Modem Auto-Answer Project
Convert your modem

Genealogy of the Microchip

Circuit Supplement
Pages of Useful Circuitry!

Echo Reverb Project
All solid state

Coping With Components
Parts primer

Computer Review:
Multitech MPF III
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319 College St., Toronto, Ont. M5T 1S2

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- Microtek: $139

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- 80-Column Card: $84.00
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- Roll and DG: $419

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- Apple a la Modem (300 Baud): $215
- Micromodem (Apple Comp): $475
- Signalman (300 & 1200 Baud): $495
- Smart Modem 1200 Baud: $599

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**FAMOUS MULTIFLEX Z80 STARTER KIT:**
- SPECIAL $349.00
- Ideal Learning Tool, with EPROM programmer
- see page 18 of catalogue

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- 4164-150ns (1x64K single +5V): $9.95
- Motorola: $7.95
- 4116-200ns (1x16k): $1.74
- 4116-150ns (1x16k): $1.99
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- 2016-150 ns (2x8k static): $8.74
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- 2716-2(8x8) EPROM single +5V: $5.50
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  - Flip N File 50: $44.95
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Remember that at Exceltronix all prices are negotiable for quantity purchases. If you cannot afford large quantities on your own how about starting a Co-op.

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**UNIVERSITY OF TORONTO/MULTIFLEX 6809**
Board, great for learning about 6809 and computing in general with A & T $499.00

---

**模式**

- EPM 310: $99
- Smart Modem (300 Baud, IBM Comp): $359
- Apple a la Modem (300 Baud): $215
- Micromodem (Apple Comp): $475
- Signalman (300 & 1200 Baud): $495
- Smart Modem 1200 Baud: $599

---

**IBM CARDS**

- Apple II cards
- A&T Cards

---

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- 2716-2(8x8) EPROM single +5V: $5.50
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- 2764-8(8x8) EPROM single 5V: $12.95

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**Dysan**

- $39.00

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  - Maxell MD2: $29.00
  - Verbatim: $34.00
  - CDC: $26.95
  - 3M: $32.95
  - Accutrack: $26.95
  - 2 Eclipse Diskettes in a plastic binder sheet: $5.89
  - Flip N File 50: $44.95
  - Diskminder (73): $33.95
  - Dysan: $39.00
  - BASF: $34.00
  - BASF with case: $35.00

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Send a certified cheque or money order (do not send cash). Minimum order is $10 plus $3 minimum for shipping. Ontario residents must add 7% provincial sales tax. Visa, Mastercard and American Express accepted. Send card No., signature, expiry date and name of bank.

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Circle No. 27 on Reader Service Card.
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Peripheral Boards for your IBM PC

<table>
<thead>
<tr>
<th>Board Type</th>
<th>Price</th>
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<tbody>
<tr>
<td>Prototyping Card</td>
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<tr>
<td>Floppy Controller Card</td>
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<tr>
<td>Colour Video Card</td>
<td>$299.00</td>
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<tr>
<td>Parallel &amp; Game Port Card</td>
<td>$149.00</td>
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<tr>
<td>EPROM Programmer</td>
<td>$149.00</td>
</tr>
</tbody>
</table>

Attractive Case (as shown above)$85.00

Keyboard (as shown above) $187.00

Super Power Supply, made to fit above case, with cooling fan $135.00

8088 Board, with 64K on board (provision for 255K), as described in our 8088 System.

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Huge variety of Surplus stock at low, low prices. New shipments arriving. No reasonable offers refused. Prices subject to change without notice!

Surplustronics, 310 College Street, Toronto, Ontario, M5T 1S3

Monitors

<table>
<thead>
<tr>
<th>Model</th>
<th>Price</th>
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<tr>
<td>ZVM-122 Amber</td>
<td>$149.00</td>
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<tr>
<td>ZVM-123 Green</td>
<td>$129.00</td>
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<tr>
<td>Roland Colour 1</td>
<td>$395.00</td>
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</table>

EPS Keyboard $399.00

Apple Compatible. IBM Module available. Distributor for Ogivar

Apple Peripherals

Assembled and Tested

<table>
<thead>
<tr>
<th>Board Type</th>
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<tr>
<td>80 x 24</td>
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<tr>
<td>16K RAM</td>
<td>$58.00</td>
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<tr>
<td>Prototyping Board</td>
<td>$14.50</td>
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<tr>
<td>Parallel Printer Card</td>
<td>$59.00</td>
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<td>... with cable &amp; connector</td>
<td>$69.00</td>
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<tr>
<td>Z88 Board (No IC's)</td>
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<td>... with IC'S &amp; 64K RAM</td>
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<tr>
<td>... with IC'S &amp; 128K RAM</td>
<td>$210.00</td>
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<tr>
<td>Crazy Card</td>
<td>$58.00</td>
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<tr>
<td>Eprom Programmer</td>
<td>$68.00</td>
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Disk Drives

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<tr>
<td>Controller</td>
<td>$59.00</td>
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<tr>
<td>...w/software</td>
<td>$119.00</td>
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One year warranty

All prices subject to change

Printers

<table>
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<tr>
<th>Model</th>
<th>Price</th>
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</thead>
<tbody>
<tr>
<td>A. Gemini 10x</td>
<td>$359.00</td>
</tr>
<tr>
<td>B. Special Multiflex parallel card with cable. Shop and compare</td>
<td>$69.00</td>
</tr>
<tr>
<td>Package price of A and B</td>
<td>$415.00</td>
</tr>
<tr>
<td>Gemini 15x</td>
<td>$596.00</td>
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</tbody>
</table>

5" Green Screen

Monitors. $59

Telex No.
065-24218

Mail Orders add $5.00 minimum for shipping & handling. Ontario residents add 7% P.S.T. Visa, Mastercard and American Express cards accepted: send card number, expiry data, name of bank and signature. Send certified cheque or money order, do not send cash.

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   FORTH is an interactive compiled language with the simplicity of BASIC at ten times the speed. ZX FORTH is a full implementation, with 250 commands. It works on 16-bit numbers, has some 32 bit routines, includes a 60-page user/programmer manual.
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   VU-CALC. Financial Spreadsheet. Turns ZX81 into a powerful tool to generate and calculate large tables for budgets, financial analyses and projections.
   VU-FILE. Data Storage and Filing System. Ideal for name/address files, lists, catalogue of items, etc. You can enter, list, search and print records.
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3. PROGRAMMING AIDS
   ZX ASSEMBLER. Full Editor/Assembler and Monitor. Comprehensive instruction book included.
   Z AID. Adds 5 new BASIC instructions.
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Send to: ZX81/TS1000 Offer, Moorshead Publications, 25 Overlea Boulevard, Suite 601, Toronto, Ontario, M4H 1B1

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Shipping, $1.50 1st item, $1.00 for each extra
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Offer expires July 6th, 1984

Please use this coupon or a photocopy to place your order.

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Low Cost Dwell Meter
If you've been pondering tuning up your car, don't dwell on it any longer. Here's a gadget that'll help save you time and $$$

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Our Cover
The Auto-Answer modem converter project appears on page 30 and the Multiflex computer review on page 19; photos by Bill Markwick.
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 portable 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.

Circle No. 60 on Reader Service Card.

Bi-Amplified Car Speaker

A bi-amplified speaker component system which represents a departure from traditional car speaker design configurations is being introduced to the Canadian market by Sparkomatic Canada Inc., 265 Hood Rd., Market, Ont. The new Amplidyne Series speakers are designed for the electronics market as well as for the company's established automotive after-market retailers. Included in the series are a coaxial speaker system, two deck-mount systems and a subwoofer. Each of the speaker systems incorporates separate amplifiers for the woofers and tweeter, with each pair offering 120 Watts of additional power.

Circle No. 59 on Reader Service Card.

Protection Device

Motorola has introduced its first SMARTpower® II device, which combines the best qualities of high speed CMOS logic and high-current TMOS vertical power structured on a single chip. The MPC200, 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 MPC200 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.

Circle No. 58 on Reader Service Card.
Instrumentation Amplifier

A single-chip instrumentation amplifier introduced by Analog Devices, Inc. replaces expensive modular and hybrid programmable gain amplifiers (PGA) in switched-gain applications. With the addition of an inexpensive CMOS multiplexer and resistor network, the AD625 facilitates designing 12-bit accurate software programmable gain amplifiers (SPGA) for under $20 (U.S.). This capability, combined with the industry's best nonlinearity of 0.001% maximum, lowest gain tempco of 5 ppm/°C maximum, and lowest input noise of 4nV/√Hz makes the AD65 well suited for precision applications including weigh scales, industrial measurement systems and laboratory instrumentation.

The AD625 can be configured as either a resistor programmable gain amplifier (RPGA) or as an SPGA. An AD625-based RPGA can be configured for gains between 1 and 10,000 with three external resistors. With precision low temperature coefficient resistors, users can achieve 14-bit performance. In addition, the AD625's gain sense pin has 130 dB of common-mode-rejection regardless of feedback resistor matching.

Contact: Tracam Electronics, 1200 Aerowood Dr., Mississauga, Ont. (416) 625-7752.

Circle No. 56 on Reader Service Card.

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.

Circle No. 57 on Reader Service Card.

Test Equipment

KB Electronics, 1289 Marlborough Crescent, Unit 12, Oakville, Ont., L6H 2R9, have a wide range of test gear available, including the 905 Sweep/marker Generator, the 605 RF Signal Generator, the 505 Oscilloscope, the G431 Function Generator, and more. The low-cost 505 is of particular interest to the experimenter. Contact them at the above address, or phone (416) 842-6888.

Circle No. 55 on Reader Service Card.
WINNER: Ultra-modern! Super-efficient! Fully Apple Compatible $995.00

Please note the distinct features
Winner offers:
* Dual microprocessors 6802 & 850A
* RS-232 built in
* Disk drive interface card built in
* 440 column text display and auto change video output port by soft switch
* 16K RAM with 4 expansion slots

CP80 DOT MATRIX PRINTER
78x DOT MATRIX
80 CPS, 640 dots/sine per second Bidirectional
80 Column normal
142 Compressed
Friction & Tractor Feed
Standard Centronics Parallel
Same as Epson 80

$495.00

APPLE COMPATIBLE COMPUTERS

48K Color Computer with numeric keys & function keys $549.95
64K Color Computer with numeric keys & function keys $598.95
64K Color Computers (Dual-6502 & 8B0A, CP/M), Numeric & function keys $649.95

For systems one 12" Green Monitor, 1 Disk Drive & Disk Controller card $500.00

Mini Modem $99.45

Parts

<table>
<thead>
<tr>
<th>Part</th>
<th>Price</th>
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<tr>
<td>DB-25P Connector</td>
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<td>DB-25S Connector</td>
<td>$5.95</td>
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<td>DB-9P</td>
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<td>4164 RAMS 200 N/S</td>
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<td>4116 RAMS 200 N/S</td>
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<td>2016 RAMS</td>
<td>$9.75</td>
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<td>EPROM ERASERS P.E. 14</td>
<td>$12.95</td>
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Disk Holders

<table>
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<th>Disk Holders</th>
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<td>Disk Bank (50 Disks)</td>
<td>$39.95</td>
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<td>DX 85 (55 Disks)</td>
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<td>Data Defender (70 Disks)</td>
<td>$39.95</td>
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<tr>
<td>Flip &quot;N&quot; File 10</td>
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<td>Flip &quot;N&quot; File 15</td>
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<td>Flip &quot;N&quot; File 50</td>
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<td>$29.95</td>
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Timex Sinclair 1000

6502 BOARDS & ACCESSORIES

Mini Modem $99.45

More Monitors

<table>
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<tr>
<th>Monitor</th>
<th>Price</th>
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<tr>
<td>Swivel monitor</td>
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<tr>
<td>Monitor</td>
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<td>GM 1211 Green 12&quot;</td>
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<td>GM 1210 Amber 12&quot;</td>
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<tr>
<td>Zenith Green 12&quot;</td>
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<tr>
<td>Zenith Amber 12&quot;</td>
<td>$149.95</td>
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16K Sinclair Memory $35.00

Books

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<tr>
<th>Book</th>
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<tr>
<td>Sinclair Printers</td>
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<td>Time Printers</td>
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<td>64K RAM (Memotech)</td>
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<td>50MA</td>
<td>$8.95</td>
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Additional Hardware & Software for the Sinclair ZX81 AVAILABLE ON REQUEST.

Computer Room

COMPUTER ROOM

ORION ELECTRONICS

Circle No. 20 on Reader Service Card
Genealogy of the Chip

Roger Allan looks at bells, whistles and family trees.

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 their memories 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 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, or 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 (e.g. two sets of Is and Os).

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 physically out of the computer for a start), they do have the advantage of being re-programmed. To date, the highest

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**Genealogy of the Chip**

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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 E²PROMs. Similar to EPROMs, E²PROMs 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 erase 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.

E²PROMs 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 E²PROMs 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. Next, change it, then go back to the beginning and re-program all cells up till the one you just modified. Third generation E²PROMs 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 E²PROMs 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 E²PROM write cycle takes as long as 10 msec. Once a byte-write operation begins, the E²PROMs are self-supporting, freeing the processor and all external circuitry for other tasks. Read timing of the E²PROM is identical to that of a standard EPROM, RAM or ROM.

One of the more interesting characteristics of the E²PROM is that an EPROM or ROM based system only needs an additional Write Enable line to each socket to provide retro-fitting of an E²PROM. The E²PROM'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

The iRAM is a pseudo-static RAM through the use of a circuit that reduces the voltage needed to refresh the memory. This circuit is called the Pseudo-Static (iRAM) or NOVRAM. It is still on the drawing board.
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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 or 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 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 E'PRM is its nonvolatility and reprogrammability, 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 E'PRM, cell by cell — e.g., 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 E'PRM cell and the E'PRM'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 (e.g., 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 E'PRM, and since the E'PRM 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 E'PRM 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 E'PRM 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 E'PRM 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 E'PRM (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 E'PRM 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 E'PRM (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.
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Echo-Reverb

As the audio signals enter the echo-reverb unit they split into two paths which are re-united 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
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 output 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 of 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.

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Echo Reverb

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-delay 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:

\[ D = \frac{P \times S}{2} \]

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 \( \mu \)S (400 kHz) to a maximum of 60 \( \mu \)S (16.6 kHz), thus giving a delay range of 1.28 \( \mu \)S to 30.7 \( \mu \)S. In practice, however, the delay times can be extended to 50 \( \mu \)S by adjusting PR2 to give a maximum clock period of 97.6 \( \mu \)S (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 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 switches and sockets, then set-up the pre-sets.

Setting Up Procedure

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

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)
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) 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.

**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 ........................................... 1000μF 40V electrolytic (axial)
- C2 ........................................... 10μF 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
- C17 ........................................... 1μF 35V tantalum

**SEMICONDUCTORS**

- IC1 ........................................... 78L 15 voltage regulator
- IC2, 6, 7 .................................... 741 op-amp
- IC3, 4 ....................................... TDA1022 (Signetics) or DAC1022 (National) or TMS1022 (TI)
- 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
- SW1 .......................................... DPDT miniature rocker switch
- SW2 .......................................... SPDT miniature toggle switch
- SK1, 2 ...................................... Phono Sockets Case, PCB, bolts, knobs etc.
**Echo Reverb**

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

---

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<tr>
<td>80 Col. card</td>
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<td>Flip n File 50</td>
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<td>Nashua diskettes</td>
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Circle No. 19 on Reader Service Card
18—JUNE—1984—ETI
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 ile, 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 jingle 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.
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 I 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 gun 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 to 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 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 Unitetron) 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 clones.

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.
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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 alestoric 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 connoisseurs 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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5US DELAY

15US DELAY
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 Peninsula. In the same year, Camille Rougeron, a French engineer, published his book Les Applications de L’Explosion Thermonucléaire, 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 Attrato 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.

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In addition to the above, we will be providing Apple users with a program which can be used to patch the Apple CP/M BIOS to increase the display speed of the popular Videx eighty column card. Users of other formats will receive ALIENS11, a fairly fiendish video game package ... which is too large to get on an Apple disk.

Some or all of these files may be provided squeezed in order to accommodate your disk format. While we make every effort to ensure that the programs are completely debugged, we can offer no guarantee that they will function properly for your application.

Our almost free volume one is available for the Apple II + running CP/M, and the Nelma Persona for $12.95 per disk and on eight inch single sided single density diskettes for $16.95. Ontario residents please add seven percent provincial sales tax. The files are provided on pristine brand new high quality disks which are fully formatted and checked out prior to shipment.

Whether you are up for running a business, hacking bytes, or just learning about micro-computers, these programs will be a good trip.
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.

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, diminution 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,
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 $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, involving thermonuclear devices and nitromethane compositions. They came from a variety of names — Planquin, Pre-Schooner, Cabriolet, Simmons, 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, dry rock and study the dispersion pattern of airborne 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 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 quietly 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 military 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 diversions 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.
THE AUTO-TECTOR is a general purpose telephone line interface that is 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 overridden.

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 II. 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 across I2 so that R3 has a drop sufficient to supply current to I2. For example, if the diode drop is 2.6 volts, the isolator drop is 1.6 volts, 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 K1 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 IC3. 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 established. When this occurs (before IC1 times out), current in the output of line current detector, opto-isolator II, 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 signal to 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 ringing pulses. If the latter signal is used externally, it has to be debounced.
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. 2. Timer/Digital interface schematic diagram.

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

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.

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 1kΩ resistors and 10nF capacitors to prevent IC-to-IC interaction and possible feedback via the supply rails.
Circuit Supplement

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 diagram 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 11, 13, 14). Note that either a positive-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 driver 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.

OFFBEAT METRONOME

THIS is a metronome with a difference. The initial requirement was for a simple metronome which would enable the musician or musicians 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.

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:

\[36,045 \times R1 \times C1\text{ seconds.}\]

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

Circuit diagram of the alarm extender
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°C to +150°C). I suggest the 0.00 V output should be set with the sensor in a beaker of crushed melting ice. The sensor output is best displayed on a digital voltmeter (0.01 V per degree C) or on the specialized DVM ZD1,2 and preset PRI 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°C to +150°C). I suggest the 0.00 V output should be set with the sensor in a beaker of crushed melting ice. The sensor output is best displayed on a digital voltmeter (0.01 V per degree C) or on the specialized DVM.

A voltage comparator (IC1) is used to compare the temperature sensor output with a value preset by PR3 and trigger the alarm. 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 gain to be measured. The diode network (DI 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 for the temperature sensor and alarm.

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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**

<table>
<thead>
<tr>
<th>Transformer, 3 to 6 VA</th>
<th>R1, 4</th>
<th>R2, 3</th>
<th>R5, 6</th>
<th>Volts DC</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-6, 0-6</td>
<td>120R</td>
<td>390R</td>
<td>—</td>
<td>± 5V</td>
</tr>
<tr>
<td>0-9, 0-9</td>
<td>120R</td>
<td>680R</td>
<td>—</td>
<td>± 8V</td>
</tr>
<tr>
<td>0-12, 0-12</td>
<td>120R</td>
<td>1k2</td>
<td>10k</td>
<td>± 12V</td>
</tr>
<tr>
<td>0-15, 0-15</td>
<td>100R</td>
<td>1k2</td>
<td>27k</td>
<td>± 15V</td>
</tr>
</tbody>
</table>

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

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

**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.
### BENCH POWER SUPPLY

#### Parts List

<table>
<thead>
<tr>
<th>Resistors (all 1/4W, 5%, unless otherwise stated)</th>
<th>Semiconductors</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1,10 100R</td>
<td>IC1,2</td>
</tr>
<tr>
<td>R2 10R</td>
<td>Q1,4,9</td>
</tr>
<tr>
<td>R3,5,15,18,19,22,29,30,33,36 47R</td>
<td>Q2,5,8,11</td>
</tr>
<tr>
<td>R4,23,28,31,32,41 1k0 R6 R33, 3W wirewound R7,8 2k2 R11 100k R12 10R, 1/2W R13 47R, 1W R14 1k0, 3W wirewound R16 5k6 R17 220R R20,35,37 1R8, 4W wirewound R21 10k R24,25,39 470R, 1/2W R26 1k2 R27 1k5</td>
<td>Q3,6,7</td>
</tr>
<tr>
<td></td>
<td>Q10,12,13</td>
</tr>
<tr>
<td></td>
<td>MM4002</td>
</tr>
<tr>
<td></td>
<td>D1,2,3,4,5,19</td>
</tr>
<tr>
<td></td>
<td>6,12,13,18,19</td>
</tr>
<tr>
<td></td>
<td>D7,8,9,10,14,15,16,17 1N5401 D11 IN4148</td>
</tr>
<tr>
<td></td>
<td>Miscellaneous</td>
</tr>
<tr>
<td></td>
<td>M1,2 1mA FSD meter</td>
</tr>
<tr>
<td></td>
<td>SW1 toggle, 2A</td>
</tr>
<tr>
<td></td>
<td>SW2 3 pole, 3 way rotary switch</td>
</tr>
<tr>
<td></td>
<td>PCB; IC sockets; M4 fibre washers; Heat sinks; insulated terminals; mains fuse holder and fuse; knobs; mains neon; Case, mains cable and strain-relief bush; solder tags; insulating kits for the power transistors; nuts, bolts, washers, etc.</td>
</tr>
</tbody>
</table>

#### Circuit Diagram

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

---

40—JUNE—1984—ETI
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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!
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 result of this program when folded along the dashed line 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 "NAME + MORE INFORMATION"
2 LPRINT "NAME + MORE INFORMATION"
3 LPRINT "NAME + MORE INFORMATION"
4 LPRINT "NAME + MORE INFORMATION"
5 LPRINT "NAME + MORE INFORMATION"
6 LPRINT "NAME + MORE INFORMATION"
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178 LPRINT "NAME + MORE INFORMATION"
179 LPRINT "NAME + MORE INFORMATION"
180 LPRINT "NAME + MORE INFORMATION"

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.

'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 = PI - PI
30 LET S = -PI/PI
40 LET P = INT (RND*12+1)
50 LET S = S + 1
60 PRINT AT 0, 14
70 IF PEEK (168974,P)<0 THEN GOTO 130
80 PRINT AT 0, P; "V"
90 IF RND<.5 THEN PRINT AT 9, P+RND-RND-1; "F";
100 LET P = P+(INKEYS('8')*(PT 13)-(INKEYS('5'))*P>1)
110 SCROLL
120 GOTO 50.
130 CLS
140 IF P>9 THEN LET B = S
150 PRINT "YOU SCORE "; S;", BEST SO FAR "; B
160 PAUSE 550
170 CLS
180 GOTO 30

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 (168974,P)<0 THEN GOTO 130
80 PRINT AT 0, P; "V"
90 IF RND<.5 THEN PRINT AT 9, P+RND-RND-1; "F";
100 LET P = P+(INKEYS('8')*(PT 13)-(INKEYS('5'))*P>1)
110 SCROLL
120 GOTO 50.
130 CLS
140 IF P>9 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 stretching 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 "; F; " 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>0 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"
```

```
32 FT/S/S"
```
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 constructor 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, 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).

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 × 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...
Coping with Components

Carbon Film: The standard "1/4 watt 5% carbon" type, has almost completely replaced older carbon composition resistors. Noise level is typically 1.0μV/V for any value, which is adequate for most purposes. N.B.: All dimensions are in millimeters.

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 OW125 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 of different substances to achieve the desired properties.
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.

**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.

**Table 1**

<table>
<thead>
<tr>
<th>Band Colour</th>
<th>Figure</th>
<th>Multiplier</th>
<th>Tolerance (±)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black</td>
<td>0</td>
<td>1</td>
<td>not used</td>
</tr>
<tr>
<td>Brown</td>
<td>1</td>
<td>10</td>
<td>—</td>
</tr>
<tr>
<td>Red</td>
<td>2</td>
<td>100</td>
<td>2%</td>
</tr>
<tr>
<td>Orange</td>
<td>3</td>
<td>1000</td>
<td>—</td>
</tr>
<tr>
<td>Yellow</td>
<td>4</td>
<td>10000</td>
<td>—</td>
</tr>
<tr>
<td>Green</td>
<td>5</td>
<td>100000</td>
<td>—</td>
</tr>
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<td>Blue</td>
<td>6</td>
<td>10000000</td>
<td>—</td>
</tr>
<tr>
<td>Violet</td>
<td>7</td>
<td>10000000</td>
<td>not used</td>
</tr>
<tr>
<td>Grey</td>
<td>7</td>
<td>.1</td>
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<tr>
<td>White</td>
<td>9</td>
<td>—</td>
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</tr>
<tr>
<td>Gold</td>
<td>—</td>
<td>—</td>
<td>10%</td>
</tr>
<tr>
<td>Silver</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

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/black/red (i.e., 4,7000/4,7000).

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

- 0.22 ohms = R22
- 1.0 ohms = 1R0
- 2.2 ohms = 2R2
- 22 ohms = 22R
- 220 ohms = 220R
- 2.2k ohms = 2K2
- 220k ohms = 220K
- 1.5 ohms = 1M5

If a letter follows the value, it indicates the tolerances:

- F = ± 1%
- J = ± 5%
- K = ± 10%
- M = ± 20%

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.

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
metalsheathing, 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 safety 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
circuity. 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
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.

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 forming 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.

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 plastic 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
Coping with Components

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.

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.

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See page 66
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Low-Cost Dwell Meter

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 section 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-stability 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

<table>
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</tr>
<tr>
<td>M1</td>
</tr>
<tr>
<td>PC board; case to suit; three alligator clips; hookup wire; meter scale to requirements, etc.</td>
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</table>

* R6 selected so that R6 + meter resistance equals a little under 3k
Dwell Meter

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 to a range of 30-70 for four cylinder engines; 20-47 for six cylinders; 15-35 for eight; 24-56.

The calibration 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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Circle No. 26 on Reader Service Card
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, accounting 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.

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.
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This sourcebook maps out applications for the 555 timer IC. It covers the operation of the IC itself to aid you in learning how to design your own circuits with the IC. There are application chapters for timer-based instruments, automotive applications, alarm and control circuits, and power supply and converter applications.

BP120: HOW TO GET YOUR ELECTRONIC PROJECTS WORKING
R.A. PENFOLD

We have all built circuits from magazines and books only to find that they did not work correctly, or at all, when first switched on. The aim of this book is to help the reader overcome these problems by indicating how and where to start looking for the common faults that can occur when building up projects.

PH250: EXPERIMENTER’S GUIDE TO SOLID STATE ELECTRONICS PROJECTS
R.A. PENFOLD

This book takes the mystery out of solid state electronics and enables the reader to build such useful devices as regulated power supplies, dimmers, solar cell operated radio, hi-fi amplifiers, light indicators for battery operated equipment and much more.

110 THROTTLE PROJECTS USING SCR’s AND TRIACs
MARBEN HB26 $12.95

A grab bag of challenging and useful semiconductor projects for the hobbyist, experimenter, and student. The projects range from simple burlap, fire, and water level alarms to sophisticated power control devices for electronic tools and trains. Integrated circuits are incorporated wherever their use reduces project costs.

BOOK 3: Follows on from semiconductor technology, leading up to transistors and integrated circuits.

BOOK 4: A complete description of the internal workings of microprocessors.

BOOK 5: A book covering the whole communication scene.

PH235: COMPLETE GUIDE TO READING SCHEMATIC DIAGRAMS
J. DOUGLAS-YOUNG

$9.95

Packaged under an easy-to-understand diagram, valuable troubleshooting tips as well as a circuit finder chart and a new section on logic circuits.

PH231: BEGINNER’S HANDBOOK OF IC PROJECTS
D. HEYERMAN $16.95

Welcome to the world of integrated circuit (IC) electronic projects. This book contains over 100 projects (each including a schematic diagram, parts list, and descriptive notes.)

PH232: DIGITAL ICs: HOW THEY WORK AND HOW TO USE THEM
A. BARBER

$10.95

The dozens of chapters cover everything from voltage current, and resistance relation to optimisation, and optoelectronics.

PH249: THE BEGINNER’S HANDBOOK OF ELECTRONICS
G. OLSEN & M. MIMS III $10.95

In this basic book, the authors cover the entire spectrum of modern electronics, including the use of such components as integrated circuits and semiconductor devices in record players, radio receivers, airplane guidance systems, and many others.

THE BEGINNER’S HANDBOOK OF ELECTRONICS
A. BARBER

$10.95

An excellent textbook for those interested in the fundamentals of Electronics. This book covers all major aspects of power supplies, amplifiers, oscillographs, radio, television and more.

PROJECTS

BP48: ELECTRONIC PROJECTS FOR BEGINNERS $7.75
F.G. RAYER, T.Eng.(CEI), Assoc.IERE

Another book written by the very experienced author — Mr. F.G. Rayor — and it is the newcomer to electronics, will find a wide range of easily made projects. Also, there are a considerable number of actual component and wiring layouts, to aid the beginner.

Furthermore, a number of projects have been arranged so that they can be constructed without any need for soldering and, thus, avoid the need for a soldering iron.

Also, many of the later projects can be built along the lines as those in the ‘No Soldering’ section so this may considerably increase the scope of projects which the newcomer can build and use.

BP49: POPULAR ELECTRONIC PROJECTS $7.75
R.A. PENFOLD

Includes a collection of the most popular types of circuits and projects which, we feel, will prove a number of designs to interest most electronics constructors. The projects selected cover a very wide range and are divided into four major types. Radio Projects, Audio Projects, Household Projects, and Test Eqpiment.

EXPERIMENTER’S GUIDE TO SOLID STATE ELECTRONICS PROJECTS
A. BARBER

$9.95

An ideal sourcebook of Solid State circuits and techniques with many practical circuits. Also included are many useful types of experimenter gear.

BP71: ELECTRONIC HOUSEHOLD PROJECTS $7.20
R.A. PENFOLD

Some of the most useful and popular electronic construction projects are those that can be used in or around the home. The circuits range from such things as 2 Tone Door Buzzers, Intercom, through Smoke or Gas Detectors to Baby and Firealarms.

BP74: ELECTRONIC PROJECTS FOR CARS AND BOATS $6.10
R.A. PENFOLD

Projects, fifteen in all, which use a 12V supply are the basis of this book. Included are projects on Windscreen Wiper Control, Courtesy Lights, Delay, Battery Monitor, Cassette Power Supply, Lights, Thermostat, Smoke and Smoke Alarm, Warning and Shaver Inverter.

BP92: ELECTRONIC GAMES
R.A. PENFOLD

In this book Mr. R. A. Penfold has designed and developed a number of interesting electronic game projects using modern integrated circuits. The text is divided into two sections, the first dealing with simple games and the latter dealing with more complex circuits.

BP94: MODEL RAILWAY PROJECTS $7.60

Electronic projects for model railways are fairly recent and have made possible an amazing degree of realism. The projects, covered include controllers, signals and sound effects. Strips, layouts are provided for each project.

BP95: ELECTRONIC TIMER PROJECTS $7.60

F.G. RAYER

Windscreen wiper delay, darkroom timer and metronome projects are included. Some of these circuits are most complex and are made up from simpler sub-circuits which are dealt with individually.

BOOK 2: An introduction to Programming the DRAGON 32

BOOK 1: The Beginner’s Handbook of Electronics

Prentice Hall

ETI-JUNE-1984-57
The purpose of this book is to introduce the LM3900 to the practical technician or hobbyist. It provides the groundwork for both simple and more advanced uses, and is more than a catalog of almost 200 practical circuits. This book covers the basics of the 555 timer and illustrates examples with theory and practical demonstrations. In the first section of the book, the basic timer circuit is presented and described, and the reader is shown how to use the 555 timer in a variety of applications. The second section of the book is devoted to the 555 timer in a variety of applications, including oscillators, comparators, and relaxation oscillators. The third section of the book covers the 555 timer in more advanced applications, such as astable multivibrators, one-shot multivibrators, and frequency dividers. The book concludes with a section on the 555 timer in practical projects, including a simple LED clock, a simple inverter, and a simple timer.

The book is designed for both the beginner and the advanced hobbyist, with a variety of projects and circuits to choose from. The circuits are classified according to their applications, and each circuit is accompanied by a description of its operation, a circuit diagram, and a list of components. The projects range from simple LED clocks and inverter circuits to more complex applications such as frequency dividers and relaxation oscillators. The book also includes a section on troubleshooting and fault-finding techniques, as well as a glossary of terms and a list of abbreviations used in the book.

The book's approach is practical and hands-on, with a focus on real-world applications. The circuits are designed to be easy to build and test, and the authors provide detailed instructions and advice on construction and troubleshooting. The book is intended for anyone who wants to learn about the 555 timer and its applications, whether they are new to electronics or have some experience with the subject. The book is a valuable resource for students, engineers, and hobbyists who want to explore the possibilities of the 555 timer in their projects.
If you've ever tried to find specs for a so-called 'standard' circuit, you'll appreciate this book. C.L. Hallinack has compiled specs and pinouts for most types of ICs that you've ever wanted to use.

**Electronics Design With Off-the-Shelf Integrated Circuits**

This practical handbook enables you to take advantage of the vast range of applications made possible by integrated circuits. In most cases circuits are built up from building blocks of standard type.

Details are given to aid electronics enthusiasts who like to experiment with circuits and produce their own projects, rather than simply follow published project designs. The circuits for a number of useful building blocks are included in this book. Where relevant, details of how to change the parameters of each circuit are given so that they can easily be modified to suit individual requirements.

**Radio and Communications**

**B79: Radio Control for Beginners**

F.G. Rater, T.Eng. (CEI), Assoc. IERE.

The aim of this book is to act as an introduction to Radio Control for beginners to the hobby. The book will commence by dealing with the conditions that are allowable for such things as frequency of power transmission. This is followed by a block explanation of how control-device and transmitter-receiver and between them. Advice is given on how to take components off the shelves, arrange them into circuits, and make any system perform its desired function.

**B80: Audio Projects**

F.G. Rater, T.Eng. (CEI), Assoc. IERE.

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 modulation (a.m) receivers will be of most interest to those who would like to develop their own audio quality, while the chapter on frequency modulation (f.m) receivers will appeal to those who desire high fidelity reception.

**B81: Electronic Communication**

This book tells how, in step by step fashion, to select the vast range of applications made possible by integrated circuits. The book is for you.

**B82: Transistor Radio Fault Finding Charts**

F.A. Wilson

Across the top of the chart will be found four rectangular columns. These are labelled 'diagnosis,' system descriptions of various faults, i.e., sound weak but undistorted, set dead; sound low or distorted and background hiss. The columns are then divided into such appropriate of these and following the arrows, carry out the suggested checks in sequence until the fault is cleared.

**B83: Solid State Short Wave Receivers for Beginners**

R.A. Penfold

Projects include speech processors, aerial boosters, condenser mike, aerial and filter circuits, field strength meter, power supply, RF receiver and more.

**B84: et Projects**

R.A. Penfold

Projects include speech processors, aerial boosters, condenser mike, aerial and filter circuits, field strength meter, power supply, RF receiver and more.

**B85: First Book of Hi-Fi Loudspeaker Enclosures**

B.B. Babani

This book gives data for building most types of loudspeaker enclosure. Includes corner reflex, bass reflex, exponential, horn, folded horn, tuned port, klipschorn, labyrinth, tuned column, loaded port and multi speaker panoramic. Many tips, diagrams and for every construction showing the dimensions necessary.

**B86: Mobile Discography Book**

Colin Carson

The vast majority of people who start up 'Mobile Discos' know very little about their equipment or even what to buy. Many people buy what they are sold by the uninformed or badly matched apparatus.

The only book to give enough information to enable you to have a better understanding of many aspects of 'discgo' gear.

**B87: How to Build a Small Budget Recording Studio**

Tab B1154

The author, F. Allan Everest, has gotten studios together several times, and presents to be complete, tested design for a wide variety of applications. All you own is a mono cassette recorder, you don't need this book. If you don't want your new four track to wind up sounding like one, though, you shouldn't be without it.

**B88: Electronic Music and Creative Tape Recording**

M.K. Berry

Electronic music is the new music of the Twentieth Century. It plays a large part in "pop" and "rock" music. In fact, there is scarcely a group without some sort of synthesizer or other electronic instruments.

This book sets out to show how electronic music can be made at home, and the power of an "amateur" musical equipment. It then describes how the sounds are generated and how they may be recorded to build up the final composition.

**B89: Electronic Music Projects**

R.A. Penfold

Although many of the more recent branches of amateur electronics, electronic music has now become extremely popular and there are many projects which fall into this category. The purpose of this book is to provide the constructor with a number of practical circuits for the less complex items of electronic music equipment, including such things as a fuzz box, VCA, Waa-Waa Pedal, Sustain Unit, Reverbation and Phaser Units, Tremelo Generator etc.

**B90: Oscilloscopes**

This book is a complete reference for amateurs and engineers, it comprehensively covers all areas of four kind of type as well mobile and portable units.

**B91: Designing, Building and Testing Your Own Speaker System**

F.G. Rater, T.Eng. (CEI), Assoc. IERE

The main aim of this book is to provide the reader with the fundamental information necessary to enable him to make a satisfactory choice from the extensive range of hi-fi equipment now on the market.

**B92: Choosing and using your Hi-Fi**

Maurice L. Jat

The main aim of this book is to provide the reader with the fundamental information necessary to enable him to make a satisfactory choice from the extensive range of hi-fi equipment now on the market.

**B93: Test Equipment Projects You Can Build**

Tab B1085

An excellent source book for the hobbyist who wants to bust up his work bench inexpensively. Projects range from a vm, i.e., signal tracer and basic frequency generators to 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 build the testing equipment, but the finished projects can also be useful in the furtherance of his hobby.

**B94: How to get the Most Out of Low Cost Test Equipment**

Tab N. A.D.U.

Whether you want to get your vintage '60s transistor signal genereting, or you've got something to measure with nothing to measure with it, this is the book for you. The author discusses how to maximize the usefulness of cheap test gear, how to upgrade old equipment, and effective test setups.

**B95: The Power Supply Handbook**

Tab B1086

A complete one stop reference for hobbyists and engineers. It covers all types of power supplies for every conceivable type as well mobile and portable units.

**B96: Electronic Test Equipement**

This book gives comprehensive coverage of all aspects of "disco" gear, including brief descriptions of various faults, viz - sound low or distorted and background hiss. The chapter on frequency modulation (f.m) receivers will appeal to those who desire high fidelity reception.

**B97: series of helpful guides to all aspects of 'disco' gear**

The author discusses how to maximize the usefulness of cheap test gear, how to upgrade old equipment, and effective test setups.

**B98: The Complete Book of Oscilloscopes**

Tab B1088

This book gives comprehensive coverage of all aspects of "disco" gear, including brief descriptions of various faults, viz - sound low or distorted and background hiss. The chapter on frequency modulation (f.m) receivers will appeal to those who desire high fidelity reception.

**B99: How to get the Most Out of Low Cost Test Equipment**

Tab N. A.D.U.

Whether you want to get your vintage '60s transistor signal generating, or you've got something to measure with nothing to measure with it, this is the book for you. The author discusses how to maximize the usefulness of cheap test gear, how to upgrade old equipment, and effective test setups.

**B100: The Power Supply Handbook**

Tab B1086

A complete one stop reference for hobbyists and engineers. It covers all types of power supplies for every conceivable type as well mobile and portable units.

**B101: Oscilloscopes**

This book gives comprehensive coverage of all aspects of "disco" gear, including brief descriptions of various faults, viz - sound low or distorted and background hiss. The chapter on frequency modulation (f.m) receivers will appeal to those who desire high fidelity reception.

**B102: Basic Radio Control for Beginners**

F.G. Rater, T.Eng. (CEI), Assoc. IERE.

The aim of this book is to act as an introduction to Radio Control for beginners to the hobby. The book will commence by dealing with the conditions that are allowable for such things as frequency of power transmission. This is followed by a block explanation of how control-device and transmitter-receiver and between them. Advice is given on how to take components off the shelves, arrange them into circuits, and make any system perform its desired function.

**B103: Crystal Set Construction**

F.G. Rater, T.Eng. (CEI), Assoc. IERE.

This book covers in detail the construction of a wide range of audio projects. The book has been divided into preamplifiers and mixers, power amplifiers, tone controls and matching and miscellaneous projects.

205: First Book of Hi-Fi Loudspeaker Enclosures

B.B. Babani

This book gives an introduction to Hi-Fi loudspeaker enclosures. Many different designs and the application of these are described in order to measure just about any electrical quantity, current, capacitance, impedance and more. The chapter on applied circuitry is a comprehensive reference for the reader.

206: Mobile Discography Handbook

Colin Carson

The vast majority of people who start up 'Mobile Discos' know very little about their equipment or even what to buy. Many people buy what they are sold by the uninformed or badly matched apparatus.

This book is to give enough information to enable you to have a better understanding of many aspects of "discgo" gear.

How to Build a Small Budget Recording Studio

Tab B1154

The author, F. Allan Everest, has gotten studios together several times, and presents to be complete, tested design for a wide variety of applications. All you own is a mono cassette recorder, you don't need this book. If you don't want your new four track to wind up sounding like one, though, you shouldn't be without it.
Hardware and software between transistors and how the systems work and how to choose as well as the how-to's for making repairs from simple tuning to major problems throughout, and requires a minimum of mathematics.

**R. A. Penfold**

**FM and AM TRANSMITTERS**

$15.95

A basic course in the principles and applications of carrier telephony and its place in the overall communications picture. It is abundance illustrated, with questions and problems throughout, and requires a minimum of mathematics.

**Reference**

**B. B. Babani**

The 'First Book of Transistor Equivalents' has had to be reprinted 15 times. The 'Second Book' produces in the same style as the first book, in no way duplicates any of the data presented. This time, 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 'Second Book' of Transistor Equivalents covers semiconductors manufactured in Great Britain, USA, Germany, France, Poland, Italy, East and West Germany, Austria, Belgium, Australia, Netherlands and many other countries.

**Tower's International OP-AMP Linear IC Selector**

$9.45

There are several books around with this title, but most are a collection of manufacturers' data sheets. This one, by Bill Hunter, explains all the intricacies of this useful family of components - from the basics to the Interchangeability data covers semiconductors manufactured in Great Britain, USA, Germany, France, Poland, Italy, East and West Germany, Austria, Belgium, Australia, Netherlands and many other countries.

**CMOS Databook**

$9.45

There are several books around with this title, but most are a collection of manufacturers' data sheets. This one, by Bill Hunter, explains all the intricacies of this useful family of components - from the basics to the Interchangeability data covers semiconductors manufactured in Great Britain, USA, Germany, France, Poland, Italy, East and West Germany, Austria, Belgium, Australia, Netherlands and many other countries.

**Tab 1459: VIDEO CASSETTE RECORDERS: BUYING, USING AND MAINTAINING**

$14.95

A complete handbook for the video enthusiast. You'll learn about how the systems work and how to choose as well as take a technical look at the inside workings. There are also sections on making your own video recordings.

**Tab 1519: ALL ABOUT HOME SATELLITE TELEVISION**

$22.95

Covers such aspects as where to buy, problems in setting up your TVRO station and how to solve them, antenna using and its placement, tape exchange and understanding specifications.

**MISSCILEANEOUS**

**Tab 1541: ELECTRONIC WORKBENCH GUIDE**

$6.75

This book contains a wealth of useful data on over 5,000 Op-amps and related parts. It has a comprehensive series of appendixes which contains information on such as, pinouts, manufacturer's name and use, etc. It is a popular user-orientated selection of modern transistors. Also shown are the material type, polarity, manufacturer and type. The Equivalents are sub-divided into American, European, 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. A fantastic value for the amount of information it contains.

**BP108: INTERNATIONAL DIODE EQUVALENTS**

$6.95

This book is designed to help the user in finding possible substitutes for a possible range of diodes. The 'Second Book' of Transistor Equivalents also shows the material type, polarity, manufacturer and type. The Equivalents are sub-divided into American, European, and Japanese. The products of over 10 manufacturers are included. An essential addition to the library of all those interested in electronics, be they technicians, designers, engineers or hobbyists. A fantastic value for the amount of information it contains.

**BP112: HANDBOOK OF ADVANCED ROBOTICS**

$23.95

Here's the key to learning how today's sophisticated robot equipment can operate, how they are controlled, and the work they do. This book contains a wealth of useful data on over 5,000 Op-amps and related parts. It has a comprehensive series of appendixes which contains information on such as, pinouts, manufacturer's name and use, etc. It is a popular user-orientated selection of modern transistors. Also shown are the material type, polarity, manufacturer and type. The Equivalents are sub-divided into American, European, and Japanese. The products of over 10 manufacturers are included. An essential addition to the library of all those interested in electronics, be they technicians, designers, engineers or hobbyists. A fantastic value for the amount of information it contains.

**BP100: AN INTRODUCTION TO VIDEO**

$7.60

Principles in non-technical way as possible how a video recorder works and how to get the best out of it and its accessories. Among the topics discussed are the pros and cons of the various systems, copying and editing, international tape exchange and understanding specifications.

**BP502: HOW TO BUILD YOUR OWN WORKING ROBOT**

$10.95

Contains complete plans - mechanical schematics, diagramds and wiring diagrams - for building Buster. Buster is a sophisticated experiment in cybernetics you can build in stages. There are two phases involved: first Buster is built, then he is led, dependent on his creator for guidance, the second phase makes Buster more independent and able to get out of tough situations.

**BP101: HOW TO IDENTIFY UNMARKED IC'S**

$2.20

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.

**Tab 1421: HANDBOOK OF ADVANCED ROBOTICS**

$23.95

This book tells how today's sophisticated robot equipment can operate, how they are controlled, and the work they do. This book contains a wealth of useful data on over 5,000 Op-amps and related parts. It has a comprehensive series of appendixes which contains information on such as, pinouts, manufacturer's name and use, etc. It is a popular user-orientated selection of modern transistors. Also shown are the material type, polarity, manufacturer and type. The Equivalents are sub-divided into American, European, and Japanese. The products of over 10 manufacturers are included. An essential addition to the library of all those interested in electronics, be they technicians, designers, engineers or hobbyists. A fantastic value for the amount of information it contains.

**Tab 1412: HANDBOOK OF ADVANCED ROBOTICS**

$23.95

Here's the key to learning how today's sophisticated robot equipment can operate, how they are controlled, and the work they do. This book contains a wealth of useful data on over 5,000 Op-amps and related parts. It has a comprehensive series of appendixes which contains information on such as, pinouts, manufacturer's name and use, etc. It is a popular user-orientated selection of modern transistors. Also shown are the material type, polarity, manufacturer and type. The Equivalents are sub-divided into American, European, and Japanese. The products of over 10 manufacturers are included. An essential addition to the library of all those interested in electronics, be they technicians, designers, engineers or hobbyists. A fantastic value for the amount of information it contains.

**BP102: HOW TO GET YOUR ELECTRONIC PROJECTS WORKING**

$7.60

Literally, everything the amateur or professional musician needs to know to properly maintain his instruments, plus all the how-to's for making repairs from simple tuning to major overhauls.

**Tab 1417: ELECTRONIC TROUBLESHOOTING HANDBOOK**

$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.

**Tab 1418: ELECTRONICS TODAY BOOK SHELF**

$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-updating 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.

**Tab 1419: INTERRELATORE INTEGRATED ELECTRONICS CIRCUITS FOR THE RADIO AMATEUR, TECHNICIAN, HOBBIST AND CBER**

$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 hard-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, pass-ive devices together in benchwork, test instruments, and games.

**Tab 1518: VIDEO**

$11.75

A basic course in the principles and applications of carrier telephony and its place in the overall communications picture. It is abundantly illustrated, with questions and problems throughout, and requires a minimum of mathematics.

**Tab 1411: VIDEO CASSETTE RECORDERS: BUYING, USING AND MAINTAINING**

$14.95

A complete handbook for the video enthusiast. You'll learn about how the systems work and how to choose as well as take a technical look at the inside workings. There are also sections on making your own video recordings.

**Tab 1413: VIDEO CASSETTE RECORDERS: BUYING, USING AND MAINTAINING**

$14.95

A complete handbook for the video enthusiast. You'll learn about how the systems work and how to choose as well as take a technical look at the inside workings. There are also sections on making your own video recordings.

**Tab 1414: VIDEO CASSETTE RECORDERS: BUYING, USING AND MAINTAINING**

$14.95

A complete handbook for the video enthusiast. You'll learn about how the systems work and how to choose as well as take a technical look at the inside workings. There are also sections on making your own video recordings.

**Tab 1415: VIDEO CASSETTE RECORDERS: BUYING, USING AND MAINTAINING**

$14.95

A complete handbook for the video enthusiast. You'll learn about how the systems work and how to choose as well as take a technical look at the inside workings. There are also sections on making your own video recordings.

**Tab 1416: VIDEO CASSETTE RECORDERS: BUYING, USING AND MAINTAINING**

$14.95

A complete handbook for the video enthusiast. You'll learn about how the systems work and how to choose as well as take a technical look at the inside workings. There are also sections on making your own video recordings.
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
Convert your regular drill to a variable speed or use a blender to slowly rotate your gerbils - precision motor control with next month's project.

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.

Expand
If you've been enjoying the micro computing features in Electronics Today... or if you're just interested in the continuing development of this powerful new technology... you'll want to consider a subscription to Computing Now!, Canada's largest micro computer publication.

Whether you are a beginner, a business user, a programmer or a bleary eyed hacker up to your clavical in lost bytes you'll find something of interest in every issue of Computing Now! In the next few months we'll be looking at, among other things, computer aided drafting packages for personal computers, telecommunications, macro assemblers, programming in other higher level languages... there'll also be a massive directory of computer products in an upcoming issue which you won't want to miss.

A subscription to Computing Now! costs $22.95 for one year (12 issues), or $37.95 for two years (24 issues). This not only assures you of getting every copy fresh from the hairy palms of the post office, but saves you money - you'll save $12.45 with a one-year subscription, and $32.85 for two - plus getting the satisfying feeling of beating the gum-mint for the sales tax.

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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 280 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 2^7-1 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^n 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, i.e. 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.](image-url)
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° figure and a 160° figure (as in tens and units). A register pair would hold figures for 16³, 16², 16¹ and 16⁰.

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<th>16³</th>
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<td>9</td>
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<td>B</td>
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<td>2716</td>
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<td>11</td>
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<td>E</td>
<td>57344</td>
<td>3584</td>
<td>224</td>
<td>14</td>
</tr>
<tr>
<td>F</td>
<td>61440</td>
<td>3840</td>
<td>240</td>
<td>15</td>
</tr>
</tbody>
</table>

Using the table: decimal 15 in a register pair = 000F whereas 240 decimal in a single register would = F0.
A080 hex = 40960 + 176 = 41136 decimal
FEDC hex = 61440 + 3584 + 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 1.
The very first remainder we obtained the value of 2⁰, the next is 2¹, the next is 2², 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 2⁵ (32) but under 2⁶ (64) so the binary bit corresponding to 2⁵ is 1
365 - 32 = 333
333 is over 2⁴ (16) but under 2⁵ (32) so the binary bit corresponding to 2⁴ is 1
333 - 16 = 317
317 is over 2³ (8) but under 2⁴ (16) so the binary bit corresponding to 2³ is 1
317 - 8 = 309
309 is over 2² (4) but under 2³ (8) so the binary bit corresponding to 2² is 1
309 - 4 = 305
305 is over 2¹ (2) but under 2² (4) so the binary bit corresponding to 2¹ is 1
305 - 2 = 303
303 is over 2⁰ (1) but under 2¹ (2) so the binary bit corresponding to 2⁰ is 1

We follow this through in the same way as before.
Machine Language

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

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 pertaining 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 use 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 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 periodically 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 is 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;
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 - 1); 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 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.

 Continued in the next issue.

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See page 66
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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.

---

Incremental Timer

R.A. Penfold

THE LM3914 LED display drive, IC1, is connected as a zero to 5 V (full scale) voltmeter to display in the bargraph mode. Thus, each LED will turn on at increments of 0.5 V 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 5 V 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.

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