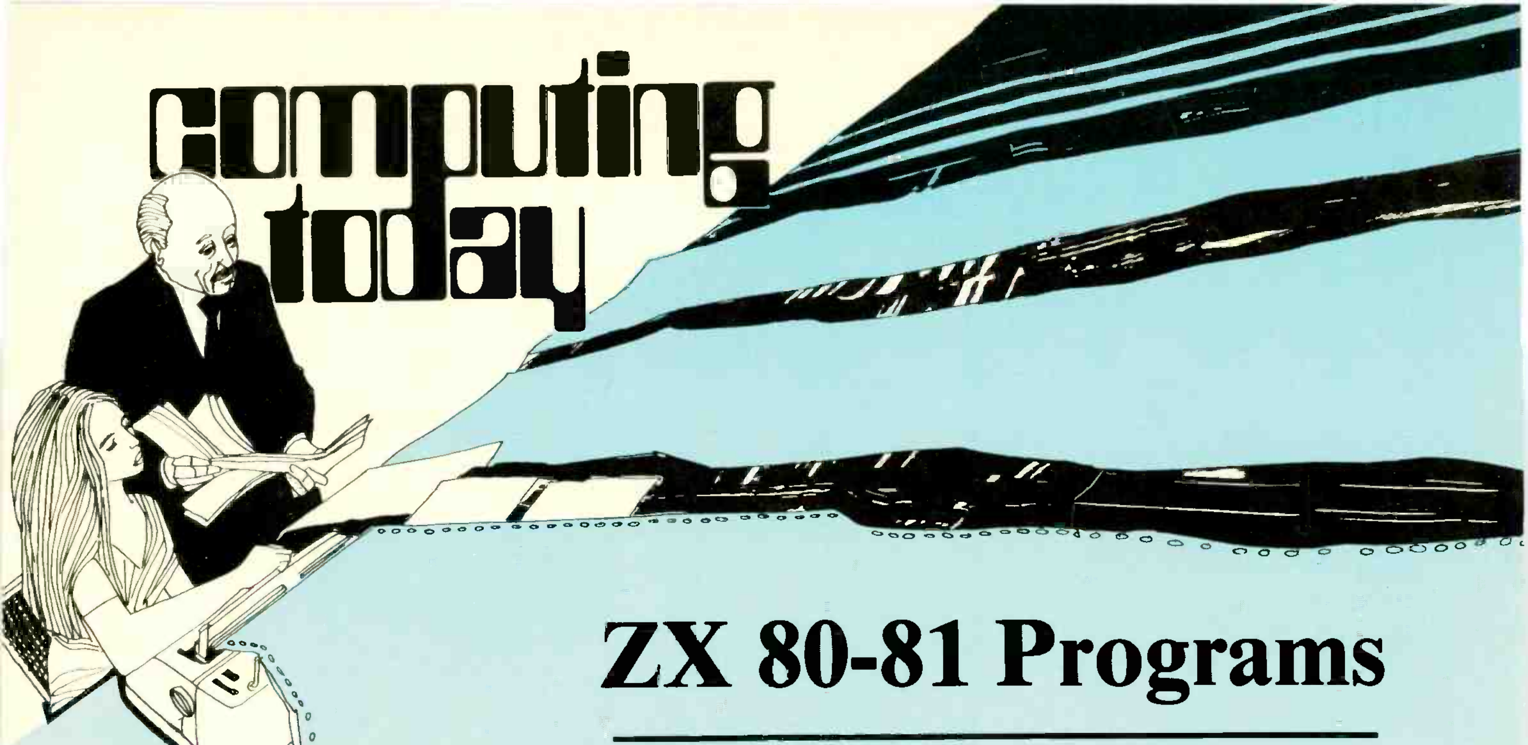


ZX 80-81 Programs

Are you starving your ZX80 or ZX81? Here's more food for that voracious little devil.

Trigonometric Fourier Synthesis Program (ZX81 with 16K RAM)

by Michael Krochmal

ANY periodic waveform can be expressed as the sum of a number of sinusoidal functions, provided that it satisfies certain conditions known as the Dirichlet conditions. These are that:

1) The waveform must have only a finite number of discontinuities per period;
2) The waveform has a finite average value for the period, and
3) The waveform has a finite number of positive and negative maxima.

Unfortunately, it is not immediately obvious to the neophyte that a few sinusoids thrown together can really end up producing squarewaves, sawtooth waves and all manner of marvellous shapes!

My encounter during undergraduate days with Fourier analysis and synthesis was limited to a series of tedious manual calculations, and frankly, left me cold. Insight into principles lagged far behind. (Sorry, lecturers).

The accompanying program, for a ZX81 with 16K expanded RAM, graphically illustrates Fourier trigonometric synthesis. The program is largely self-explanatory, and is intended as a framework for exploration of the mysteries of Fourier methods. Although the present listing produces a squarewave, modifications are given for production of a sawtooth, and similar modifications will enable generation of any periodic shape desired.

Note that since calculation of the resultant occurs point-by-point, the limit to the number of harmonic components is very large (approximately 65,000 I believe). Naturally, calculations involving such a large number of components might take a little longer!

```
FOURIER TRIGONOMETRIC SYNTHESIS PROGRAM.

10   REM COPYRIGHT M.S. KROCHMAL 1982
20   SLOW
30   PRINT "FOURIER TRIG SYNTHESIS"
40   PRINT "ENTER NUMBER OF ODD HARMONIC COMPONENTS"
50   INPUT B
60   PRINT B
70   PRINT "IF YOU ONLY WISH TO VIEW COMPONENTS, THEN ENTER
""C"". IF YOU ONLY WISH TO VIEW RESULTANT, THEN ENTER ""R"". TO
VIEW BOTH, ENTER ""B"" "
80   INPUT W$
90   PAUSE 100
100  CLS
110  DIM X (2*B)
120  DIM Z (64)
130  FOR N = 0 TO 63                              #
140  FOR C = 1 TO 2*B STEP 2                      #    NOTE 1
150  LET X(C) = (1/C)* SIN (C*(N/32)* PI)         #
160  NEXT C                                       #
170  IF W$ = "R" THEN GOTO 220
180  FOR E = 1 TO 2*B STEP 2                      @
190  PLOT N, 22 + 20*X(E)                         @    NOTE 2
200  NEXT E                                       @
210  IF W$ = "C" THEN GOTO 320
220  LET Y = 0                                    ^
230  FOR D = 1 TO 2*B STEP 2                      ^
240  LET Y = Y + X(D)                             ^    NOTE 3
250  NEXT D                                       ^
260  LET Z(N+1) = Y                               ^
270  PLOT N, 22 + 20*Y                            \    NOTE 4
280  NEXT N
290  IF W$ = "FINISH" THEN GOTO 410
300  IF W$ = "R" THEN GOTO 410
310  IF W$ = "B" THEN GOTO 390
320  IF W$ = "C" THEN NEXT N
330  PRINT "DO YOU WANT TO PLOT RESULTANT NOW ? (YES OR NO)"
340  INPUT W$
350  IF W$ = "NO" THEN GOTO 450
360  LET W$ = "FINISH"
370  LET N = 0
380  GOTO 220
390  PRINT
400  PRINT
410  PRINT "ANOTHER SYNTHESIS ? (YES OR NO)"
420  INPUT A$
430  CLS
440  IF A$ = "YES" THEN GOTO 30
450  PRINT "DO YOU WANT TO PRINT A LIST OF RESULTANT MAGNITUDES
VERSUS PHASE ANGLE ? (YES OR NO)"
460  INPUT B$
470  IF B$ = "NO" THEN STOP
480  PRINT "POSITION";TAB 10;"DEGREES";TAB 20;"VALUE"
490  FOR N = 1 TO 64
500  PRINT N;TAB 10;(N-1)/64*360;TAB 20;Z(N)
510  NEXT N
520  STOP

NOTES:
1    THESE LINES DEFINE THE RESULTANT WAVESHAPE.
2    PLOT OF COMPONENTS.
3    THESE LINES "BUILD UP" THE RESULTANT FROM THE COMPONENTS,
ONE POINT AT A TIME.
4    PLOT OF RESULTANT.

POSTSCRIPT:
FOR A SAWTOOTH GENERATOR, MAKE THE FOLLOWING CHANGES:

140  FOR C = 1 TO B
150  LET X(C) = (0.5/C)* SIN(C*(N/32)* PI)
180  FOR E = 1 TO B
190  FOR D = 1 TO B
```

Program Labels, for ZX81 With Printer

by W. Herlihy

THE following is a program which can be used to generate labels for cassette programs. The paper from the ZX printer is just the right width to fit inside a standard cassette case and this program gives the correct spacing of folds and titles; the required names and tape counter readings are quickly inserted into the program using the edit facility.

The dashed lines given by lines 1, 19, 13 and 35 in the program create just the right spacing for folds to enable the label to fit snugly in a cassette case. A sample is shown below the program.

```
THE PRINT-OUT FROM THIS PROGRAM,
WHEN FOLDED ALONG THE DASHED(--)
LINES,WILL FIT NEATLY INTO THE
STANDARD CASSETTE CASE.
LEAVE A LITTLE BLANK PAPER AT
THE START AND END OF THE RUN TO
BE FOLDED OVER
THE LABEL CAN BE FASTENED WITH A
LITTLE STICKY TAPE.

   1 LPRINT "-------------------
-------------"
   2 LPRINT
   3 LPRINT
   4 LPRINT
   5 LPRINT TAB 5;"CASSETTE NAME
"
   6 LPRINT
   7 LPRINT
   8 LPRINT
   9 LPRINT "-------------------
-------------"
  10 LPRINT
  11 LPRINT TAB 5;"CASSETTE NAME
"
  12 LPRINT
  13 LPRINT "-------------------
-------------"
  14 LPRINT
  15 LPRINT "NAME + MORE INFORMA
TION, ETC"
  16 LPRINT
  17 LPRINT "*******************
*************"
  18 LPRINT "SIDE 1"
  19 LPRINT
  20 LPRINT "0-20    TRACK NAME"
  21 LPRINT "20-35    ETC,ETC"
  22 LPRINT
  23 LPRINT "*******************
*************"
  24 LPRINT
  25 LPRINT "SIDE 2:"
  26 LPRINT
  27 LPRINT "0-20    TRACK NAME"
  28 LPRINT "20-65    ETC,ETC."
  29 LPRINT
  30 LPRINT
  31 LPRINT
  32 LPRINT
  33 LPRINT
  34 LPRINT
  35 LPRINT "-------------------
-------------"
  36 LPRINT
  37 REM :A LIMITED AMOUNT(ABOUT
11 LINES OF INFORMATION CAN BE
ENTERED HERE AND CAN BE READ
WITH THE CASSETTE CASE OPEN.

NOTE THAT THE LINE NUMBERS OF
THE DASHED LINES ARE THE ONLY
ONES THAT SHOULD NOT BE CHANGED.
THE OTHERS CAN BE ALTERED TO FIT
THE PROGRAMS ON THE CASSETTE.
```

```
--------------------------------

        ZX81  GAMES (1)

--------------------------------

        ZX81 GAMES  (1)

--------------------------------
GAMES FOR ZX81. (3K RAM NEEDED
FOR MOST.)
********************************
SIDE 1

 0-15   INDEX
15-30   SLIDING LETTERS
30-45   MAZE GAME
45-80   DRAUGHTS
80-95   ESCAPE
********************************
SIDE 2

 0-50   GOLF
50-75   ZX81 CIPHER
75-90   HANGMAN


--------------------------------
MOST GAMES ARE SELF EXPLANATORY.
IN "GOLF" THE DIRECTION IS GIVEN
AS CLOCK MARKINGS; FRACTIONAL
DIRECTIONS (E.G.2.7)ARE ALLOWED.
```

'Dodge' Game For The ZX81, 1K (or 16K)

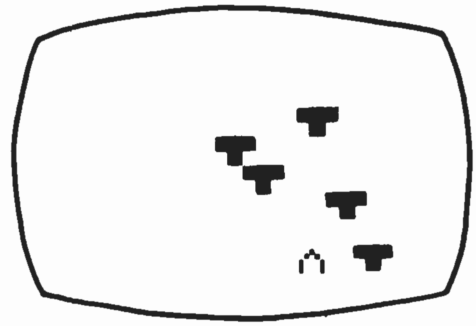
by Benjamin Smith

'DODGE' is a fast, real-time moving graphics game in which the player must try to guide his spacecraft (represented by 'V'(across an enemy space zone without being hit by one of the missiles which constantly emerge from the lower part of the screen. The keys '5' and '8' are used to move the craft left and right respectively. If the ship is hit, a score appears, along with the highest score so far. In the next game (which begins as soon as a key is pressed), the player must attempt to beat this record. The program may be terminated by BREAK.

This particular version is designed for the 1K ZX81, hence the use of expressions instead of numbers in lines 20 and 30 (numeric literals on the Sinclair chew up an additional six bytes). If 16K is available, however, the following modifications should be made:

```
20 LET B = 0
30 LET S = -1
60 PRINT AT 0, 31
70 IF PEEK (16928+P)<>0 THEN GOTO 130
85 PRINT AT 9, P+RND-RND-1;
90 IF RND<.3 THEN PRINT "■";
95 PRINT TAB 31
```

Beware of making any other alterations as the address reference in line 70 will be invalidated.



```
10  POKE 16418, 14
20  LET B = PI-PI
30  LET S = -PI/PI
40  LET P = INT (RND*12+2)
50  LET S = S + 1
60  PRINT AT 0, 14
70  IF PEEK (16897+P)<>0 THEN GOTO 130
80  PRINT AT 0, P; "V"
90  IF RND<.3 THEN PRINT AT 9, P+RND-RND-1; "■"
100 LET P = P+(INKEY$ = "8")*(P< 13)-(INKEY$ = "5")*(P> 1)
110 SCROLL
120 GOTO 50
130 CLS
140 IF S>B THEN LET B = S
150 PRINT "YOU SCORE "; S; ", BEST SO FAR "; B
160 PAUSE 550
170 CLS
180 GOTO 30
```

"Rapid Descent" For The 1K ZX80

by R.A. Chalmers

THE program starts by giving the height and acceleration, in this case 1,000 feet and acceleration of 32 ft/sec/sec*, the pull of gravity. After inputting both the period of time one wishes to check, and the initial velocity at the 1,000 ft. mark, the program will give adjusted height and new velocity. The catch now is to bring the vehicle to zero height and velocity. Input F is the accelerator, and -F will allow the vehicle to move towards the surface, while F will increase height by applying sufficient retard acceleration to reverse the vehicle.

The program is based on the calculations of acceleration and velocities, and as it stands, is streching the memory to its limits. However, as the calculations remain the same, the program is eminently suitable for expansion and use on larger computers.

Notes:

U = initial velocity

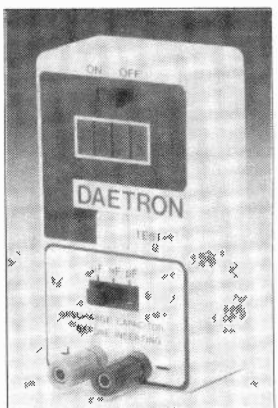
F = given acceleration

V = velocity at end of time, T, in feet/second.

* The program is run in feet as the equivalent in metric to 1 ft/s/s is 981 cm/second/second. The ZX80 has limited maths ability. The reason for the program's name will be immediately obvious to anyone attempting to land safely!

```
5  LET H=1000
10 PRINT " INITIAL HEIGHT = ";H;"FEET AND ACC.OF 32 FT/S/S"
12 PRINT " INPUT T(FLIGHT TIME IN SECONDS)"
13 PRINT "AND U(INITIAL VELOCITY)"
15 INPUT T
16 INPUT U
18 CLS
40 LET T=T
55 LET F=32
56 LET V=U+F*T
65 IF U>Ø THEN LET S=((U+V)*T)/2
70 LET H=H-S
80 PRINT " HEIGHT NOW  ";H;" FEET"
85 PRINT
90 PRINT "VELOCITY = ";V;" FEET/SECOND"
95 PRINT
100 PRINT "DISTANCE TRAVELLED ";S;" FEET"
102 PRINT "INPUT F +/- ACC, TO RETARD FLIGHT"
105 INPUT F
106 CLS
120 PRINT H; "= LAST KNOWN HEIGHT"
130 PRINT
200 LET S= U*T+(-F)*T**2
300 PRINT
400 PRINT S;"  FEET = DISTANCE TRAVELLED TOWARDS EARTH"
500 LET V= U+(-F)*T
501 PRINT
555 PRINT V; " FT/SECOND = VELOCITY AFTER ";T;" SECONDS WHEN
    ACC, IS RETARDED BY  ";F;" FT/S/S"
556 PRINT
560 LET H=H-S
567 IF S AND V<Ø THEN PRINT" VEHICLE IN REVERSE "
568 PRINT
570 PRINT H; "= NEW HEIGHT "
580 GO TO 102
```

ETI



Coping with Components Part I

In Part I of this two-part series, Tony Bailey looks at resistors in all their various forms and applications, and show how to identify them when it comes to selecting them.

HOW MANY TIMES have you looked at a strange capacitor bearing a legend such as "102", or a resistor with more identifying bands than normal, and wondered what value it is? Or do you have a collection of resistors and capacitors that you never use because you aren't quite sure what type they are, or whether they will be suitable for the application you have in mind?

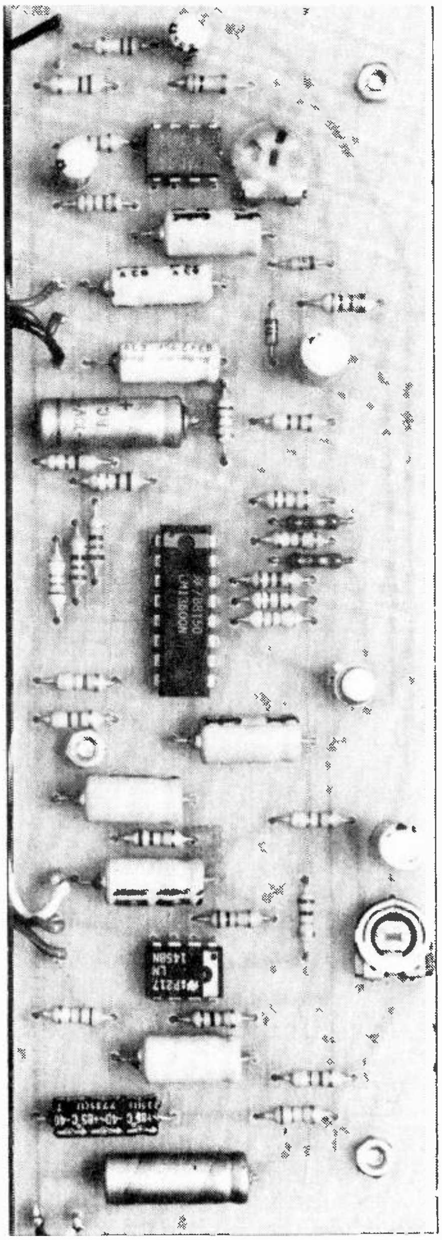
In this article we hope to pass on enough information to enable selection and identification of suitable components for the job in hand. Those of you laying hands on a soldering iron for the first time will find this of special interest, and hopefully there is some information also for the seasoned constructor.

During the past decade, the changes in components have not been so much in their type, but the sizes, with such items as IF transformers now obtainable in cans 5mm square, whereas ten years ago, the standard was at least 1 inch square for most people — not that the smaller type weren't around, they were just virtually unobtainable for the average constructor.

A Little Change

The same happened with resistors and capacitors, with very small sizes now common, a result of the need to miniaturize for high density printed circuit work, together with the introduction of different constructions. Also, the power consumption of the active devices we now all use can be measured in microwatts, with commensurate decrease in the power dissipation of the passive devices supporting them. Consider that even on standby, the average tube consumed a good few watts of heater power alone, and a pair of 813s would need a massive 100 watts per pair just to keep the heaters going!

Another consequence of miniaturization is that all the components needed for the higher power applications are increasingly difficult to obtain. The average con-



structor of a new linear amplifier has to attend rallies and surplus shops (Second World War surplus is of course also drying up) to find the air spaced capacitors he needs, and high voltage/current capacitors: Tube bases cost an arm and leg, without even mentioning the tubes themselves.

There are of course, many applications still requiring the higher power components. However, most of the constructional projects published today will use either discrete semiconductors, or an array of integrated circuits, with a requirement for suitable support components. It is here that the problems start.

The average junkbox may contain a high proportion of what appear to be 'almost' suitable components i.e., "the circuit calls for a 330pF silver mica capacitor, but I have a 330pF polystyrene which will fit into the same space, so lets use that." If value is the only consideration then this may well be suitable, but there is probably another reason why the mica may have been specified. A good article should tell you of any critical needs, but very few actually do, and you are left to your own devices. Similarly, will a wirewound resistor do instead of the carbon composition specified?

So, with these points in mind let's have a look at the various classes of resistor and capacitor you are likely to come across and how to identify and select them. We will also quickly look at how they are manufactured and constructed.

Resistors

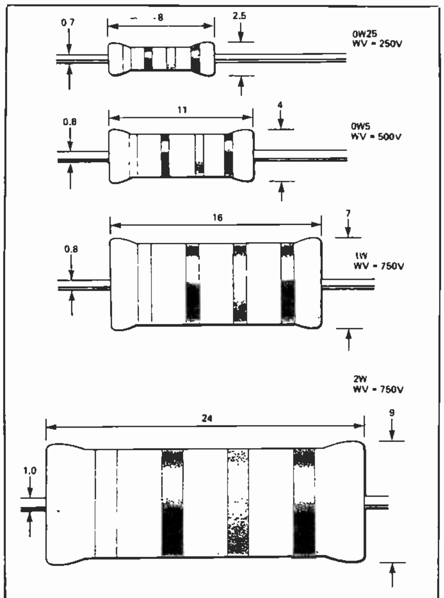
The humble resistor is an essential part of almost all electronic design, but comes in a variety of sizes and compositions, all intended for specific applications, but with a degree of overlap from the practical viewpoint.

One of the major points to remember when selecting any resistor is the power rating. As all resistors convert electrical energy into heat, care needs to be taken to ensure a safe rating within any circuit. For most solid state designs, this power dissipation is very small, and a 0W25 rating will usually suffice.

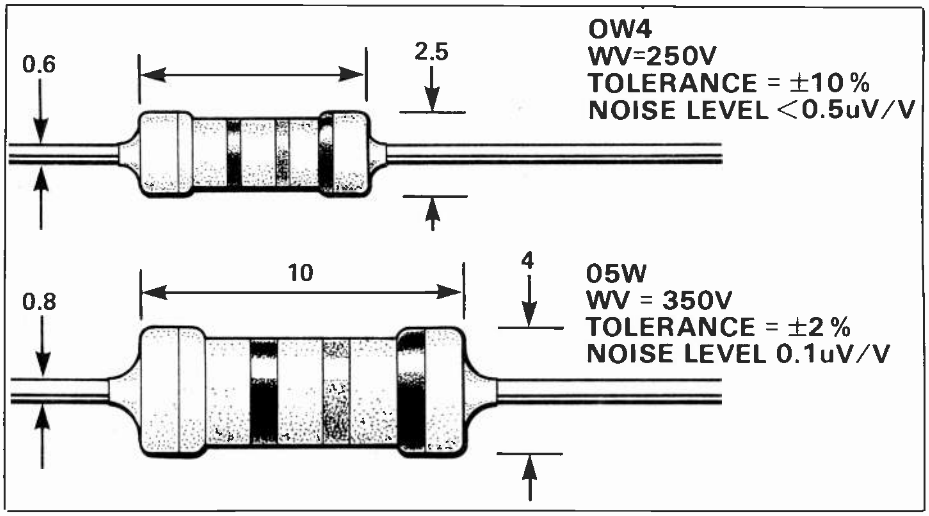
For higher power work, calculate the maximum power dissipation ($P = 12 \times R$) and select a resistor rated at least two times this value if ventilation is good — higher if not. Several hot resistors placed next to each other will require a higher rating as radiated heat from resistor to resistor has to be taken into account. Bear in mind that the cooler a resistor can be kept (especially non-wirewound types) the longer its life will be, and adjacent components will not suffer from thermal effects (reduced drift in oscillators for example).

Carbon Composition

These are the cheapest resistor to manufacture, and were once the most common type, although generally carbon film types now see more usage. They are



Carbon Film: The standard "¼ watt 5% carbon" type, has almost completely replaced older carbon composition resistors. Noise level is typically 1.0uV/V for any value, which is adequate for most purposes. N.B.: All dimensions are in millimeters.



Metal Film: General purpose high stability types with low temperature coefficient. Five-band colour code gives three significant figures, multiplier and tolerance. Metal Oxide: Used where a low noise figure is required.

reliable, and seldom suffer from failure, except through excessive heating, usually first seen as smoking followed eventually by total failure. A major advantage is in RF circuits, as they have very low inductance and capacitance, and are the type to choose when making dummy loads.

At audio, composition resistors generate appreciable noise, due to thermal and current effects between the carbon particles. If low noise is a requirement, use film types instead.

For high voltage work, carbon composition types are better than film types, and the higher the wattage rating, the higher the voltage rating. A typical 0W125 resistor may have a voltage rating of 150V, whereas a 2S type will be around 750 V.

These resistors are manufactured from a compressed and bonded mixture

Table 1
Standard Colour Code

Band Colour	Figure	Multiplier	Tolerance (±)
Black	0	1	not used
Brown	1	10	—
Red	2	100	2%
Orange	3	1000	—
Yellow	4	10000	—
Green	5	100000	—
Blue	6	1000000	—
Violet	7	10000000	not used
Grey	7	.01	—
White	9	.1	—
Gold	—	—	5%
Silver	—	—	10%

No tolerance band colour = ±20%

Metal film/oxide types have an additional value band to give the three significant figures rather than two, so that a standard 47k resistor would be coded yellow/violet/orange, whereas this type would be coded yellow/violet black/red (i.e., 47,000/4,7000).

An alternative system uses letters to identify the multiplier as follows (recognize it from ETI?):

0.22 ohms	= R22	
1.0 ohms	= 1R0	If a letter follows the value, it indicates the tolerances:
2.2 ohms	= 2R2	
22 ohms	= 22R	
220 ohms	= 220R	F = ±1%
2.2k ohms	= 2K2	J = ±5%
220k ohms	= 220K	K = ±10%
1.5 ohms	= 1M5	M = ±20%

of powdered graphite, a filler, and a resin binder — the more carbon, the lower the resistance. A moulded case protects the inner core against environmental effects, although moisture pick-up can be a problem (moisture can be removed by heating). Leads are inserted in each end for connection for the external circuit.

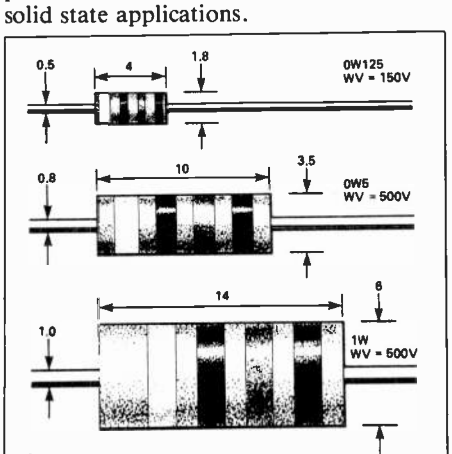
Carbon Film

For standard electronic work, the most common is the 0W25 carbon film variety, and ordering a value of resistor without any further specification would probably result in supply of these.

As the name implies, this type is made by depositing pure carbon onto a ceramic rod used as a former, usually by high temperature decomposition of gaseous hydrocarbons. The thickness of the coating controls the resistance value, and without further treatment, values of up to 1000 ohms are possible.

To achieve higher resistance values, a technique known as spiralling is used. The tube element is rotated, and a very thin track (around ten thousandths of an inch wide) cut around the tube in a helical fashion, using a laser, or cutting wheel. This increases the path length through which the current flows, thus increasing the resistance.

Problems arising from this method of construction are that the resistor cannot withstand even small overloads, with the track fusing open circuit (although this effect can be used to advantage). Also, above about 2MHz, the spiralling introduces capacitive reactance, which may be a problem at higher frequencies. However, the improved stability, low cost and lower resistance change over a long period make these a popular choice in solid state applications.

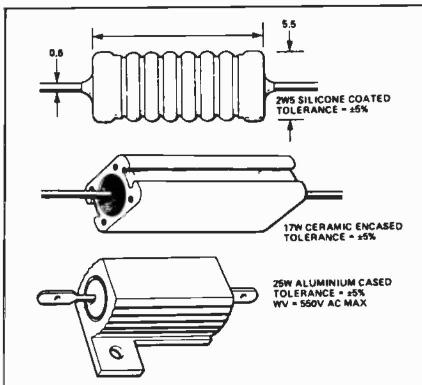


Carbon Composition: Older type resistor, for general use where temperature coefficient and tolerance are not critical; noise levels generally greater than 2uV/V. Carbon comp resistors are not usually available in values below 10R.

Metal Film/Oxide

For more precise values, these are the normal choice, and are easily available in two and one percent tolerance selections. Precision types come as low as 0.01%, depending on the exact construction, and of course you pay more for this sort of specification figure.

Like carbon film, a ceramic (or glass) tube acts as a former, with a thin film of metal, or metal oxide as the resistive element. Spiralling is normal, and the overload factor is better than that of carbon film. They are very reliable, and should be used where dependability and close tolerance are required.



Wirewound: Silcone coated types (top) suitable for general use up to 10W rating. Ceramic encased (middle) types are useful where high insulation resistance is needed (eg., power circuits); also supplied at 4W, 7W and 11W ratings. Aluminum-clad resistors (bottom) will rarely be used by the home constructor!

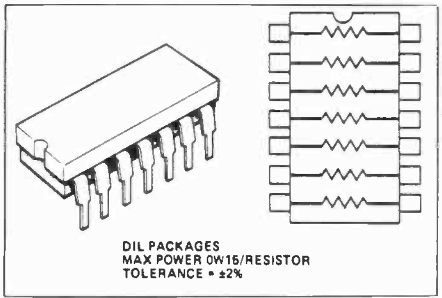
A number of metal films can be used — nickel-chromium being usual, but cermet and tin oxides will also be met. Cermet resistors are exceptionally stable, generally found as high (megohm ranges) value types, and of value under adverse climatic conditions — more often met as variable preset types than fixed. These thick cermet film types are also used for the dual in-line package types, of value for high density PCB work, for instance as LED display dropping resistors.

Again, capacitive reactance is a problem at higher frequencies. This type of resistor has a slightly different coding system to the composition and carbon film types, with an extra band introduced for the third figure (see Table 1) which makes the value decoding difficult if you haven't used them before.

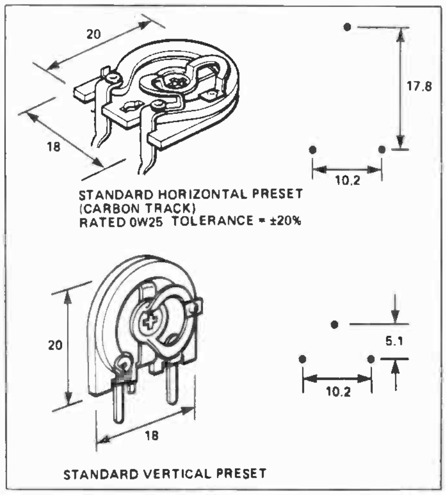
Wirewound

For applications of high power ratings, low noise or low resistance values, the wirewound resistor, in one of its many forms is the answer. Also, high pulse currents are better handled by these. Tolerance values range from 10% down to .05% for precision work, such as divider networks on test instruments.

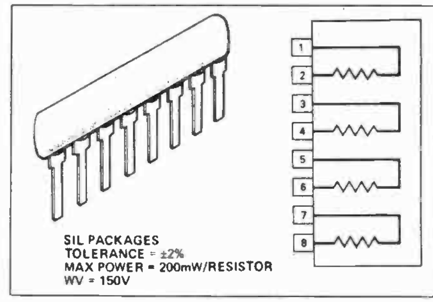
Construction is by using a spirally wound high resistance wire element on a ceramic former (sometimes fibreglass on low wattage types). The outer casing is very variable, depending on the application, but typically ceramic, vitreous enamel, plastic, or silicone. Types with



DIL Package: Compact resistor form offering considerable space savings, and very convenient for eg. current limiting LED arrays, 7-segment displays, pull-up/down in logic circuits etc. Also supplied containing 13 commoned resistors.



Standard Horizontal Preset (top): miniature types have pin spacings of 10.2 and 5.1mm in the same pattern.
Standard Vertical Preset (bottom): miniature variety pin spacing is 5.1 and 2.54mm, in the same pattern.



SIL Package: Also available with 7 or 8 commoned resistors. As with DIL resistors, values are limited and all resistors in the package are the same value.

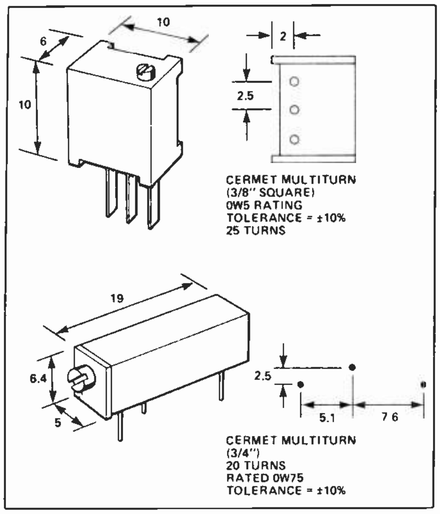
metal sheathing, which can be screwed to a chassis are available with ratings up to 50 watts.

Power types, often seen as dropping resistors on TV chassis are primarily designed for heat dissipation rather than electrical performance, with wide tolerances. Types used in consumer applications are generally flameproof, for saftey reasons, with an outer ceramic coating.

By the nature of the construction, wirewound resistors are highly inductive and should not be used in high frequency circuitry. It is possible to obtain non-inductive types, where two parallel windings are made on the same core, but in opposite directions, to reduce the inductance to around 1/100th of normal. Precision wirewound types are often made by this method, although a typical 0.1% value will set you back $4.00 or more each.

Variable Resistors

To vary the voltage in an electrical circuit, a variable resistor is required, otherwise known as a potentiometer or trimmer resistor. All function in a similar manner, having one terminal at each end of a resistive track, and another terminal connected to some form of flap that can be slide up and down the resistive element. One other form of potentiometer is the Rheostat which is strictly a two terminal device of high power capability, but the term is often applied to a three terminal



Cermet Multiturn Presets: Essential for precision adjustment. A large range of single-turn cermet trimmers are also available, eg. square, vertical, horizontal and round.

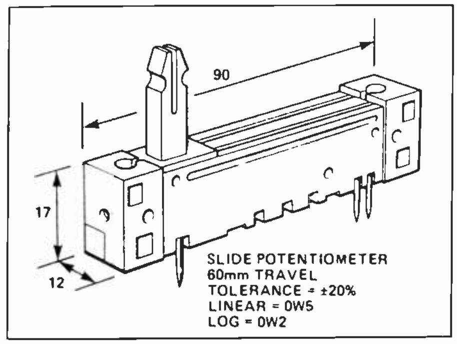
device of similar high power. They are normally used for current limiting purposes.

Like fixed resistors, these come in a variety of shapes and sizes, often with switches attached. Caution should be observed when using switched types that the switch contacts are rated for the job in hand — especially when AC power is involved as the DC rating is very different to the AC. Details of the rating will normally be found on a unit.

Multiple section types are often encountered and used for such applications as ganged stereo balance controls. Many of the types imported from the Far East have additional features such as centre click stops, for the preceding application, or multiple click stops for the type of volume control now popular on hi-fi equipment.

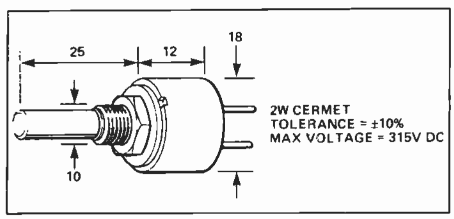
Selection of the variable resistor to suit the application will involve deciding on the type of taper the device has. Taper is a term referring to the track law, or in what manner the resistance changes as the control is rotated. Linear types vary in a linear fashion so that the centre position would be expected to have held the total resistance. Logarithmic law varies slowly at first as the control is rotated from its fully anticlockwise position and then more and more rapidly as the other end is reached, thus obeying a logarthmic law (these are normally used in volume controls).

Reverse log laws vary in the same manner but in the opposite direction, and a mix of linear and log termed semi-log can be obtained for special purposes. There are other types but they are not frequently met by hobbyists. All of these tapers are formed by varying the mix used to form the resistive element over the element length.



Slide Potentiometers: Favoured for application where controls are being operated continuously.

The power rating of a potentiometer will vary with its size and construction. Unlike a fixed resistor, you cannot look at one and say what the power rating will be, so inspection of the manufacturers data is advised if in doubt.



Rotary Cermet: The cermet track provides good electrical and temperature stability, and linearity.

Carbon Composition

These were one of the earliest types to be introduced and can still be found. There are two types of construction — moulded and film coated. The former are made by filling a cavity in a moulded base with a carbon composition mix, with the slider formed as a pure carbon brush. The outer case is usually made as an environmental seal, making this type useful under adverse conditions. Track life is long, with low wiper noise.

Conductive Plastic

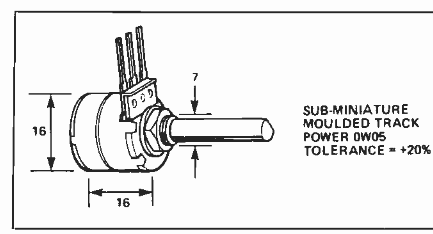
These are the type more normally met in day-to-day applications, usually in the form of a thick film carbon-resin mix screened onto a base of plastic, phenolic or ceramic material. The wiper is made from a variety of metals, depending on the specification, normally in the form of a spring loaded skeleton.

In use the track eventually wears producing erratic voltage variations or noise in audio circuits. Very short term relief can be obtained by using switch or contact cleaning liquids, but it is usually best to replace the faulty unit without delay. Many of the low cost potentiometers of this type are not sealed against dust contamination which can lead to premature failure under adverse conditions, such as dusty environments.

Wirewound

For higher powers, wirewound types are a natural choice, but their inductive construction limits them to DC and some audio applications. All are made by winding a length of bare resistance wire around a core of insulating material, with the resistance value controlled by varying the type of wire, size of the core, turns spacing and/or wire diameter. A rotating metal wiper pressing on one edge of the former then acts as the resistance control.

The main disadvantage of this type of construction is that the resistive increment as the control is rotated will vary in discrete steps, termed the 'resolution'. This parameter is determined by the diameter and spacing of the wire, and by the contact area of the wiper. In many applications, a fairly high resolution is required as in varicap control voltage applications, and this can only be achieved by using finer wire with closer spacing, which means a more fragile winding. There is also a practical limit to the wiper size.



Sub-miniature Carbon: Suitable for panel or PCB mounting where space saving is important.

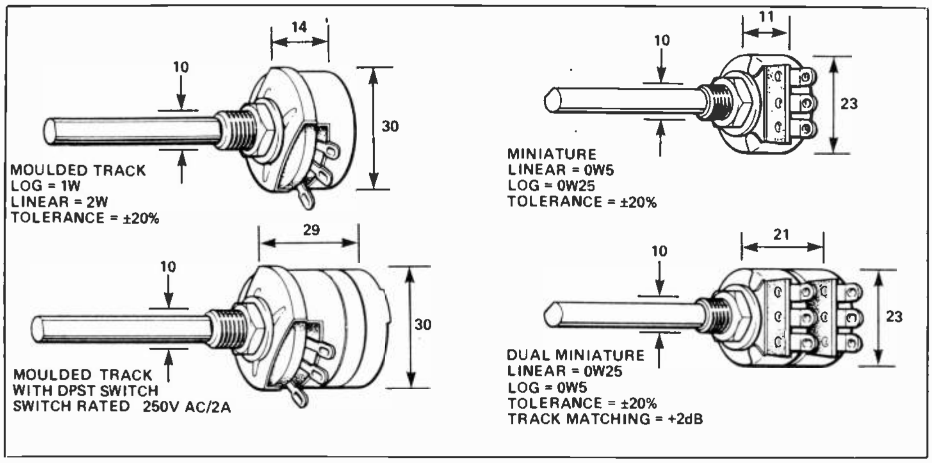
Precision Types

While single turn precision potentiometers are available (with much longer element lengths and special wipers), it is normally a multi-turn unit which will be encountered for precision applications. The construction and housing are varied, with the elements invariably made from wire, although it is possible to use cermet or conductive plactic in smaller types.

The housings usually incorporate much better shaft arrangements, often with ball bearings, and precious metal wipers. The method of winding the coil gives much higher resolution over single turn types, although there is still a practical limit — for a ten-turn unit, this would be about .01% for a 10kR value. The linearity of the winding is also vastly improved to about =0.25% at any point on the track.

Trimmer Resistors

Most of the preceding types of variable resistors have their small trimmer equivalents. Nowadays, virtually all trimmer types come as printed circuit board mounting types, with sizes varying down to 6mm diameter. The skeleton preset is



Moulded Carbon Track: The usual potentiometer chosen for panel mounting in non-critical applications. Also available with DPST switch rated for mains voltage (bottom).

Miniature of "Midget": Carbon track potentiometers for general purposes. Dual (aka 'tandem' or 'ganged' pots) have closely matched tracks.

familiar to most readers, and is used in many non-critical applications. For higher reliability, cermet track types should be used — these also have a lower temperature coefficient.

Totally enclosed types are available where environmental conditions are hazardous or where long life is required.

Multi-turn trimmers normally come in a long rectangular case, with a screwdriver adjustment at one end, and a slipping clutch arrangement to prevent damage to the unit. If you want to panel mount these types, it is possible to obtain special holders with a panel mounting bush. The actual sliding wiper is usually carried on a screw or wormgear arrangement. Note that all these types have a limited dissipation, and are not designed for continual adjustment — use a proper variable type if you continually need to adjust the value or the operational life will be poor.

Next month, an investigation into capacitors.

ETI

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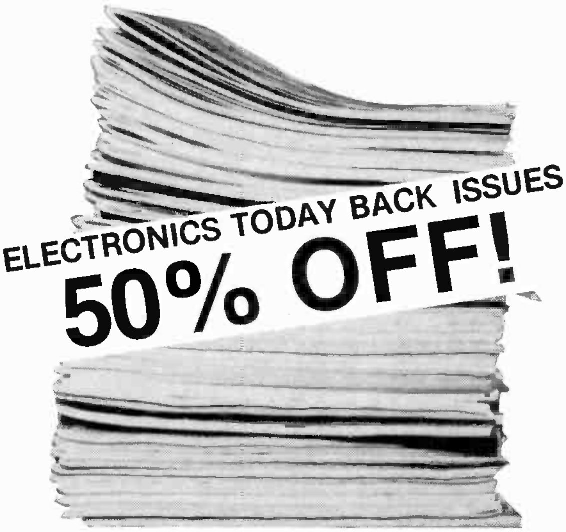

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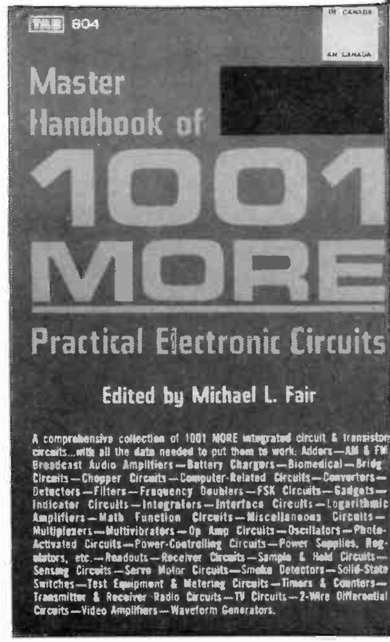

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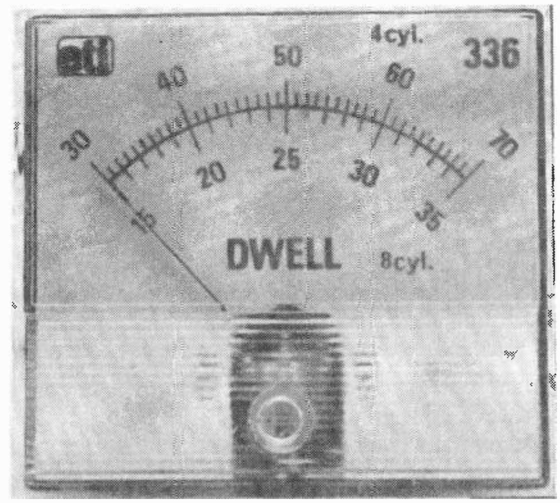
PROJECT

You can do your own vehicle tune-ups at home and save the cost and inconvenience of sending it to the garage. A dwell meter can be bought 'over the counter', but you save even more money and increase your personal satisfaction by building your own.



THE FACT THAT you've started to read this article means you probably know quite well what *dwell* is, and the advantages of owning a dwell meter, rather than letting your regular mechanic do the adjustment periodically. (If not, please see the secion explaining dwell in automotive ignition systems, because that is where the automotive content of this article is dealt with).

You are possibly also aware that one can readily buy a tacho/dwell meter in local automotive or electronic shops for around $25 to $30, which is marginally more than the cost of this project, box and large meter included. So why describe a project that merely reads dwell?

The reasons are threefold: First, if you have ever dissected one of the commercial units, you may be aghast to note the lack of any transistors — often they rely on diodes alone, and a few quarter-watt resistors on a small board. The circuit, though ingenious, is rather simple and does not inspire this author to praise the accuracy or long-term stability.

This project, once calibrated carefully (emphasis on this, as there are pitfalls, outlined later), will be as good as the components you use, which is comparatively very good. In addition, if you have built the thing yourself, it is easy to repair should anything go wrong, from a blown transistor to a crushed meter, and there is a good chance of that if you throw it around like other car tools.

Secondly, this project can be quite cheap. The major expense is the meter, so if you wish to build it as an addition to a multimeter and house it in something cheap, or not at all, it becomes very economical. None of the components is critical, except those resistors specified as high-stablity types (readily available these days), so it can be a junk-box job if you need.

All you require in addition, is a microamp-to-degrees conversion scale (see later) and you're away.

A second advantage occurred to me as I wandered from car to car testing the prototype. The board is sufficiently cheap that you could leave one connected permanently to the car (it does not effect the running) and, if you are into stacks of dials on your dash, have another one!

Finally, many cars have tachometers of the electronic genre already, and offer more accurate rpm indication than the cheap commercial tacho/dwell units anyway. If you have such a car, there is no incentive to have a second tachometer function which clutters up the scales etc.

Construction

Construction of the Dwell Meter is very straightforward. The first step, if you are going to mount it in a case, is to cut the meter mounting holes. Once you are satisfied that the case is prepared, check the printed circuit board to ensure that the holes on it are of a suitable size. If you intend to mount the board on the rear of the meter itself, as I intended, ensure that the meter connection holes are large enough to fit the meter posts.

Once prepared, mount the components on the PC board, taking care to orientate the IC and other semiconductors correctly. Also check that the electrolytic and tantalum capacitors are the correct way around. Reversing C4 could produce devious and subtle problems! While attaching the components, tin the copper areas around the meter mount holes so that the meter post nuts make good contact on to the board. If you do not do this, the lacquer put on the PC board to stop corrosion could insulate the meter posts completely.

Connect lengths of hookup wire to the battery and points connections. These will be led out of a hole in the case, and alligator or other suitable clips attached to them for connection to the car electricals.

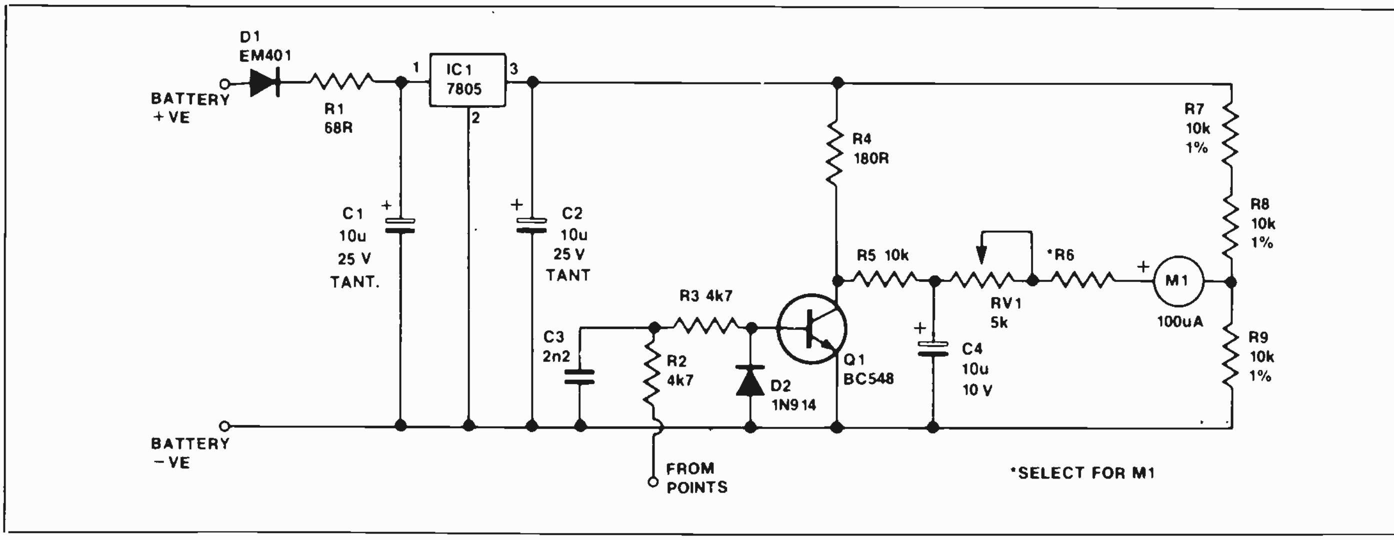
Next fit the meter in the case, then fit the PC board to the meter, leaving the

PARTS LIST

Resistors (All ¼ W, 5% unless noted)	
R1	68R
R2,R3	4k7
R4	180R
R5	10k
R6	1k selected, see text
R7,R8,R9	10k (1% or 2%)
RV1	5k (min. trimpot)
Capacitors	
C1,C2	10u/25 V tantalum
C3	2n2
C4	10u/10 V electro
Semiconductors	
D1	1N4001, 1N4002 etc.
D2	1N914, 1N4148 etc.
IC1	7805 or 78L05 etc.
Q1	2N3904 or equiv.
Miscellaneous	
M1	100uA panel meter, eg., Minipa MU-65, University TD86

PC board; case to suit; three alligator clips; hookup wire; meter scale to requirements, etc.

* R6 selected so that R6 + meter resistance equals a litle under 3k



The dwell meter schematic diagram

HOW IT WORKS

The dwell meter is simply a 'duty cycle' meter with a zero offset and suitable scale markings on the meter face. It measures the closed-to-open ratio of the vehicle points.

Referring to the circuit diagram, D1 and R1, in conjunction with IC1, provide a reverse polarity protected +5 volt supply from the car battery. Capacitors C1 and C2 remove interfering pulses and ensure that IC1 remains stable.

The square wave voltage created by the 'points' opening and closing is filtered to remove the inductive 'spikes' by R2, R3 and C3. Diode D2 protects Q1 from negative voltages which may appear at the input. The square wave is then inverted and set to a fixed amplitude by Q1, which alternately turns hard on (saturates) and cuts off as the points open and close respectively.

The average voltage appearing on the collector of Q1 is thus proportional to the time the points spend closed, ranging from almost zero for open points to +5 volts when the points are closed. Resistor R5 and capacitor C4 filter this square wave to reveal a relatively steady level. Meter M1 and surrounding components are set to give a minimum scale reading of 33% and a FSD reading of about 78%. This corresponds to a range of 30-70 for four cylinder engines; 20-47 for six cylinders; 15-35 for eight; 24-56 for five; 10-23 for twelve, etc. It is simple to calculate the duty cycle given the formula:

% duty cycle = (degrees of dwell) × (no. of cylinders) × (100/360).

Resistor R7 is selected to allow for the internal resistance of the meter. The meter type used in the prototype had a resistance of about 1,800 ohms. The sum of meter resistance and R7 should equal a little under 3,000 ohms. The trimpot, RV1, is set to calibrate the meter full-scale deflection (FSD). Meter zero is held correct by the resistors R7, R8 and R9 which provide an 'offset' voltage.

Without the points connected, the meter needle goes to full scale as the positive terminal is returned to +5 via R4, R5, RV1 and R6, while the negative terminal is at a lower voltage via the R7-8-9 voltage divider. This will not damage the meter.

trimpot accessible. Final assembly should be left until the calibration has been completed.

Calibration

A known calibrating signal will be required to set up the meter. It is not advisable to use a sine wave source (such as from a low voltage power transformer) as this can introduce some error. A square waveform is desirable. This must be of known duty cycle. If you have a signal generator which delivers a known duty cycle square wave, typically 50%, set it to deliver 10 to 30 volts peak-to-peak output, and adjust the trimpot for the correct reading.

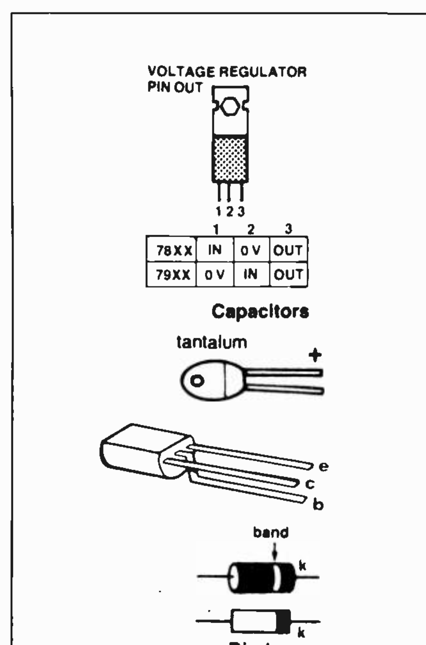
The calibrating signal must have a duty cycle of between 40% and 78%. The higher the better, for accuracy.

If you do not have access to a suitable source, proceed as follows. You will need a sine wave of between 30 and 50 volts peak. If you have a transformer delivering nominally between 7 and 20 volts RMS, it will do nicely. Connect the transformer to put the full AC voltage between the 'batt-' terminal and the 'points' input. Adjust the trimpot for a reading of 50% duty cycle, or 45° dwell on the four-cylinder range. If an oscilloscope is available, it may be used to check the duty cycle at the collector of Q1, and the trimpot used to set the meter to agree with the measurement taken by the oscilloscope. The frequency of the input is not important, of course, provided it is less than a few hundred Hertz.

Using It

Use of the dwell meter, if you have never used one before, is elementary. Simply place the meter in a convenient location near the engine bay. Note that the typical panel meter changes its calibration when it is moved from the horizontal to the vertical, *so it should be used in the position in which it was calibrated initially.*

Connect the 'batt+' lead to the car battery positive terminal, and the 'batt-' lead to the battery negative connection. Connect the points lead to the junction of the ignition coil and the points in the distributor. When the car is running the meter reads dwell. Adjustments should be made according to the manual for the particular car, but in an emergency, all cars are likely to have dwell specifications which lie roughly at the half-scale point on the meter.



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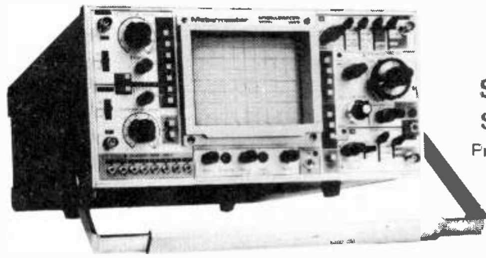

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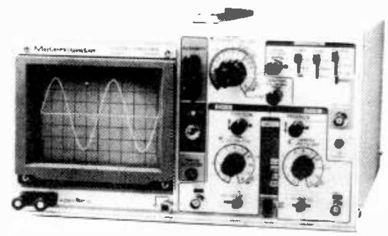

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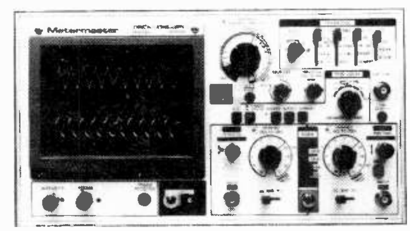

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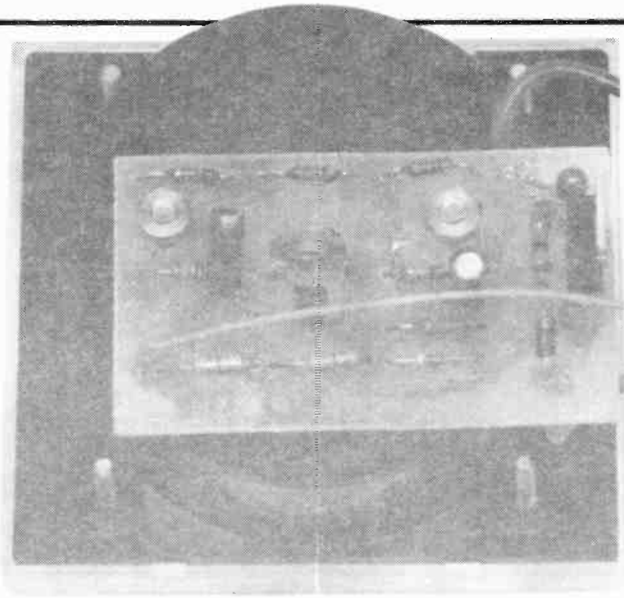
Dwell In Automotive Ignition Systems

The distributor in the standard type of car has two functions. First, it 'distributes' the spark energy from the ignition coil to each spark plug in turn by means of the rotor and cap of the assembly. This is the most obvious job of the distributor, and the one from which it gets its name. But it is not the most critical, or the one requiring the most attention and adjustment.

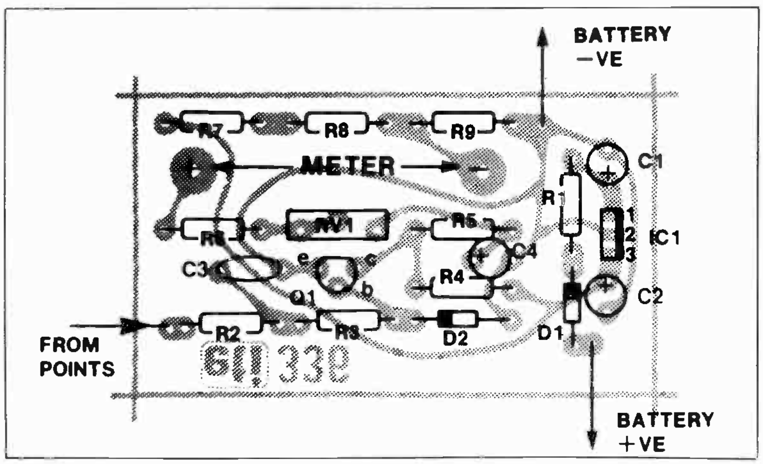
It also contains a mechanism for opening and closing the points, which interrupt the ignition-coil primary current and generates the spark itself.

These points are subject to considerable wear, and as they effect both the spark strength and its timing, they are perhaps one of the weakest links in the ignition system.

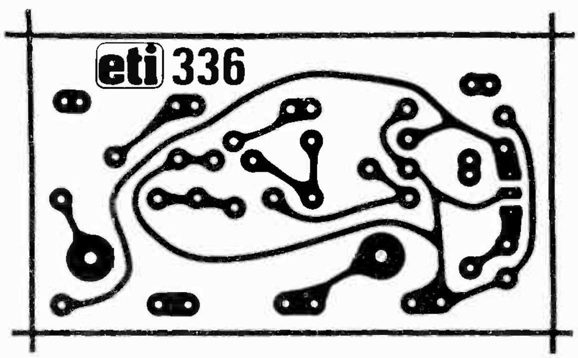
The lower assembly of the distributor must open and close the points *once* for each cylinder for each *two* revolutions of the main engine shaft. Each time it is responsible for ensuring that the coil has enough time to build up primary current, and that the opening occurred at the correct moment, acocunting for engine RPM and possibly also the degree of vacuum fed to it down a small pipe from the inlet side of the engine carburetor.



Rear view. The board mounts directly on the terminals of a University TD-86 meter. On other types, use heavy-gauge tinned copper wire to secure the board to the meter terminals.



PCB Overlay.



The two functions which must be adjusted are *dwell* and *timing*. These are analogous to the duty cycle and phase of the square wave (current) generated by the regular opening of the points. Dwell actually means the amount of time, per revolution of the distributor shaft, which the points spend closed.

Timing means the relative phase, referred to the moment when the piston is at the position of maximum compression (top dead centre of 'TDC') of the moment of delivery of the spark energy. The latter can be set statically by aligning marks at various positions, and the former by judicious use of feeler gauges on the points, but neither method is as accurate as the electronic methods.

A stroboscope is used for the timing adjustment, and a duty-cycle meter, called a dwell meter, with special scales, is used for the dwell measurement.

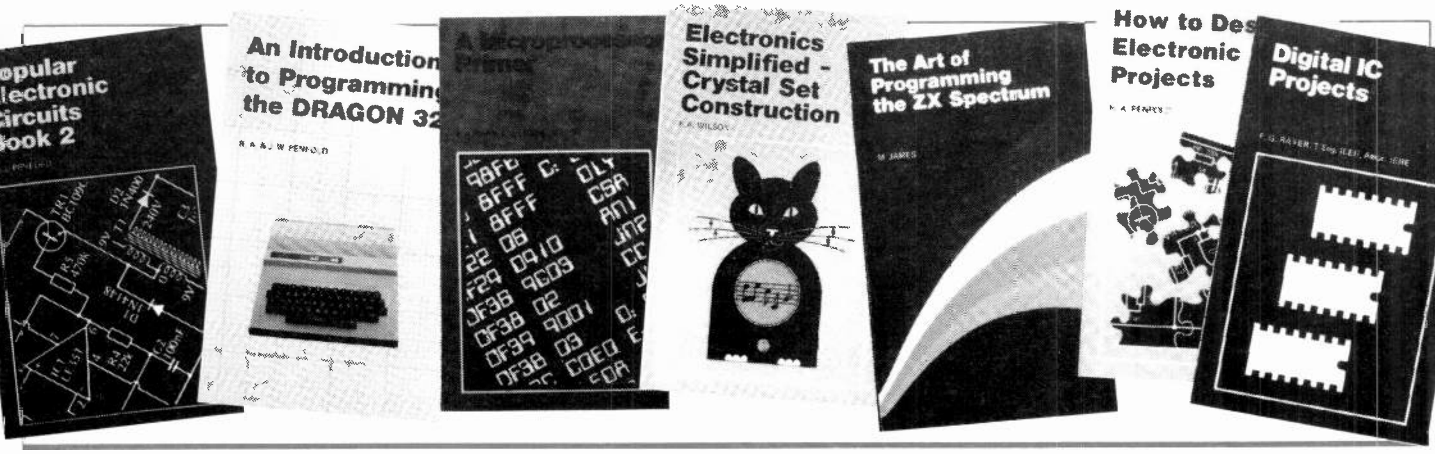
Dwell is specified, not by the kind of figure that an electrical engineer would expect — namely a % duty cycle or a number of electrical degrees — but by the actual number of mechanical degrees traversed by the distributor shaft while the points are closed. Thus, although the actual duty cycle may be similar in all engines, irrelevant of number of cylinders, the degrees of dwell specified appears to change with the number of cylinders. This is because the distributor must deliver one spark for each cylinder each 360 degrees of revolution.

A four-cylinder car has 90 degrees (360/4) of a revolution, so a specified figure of 50 degrees of dwell means 50/90 or 56% duty cycle. A 12-cylinder car has only 30 degrees per cylinder, so 17 degrees of dwell means about the same duty cycle.

Clearly, it is possible to convert any quoted dwell figure into duty cycle by knowing the number of cylinders, then a universal scale of duty cycle on a duty cycle meter would suffice. However, it is usual practice to have several scales on the meter face to achieve the same thing.

Also, since doubling the number of cylinders merely means that the scale reads twice the actual mechanical reading, scales for four and six cylinders enable easy use on eight and twelve cylinder cars, merely by halving the read value.

Equations for converting dwell into duty cycle and vice versa are given in the 'How it Works' section, so if you happen to have an engine with an unusual number of cylinders, you may construct a scale for yourself, or convert the manufacturers specified dwell for, say, a five cylinder car into what the meter will read on the scale for a four cylinder car. **ETI**



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Details are then given of actual solid state transmitting equipment which the reader can build Plain and loaded aerials are then discussed and so is the field-strength meter to help with proper setting up

The radio receiving equipment is then dealt with which includes a simple receiver and also a crystal controlled superhet The book ends with the electro-mechanical means of obtaining movement of the controls of the model

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BP46: RADIO CIRCUITS USING IC's $5.40
J.B. DANCE, M.Sc.
This book describes integrated circuits and how they can be employed in receivers for the reception of either amplitude or frequency modulated signals The chapter on amplitude modulated (a m) receivers will be of most interest to those who wish to receive distant stations at only moderate audio quality, while the chapter on frequency modulation (f m) receivers will appeal to those who desire high fidelity reception

BP92: ELECTRONICS SIMPLIFIED—CRYSTAL SET CONSTRUCTION $6.80
F.A. WILSON
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PH245: ELECTRONIC COMMUNICATIONS $16.95
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BP70: TRANSISTOR RADIO FAULT-FINDING CHART $1.90
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BP90: AUDIO PROJECTS $7.60
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BP47: MOBILE DISCOTHEQUE HANDBOOK $5.40
COLIN CARSON
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HOW TO BUILD A SMALL BUDGET RECORDING STUDIO FROM SCRATCH. . .
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This book sets out to show how electronic music can be made at home with the simplest and most inexpensive of equipment It then describes how the sounds are generated and how these may be recorded to build up the final composition

BP74: ELECTRONIC MUSIC PROJECTS $7.20
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BP81: ELECTRONIC SYNTHESISER PROJECTS $6.80
M.K. BERRY
One of the most fascinating and rewarding applications of electronics is in electronic music and there is hardly a group today without some sort of synthesiser or effects generator Although an electronic synthesiser is quite a complex piece of electronic equipment, it can be broken down into much simpler units which may be built individually and these can then be used or assembled together to make a complete instrument.

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Help is given to the reader in understanding the equipment he is interested in buying and the author also gives his own opinion of the minimum standards and specifications one should look for. The book also offers helpful advice on how to use your hi-fi properly so as to realise its potential A Glossary of terms is also included.

TEST EQUIPMENT

BP75: ELECTRONIC TEST EQUIPMENT CONSTRUCTION $6.80
F.G. RAYER, T.Eng. (CEI), Assoc. IERE
This book covers in detail the construction of a wide range of test equipment for both the Electronics Hobbyists and Radio Amateur Included are projects ranging from an FET Amplified Voltmeter and Resistance Bridge to a Field Strength Indicator and Heterodyne Frequency Meter Not only can the home constructor enjoy building the equipment but the finished projects can also be usefully utilised in the furtherance of his hobby

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HOW TO GET THE MOST OUT OF LOW COST TEST EQUIPMENT
AB017 $9.95
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THE POWER SUPPLY HANDBOOK
TAB No 806 $15.95
A complete one stop reference for hobbyists and engineers Contains high and low voltage power supplies of every conceivable type as well mobile and portable units

PH246: ELECTRONIC TEST EQUIPMENT $19.95
Covers analog and digital meters, oscilloscopes, frequency generation and measurement, and special measuring instruments

Tab1532: THE COMPLETE BOOK OF OSCILLOSCOPES $19.95
This totally up-to-date handbook is both an in-depth reference source and a practical applications guide Information is included on both ordinary service and laboratory 'scopes, waveform analysis, vectors, vectorscopes, high and low frequency analysis, sampling, storage, digital scopes, and signature analysis The author, Stan Prentiss is one of the leading technical writers in the U S

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REFERENCE

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ADRIAN MICHAELS
This book will help the reader to find possible substitutes for a popular user-orientated selection of modern transistors. Also shown are the material type, polarity, manufacturer selection of modern transistors. Also shown are the material type, polarity, manufacturer and use. The Equivalents are sub-divided into European, American and Japanese. The products of over 100 manufacturers are included. An essential addition to the library of all those interested in electronics, be they technicians, designers, engineers or hobbyists. Fantastic value for the amount of information it contains.

BP108: INTERNATIONAL DIODE EQUIVALENTS GUIDE
ADRIAN MICHAELS $8.95
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BP1: FIRST BOOK OF TRANSISTOR EQUIVALENTS AND SUBSTITUTES $5.75
B.B. BABANI
This guide covers many thousands of transistors showing possible alternatives and equivalents. Covers transistors made in Great Britain, USA, Japan, Germany, France, Europe, Hong Kong, and includes types produced by more than 120 different manufacturers.

BP14: SECOND BOOK OF TRANSISTOR EQUIVALENTS AND SUBSTITUTES $6.75
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The "First Book of Transistor Equivalents" has had to be reprinted 15 times. The "Second Book" produced in the same style as the first book, in no way duplicates any of the data presented in it. The "Second Book" contains only additional material and the two books complement each other and make available some of the most complete and extensive information in this field. The interchangeability data covers semiconductors manufactured in Great Britain, USA, Germany, France, Poland, Italy, East Germany, Belgium, Austria, Netherlands and many other countries.

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TAB No.984 $9.45
There are several books around with this title, but most are just collections of manufacturers' data sheets. This one, by Bill Hunter, explains all the intricacies of this useful family of logic devices — the missing link in getting your own designs working properly. Highly recommended to anyone working with digital circuits.

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MISCELLANEOUS

BP101: HOW TO IDENTIFY UNMARKED IC'S $2.20
K.H. RECORR
Originally published as a feature in 'Radio Electronics', this chart shows how to record the particular signature of an unmarked IC using a test meter, this information can then be used with manufacturer's data to establish the application.

AUDIO AND VIDEO INTERFERENCE CURES
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A practical work about interference causes and cures that affect TV, radio, hi-fi, CB, and other devices. Provides all the information needed to stop interference. Schematic wiring diagrams of filters for all types of receivers and transmitters are included. Also, it supplies simple filter diagrams to eliminate radio and TV interference caused by noisy home appliances, neon lights, motors, etc.

BASIC TELEPHONE SWITCHING SYSTEMS
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HB27 $15.50
The Revised Second Edition of this book, for trainee and engineer alike, includes updated statistical data on telephone stations, and new and improved signaling methods and switching techniques. It also includes E & M signaling interface for electronic central offices and automatic number identification methods used in step-by-step, panel and crossbar central offices.

INTERRELATED INTEGRATED ELECTRONICS CIRCUITS FOR THE RADIO AMATEUR, TECHNICIAN, HOBBYIST AND CB'ER
MENDELSON
HB29 $10.95
This book provides a variety of appealing projects that can be constructed by anyone from the hobbyist to the engineer. Construction details, layouts, and photographs are provided to simplify duplication. While most of the circuits are shown on printed circuit boards, every one can be duplicated on hand-wired, perforated boards. Each project is related to another projects so that several may be combined into a single package. The projects, divided into five major groups, include CMOS audio modules, passive devices tohelp in benchwork, test instruments, and games.

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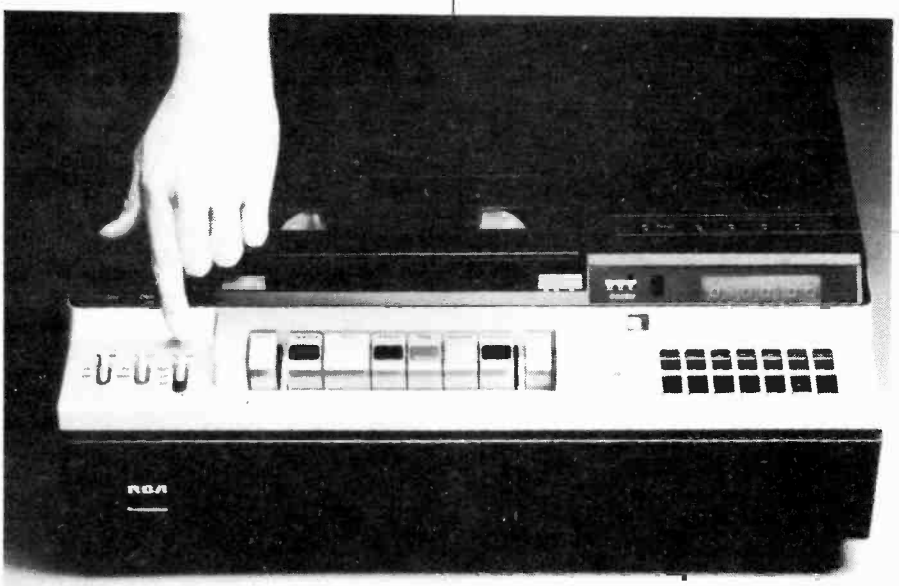
BP110: HOW TO GET YOUR ELECTRONIC PROJECTS WORKING $7.60
R.A. PENFOLD
We have all built circuits from magazines and books only to find that they did not work correctly, or at all, when first switched on. The aim of this book is to help the reader overcome just these problems by indicating how and where to start looking for many of the common faults that can occur when building up projects.

ELECTRONIC TROUBLESHOOTING HANDBOOK
AB019 $11.95
This workbench guide can show you how to pinpoint circuit troubles in minutes, how to test anything electronic, and how to get the most out of low cost test equipment. You can use any and all of the time-saving shortcuts to rapidly locate and repair all types of electronic equipment malfunctions.



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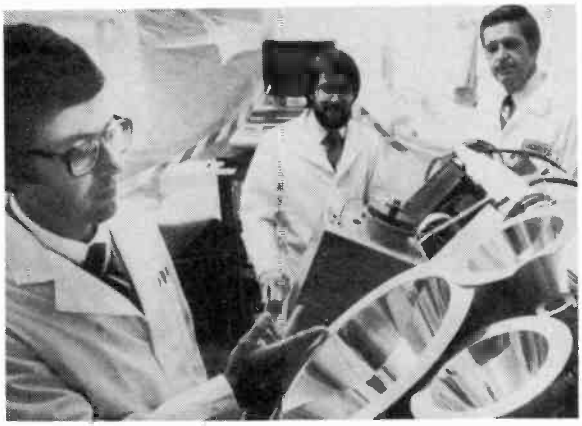
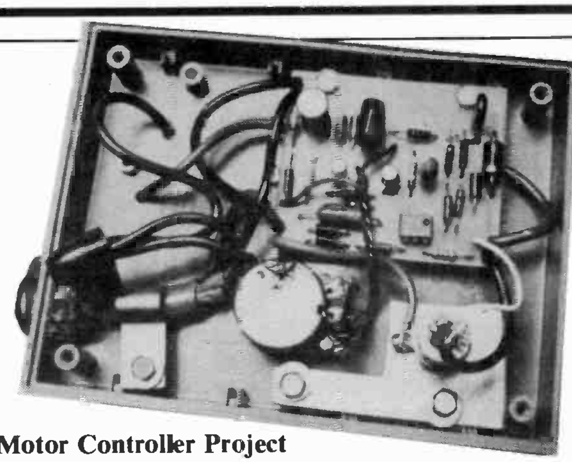


VLFs and the Magnetosphere

Roger Allan reports on how radio waves can be guided and amplified using the Earth's magnetic field.

Stylus Timer Project

If you're wondering why your records sound like the audio equivalent of steel wool, this timer will keep track of the stylus hours-in-use.



Motor Controller Project

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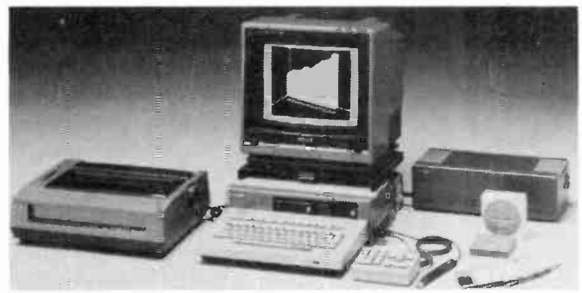

Sony SMC-70 Review

Add a special graphics capability to a CP/M-based computer and you've got next month's look at the SMC-70.

Machine Code Programming Part One

Machine code programming has two uses: firstly, as a way of getting your (normally BASIC-loving) microcomputer to go faster; and secondly, it's the only way to get a 'naked' microprocessor to do what you want. However, it's pretty difficult to learn on a bare micro, so in this short series, Bob Bennett will be showing us how it's done on a home computer, with some comments on using a microprocessor in the raw.

THE BEST way to learn to program using machine code is to have a go. After all, that was how you learned to program in BASIC. But then, BASIC does bear some resemblance to everyday English, and machine code looks like. . .well. . .code, so how is it done? To answer that, you need to have an insight into what is happening inside the computer — not a lot, just enough to make machine code programming clearer. I'll start with a short recap of some of the points relevant to machine code programming.

Deep In The Heart (of Texas?)

At the heart of any computer is a processor, and in most home computers it is a single chip. Many use a Z80 type, the processor in the Vic 20, Apple, etc., is a type 6502. Each processor has its own instruction set, which is a repertoire of instructions the processor will obey, and each processor has a register set, most of which can be used directly by the programmer. It is by the judicious use of the instruction set that the programmer manipulates the data in the registers to execute, in a controlled sequence, the various effects which constitute the desired aim of the overall program.

CPUs differ quite a lot in both the sizes of their instruction repertoires and in the number of registers that they contain. We'll be looking at registers in a moment.

The two more common types of memory used in home computers are random access memory (RAM), and read only memory (ROM). Fundamentally they appear the same in general makeup, inasmuch as they both have a number of locations (called addresses) where data can be placed, but in ROM that data is sealed in and cannot be altered, hence read only. It is in the ROM where the designer has put the routines to control all the effects I mentioned earlier, such goodies as PRINT, PLOT, SCROLL, etc., in fact everything your computer can do. RAM is where the machine code programmer (that's you!) places the instructions (program) which the processor hopefully will obey. The designation random is a bit of a misnomer: there is nothing random in the way the memory is accessed, at least, not (we hope) in a computer!

Bits And Pieces

So what's the connection between RAM, ROM, registers and the processor? The answer is a bus. Not the number 8 to the office, but another name for a connecting wire, or, as is more usual in a computer, a group of wires (or tracks on a PCB). These wires carry information in the form of electrical signals, and it is the level of the voltages present on the bus which conveys the meaning of the signals. An acceptable high level can be taken to mean a 1, and an acceptable low level can signify a 0, which leads us to use binary notation on computing (convenient isn't it?).

If there are n wires making up a bus, then the total information on the bus can be represented as 2^n. Most home computers have eight-bit registers (where bit is a contraction of Binary digIT), so the highest number this register can hold is 2^8-1 which is 255 if all the bits are 1s. These eight bits are known as a byte.

255 is not a very high number to play around with, so it is arranged that registers can be used in pairs, but only in certain combinations. This combination broadens our horizons somewhat because we can now use numbers up to 2^{16} which is equal to 65,536 decimal. The normal way to present data is one byte at a time, so our data bus usually has only eight wires. However, because we need a lot of memory, we use 16 wires on the address bus which allows up to 65,536 addresses, or locations to be used. This is known as 16K or 16 Kilobytes because it gets tedious writing out complicated binary numbers in decimal all the time. A K is 2^{10}, and this is equal to 1024 — it's the nearest convenient binary number to 1000, but note that a capital K is used to distinguish it from the decimal k (= 1000).

When you see advertisements extolling the virtues of home computers you will probably notice something along the lines of "16K ROM and 16K RAM". You will know that the ROM is for the routines that the designers have built into the machine. The start of the ROM area is usually (but not always!) address 0, so in the example given, it will extend up to address 16 X 1024 — 1, ie 16383 (the — 1 is because we've started counting at 0 rather than 1 as is usual outside computers — think of a street with 16 houses, if the first is numbered 0, the last will be number 15).

Unfortunately, this doesn't leave the RAM entirely free for the user to place all his or her programs, data, etc, because the computer needs some space to use for its own internal housekeeping (it stores what are known as the systems variables). It is very important not to over-write or **corrupt** the areas that the computer needs for this

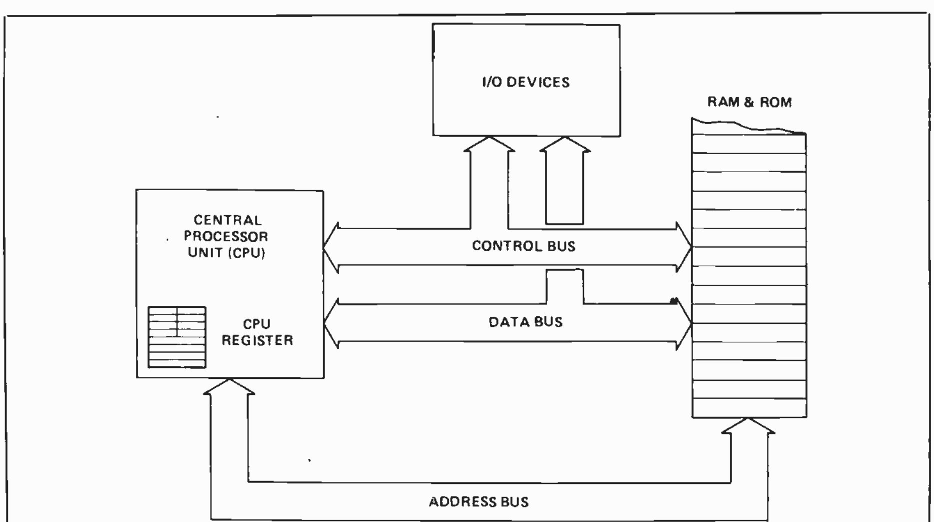

Fig. 1 Layout of a minimal computer.

CONVERSIONS

CONVERSION OF HEXADECIMAL TO DECIMAL

A single hexadecimal register holds up to 256, and, as we do when counting in tens, we split this into a 16^1 figure and a 16^0 figure (as in tens and units). A register pair would hold figures for 16^3, 16^2, 16^1 and 16^0.

hex	16^3	16^2	16^1	16^0
0	0	0	0	0
1	4096	256	16	1
2	8192	512	32	2
3	12288	768	48	3
4	16384	1024	64	4
5	20480	1280	80	5
6	24576	1536	96	6
7	28672	1792	112	7
8	32768	2048	128	8
9	36864	2304	144	9
A	40960	2560	160	10
B	45056	2716	176	11
C	49152	3072	192	12
D	53248	3328	208	13
E	57344	3584	224	14
F	61440	3840	240	15

Using the table: decimal 15 in a register pair = 000F whereas 240 decimal in a single register would = F0.
A0B0 hex = 40960 + 176 = 41136 decimal
FEDC hex = 61440 + 3854 + 208 + 12 = 65514

CONVERSION OF DECIMAL TO BINARY OR HEXADECIMAL

Conversion can be achieved in two ways, successive division or by spotting powers of two. Let's look at an example:
To convert 365 into binary by successive division goes as follows:

365 divided by 2 is 182 remainder 1
182 divided by 2 is 91 remainder 0
91 divided by 2 is 45 remainder 1
45 divided by 2 is 22 remainder 1
22 divided by 2 is 11 remainder 0
11 divided by 2 is 5 remainder 1
5 divided by 2 is 2 remainder 1
2 divided by 2 is 1 remainder 0
1 divided by 2 is 0 remainder 1

all successive divisions by 2 will yield the result 0 and the remainder 0.
The very first remainded we obtained the value of 2^0, the next is 2^1, the next is 2^2, etc
So the binary for 365 is 0001 0110 1101 and the hex is 01 6D.
Spotting the powers of two would work as follows:
365 is over 256 (2^8) but under 512 (2^9) so the binary bit corresponding to 2^8 is 1
365 − 256 = 109
109 is less than 128, so the bit for 2^7 is 0
109 is greated than 64 so the bit for 2^6 is 1
109 − 64 = 45
45 is greater than 32 so the bit for 2^5 is 1
45 − 32 = 13
13 is less than 16, so the bit for 2^4 is 0
13 is greater than 8 so the bit for 2^3 is 1
13 − 8 = 5
5 is greater than 4 so the bit for 2^2 is 1
5 − 4 = 1
1 is less than 2 so the bit for 2^1 is 0
1 is equal to 1 so the bit for 2^0
We follow this through in the same way as before.

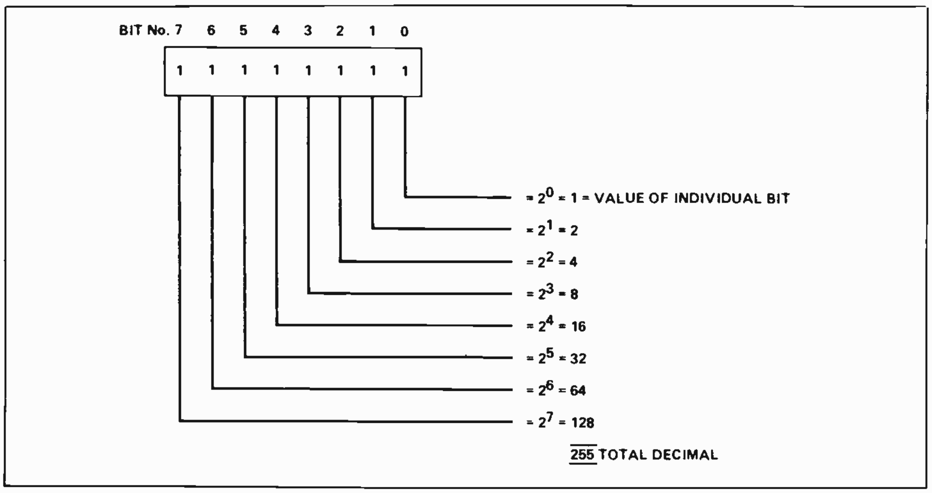

Fig. 2 The make-up of an eight-bit register.

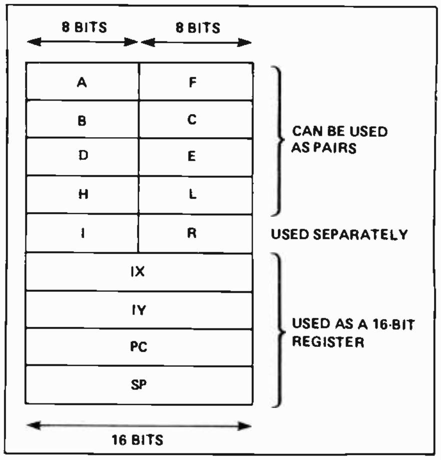

Fig. 3 The Z80 register set. Note that there is also an alternate set of registers A,B,C,D,E,F,H,L, usually referred as A',B', etc.

purpose — doing so is a very effective way of bringing your micro to its knees (or whatever the micro equivalent of knee is). However, even in the most modest of systems, there will be more than enough space left for a decent machine code program.

Do You Do Voodoo?

If you are a student of the occult you may have come across the word hex before (I believe it has something to do with casting a spell), but in computing circles it is a word that machine code buffs drop all over the place. Actually it is short for hexadecimal, where hexa is from the Greek pertraining to six, and decimal of course is all about tens, so putting them both together means we are counting using the base 16. Some people may believe that this is the Martian base of counting because they have sixteen fingers! Starting at zero (written as 0) we count up to 9 and then we go from A to F where A = 10 decimal and F = 15 decimal.

Note that we would write down 10 decimal as OA hex (or OAH), and 15 decimal is OF hex (or OFH): you must get used to the idea of writing hexadecimal numbers as two characters; for example, F on its own is meaningless whereas OF equals 15 decimal, and FO equals 240 decimal. FF hex equals 255 decimal which, if you remember, is the maximum that a register can hold, and also the number that eight bits would represent if they were all 1s which in turn represents one byte (see how it all fits in?), so two hex characters equal one byte. All this means that it is possible to write a machine code program in either binary, decimal or hexadecimal and still get the same result, but I think that you can discount using binary because it's far too cumbersome (although a knowledge of the binary system is essential for some applications as you will see).

To sum up so far: a machine code program is written to (or placed in) addresses in RAM one byte at a time, some bytes representing instructions, and some representing data. Registers, either singly or in pairs, are used to manipulate the instructions and data, and the processor sorts it all out. According to the information in the program, different routines in ROM are called into used to give different effects. This is a very simplified explanation, but essentially correct, and although I have only been talking about typical home computers, very much the same sort of process happens in larger computers, only on a much grander scale.

I mentioned earlier that I would discuss register in greater detail, so here we go. Using the Z80 set as a model (Fig. 3), the A register is historically called the accumulator because it was used to accumulate the results of computations. It is still a hard worked register, and there are certain operations that can only be carried out using the A register, but more of that later. The F register is the flags register alias the status register. This is so important to machine code programming that it warrants a section to itself. The B, C, D, E, H, and L registers are general purpose registers which are not found in a lot of CPUs.

When an input device requires the attention of the CPU it sends out a signal called an interrupt. What happens then depends on the CPU type, but usually an indicator signals the fact that an interrupt has occurred, and then the interrupt routine is entered. The Z80 has a rather unique way of dealing with an interrupt, however. Once an interrupt has been acknowledged, the device puts the low byte of an address onto the data bus. The high part of the address is in the I register, the two parts forming the address of a routine to handle the interrupt.

The R register is a simple counter (0 to 255) which is used to periodicaly refresh memory cells in RAM in order not to lose the contents. When a GOSUB is used in BASIC the computer uses portion of RAM as a stack to store the address of the next instruction to be executed after meeting a RETURN. The stack is also used when pushing and popping (more later) to keep tabs on the addresses. It seems quite logical therefore to have a stack pointer to hold the address of the last item to be put onto the stack; this is the SP pair. The last registers in this set are the two used as a program counter (PC); the PC holds the address of the current instruction.

I have saved the two sets of register pairs IC and IY until now because not many CPUs have the sets. They are used for indexed addressing which, very simply, is this, using IX as an example. The IX pair are made to hold the address of a table where information relating to your program has been stored; this is known as the base address. When required the IX pair will meet instructions pertaining to their role in the program. These instructions are in two parts, the first part is a number, which is added to, so subtracted from the base address. This will point to an address in the table. The second part is an instruction relating to what will happen at that address, and this may, or may not influence what happens next in your program.

A Bit Of Flag Waving

As well as the general purpose registers, each processor will have a **flag**, or **status register.** These are constructed in exactly the same way as any other register, but the bits are used as indicators, or **flags**, to signal whether or not certain conditions have been met. The convention is that when a bit is set it is 1, and when reset, it 0; when the condition has been met the flag is set, and reset otherwise.

Every micro I know of has a zero flag of some sort — one that is set when the contents of a particular register are Zero. As an example, let's look at what is involved in the execution of a FOR-NEXT loop;

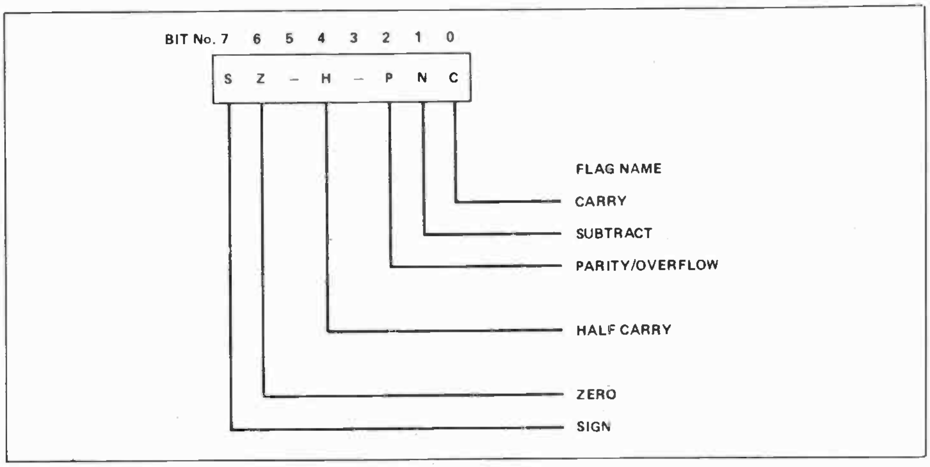

Fig 4. The flags available in register F.

something like this will be taking place: load a register with n (the loop count); do the task contained in the loop; decrement the count (n = n–l); test the flag to see if the register is zero. If it is not, then go back and do the task again; if it is, go on to the next task. Note that both conditions of the flag can apply, and we program the computer to do one thing if the flag is set, another if it it isn't.

The more usual flags are **zero, parity/overflow, sign, carry, half-carry, substract,** and others may be **interrupt, decimal** and **break.** Whatever flags your processor uses, get to know them along with the instruction set. Any good computer handbook should give the instruction set, and any good library will have a computer section with a good selection of books on micros.

Other registers will include the **stack pointer** (SP) which may be a pair or a single register, which is used as a pointer to the stack area of memory. **Index registers** may come singly or in pairs, and are usually designated X and Y singly, and prefixed with I in pairs. As their names implies, these are used for indexing along tables of data. If you remember, a program is stored in a number of addresses, so a **program counter** (PC) is used as a pointer to these addresses. One last register: dynamic RAM will need refreshing (electrically) every now and again so that information isn't lost, so there is a **refresh register** (they think of everything). This list isn't exhaustive and don't worry if it isn't all completely clear what's going on. However, I hope that your appetite is whetted enough to probe further into your computer.

ETI

Continued in the next issue.

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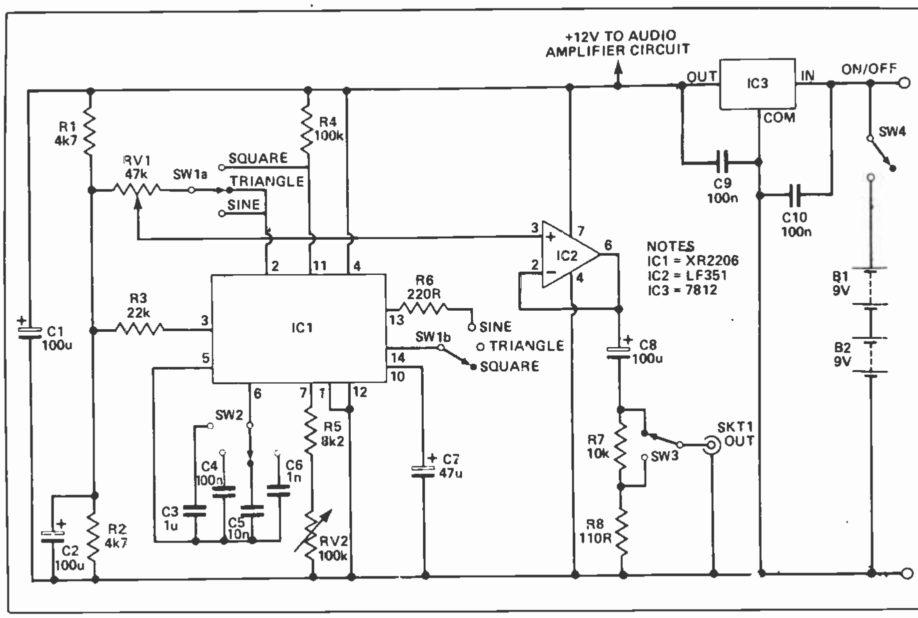
TECH TIPS

Signal Generator

G. Teesdale

THIS unit is based on the XR2206 function generator integrated circuit, as can be seen from the circuit. The charge/discharge capacitor connects between pins 5 and 6 of IC1, and in this case four switched capacitors are used to give the unit its four frequency ranges. Variable resistor RV2 is the fine frequency control and C7 is a bypass capacitor for an internal circuit of IC1. The sinewave/triangular output is taken from pin 2 of IC1, and the output from this is normally the triangular waveform. The sinewave signal is obtained by connecting a resistor (R6) between pins 13 and 14 of IC1.

Rather than having separate amplifiers for the triangular output buffer and the sinewave shaping circuit, the XR2206 uses the same amplifier for both functions, and switching in R6 connects the shaping components into the feedback circuit of the amplifier. This resistor could be replaced with a preset resistor, which would then be adjusted to optimize performance, but results should be more than adequate using the specified (fixed) value.



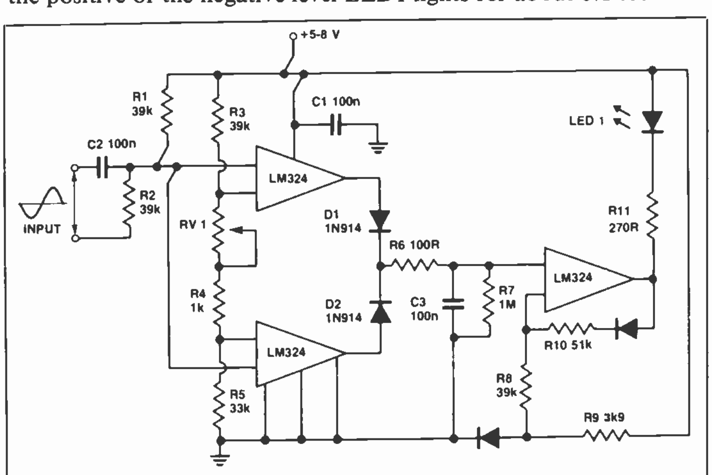
Peak Level Indicator

David Hamill

This peak level indicator is useful for recording when it is more important to know what the peak level of a signal is, rather than its average level.

VU meters are normally used for this purpose; however, you will find that the LED output of this circuit is easier to interpret and makes the recording more accurate as the distortion will be reduced.

IC1a gauges the positive peaks while IC1b does the same for the negative peaks. Both positive and negative are set by RV1. You can select any threshold from ±1 V. Whenever the input exceeds the positive of the negative level LED1 lights for about 0.1 second.



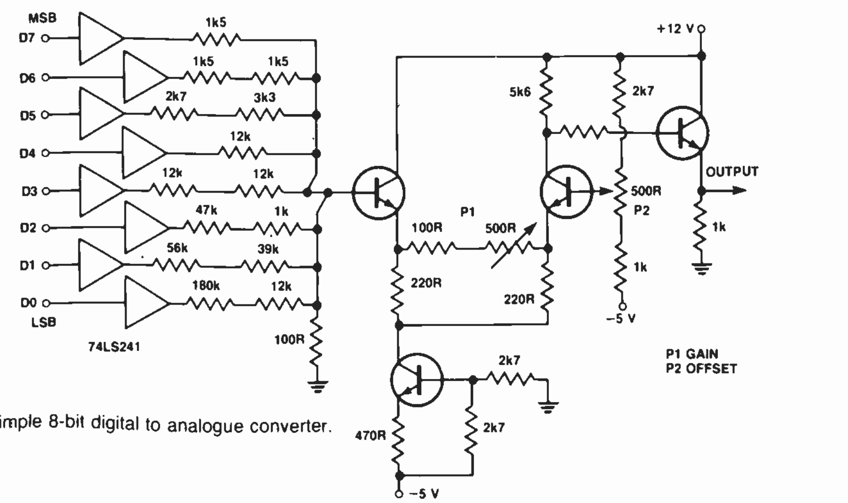
Two circuits for the 74LS241

Brian O'Conner

These circuits use the 74LS241 and in each case pin 1 is tied to ground and pin 19 to Vcc.

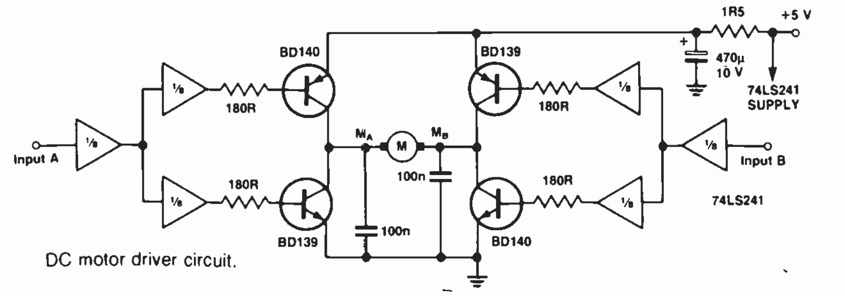
The first circuit is for a DC motor driver suitable for use with 400 mA/6 V motors. Little or no heatsink is required as all transistors are either saturated or off.

The second circuit is for a very simple 8-bit digital to analogue converter which can be built from scrap box components. It will give a linear output of 8 V p-p and the ramp produced by an 8-bit increment is quite smooth.



Simple 8-bit digital to analogue converter.

Input A	Input B	M_A	M_B	Result
0	0	+5V	+5 V	no operation
0	1	+5 V	GND	motor turns
1	0	GND	+5 V	motor turns opposite
1	1	GND	GND	no operation



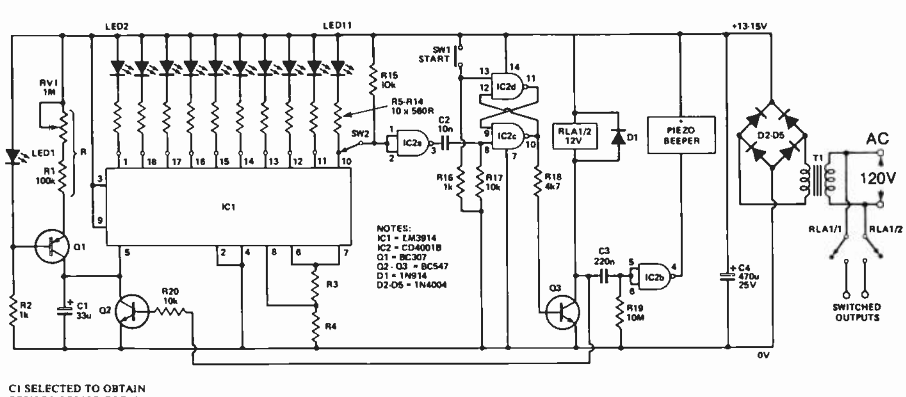
DC motor driver circuit.

Incremental Timer

R.A. Penfold

THE LM3914 LED display drive, IC1, is connected as a zero to 5V (full scale) voltmeter to display in the bargraph mode. Thus, each LED will turn on at increments of 0V5 as the input of IC1 is driven by the voltage across capacitor C1. This is charged with a constant current so that the voltage across it will rise linearly with time. That is, the voltage across C1 rises, the LEDs will light up one by one until the voltage reaches 5V or until C1 is discharged.

A relay and alarm circuit is built around IC2 plus Q3 and associated components. SW2 selects at which 'increment' the relay and alarm are operated by selecting one of the outputs of IC1. When the output goes 'active' (when the LED lights), the alarm sounds, the relay drops out and the timer is reset by discharging C1. For example, if the third increment is selected (pin 17, IC1), then LEDs 2, 3 and 4 only will light, the alarm sounding when LED4 lights. C1 is then discharged at that time, resetting the timer ready for its next use.



The complete circuit of the Incremental Timer. T1 is 9 to 12 V, 6 VA

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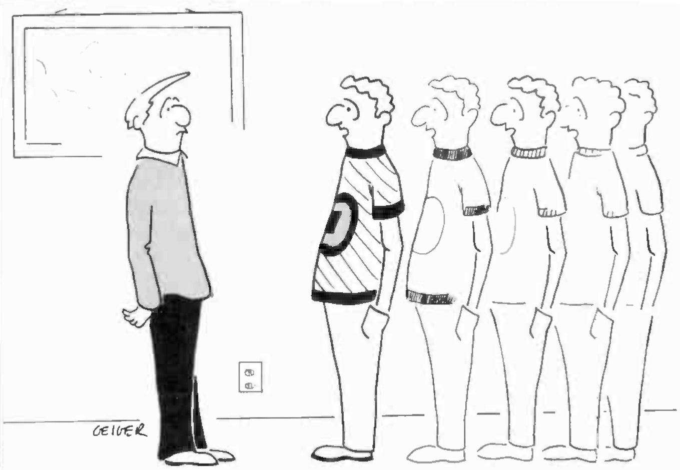
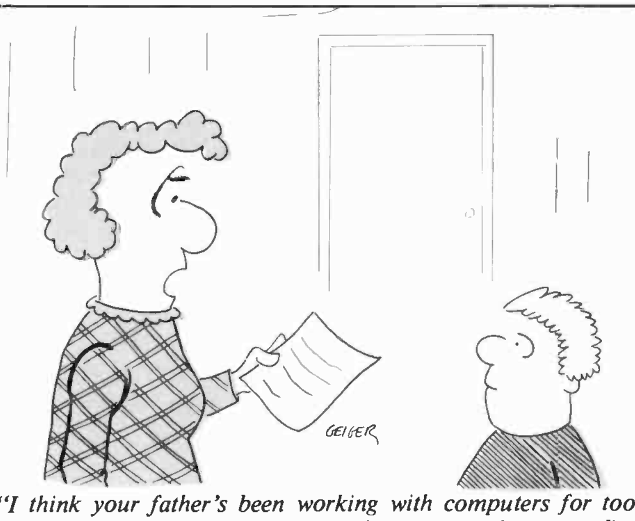
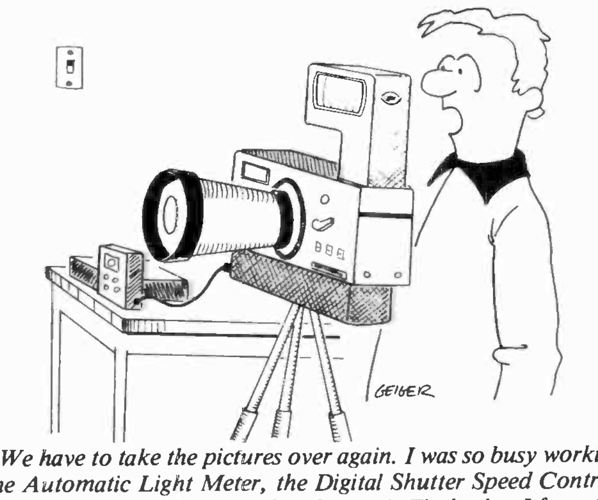


"I think I've been playing with my strobelight too much."

"What's this roll of toilet paper doing in my adding machine, and where's my expensive calculator paper?"



"I think your father's been working with computers for too long. He left a message that says "If I am Late, then store dinner in fridge. Else go to oven and heat dinner."



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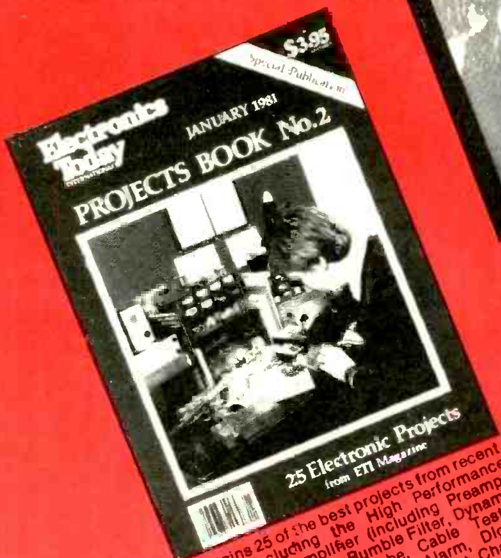

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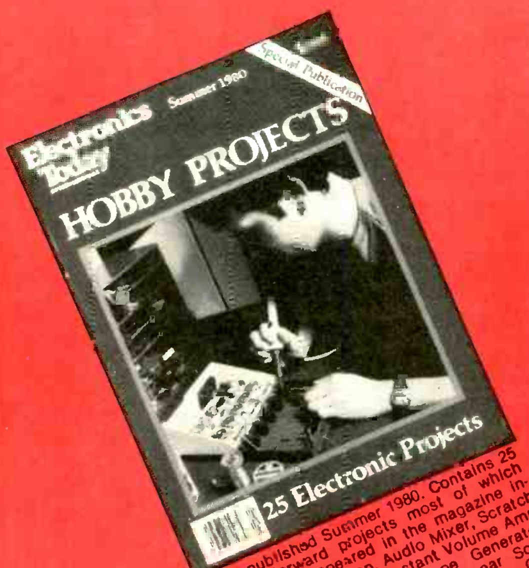

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