Voice Prints
The truth... the whole truth!

Digital Kitchen Scales
A weighty project

Close Captioning TV
For the hearing impaired.

Logic Probe
Highs and lows

dbx
The sounds of silence.

Designer's Notebook
Unusual Techniques

Zenith Z-100 Computer Reviewed
Exceltronix

AppleTM Computer

Apple II Plus
with 48K RAM
SPECIAL
$1545
Apple disk drive
with controller
$7795
Apple drive without
controller
$700

We provide our own 120 day warranty

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Zenith Monitors complete with power supply ready-to-use with any composite video signal. 12" green phosphorus screen switch selectable for 40 or 80 characters. 90 day warranty; quantity discounts available.

80x24 VIDEO BOARD FOR APPLE
Made by Multiflex Tech, this video board is based on 6845 CRT controller, and switches automatically between 80x24 and 40x24, composite video out. Designed to work with CP/M, PASCAL, DOST (good stock) 120 day warranty. A&T.

SPECIAL
$159

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AMDEK 310 — A AMBER MONITOR $249
90 day warranty

OSBORNE COMPUTER

New model on sale now $2289
$2395 With 12" Zenith green screen + adapter (This month only)

MULTIFLEX SUPER PACKAGE
Price Kit $1195
A&T $1389

NEW MULTIFLEX PORTABLE PACKAGED SYSTEM
$1895

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New professional looking aluminum case for the 6502 board, at unbeatable $48.95
Also Multiflex keyboard A&T which fits into case, ready to plug into 6502 $99
Combination case & keyboard A&T (while they last — limited stock only!!! Hurry. $139
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GEMINI 10 $619
GEMINI 15 $799

SERIAL CARD $119

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EPSON

MX80 type III .......................... $759
MX80FT type III .......................... $699
MX82 type III .......................... $625
MX82FT type III .......................... $959
MX100 type III (limited special)........ $995
Note: All type III printers include graphics. All printers come with 90 day warranty.

Special Hameg Scopes HM203-2 $629 While quantities last.

PRICE POLICY

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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ALL PRICES ARE IN CANADIAN FUNDS, 9% FEDERAL SALES TAX INCLUDED

Circle No. 7 on Reader Service Card.
**Multiflex Static 64K RAM Board $100 BUS**

With provision for battery backup

Special (using 6116 150 ns RAMS)
- 16K version = $299 A&T = $350
- 32K version = $349 A&T = $395
- 64K version = $485 A&T = $519

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(with 4 page memory)

This multiflex intelligent terminal comes with a keyboard, and 8k of RAM. 80x24 character composite video display and RS232 output (uses 6845 CRT controller and Z-80A CPU) has many attributes, works at 75 to 9600 baud rate. This product is one of our best sellers and you can't afford not to have it at our low price.

Terminal kit with 8k RAM
**$259**

Assembled & tested (No cases & supply)
**$289**

Options are as follows:

- Case - $39.00, Power supply - $45.00, TV option - $29.00

**This Month Special**

Complete terminal with power supply & case assembled & tested
**$350**

With every terminal you buy you get 10% discount on a Zenith 12" green screen monitor.

**U of T 6809 Board**

(Used in courses at U of T)

Requires any RS232 terminal (Multiflex terminal works great with it). Includes 6869 CPU, (26522) parallel ports, 26551 serial ports) 48K of dynamic RAM, 4k of monitor and 8k of assembler.

This month only save **$160.00**

6809 Kit with assembler & editor & full documentation only **$375.00**

**Multiflex Modem Kit**

300 and 800 works great

**$149**

**Multiflex Logic State Analyser**

(see pg. 24 catalog)

This instrument is a must for debugging complicated digital & microprocessor circuits.

- 16 channel inputs (low loading) Kit (with case)
**$289**

- A & T — **$349**

**Multiflex S100 Floppy Controller**

Features 1) S100 Compatible. 2) DMA. 3) Based on 1793 — capable of handling up to four 8 inch of 5 ¼ inch drives in double sided double density or SS, SD.

Special kit with DMA
**$295**

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**S100 Video Board by Multiflex**

Based on 8275 CRT controller and 280A CPU processor, and 8k of RAM, you get a 80x24 composite video, output with features comparable, if not better, to a board twice more expensive.

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2114 (200ns) ............................................ $1.95
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Special: 24 of above .................................... $39.00
2716 ......................................................... $4.95
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2732 ......................................................... $8.95
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6502 ......................................................... $6.89
All sockets, Super quality ............................ 1¢ per pin
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GEMINI 10 $595.00
GEMINI 15 $769.00
SERIAL CARD $109.00

ASCII KEYBOARD

Fits aluminum case perfectly, ready to plug into 6502 board. Assembled & tested with ALC documentation $99

(Keyboard uses EPROM, which makes it very flexible. Combination at special Aluminum case & Keyboard. $139

ASCII KEYBOARDS

This keyboard is ready to plug into your 6502 board and fit your case perfect. SPECIAL $89

VIDEO CARD 80x24

BARE BOARD = $17.95

Assembled & tested ready for use (Auto switching between 80x24 and 40x24) Fully compatible with CPM, Wordstar, Pascal, DOS 3.3. $89

—Note again that to build this card it probably cost you more than to buy it assembled & tested.

Floppy cont bd. which has provision for 2716 EPROMS (350ns) $17.95

DISK DRIVES

New Shugart SA400L Disk Drives

Disk Drives (all drives are brand new and fully pre-tested). 5¼ Single side single or double density. Ideal for modifying (for your 6502 board)

DRIVE CASE $14.95

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80x24, we doubt that you can find a better buy, ready to be plugged in,

SPECIAL (While they Last) $119

ATTRACTIVE LOOKING $42
AT AN UNBEATABLE ALUMINUM CASE,
Beige colour, (provides excellent RF shielding)

EPROM PROGRAMMER WITH DOCUMENTATION & SOFTWARE

Provides its own 25V on board. Programs 2716, 2732, 2732A, 2764, also has ZIF socket.

SPECIAL $85

6502 BOARD SPECIAL $57.95

Expected release March 15, 1983
This new board is so advanced that it will make you think about getting rid of your old 6502 board, and if you do not have one yet it is worth it to wait a little and get the STATE OF THE ART product!

Has on-board provision for: 16K RAM, 80x24 Video, Floppy Controller and 6 slots for some of the above boards.

SPECIAL

16K RAM CARD

For your 6502 board allowing you to expand your 48K system to 64K fully assembled and tested ready to plug in ONLY $69

BARE BOARD $16.95

NOTE: We believe that to buy the parts for your bare 16K board may end up costing you more, than to buy the finished product. (also no debugging headaches.)

310 College Street, Toronto, Ont. M5T 1S3 (416) 925-8603
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ZX81 Printer Review ........................ 46
We examine the printer that gives you hard copy for your ZX81 at a reasonable price.

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MARCH 1983
Vol. 7 No.3
ISSN 0703-8984
Microcomputer Courses

Seneca College of Toronto has a variety of microcomputer courses to choose from, including BASIC on the Apple II, personal application (budgeting, mortgages, bookkeeping, etc.), and business applications such as VisiCalc and word processing.

There are courses on programming languages such as BASIC and LOGO, and includes an introduction to applications of microcomputing, a course for young people 10 to 16 "Microcomputers for Children", and a course to choose from, including BASIC and LOGO programming.

Seneca College of Toronto has a variety of microcomputer courses to choose from, including BASIC on the Apple II, personal application (budgeting, mortgages, bookkeeping, etc.), and business applications such as VisiCalc and word processing.

One of the courses is "Microcomputers for Children", a course for young people 10 to 16 years old. The courses are available in a variety of contact configurations, including switchboards and systems.

For further information regarding Omron's low-profile and space-saving PCB relays, contact Joanne Sullivan, Marketing Manager, Control Components Division, Omron Electronics, Inc., 650 Woodfield, Schaumburg, IL 60195. Telephone: (312) 843-7900. (Budgetting, mortgages, bookkeeping, etc.)

Commodore Computers

Commodore International has announced the Spring release of three portable systems. All have 64K of memory, a 5-inch display monitor, and the option to use one or two floppy disk drives, and compatibility with the Commodore 64 computer software and peripherals. Expected retail prices are $995 (U.S.) for a monochrome display with single disk, and $1495 (U.S.) for a colour display and dual disks.

Also announced was the initial shipping of the Commodore 128, a P500 series microcomputer, to regular computer dealers. It has 128K of memory and a suggested retail price of $795 (U.S.).

Every purchaser of a Commodore 1541 disk drive will receive a program package at no charge from authorized Commodore dealers. The package includes a disk and a manual, and covers education, games, sound, graphics and utilities categories.

Finally, Commodore owners who would like to run CP/M adds 64K of additional RAM. This increases Commodore compatibility with the Commodore 64 and 6502 CPU's, and in addition to CP/M adds 64K of additional RAM. This increases Commodore applications ten-fold, giving access to word processing, VisiCalc, and high level languages such as Pascal. It's available through Commodore dealers, or contact Computer Workshops Ltd., 465 Clanton Park Road, Downsview, Ontario, M3H 2C9; (416) 631-6913.

Transient Suppressors

CSA, Canadian Standards Association, has approved Surge Sentry power line transient suppressors, manufactured by RKS Industries of Scotts Valley, California. The unit protects devices such as computers, medical electronics, word processors, and other sensitive equipment from high-speed, high-energy transient impulses occurring during virtually all power lines. The Surge Sentry line, which includes models that protect against voltage dropout, is distributed in Canada by Morley Agencies, Ltd., 71 Clanton Park Road, Downsview, Ontario, M3H 2C9; (416) 631-6913.

Versatile New Video Switch

The Winegard Model VS-6004 video switch provides an inexpensive and easy way to control, from one convenient location, all TV or video signal sources connected to a TV set.

The VS-6004, as a list price of $41.75 U.S., eliminates aggravating cable connecting and disconnecting and does away with messy behind-the-set cables. By simply flipping a switch, up to four signal sources may be attached to a TV set and two to a VCR.

Viewers will have, at their fingertips, easy access to off-the-air or cable programs, video games, VCRs, video discs, satellite receivers or home computers.

Winegard's new switch also allows the viewer to monitor and edit programs being recorded on a VCR or copied from one VCR to another.

High isolation switching circuits reduce interaction between signal sources and prevent interference. The completely passive device requires no AC power to operate and is compact and lightweight. Bypass is Channel 2 through 83. All connections are 75 ohm type.

New BiMOS Operational Amplifier

RCA's new CA3420 BiMOS operational amplifier solves design problems with notable features such as 1 PA bias current over the operating temperature range, supply voltage down to 2 V and an output that generates essentially rail-to-rail output swings. At RCA dealers, or send for File 1320, RCA Solid State Division, Box 3200, Somerville, NJ 08876, or call toll-free (800) 526-2177.

Continued on page 10
GRAND OPENING

MICRO COMPUTECH ELECTRONICS LTD.

ELIMICRO

COMPUTECH ELECTRONICS LTD.

ATI FDD-810 series

THE "FDD-810" MINIFLOPPY DISK DRIVE IS A HIGH PERFORMANCE
AND ECONOMICAL MINI TYPE DISK DRIVE WHICH IS SPECIALLY
DESIGNED FOR APPLE II™ PERSONAL COMPUTER.

- Double Storage Capacity enables the use of both sides of diskettes.
- Switch circuit (patent pending) enables the use of both sides of diskette.
- Slim type Disk Drive is 2/3 the height of conventional minifloppy disk drives.
  - Instant installation.
  - Auto eject
  - Fully compatible with Apple II™
  - Compact size
  - Fast data access (12 msec between tracks)

Software transparent.
Higher precision positioning than conventional drives.
Uses standard 5.25" diskette.

INTRODUCTORY OFFER

$425.00
Reg. price will be $475.00

DEALER INQUIRIES INVITED

We carry a full range of Apple II™ compatible products: bare boards, part kits, as well as fully assembled and tested boards.

- 80 x 24 VIDEO CARD
- Z80 CARD
- LANGUAGE CARD
- INTEGER ROM CARD
- DISK CONTROLLER CARD
- EPSON CONTROLLER CARD
- EPROM WRITER CARD
- R.F MODULATORS
- JOY STICK
- NEW CASE
- NEW KEYBOARD
- HIGH WATTAGE POWER SUPPLY WITH BUILT IN LINE FILTER.

NEW 6502 COMPUTER

$1199.95

- 64K RAM
- UPPER AND LOWER CASE
- NUMERIC KEY PAD
- NEWLY STYLED CASE
- HIGH WATTAGE POWER SUPPLY
- FULLY APPLE™ HARDWARE AND SOFTWARE COMPATIBLE
- 90 DAY WARRANTY

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ALL PRICES ARE IN CANADIAN FUNDS, 9% FEDERAL SALES TAX INCLUDED

Apple II™ is a trade mark of Apple Computer, Inc.

Circle No. 18 on Reader Service Card.
The ZX81's advanced capability. The ZX81 uses the same fast microprocessor (Z80A), but incorporates more powerful 64K BASIC ROM - the "brain" intelligence of the computer. This chip works in terminals, handles logs and trip, allows you to plot graphs, and produces graphics displays. And the ZX81 incorporates other operation refinements - the facility to load and save named programs on cassette, or to select a program off a cassette through its keyboard.

New, improved specification.

- Unique "one-touch" key word entry; eliminates the great deal of timeconsuming typing. Key words (PRINT, LIST, RUN, etc.) have their own single key entry.
- Unique syntax-check and report codes identify programming errors immediately.
- Full range of mathematical and scientific functions accurate to eight decimal places.
- Graph-drawing and animated display facilities.
- Multi-dimensional string and numeric arrays. "Up to 26 dimensioned strings can be stored and manipulated in any combination, together with numeric arrays of a variable size."
- Special function, "Randomize". "Programmable in machine code, this function allows you to put a "shock" into the program," changing the program's sequence or data." The ZX81 can be used as an interactive "math engine". "It can be programmed to perform any arithmetic calculation or operation; to produce a graph; to store and recall data; to control a process; and so on."
- "Continuous display, including moving graphics. Multi-dimensional string and numerical arrays. Math and scientific functions accurate to 8 decimals.
- Unique one-touch entry of "key words". In the ZX81 system, the "key word" has been kept to a minimum. It is possible to "drop-in" a new program, disassemble it, and use the information directly as part of another program.
- Power supply (24V at 500 ma) optional for £14.95. 1K of memory is included.

Memopak...

MEMOPAK 52K $179.00 and 16K $109.50 MEMORY EXTENSIONS

MEMOPAK 64K MEMORY EXTENSION

The 64K Memopak extends the memory of the ZX81 by 64K, and with the ZX81 gives 84K, which is neither switch-chipped nor paged and is directly addressable. The unit is user transparent and accepts commands such as 10 DIY "ADD 3 4"

Breakdown of memory areas... 0-8K Sinclair ROM...

MEMOPAK HIGH RES GRAPHICS PACK

HRG Main Features - Fully programmable Hi-Res (192 x 245 pixels) - Video page is both memory and bit mapped and can be located anywhere in RAM.

- Number of Video pages is limited only by RAM size (both takes about 6.5K RAM).
- Instant inverse video effect gives flash effect to graphics characters.
- Video pages can be superimposed, and the display is similar to BASIC printout.
- Contains 2K EPROM monitor with full range of graphics subroutines controlled by machine code or USF function.

MEMOPAK CENTRINOS V.2 PARALLEL PRINTER INTERFACE

MEMOPAK CENTRINOS TYPE PARALLEL PRINTER INTERFACE

Main Features - Enables use of a popular dot matrix and daisy wheel printers with ZX81.

- With ZX81 Basic, prints from LISP, LPRINT and COPY.
- Contains firmware to convert ZX81 character code to ASCII code.

- Gives lower-case characters from ZX81 Inverse character set.

- Main Interface for any serial printer or 4 character code.

- Full function printer: includes columns, control and detailed manual.

- Master Charge & Visa, COD, Charge Money.

- Free delivery...

- Prices subject to change without notice.
What can you honestly expect from an interactive data terminal that costs only $475.95

Well, to begin with, color graphics. RCA's VP-3001 has unique color-locking circuitry that gives you sharp, jitter-free color graphics and rainbow-free characters.


The VP-3301 can be used with a 525-line color or monochrome monitor or a standard TV set through an RF modulator. It serves a wide variety of industrial, educational, business and individual applications including communication with time sharing and data base networks such as those provided by Dow Jones News/Retrieval Service and such as those provided by Dow Jones News/Retrieval Service and such as those provided by Dow Jones News/Retrieval Service.

START WITH ORION FOR A NEW ERA IN THE WORLD OF ELECTRONICS

We have the most complete selection of electronic components. Full line of TTL, CMOS, Linear, 1cs, Computer Interface, Support Chips and CPUs.

Circle No. 6 on Reader Service Card.
Digital Storage Scopes

Gould has three new low-cost storage scopes in their 1400 series units. These are portable, lightweight, quality instruments as roll, refreshed, single shot, display hold, and pretrigger storage. Contact Mrs. Debbie Muraca, Allan Crawford Associates Ltd., 6503 Northam Drive, Mississauga, Ont. L4V 1J2, (416) 678-1590.

also...

A report by the Evans Research Corp. says that sales of computers costing over $500,000 could drop by as much as 44%, and the best forecast for 1983 is a repeat of 1982's performance. Software and microcomputer sales, however, should make the total computer sector growth about 13% (compared to 25% in previous years).

Each subscriber to SATN, the bi-monthly journal for VisiCalc users published by Software Arts, 224 Clarendon St., Boston, MA 02116, will spend $30,000 on computer hardware in the next six months. Subscribers responding to a Software Arts survey also claimed that they will purchase 14 microcomputers during the next six months, as well as other hardware and software.

Wrist Watch Radio

Sony has unveiled the prototype of their one-chip wrist watch radio, featuring alarm and sleep settings, frequency synthesised AM radio, four station presets and a display that shows the AM frequency. This technology applied to cars would solve your parking problem. No price or production date is available.

Toronto Computer Show

The Toronto Computer Show will be running concurrently with the Data '83 conference at the Automotive Building, Exhibition Place, Toronto, Ontario on June 22 and 23. Last year the show drew 51 exhibitors, and features many types of hardware and software. The Data '32 conference will be a state-of-the-industry meeting of North American experts reviewing concepts such as the electronic office and new solutions to data processing. For information call Laurie Whitshed at (416) 967-6200.

Production Show '83

Three shows are to run concurrently at the Coliseum Complex, Exhibition Place, Toronto: The National Industrial Production and Machine Tool Show, The Canadian Welding Show and The Plastics Show of Canada. Their theme is "solutions to Canada's productivity crisis" and the idea is to extend and improve the use of technology in manufacturing. The shows will be from May 9 to 13, and further information can be obtained from Industrial Trade Shows at (416) 252-7791, or from Jim Myles, 20 Butterwick Rd, Toronto M8W 3Z2.

IC Master

This tome is to integrated circuits as the Oxford English Dictionary is to words. It lists 35,000 devices in its 3300 pages, including sources, key specifications, discontinued devices and 55,000 substitutes. You'll find linears, interfaces, micros, micro supports, custom IC's and PROM programmers, all organized according to key specifications. Available at branches of Active Component Sales Corp., or contact them at 5651 rue Ferrier St., Montreal, Quebec H4P 2K5, (514) 731-7441.
"When will someone introduce high-performance scopes without the high prices?"

<table>
<thead>
<tr>
<th>Model</th>
<th>Frequency</th>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>V-152F</td>
<td>15 MHz</td>
<td>15 MHz, dual-trace scope, sensitive to 1 mV/div at 7 MHz. It has a 5&quot; CRT.</td>
<td>$820</td>
</tr>
<tr>
<td>V-202F</td>
<td>20 MHz</td>
<td>20 MHz, dual-trace scope, sensitive to 1 mV/div at 7 MHz. It has a 5.5&quot; CRT.</td>
<td>$968</td>
</tr>
<tr>
<td>V-302F</td>
<td>30 MHz</td>
<td>30 MHz dual-trace scope, sensitive to 1 mV/div at 7 MHz. It features signal delay and a 5&quot; CRT.</td>
<td>$1,024</td>
</tr>
<tr>
<td>V-353F</td>
<td>35 MHz</td>
<td>35 MHz, dual-trace delayed sweep scope, sensitive to 1 mV/div at 7 MHz. It features a 5.5&quot; square CRT.</td>
<td>$1,357</td>
</tr>
<tr>
<td>V-650F</td>
<td>60 MHz</td>
<td>60 MHz, dual-trace scope, sensitive to 1 mV/div at 10 MHz. It features delayed sweep and a 6&quot; CRT.</td>
<td>$1,949</td>
</tr>
<tr>
<td>V-509</td>
<td>50 MHz</td>
<td>50 MHz, dual-trace, mini-portable scope with optional battery pack, sensitive to 1 mV/div at 10 MHz. It features delayed sweep and a 6&quot; CRT, and weighs 11 lbs.</td>
<td>$2,590</td>
</tr>
<tr>
<td>V-1050F</td>
<td>100 MHz</td>
<td>100 MHz, quad-trace scope, sensitive to 0.5 mV/div at 5 MHz. It features delayed sweep and a 6&quot; CRT.</td>
<td>$2,973</td>
</tr>
</tbody>
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HITACHI HEARD YOU.

Ask no longer. Hitachi has just answered your question with 8 new portable oscilloscopes. In fact, they're the highest-quality scopes around for the money.

We call them our F series. They range from 15 MHz to 100 MHz and can be used for all types of bench and field work. There are dual-trace and quad-trace models. Several have delayed sweep. All are lightweight. Compact. And feature functionally grouped operating controls and bright, easy-to-read CRTs. Here's a closer look at each model:

- **V-152F**: A 15 MHz, dual-trace scope, sensitive to 1 mV/div at 7 MHz. It has a 5" CRT. *$820.*
- **V-202F**: A 20 MHz, dual-trace scope, sensitive to 1 mV/div at 7 MHz. It has a 5.5" CRT. *$968.*
- **V-302F**: A 30 MHz dual-trace scope, sensitive to 1 mV/div at 7 MHz. It features signal delay and a 5" CRT. *$1,024.*
- **V-353F**: A 35 MHz, dual-trace delayed sweep scope, sensitive to 1 mV/div at 7 MHz. It features a 5.5" square CRT. *$1,357.*
- **V-209**: A 20 MHz, dual-trace, mini-portable scope, sensitive to 1 mV/div at 5 MHz. It features AC/DC operation and has a 3.5" CRT, and weighs only 10 lbs. Battery included. *$1,348.*
- **V-650F**: A 60 MHz, dual-trace scope, sensitive to 1 mV/div at 10 MHz. It features delayed sweep and a 6" CRT. *$1,949.*
- **V-509**: A 50 MHz, dual-trace, mini-portable scope with optional battery pack, sensitive to 1 mV/div at 10 MHz. It features delayed sweep and a 6" CRT, and weighs 11 lbs. *$2,590.*
- **V-1050F**: A 100 MHz, quad-trace scope, sensitive to 0.5 mV/div at 5 MHz. It features delayed sweep and a 6" CRT. *$2,973.*

There they are. High-performance scopes without the high prices. And all are backed by Hitachi's reputation for quality. To learn more, write or call us today. Hitachi Denshi, Ltd. (Canada)

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The Alternative! The Compatible! The Affordable! 48K Color Computer!

**KIT FORM**

- Fully compatible with Apple® II +
- Singleboard for easy assembly
- Popular 6502 MPU for large amount of software
- Built-in 2-watt amplifier for realistic sound effect with volume control
- Game paddle connector on both sides of case
- 8 on board peripheral connectors for expansion
- 14 key numeric key-pad
- 5-amp switching power supply

**FEATURES:**
- Modern 6502 MPU
- Single board for easy assembly
- 2-watt amplifier for realistic Apple® II + sound effect
- 80 x 24 video
- Game paddle connector on both sides of case
- 14 numeric keys

**PRICE:**
850.00

*(Please add 5% shipping and handling)*

Easy to assemble! All components are clearly silk-screened on the high quality double-sided mother board. All integrated circuits, IC sockets, peripheral connectors, keyboard, switching power supply and the professional high impact plastic case are included.

---

**Verbatim**

**FLEXIBLE DISKS**

- 5¼" (S.S.D.D.) $60. ea.
- box of 10 w/Case
- 5 year warranty

**DISC DRIVE SPECIAL**

- SA200 (5¼") .................................. $280.
- SA801 (8") .................................. $675.
- 5¼" disc drive 100% Apple & Pineapple compatible (SA200)
  - $385 each
  - $485 each (w/Controller)

**THE OKIDATA SERIES**

- ML82A .................................. $780.
- ML83A .................................. $1250.
  (w/TRACTOR)

**MONITORS**

- 12" Zenith green ................................ $160.
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The development of the voiceprint was to have brought the accuracy of fingerprinting to audio identification. Eric McMillan looks at the technique and its courtroom controversy.

IN 1966 Lawrence G. Kersta was called to the stand in a Westchester County, New York, courtroom as a star witness for the prosecution. The fate of the accused, a policeman, hinged on Kersta's testimony. The court wanted to know whether the voice that had tipped off a bookie to a police raid belonged to the defendant.

Kersta gave his opinion that it was the officer's voice and the defendant was subsequently convicted of perjury.

Kersta had not been present during the tip-off, nor had he been acquainted with the accused. Rather, he had examined tapes of the warning to the bookie and of the policeman and testified as an expert in voice identification.

What made his testimony unusual however was his method of comparing the tapes. Instead of simply listening and making an aural judgement, Kersta had produced pictorial representations which could be measured and matched visually.

For the first time evidence from "voiceprints" was accepted in a court of law.

Since then voiceprinting has featured in dozens of trials and countless more criminal investigations, although not without continual controversy.

Proponents claim that voiceprints can be used by a trained examiner in a manner similar to fingerprints, although the reliability of positive identifications by voiceprints is lower than the near-infallibility of fingerprint evidence.

Critics however say the only similarity is in the name, "voiceprint" being coined by Kersta who later patented it for his private company Voiceprint Laboratories. Some prefer to call the printed patterns "voicegrams" or "spectrograms."

Since 1966 courts in North America have ruled both for and against the admissibility of voiceprint evidence and scientific studies have been similarly split on its reliability, with the most authoritative investigation coming down on the negative side.

It hasn't helped the case for voiceprinting that another person later confessed to tipping off the bookie in the 1966 crime.

The sound spectrograph

The technique of voiceprinting is simple enough that no one disputes it creates an accurate picture of a human voice at a particular moment. The debate arises over the possibilities for identifying voices this way.

Working at the Bell Laboratories in New Jersey, Kersta theorized that since speech depends on the individual anatomy of each person's vocal apparatus (mouth, throat, vocal cords, etc), everyone's voice is unique. By 1962 he developed the use of a sound spectrograph to produce charts of the frequencies, emphasis and durations of given sounds as spoken by subjects.

Varying techniques have been employed over the years but most voice analysts have focused their attention on small units of speech such as isolated words, syllables or phonemes (single speech-sounds such as "p" or "sh").

A taped sample is placed in a recorder on a continuous loop. With each play-through, a chosen frequency is filtered out and activates a pen which makes a mark on a sheet of paper. The louder the voice at this frequency, the darker the mark. On succeeding play-throughs, slightly higher frequencies are selected and the pen marks the sheet just above the previous mark.

When all the frequencies in the voice sample have been exhausted, the result is a chart showing the frequency bandwidth for each component sound set against the duration of the sounds, with volume indicated by relative darkness.

According to Kersta's theory, certain characteristics can be found in common between the voiceprints made from the same sounds spoken by one person, although the time and conditions may change. Moreover, these characteristics are distinct enough to differentiate the voiceprints made by separate individuals speaking identical words.

In a police application this usually involves matching the voiceprint made from an anonymous bomb threat or obscene phone call against one made from a suspect. Police ask a suspect to repeat the exact words and the voice of the original tape. Sometimes however they have to make do with recordings from uncooperative suspects who may not even realize they are being taped. In that case the voiceprint expert must...
pick out comparable sounds from differing contexts.

The expert seeks congruences of vowel frequency, consonant patterns, bandwidths, vertical streaking, duration, gaps, contours, intensity and other features. But since there are no objective rules for determining what characterizes a person's voice, the judgement lies ultimately with the examiner's perception.

A voice identification expert told a Canadian court in 1977, "You don't look for points (of similarity) per se. You make a subjective decision based on the aural and the visual."

In an attempt to decrease the margin of error due to fallible human senses, computers have been programmed to compare voices on the basis of voiceprints as well as on related data. The results so far have been mixed.

The "Shah of Iran" tapes

Experts considering the same voice samples have often found themselves on opposite sides in courtroom battles, but never did their findings conflict as revealingly as when they faced off with their voiceprints and computers over the controversial "Shah" tapes of 1979.

Shortly after Shah Reza Pahlavi was forced to flee the Iranian revolution, a Los Angeles TV station received a tape which purported to record the Shah advising his military aides to turn the army's guns against the people. The tape was examined by leading experts before it was pronounced authentic and reported on the CBS Evening News.

CBS' most prestigious expert was Dr. Oscar Tosi, director of the Institute of Voice Identification at Michigan State University where he had carried out a two-year study of voiceprinting. Dr. Tosi tested the "Shah" tape with a panel of five trained listeners and a computer program designed to eliminate individual variation between words and to bring out the unique features of the speaker. The listeners and the computer delivered positive identifications. "There was no doubt" it was the Shah's voice, said Dr. Tosi.

Quizzed in greater detail about his methods, the CBS expert Dr. Tosi admitted he really hadn't had enough time with the tapes. Possibilities were raised that the tape was a speech of the Shah edited to give an unintended meaning or that it mixed the Shah's speech with a mimic's. To make a final validation would probably take a month of fulltime study, said Dr. Tosi.

More experts were recruited but the story sank from sight under the weight of confusion and was overshadowed by new developments in Iran.

Questions linger after the episode. How objective is the analysis of voiceprints where experts can come up with different results from the same samples? Can the expert (and police and courts) be fooled by clever editing or imitations?

And a question more relevant to our topic may be asked: Without the glare of publicity that surrounded this case, raising doubts about the evidence, can the word of one (or two or three) voice identification experts be relied upon in a courtroom?

Voicegrams of two people speaking the same words with identical taping equipment show similarities as well as differences of pattern. The scientific question is how accurately prints can be identified or differentiated. In these samples time is measured horizontally for a duration of under 1.5 seconds, while frequency is scaled vertically in a range of 4,000 Hz. Relative darkness indicates intensity.
Trials and errors

Dr. Tosi had been one of the prime movers in legitimizing the voiceprint in the eyes of American and Canadian courts.

After 1966 when the father of voiceprinting, Kersta, testified for the first time, court decisions had gone both ways. In 1967 the U.S. Air Force Board of Inquiry upheld the admissibility of Kersta's evidence from spectrograms in a court-martial.

The first civilian test in an appellate court however turned out differently. The case arose from a TV documentary on the Watts riot of 1965. An unidentified youth in the film confessed to arson. When a youth was later arrested on an unrelated charge, police suspected he might be the arsonist. The voices were compared by Kersta and the youth was convicted. But the California Court of Appeal reversed the decision on the basis of voiceprint evidence being of insufficient scientific certainty.

Dr. Tosi tried to provide this scientific basis by testing identification under a variety of conditions. In his two-year study for Michigan State University, voiceprints were made from samples taped a month apart, from sounds taken out of different contexts and from voices recorded without the speaker’s cooperation. One third of the samples duplicated the kind of conditions found in forensic applications such as rapid speech, background noise and telephone recordings.

Released in 1971, the study found that under simulated forensic conditions, false identifications were made in 4.2 percent of the trials when the words were taken from identical sentences and 6.4 percent of the instances when they were taken from differing contexts. Furthermore, 60 percent of the wrong decisions were recognized as “uncertain” by the examiners at the time of decision and presumably would not be the kind of choices that would be presented to a court as positive identifications.

Parallel with Dr. Tosi’s study, Lieutenant Ernest Nash carried out a survey of cases handled by the Michigan State Police. In 673 cases of voice analysis, 105 identifications and 172 eliminations were made. Of the identifications, 30 resulted in convictions, 35 of 37 state courts in the US admitted evidence from spectrographic analysis of voice.

The first Canadian case followed suit. Lt. Nash was called up from Michigan to Ontario to compare the voice on an extortion attempt to the voice of a defendant. Lt. Nash made a positive identification at the preliminary hearing but was not needed at the trial because the accused admitted through his counsel that he was the anonymous caller.

But in the latter half of the 1970s the higher level courts began taking a more sceptical look at voiceprint evidence. The Michigan Supreme Court ruled that both Lt. Nash and Dr. Tosi lacked the necessary impartiality because their “reputations and careers have been built on their voiceprint work.” Supreme Courts in Maine and Massachusetts, who found that the analysis of voiceprints had “general acceptance”, were balanced by those in California and Pennsylvania who discovered that it did not.

In this context of uncertainty, the only Canadian case to come to trial was decided. A bomb scare had been received and recorded at a Manitoba school. The accused willingly gave samples of his voice for comparison by a sergeant who has taken over from Lt. Nash as the Michigan police’s star witness in voiceprint cases.

The judge interrupted the defence counsel’s questioning of the reliability of spectrograms because “that has nothing to do with (the sergeant’s) expertise in the field.” He told the jury they could accept the evidence as coming from a man who knew what he was talking about. The jury apparently did and they found the accused guilty.

A Court of Appeal upheld the decision, although a dissenting opinion noted, “Witnesses have come to court to say they were expert in palmistry and fortune-telling, but they have not been allowed to testify, notwithstanding that they knew what they were talking about, since palmistry and fortune-telling are not recognized as scientific.”

Science or fortune-telling?

The comparison may be unfair. Voicegrams do seem to produce pictures of how a person speaks at given moments. And there is a similarity between how a person speaks at different moments — otherwise we wouldn’t be able to recognize our friends’ voices without seeing their faces.

Rather than discard the sound spectrograph, it would make sense to critically evaluate the theoretical basis for its use and to understand its limitations. Then, if possible, the analysis of voiceprints could be perfected.
Voiceprints

In 1976 the FBI commissioned the US National Academy of Science to carry out a more robust study of voiceprint techniques. The investigating committee drew together eight speech, audiology and electronics experts, including Dr. Tosi, and one lawyer.

The report, published three years later, exposed the lack of scientific backing for the theory of voice uniques: "At present, dependable voice features are not known and the examiner's task remains largely an empirical art."

The academy found voiceprints were affected by a host of factors including stress, fatigue, illness, alcohol, allergies — and even by such everyday activities as waking up, shouting in a crowded room or whispering.

The acoustics of the recording could be affected by background noise and variables in equipment such as microphones, recorders and telephone links.

In short, the committee called voiceprint evidence "ambiguous."

Without taking a stand on admissibility in court cases, it urged "great caution" and an explanation of the method's limitations to be given to a judge or jury along with voiceprint testimony.

At the time of the report's release the courts in only 23 states were still accepting voiceprint evidence.

In Canada voiceprints have not been introduced in court since the 1977 Manitoba decision. The head of the audio analysis unit at the RCMP Ottawa headquarters has recently been quoted as saying there are "just enough questions" about the method that identifications should be considered "probable rather than positive." The director of the Ontario Forensic Sciences Centre concurs, saying the centre is not prepared to submit findings from sound spectroscopy to a court as positive evidence.

Computer cops

In the meantime research is being carried on in another direction — voice recognition by computer programs. The major processes is similar to voiceprint analysis with component frequencies of sound samples broken down electronically. Incoming signals are measured at tiny intervals and the values stored in digital form.

In one experiment the computer stored five sets of 16 monosyllabic words for each speaker. The arrays of sounds are averaged to account for variability within each speaker's voice. The computer later asks a speaker to pronounce four random words from those stored. The words are adjusted for variability, compared with the original sample and the person is accepted or rejected as the original speaker.

The decision process in the program is actually quite a bit more complex than this simplified explanation — so complicated that it is doubtful an examiner, unaied by computer, could carry it out.

Such a system was supplied to the U.S. Air Force for the purposes of access control. Incorrect rejections occurred only one percent of the time and false admittances only two percent. Verification time was 6.2 seconds.

Two University of Victoria linguists have been working on a computer-controlled system that focuses on consonant sounds such as "m," "n," and "sh," on the theory that the frequencies in these sounds are the most characteristic in a person's speech. They hope to improve upon the reliability of voicegrams.

Of course, no self-respecting extortionist or obscene caller is likely to cooperate by storing pre-selected sounds in a computer for later matching. But as the computer method is perfected, it could be adapted to forensic use. It not only performs more thoroughly and quicker than Dr. Tosi's trained listeners, but it has also proven resistant to mimicry.

And computers make impressive court witnesses, as any Star Trek fan knows.

Designer Circuits

Overload Current Trip

Most power supplies incorporate some form of protection circuitry so that an excessive output current cannot flow in the event of an overload. However, these protection circuits are often designed merely to prevent the supply circuitry from sustaining damage, and in the event of an overload permit a level of current flow that is sufficient to damage the circuit being powered. This overload current trip can be used between the powered equipment and the power supply and will cut off the supply almost instantly if a preset threshold current is exceeded. The trip current can be varied from just a few to a few hundred milliamperes. The unit will work with supply voltages of 5-40 V.

When power is first applied to the circuit, power FET Q1 will be biased hard into conduction by bias resistor R1. Power is, therefore, supplied to the load via Q1, D1 and R2. There will be a voltage drop across these components, and to some extent this varies with changes in the supply current.

RV1 is adjusted so that at output currents below the required threshold level the proportion of the voltage dropped across Q1, D1 and R2 (and fed to Q2's base terminal) is insufficient to switch on Q2. If the threshold current is exceeded, the voltage fed to Q2's base is then adequate to switch the device on and it diverts the bias current that formerly went to Q1's gate terminal. Q1 then switches off and cuts the supply to the load. Q2 remains switched on as it receives a strong base bias from the positive supply through the load, current limiting resistor R3 and RV1. Once tripped, the circuit thus latches in the "off" state. It can be returned to the "on" state by clearing the overload and then briefly operating SW1 so that the supply is momentarily disconnected from the unit. When the supply is restored it then starts at the "on" state once again. C1 ensures that the circuit does not always initially assume the correct state and it also helps to prevent spurious triggering of the unit.

When using the unit it should be kept in mind that about 1V is lost through the device and the output voltage from the supply must be adjusted to compensate for this. The current trip generally causes some loss of regulation efficiency, but this is only marginal. If the unit is to have a trip current of about 100 mA or more, R2 can be reduced to 1R8 in order to maintain the low voltage drop.

16—MARCH—1983—ETI
Multipurpose PC Board

Make five different projects from one board, including a heat/light controller, an IF tester, an electronic doorbell, a touch switch, and a sound-to-light unit.

Radar

Roger Allen investigates the development of radar technology in WWII, including the equipment and strategy used. Also included is a look at German advances in the field; they were further ahead than is usually believed.

Plus!

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A carefully thought-out unit that disconnects your speakers automatically on overloads and other excessively bad news coming down the leads. Self-powered, self-resetting, and low cost.

Inertial Navigation

Inertial navigation and guidance systems are built to amazing standards of precision. Commercial aircraft can be guided thousands of miles with almost negligible error. They still manage to lose your luggage, though.
Dual Logic Probe

With all the logic probe designs that have been published, you didn't think we could come up with an original design, did you? Oh ye of little faith ... this one's cheap, compact, and clever. Design and development by Phil Walker.

THIS MONTH'S 'project par excellence' from the ETI workshop is very useful dual purpose logic tester. It is designed with CMOS in mind and uses mostly logic ICs of that family. Our prototype gives results with pulses down to 200 nS wide at frequencies from DC to over 2 MHz.

The ETI Dicrobe is designed as a dual purpose test instrument. One half of it is a reasonably conventional logic probe giving indications for logic high, low, and pulsing states while also having a transition memory to store those events you might otherwise miss. All these conditions are displayed on a seven-segment LED display to give a practical representation of conditions at the probe tip.

Probing For Pulses

The other half of the unit is a logic pulser which automatically senses the logic level of the secondary probe and gives it a short pulse to the opposite state. This can either be a square wave drive at about 5 Hz or 2 µS pulses, again repeated five times per second.

Two LEDs indicate the logic state on this probe but no indication of pulse conditions is given. The two parts of the instrument can be used independently or together. This enables a considerable amount of useful testing to be carried out with this unit alone.

For instance, the pulser could be applied to a clock input while the primary probe looks at the outputs to see if anything happens. Both probes could be applied to a part of the circuit to see if it is shorted to 0V or the positive supply; in this case pulses will be seen if everything is OK (even if there is an output from a gate driving it).

On TTL circuits the probe may not operate so quickly due to the low supply voltage but a useful indication of functions should be possible. Bear in mind, however, that the logic high and low levels for TTL are much lower relative to the supplies than for CMOS.

A Tour Round The Circuit

The primary probe circuit uses a 4049 to sense the input, with the advantage of high speed, high input impedance and CMOS logic thresholds. The output from three sections of this drives the edge detector and two segment drivers. The edge detector drives a set-reset latch (to store the fact that a transition occurred) and a monostable (to give indication of previous conditions).

The secondary probe circuit is a little simpler than the primary probe as it is not designed for high speed. Part of a hex Schmitt trigger senses the input and the result of this is stored on a set-reset latch. Another part of the Schmitt package works as an oscillator at about 5 Hz and drives two other sections via CR networks to provide reset pulses for the set-reset latch and enable pulses for the output circuit.

The output transistors are connected so that they are normally off. When a pulse is to be applied to the output the logic drivers apply base drive to one of the transistors. The particular transistor driven is the one which gives a pulse of the opposite polarity to the normal state of the circuit point to which the probe is connected. After the pulse the state of the circuit is sensed ready for the next pulse.

The three-position switch allows the secondary probe to act as a straight logic probe or an automatic pulser with short duration or square wave pulsing.

Construction

The PCB for this project has been designed to fit inside a small plastic box. There is very little room to spare inside the box so great care must be taken to use small components and make the connecting wires as thin and short as possible.

A fine tipped soldering iron is essential for this project and great care must be taken to avoid solder splashes between tracks. The ICs can be mounted in sockets of the low profile type and the seven-segment display should be mounted in a socket as well. For the display we used some Soldercon connectors; these are taller than the low profile sockets on the other ICs and held it higher above the board to project through the case lid when assembled. Apart from the LEDs and two resistors, all the other components mount normally on the PCB. Take care to get the diodes, transistors, ICs and capacitor in the correct way round. The LEDs are mounted so that they will project through the lid.

Two resistors have to be mounted on end so refer to the overlay to see where they should go. Two wire links are needed near IC1 so don't forget these either. The links are close together and should be made with insulated wire. When wiring up, connect lengths of 6" or so to
all the connection points indicated except the power supply, which should be 18" or so.

Fit the sockets for the probes into the end of the box where the board mounting pillars are closest together. They must be as near to the bottom of the box as possible. Also fit the reset switch into the side of the box in a similar manner. This switch must be very small to fit in the space provided. If a suitable component cannot be obtained, increase the value of R3 to 10M and use two small bolts as a touch switch. This is suggested only as a last resort!

A small grommet should be inserted in the opposite end of the box to the probe connectors to take the power supply wires. The box lid must have holes cut or drilled in it to clear the display, LEDs and mode switch SW1. SW1 is bolted to the lid and the interpin connections made before wiring to the board.

When fitting the PCB into the box the wires from it must all pass over the ends as there is not enough clearance at the side for them. The probe and switch wires should be short or they will get in the way of the lid. Our prototype used small grommets cut in half as spacers between the PCB and the mounting pillars to get the correct height.

**Probing Deeper**

The probes themselves were very simple. The main one was a piece of brass threaded rod turned to a point in a drill with a file. This was soldered into a metal tube taken from a piece of plastic connector block. A small piece of thick wire was soldered into the 2 mm plug and then this was soldered into the other end of the metal tube. You may care to experiment with a sewing machine needle instead of the brass rod as these form very durable probe tips.

The other one was simply a piece of wire with a spring probe on the end terminated in another 1 mm plug.

The two probes are interchangeable as required. Power supply wires can be terminated in crocodile clips or anything convenient.

**What's The Diagnosis?**

The probe is intended for diagnostic work on CMOS circuits where the main part is used to look for the effects caused by the pulser probe being applied to an earlier part of the circuit. This lets us find faults in com-

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**Fig. 1 Complete circuit diagram of the logic probe.**

**Fig. 2 Component overlay. Note that one end of R12 is soldered to two flying leads, not the board.**

**NOTE:**
- IC1 IS 4049B
- IC2 IS 4070B
- IC3 IS 4093B
- IC4 IS 40106B
- IC5 IS 4011B
- Q1 IS 2N3905
- D1 IS 1N4148
- LED 1 IS 3mm RED LED
- LED 2 IS 3mm GREEN LED
- DISP 1 IS FN0257
- COMMON CATHODE
components such as gates and many counters and other devices. By connecting both probes to the same point, a check can be made to see whether a short circuit exists to either power rail (no pulses detected). It can also be used as a crude signal source if nothing else is available.

The pulser works best if the point to which it is attached is static, as it has a fairly slow response time. Note that when it is in the active pulsing mode, the LED display does not give a true picture of the logic level at the pulse probe.

The main probe will catch pulses down to 200 nS with a 9 V supply which should be adequate.

**How it Works**

**Main Logic Probe**

This part of the circuit is based around IC1, IC2, and IC3. The input from the probe tip passes via a simple protection network R1, R2, R3, C1, C2, C3, R4, and C4. This device senses the logic level at the probe tip while also presenting a very high impedance to the circuit under test. Two more sections of the device, IC1b and IC1c, are used to speed up the transition time when the logic state changes at the input. The output from IC1c is used by IC1f to drive one of the segments of the display. IC1c's output is inverted by IC1d and used by IC1e to drive another segment. These two display segments form the immediate logic state indicator.

The outputs of IC1c and IC1d go to IC2b and IC2c. IC2 is a quad exclusive-OR gate which in this case is being used as an inverter. The outputs from these two sections drive two more segments of the display but these are the ones which indicate the previous logic state.

To detect a transition from one state to another, the output from IC3c is applied to one input of IC2a while the output from ICId is applied to the other via R2 and C2. These components cause the inputs to IC2a to be slightly out of phase with each other. In their normal rest state the inputs to IC2a would be at opposite logic levels causing the output to be high, but for a short time after a transition the inputs to IC2a will be at the same level and the output will be low during this period.

This low pulse has two effects. The first is to set the latch formed by IC3a and IC3b such that the decimal point LED in the display is lit, indicating that a transition has occurred. The second is to force the output of IC3c high, enabling the astable oscillator formed around IC3d. In fact IC3c and IC3d form a monostable to effectively stretch input pulses and transitions so they can be seen. The low pulse on IC3c input puts a high on IC3d input which, since C3 has been reset at a high level, will make the output of IC3d go low immediately. This forces IC3c output to remain high via its second input until C3 discharges enough to allow IC3d output to go high again.

The output of IC3c is connected to IC2d which acts as a buffer to drive the centre segment of the display. This flashes to indicate that a transition has occurred. IC3c output also drives IC2b and IC2c, causing them to invert the signal on their other input while the monostable is active. The effect of this controlled inversion is that the last transition is mimicked on the display. The transition memory, IC3a, b, c can be reset at will by pressing PB1. The decimal point on the display will go dark until another transition occurs at the input.

**Pulser Probe**

The input from the probe tip is sensed by IC4e, part of a hex Schmitt trigger. Some protection is provided by R12, R13, D3 and D4 against excess input voltage. The output from IC4e goes to the latch formed by IC5a and IC5b via R15. A low on IC4c output will set the latch such that LED1 is alight and LED2 is off.

IC4a, R11, and C4 form a slow speed oscillator which, via a buffer IC4b, drives the pulse generation circuits. On the rising edge of the output from IC4b, IC4d is driven by C6 and R14 to produce a low pulse of short duration. This pulse tries to reset the IC5a, b latch but will only succeed if IC4c output is high. This updates the latch every cycle of the slow clock.

On the falling edge of the slow clock a signal may be passed to IC4e via C5 and Sw1. Position 1 of the switch does not allow the pulse to pass and the circuit acts as a slow logic probe only. Position 2 of the switch allows the signal through but connects R16 into the circuit such that it forms a differentiator with C5 and makes the output from IC4e appear as short pulses. In position 3 the output of IC4b is coupled to IC4e via C5 virtually without change. This means that the pulses will be approximately 50% duty cycle.

The output from IC4e (consisting of a low logic level with or without positive-going pulses) passes to IC5a and IC5d. The other inputs to these gates are taken from the output of the input sense latch, IC5a and IC5b. If the output of IC4e goes high, then one or other of the outputs of IC5c or IC5d will go low. A low level on IC5c will turn Q1 on via R19 and pull the probe to a high level via R21. If IC5d goes low instead, IC4f output will go high and turn Q2 on via R20. This will pull the probe probe to the negative supply via R22. D6 and D7 provide a small amount of protection for this part of the circuit while D8 provides overall polarity protection for the probe supply.
Piezo-electric 'buzzers' such as the PB-2720 are super-efficient and inexpensive sound generators, easily driven by simple CMOS circuitry. In this month's Notebook, Ray Marston shows how to use them.

There is a frequent requirement in instrumentation designs, for example, for some form of alarm or 'fault condition' indicator, perhaps to warn of a short-circuit or overload condition in a power supply or an overspeed condition, loss of oil pressure and so on in a car or truck. If you ever need to design such an alarm, you have the options of using either a visual (lamp or LED) or an acoustic type of output indicator.

The major snag with purely visual indicators is that they are only effective if you happen to be looking at them when they activate. Clearly, acoustic indicators are the most effective types of 'attention grabbers', but in the past they tended to be rather expensive to implement both in terms of money and in power consumption and physical bulk.

The recent introduction of small, inexpensive and highly efficient piezo-electric acoustic transducers such as the Toko PB-2720 has totally changed this situation, however, and it is now possible to build effective acoustic indicators at costs that are very low.

PB-2720 Basics

The PB-2720 piezo-electric transducer is a super-efficient electric-to-acoustic power converter. It consists of a metal plate bonded to a thin slice of piezo-electric ceramic and is housed in a small plastic-moulded resonant chamber.

If you apply an AC signal across the two input terminals of the PB-2720, you get a corresponding audible output. Figure 1 shows the frequency characteristics of the device when it is fed with a 1V5 RMS input and the output level is measured at a range of 10 cm. Note that a good output level is available across a wide frequency band but this peaks at about 4.5 kHz, at which point an output sound level of roughly 85 dB is obtained at a range of 10 cm from a 1V5 RMS input. If you are not familiar with acoustic terminology, 85 dB is typical of the subjective sound level of a noisy office or busy street.

The really impressive feature of the PB-2720 is its high level of power conversion efficiency and consequent low power input requirement for a given power output. Figure 2 shows the input voltage characteristics of the device in terms of current consumption and generated sound pressure.

The explanation for these apparently miraculously low levels of power consumption is very simple. Conventional electromagnetic speaker-type transducers have incredibly low conversion efficiency levels, rang-
Designer's notebook

ing from a mere 0.1% for hi-fi speakers to 2% for 'cheapo' types. The PB 2720, by contrast, is a piezoelectric device and has an efficiency level of about 50%. Thus, for a given output level it needs an input power of only 1/500th to 1/25th of conventional sound generators.

Driving The PB-2720

The PB-2720 is a very easy device to drive. Being ceramic, its input terminals appear to the outside world as a simple capacitor with a static value of about 20nF and a DC resistance of near-infinity: if you drive it with a pure sine wave, you simply find that its impedance decreases as frequency increases.

The most effective and cheapest way to drive the device is to feed it with square waves, but in this case the driver must be able to source and sink currents with equal ease and must have a current-limited (short-circuit proof) output. CMOS drivers fit this bill perfectly.

Figures 3 and 4 show two very inexpensive ways of driving the PB-2720 from a gated 4011B CMOS oscillator; both circuits generate a continuous-tone signal when they are enabled, are gated on by a high (logic 1) input signal, and can use any supply in the range 3 to 18V.

Fig. 3 This basic buzzer circuit is gated by a high (logic 1) input and generates a 2 kHz continuous tone. The PB-2720 drive is single-ended. Sound output (at 10 cm) is about 82 dB from a 10 V supply.

Fig. 4 This version of the basic buzzer circuit uses bridge drive to the PB-2720 and produces an output that is four times louder than the Fig. 3 circuit.

The Fig. 4 circuit is rather more difficult to understand. IC1c and IC1d are series-connected and used to give a 'bridge' drive to the transducer, in which antiphase signals are fed to the two sides of the PB-2720. The consequence of this cunning drive technique is that the load (the PB-2720) actually sees a square wave drive voltage that has a peak-to-peak value equal to twice the supply voltage and thus gives four times more acoustic power than the Fig. 3 circuit. The effective RMS voltage across the load of the Fig. 4 circuit is equal to the supply voltage. Mystified?

Points Of View

The solution to the action of the bridge-driven circuit of Fig. 4 can be understood with the aid of Fig. 5, which shows the waveforms applied to the load from a bridge circuit when it is fed with a 10 V peak-to-peak square wave input signal. The important thing to grasp when looking at this diagram is the basic concept of reference points. You and I are accustomed to thinking in terms of the common or ground line as being the 'zero voltage' reference point. Thus, when we look at point A in Fig. 6 we see a square wave signal that alternates between 0 V and +10 V. Similarly, when we look at point B we again see a 10 V peak-to-peak signal, but in this case it is in antiphase to the A signal (shifted by 180°).

Now the load in the Fig. 5 circuit (irrespective of whether it is a simple resistor or a PB-2720) sees drive voltages purely with reference to one arbitrary side of itself. With this concept in mind, let's look at the drive voltage as seen by the load (the third waveform, the true voltage across the load), which assumes that the load is always seeing point A as its 'zero reference' point.

In this case, during period '1' of the drive signal, point B is 10 V positive to point A and is thus seen as being at +10 V. In period '2', point B is 10 V negative to point A, and is thus seen as being at -10 V. Similarly, when we look at point B we again see a 10 V peak-to-peak signal, but in this case it is in antiphase to the A signal (shifted by 180°).

Thus the load in a 10 V bridge-driven circuit sees a voltage of 20 V peak-to-peak, or twice the single-ended input voltage. Since doubling the drive voltage results in a doubling of the drive current, and power is equal to the V.I product, the bridge-driven circuit will produce four times more acoustic power than the single-ended circuit (Fig. 3).
times more power than the single-ended circuit. If you don’t believe it, check it with a ‘scope, but don’t forget to reference your ‘common’ terminal to one side of the load.

Sound Practice
Gated CMOS oscillators/drivers can be used in a variety of ways to produce useful alarm sounds from the PB-2720. A few variations are shown in Figs. 6 to 9. If you are not bothered about wave form degradation and need to use the minimum possible number of gates, you can, for example, drive the PB-2720 directly from the output of the CMOS astable, as shown in Fig. 6. Alternatively, if you want the alarm to be gated on by a low (logic 0) input, simply substitute a 4001B for the 4011B, as shown in the bridge-driven circuit of Fig. 7.

Figure 8 shows how you can use a single 4011B to make a pulsed-tone (bleep-bleep) alarm circuit with direct drive to the PB-2720. Here, IC1a-IC1b are wired as a gated 6 Hz astable which is used to gate the IC1c-IC1d 2 kHz astable on and off. The circuit is gated on by a high input; if you want low-input gating, simply swap the 4011B for a 4001B and transpose the positions of PB1 and R1.

Figure 9 shows a warble-tone version of the gated alarm. Here, low-frequency astable IC1a-IC1b is used to modulate the frequency of the IC1c-IC1d astable; the depth of frequency modulation depends on the value used for R3.

There are plenty of other gated CMOS generator circuits that can be used to drive the PB-2720. The generators can be gated by a wide variety of sensor circuits, so that the alarms are automatically activated by excesses of light, temperature, voltage or current, and so on; lots of suitable circuits can be found in past issues of ETI.
Closed Captioning

How does the close captioning facility that we see offered at the start of several TV programmes work? Roger Allan explains.

CLOSED CAPTIONING for the hearing impaired reached the operational phase after more than seven years of development at the PBS in the US, inaugurated as a regular service in the US in March 1980 and on the CBC here in Canada in January 1981.

Closed captioning refers to captions that are encoded in the video signal and cannot be seen on a home receiver unless a decoder is used. The purpose of the 'closed' captioning system is primarily to provide a service for the hearing impaired without distracting the majority of viewers who have normal hearing. The captioning data signal is encoded in the television signal vertical interval of TV Line 21, Field 1. At present, all captioning in English is done by the National Captioning Institute (N.C.I.) either at their Falls Church, Virginia, facility or in Hollywood, California. A French language facility in Montreal (the Canadian Captioning Development Agency) provides the CBC with a few hours of captioned programming each week. An English language captioning centre is expected to be built in Toronto sometime in the spring of 1983.

The process of captioning is relatively straight-forward. At N.C.I., an editor is supplied with a 3/4" video cassette complete with S.M.P.T.E. time code dubbed from the original 2" video master tape of the television program. The captioning editor makes the decision about wording of captions, the timing of when each caption appears and disappears, and also the placement of the captions on the screen. This process is carried out on an editing console in which there is a Sony 3/4" tape machine, disc drives, colour monitor and microprocessor with a "light pen" attachment which is used to arrange the captions on the screen so as to present them in the most readable form and not obscure important picture detail.

The heart of real-time closed-captioning is a stenocaptioner who transcribes what he hears into a machine. Here Marty Block of NCI prepares captions for ABC's World News Tonight. Photo B. What you see if you have a converter; they are available from Sears for $369.00.

The TeleCaption decoder is marketed by Sears, as a non-profit item, currently retailing (upon presentation of a doctor's certificate) for $369.00 (Canadian).

The N.C.I. presently caption a total of 40 hours of popular commercial and public television programming each week, in addition to commercials for over 170 advertisers. Further, the service has attempted to expand to include 'live' programs. All US Presidential speeches are captioned as is ABC's World News Tonight. More recently, Metrosports, North America's largest independent sports syndicator for television, entered into an agreement with N.C.I. to close caption sports events such as NFL games. Originally, sports captioning began with the 1981 Sugar and Super Bowls. The original service provided basic game statistics, such as down and yards to go, time outs remaining, scoring summaries, penalties and change of possessions. The Metrosports agreement provides for play-by-play descriptions as well as the background information.

At the CBC, Canadian programming such as the Beachcombers and Hangin' In are sent to the NCI Center in Falls Church where the captioning

Continued on page 78
We now turn our attention to weighty matters. Surely it's time, in these days of digits with everything, that we get rid of the analogue scales readout? You bet it is. Design and development by Rory Holmes.

AT LAST, the electronics enthusiast can make amends for the state of the kitchen table, sinking beneath an ever-growing pile of constructional debris. The ETI Digital Kitchen Scales offer a means of adding a digital readout to an ordinary mechanical pointer type of instrument.

The mechanics of weighing scales are particularly difficult for the DIY approach, requiring a frictionless movement with only one degree of freedom — vertical displacement. We decided to use the ready-built mechanics of a low cost spring movement scale and concentrated on the electronic problem of measuring displacement with high linearity, high resolution, and zero friction!

The resulting design consists of an easily wound inductive displacement transducer and the associated drive electronics on a small PCB, all supplied from a 9 V battery. An analogue voltage proportional to weight is obtained, which is then displayed on a 3½ digit LCD panel meter module. Up to 2 kg can be displayed on the scales, but a zero-offset control allows a given weight to be re-zeroed. This provides the useful facility of weighing and mixing ingredients simultaneously — when preparing cake mixture, for example.

The accuracy and resolution obviously depends a great deal on the initial accuracy of the spring and pivot system used in the scales, but ¼% (5 grams in 2 kilograms) should be easily obtainable.

The inductive transformer we are using is known as a Linear Variable Differential Transformer, or LVDT for short. These are used extensively in industry for just such applications as this project — weighing machines, load cells, machine positioning and so on. The circuit features some
novel techniques for allowing an LVDT of few turns to be used; specifically, a phase-lock detection system based on a digital sine wave generator, and a self-stabilising bandgap power supply for precision voltage levels. The block diagrams and boxed-off text give an explanation of the circuit operation and explain how the displacement measurement works.

Construction

Assemble the PCB in the usual fashion, noting the IC orientation, and the polarity of ZD1 and the tantalum capacitors. Also check the MPS6515 pinouts; these often cause confusion. Twelve Veropins should be inserted at the points marked for external connections. Another point to watch is the hole marked beneath preset PR1; this should be drilled out to 3 mm diameter before mounting the preset, thus allowing its adjustment from either side of the board. Likewise, a 3 mm hole drilled on the other centre allows a secure 4-40 or 6-32 mounting bolt for the board.

When complete, the board may be initially tested by inserting all the ICs into their sockets and connecting a 9V battery to the supply terminals as indicated. If a scope is available,
the digital sine wave approximation should be observed at the junction of R14 and C6; it could also be checked with a crystal earpiece, when a high pitched tone of 10 kHz should be heard. The reference supply voltage can be measured with a multi-meter across the wire link and a 0 V terminal. It should be in the region of 5 V if all is well, the exact value being unimportant. At this stage the transducer should be built and wired up before further testing of the PCB.

**Fig. 5 Coil winding details.**

**Winding You Up**

The LVDT is wound using 32 swg enamelled copper wire on a piece of 20 mm diameter plastic tubing of the type used for electrical conduit, and available from DIY shops. Any similar piece of tubing will suffice since the dimensions are not critical. Figure 6 shows the winding arrangements. Two separate secondaries are wound either side of the central primary winding. All the windings consist of 100 turns wound in the same direction in flat layers; four layers of 25 turns for each secondary, and two layers for the primary. The accuracy and linearity of the LVDT transducer depends upon the two secondaries being as similar as possible and symmetrically positioned about the primary winding. Care should thus be taken to ensure the layers are evenly wound and tightly packed. Super-glue may be used to retain each layer as it is wound. After completing the windings and finishing with a liberal coat of glue the two secondaries are then wired in series opposition to form one coil by connecting together the end of each winding.

**Fig. 6 An artist's impression of the sensor to help with construction.**

The LVDT should now be wired up to the PCB using shielded leads as illustrated on the overlay diagram. On our prototype assembly we used a four way 'Molex' PCB plug and socket for this connection since the transducer assembly could then be conveniently plugged in. Figure 7 shows how the LVDT is mounted to measure displacement. As described last month the mechanics of an ordinary pointer scale are utilised to provide the linear displacement with weight via the built spring and pivot.

For our prototype we used a small low cost scale which incorporated a ball-race slide mechanism mechanics of the original scale, the greater the degree of accuracy that can finally be achieved with the electronic transducer. The principle is to attach the main coil to a fixed part of the scale while the ferrite core is attached via some rigid element to the weighing pan movement, such that as weight is put on the scale the core moves linearly along its axis into the coil former.

In our prototype the two steel plates of the slide were used to support the transducer as represented in the diagram. Two pieces of PCB material fixed with epoxy act as brackets for the coil former and ferrite core.

The mounting arrangement is not too critical but the following points should be observed. The coil must not be too close to steel or other magnetic material and likewise the ferrite core mounting should be non-magnetic and non-conductive. Remember to allow sufficient leeway on the ferrite mounting for the full

**Scaling The Heights**

Obviously, the more precise the
Kitchen Scales

displacement (about 1 cm). The ferrite core must be central in the tube, with the axis of both coil and core parallel to the direction of weight displacement. Sufficient rigidity can be achieved using epoxy glue on the transducer, but initially the ferrite core should only be secured to its bracket with tight rubber bands until the calibration procedure.

Having completed the transducer the entire unit can now be tested by wiring up to the LCD meter module. This module comes as the ICL7106 Evaluation Kit from Intersil distributors, and contains all the components you'll need to make a working DVM with the exception of the PC board and decimal drive circuit. We've included the PCB foil pattern, and the three resistors, capacitor, and transistor for the drive are shown on the schematic of the DVM. Complete the module and connect a flying lead from the drive output to DP1. RV1 is adjusted to give a full-scale reading of 1.999 for a 200 mV input.

### PARTS LIST

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NOTES:
* NOT USED FOR 200mV
10kΩ FOR 20V
100kΩ FOR 200V
** THESE POINTS CANNOT BE MEASURED WITHOUT AFFECTING OPERATION EXCEPT BY A VERY HIGH IMPEDANCE ( > 1GΩ) VOLTMETER

28-MARCH-1983-ETI
The input voltage at point B should then be connected to the corresponding point on the PCB; point A temporarily connects to the 2V5 reference terminal shown in Fig. 7. After connecting the DVM supply rails to the 9 V terminals on the PCB, power can be switched on. When the ferrite core is near the middle of the coil the meter should be close to 0 V and will indicate + or — readings as the core is moved to either side of the null position. The 100 mV sine wave across the primary coil can be observed on a scope along with the other waveforms illustrated last month. If all is well, the electronics can be assembled inside the scale. Figure 9 shows how we arranged the various components to fit into the existing scale box. The back of the case has now become the front to allow room for the LCD display! The 10 turn potentiometer, RV1, should also be connected up at this stage, along with the on/off switch, so completing the interwiring.

**Calibration**

Once you are satisfied with your mechanical arrangement for mounting the transducer and associated electronics, the scale should be calibrated using standard or known weights. First, the offset voltage input to the DVM module, marked as 'A' on the wiring diagram, should be temporarily connected to the 2V5 reference terminal shown on the PCB overlay. The preset PR1 should be set at roughly half travel, and the scale loaded up with about 1 kg. After switching on the supply, the ferrite core should be adjusted relative to the coil until it’s approximately in the middle at the null output position (this corresponds to half scale deflection). As the null position is approached the DVM will accordingly decrease to zero reading. The ferrite core should now be fixed permanently to its mounting plate using epoxy and allowed to set. When set, the DVM reading must be brought exactly to zero by the addition of small increments of weight, sugar or salt being ideal. The known weight, which can be anywhere between ½ and 1 kg, should be added to the scale pan, and PR1 adjusted until this weight is shown on the LCD display (turning PR1 clockwise increases the reading).

Now remove the weight to check that the reading returns to zero, and adjust PR1 accordingly (a few adjustments to PR1 may be necessary to set the correct reading for the known weight).

Finally, the offset input 'A' can be disconnected from the 2V5 reference and wired to the slider of RV1. Rotating RV1 will alter the reading and the meter can now be easily zeroed for any weight measured, including the empty scale pan. You may now proceed to calibrate the pantry.

---

*Fig. 7 Component overlay.*

*Fig. 8 Artist's impression of the 'view from the top'.*
Live musical performance can have a dynamic range as great as 90 dB, though 80 dB is probably a more 'usual' figure. The very best discs achieve about 65 to 70 dB, as do the best open reel tape decks, whilst top cassette decks get only 55 dB or so. Hence signal compression is used on recording, followed by expansion on playback. The dbx system of compansion claims to be able to achieve 90 dB, a figure being claimed by digital recorder makers — and without compansion. Brian Dance explains.

PERHAPS the most difficult of all the problems one meets in both disc and tape recording systems is that of preventing unwanted noise from appearing in the output. Such noise is, non-homogeneities in the groove of a disc, while tape hiss arises as each particle of the magnetic material on a tape passes across the replay head gap. The best known noise reduction technique is the Dolby system, but the more recently developed dbx system discussed here operates on different principles. Both have their own advantages.

**The dbx system**

In equipment using the dbx system, all the incoming signals are compressed by a 2:1 ratio (as measured in dB). For example, if the difference between the loudest and quietest passages to be recorded is 60 dB, the dbx recording circuitry will compress the dynamic range so that there is only 30 dB between the maximum and minimum signal levels.

When the recording is replayed, the circuitry 'restores' the signal to the original 60 dB dynamic range by providing greater amplification for the higher-level signals than for the lower-level signals. Any tape noise will, hopefully, be at a level below that of the smallest signal and will thus be amplified very little. This is illustrated in Figure 1.

In the case of disc recordings, the disc must have been recorded using a dbx compression circuit, in which case it can be replayed with no appreciable playback hiss. Ordinary recorded discs cannot benefit from dbx.

Unlike the Dolby system, the dbx system operates at all frequencies with a compression and subsequent expansion dependent only on the signal level. (Obviously this is a simplification, since there will be certain 'attack' and 'decay' times during which the gain change takes place.)

**Dynamic range**

A good human ear can perceive sound levels from the threshold of audibility (0 dB) up to a level of the order of 120 dB, which produces severe discomfort or even pain. Occasional transient peak levels of 120 dB occur during live musical performances. However, the background noise level due to movements of the audience, etc, can reach levels of 30 dB (Figure 2) or even more. Thus the dynamic range which a perfect system should be able to handle should not be less than some 80 dB, although some experts regard 90 dB as being a more desirable figure.

When one is recording music on either a magnetic tape or on a disc, the signal must be suitably compressed so that the loudest passages do not overload the equipment and thus cause distortion, yet the quiet passages must be well above the level of the tape hiss or record noise. The maximum dynamic range which can be accommodated on a vinyl recording disc is normally about 55 dB, although 65 dB to 70 dB is said to be obtainable from the very best pressings. Clearly this is well below the desirable dynamic range.

Similarly, the dynamic ranges of professional studio tape recorders are limited to around 60 dB to 70 dB or so for the open reel models, while that of a good cassette recorder may be only about 55 dB (weighted, sans noise reduction figures).

If circuitry is not employed to increase the dynamic range of the recorded signal where necessary, the music as reproduced from the disc or tape sounds uninterestingly flat, and the contrast between the loud and quiet instruments is considerably blurred. Thus the excitement and realism of the performance is largely lost.

The dbx system can compress the signal for the recording process and expand it again so that a dynamic range of the order of 90 dB can be obtained. The noise from the dbx system is claimed to be appreciably below the ambient room noise, as shown in Figure 3.

**Comparison with Dolby**

One of the advantages of the dbx system over the various Dolby systems is that the expansion is provided uniformly over the whole frequency range and therefore one does not need to carry out the adjustment.
procedures which are required for setting up a Dolby circuit. A badly adjusted Dolby circuit can produce an appreciably inferior performance.

Although Dolby does its work well at high frequencies, where the hiss is generally the most obtrusive noise, the dbx equipment will also reduce any low frequency noise such as mains hum or turntable rumble that may be added to the signal by the circuitry.

Figure 3 indicates that the noise reduction obtained using the dbx tape system is, at least in theory, somewhat better than that provided by a Dolby system. In practice the dynamic range obtainable is greater than that with Dolby B, but it may not be quite so high as the values suggested in the graphs of Figure 3 owing to the need to prevent any possible tape or disc overloading in certain frequency regions.

Any tape recorded for playback through dbx equipment will sound quite peculiar if replayed through a recorder without dbx circuitry; so will any dbx disc. On the other hand a dbx-encoded tape replayed through a Dolby B circuit will provide a reasonable signal if one reduces the treble response somewhat.

Although the number of dbx discs is greatly increasing at the present time, it may be some time before the selection is considered reasonably adequate by most potential users. At present the number of pre-recorded Dolby tapes available is much greater, giving Dolby an advantage there.

Performance

It is quite uncanny to place the tonearm over a dbx disc and start playing it, since one hears virtually nothing until the first notes of the music are reached! 'Digital' dbx discs provide even quieter backgrounds, since the hiss from the master tape, together with its saturation distortion, wow and flutter, are claimed to be eliminated. However, any digital tape equipment likely to be available in the foreseeable future may be quite expensive, whilst the usual problem of lack of standards in digital equipment is likely to cause considerable difficulties, perhaps for some years to come. Nevertheless, the 90 dB approximate dynamic range of the current dbx discs enables them to achieve a very impressive performance.

Equipment

For home recording, the series II equipment manufactured by dbx Inc, Chapel St, Newton, Massachusetts 02195, USA, includes a Model 224 (with monitoring facility) and a Model 222 (without a monitoring facility). When used as an addition to one's existing equipment, they claim to provide an 85 dB range on open reel recorders and an 80 dB range even with cassette recorders. This includes a noise reduction of some 30 dB across the entire audio range together with an extra 10 dB 'headroom' at the upper level of the dynamic response.

The peak signal to the weighted background noise ratio is quoted as some 110 dB. The frequency response is quoted flat to within ±0.5 dB over the range 40 Hz to 20 kHz and about −1 dB at 30 Hz. Total harmonic distortion is quoted as being less than 0.5% from 30 Hz to 100 Hz and less that 0.1% from 100 Hz to 20 kHz, while intermodulation distortion is less than 0.2%.
The Model 222 and 224 units incorporate circuitry for the recording and the replaying of tapes and for playback of discs. However, a smaller Model 21 unit is available for the playback of dbx disc. However, a smaller Model 21 unit is available for the playback of dbx discs and of dbx-encoded pre-recorded tapes when the latter become available. The performance of this Model 21 unit, which cannot be used for recording tapes, is fairly similar to that of the 222 and 224 equipment, but the frequency response is quoted as being matched to the decoding curve to within ±0.5 dB between 30 Hz and 15 kHz, and the total harmonic distortion is given as being less than 0.2% at 1 kHz at up to 4 V RMS output.

The units mentioned are the domestic Series II units, but a Type I series is available for professional use where tape speeds are generally higher; it is not compatible with the Series II units, owing to minor signal processing differences.

When using dbx equipment, one often tends to turn up the volume before the start of the programme simply because one expects to hear some background hiss or noise and may even wonder if the system is working! However, this problem is soon overcome after the equipment has been used for some time. The dbx system can be very demanding on programme material; for example, wideband noise in the presence of high-level programme signals will be considerably amplified, but the programme material will usually mask the noise.

Expanders

The dbx company also produces a range of volume expanding equipment. Most records, tapes and radio programmes have their dynamic range compressed somewhat, and the expanders have been designed with the object of restoring the original wider dynamic range. They can be set to provide any dynamic range expansion from 1:1 (no expansion) up to 1:1.5 measured on the dB scale; the latter is usually far too great and 1:1.2 to 1:1.3 is normally as much as is needed for any programme material.

By making loud passages louder relative to quiet passages, it is claimed that these expanders restore much of the realism of recorded or broadcast music and make it more like what one hears in a live performance. In each unit the frequency response is claimed to be flat to within ±0.5 dB from 20 Hz to 20 kHz at the 1:1 setting, total harmonic distortion typically 0.1% under the same conditions and intermodulation distortion 0.15% typical.

A further unit, the dbx 118, provides continuously variable expansion from 1:1 to 1:2 and continuously variable compression from 1:1 to infinity. The compression mode is said to be useful when making tapes for playback in moving vehicles, where the ambient noise may be too high for the quieter passages to be heard without volume compression. A peak limiter is also incorporated in the unit.

Equaliser

The dbx 20/20 unit combines a microprocessor-controlled ten-band graphic equaliser, real-time analyser, pink noise generator, sound pressure level meter, and includes a calibrated microphone; it is designed to automatically adjust for the effects of furniture, drapings and other factors which alter the acoustics of the listening room. When the microphone is placed in the desired position of listening, the precise equalisation characteristic is computed within 15 seconds. This characteristic can then be stored for later use at the touch of a memory button. The best average characteristic can also be computer for a number of listening positions.

Bargraph LED readouts are provided on all ten bands in this instrument.

Conclusion

By making loud passages louder relative to quiet passages, it is claimed that these expanders restore much of the realism of recorded or broadcast music and make it more like what one hears in a live performance. In each unit the frequency response is claimed to be flat to within ±0.5 dB from 20 Hz to 20 kHz at the 1:1 setting, total harmonic distortion typically 0.1% under the same conditions and intermodulation distortion 0.15% typical.

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The dbx Model 21 decoder shown with a range of the currently available dbx-encoded discs.
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The Starlab project is likely to be the most exciting thing to happen to space science until well into the next century. It promises to revolutionise our knowledge of the universe, while at the same time assuring Canadian astronomers a place in the front rank of world astronomy — providing the funds are made available.

ASTRONOMERS have been dreaming about telescopes above the atmosphere since the dawn of the space age. Free of weather and turbulence, space telescopes promise to allow observations of phenomenal accuracy and clarity. They open up the possibility of observing objects far too faint to be seen from the ground, and of observing those objects that broadcast most of their energy in the ultraviolet and X-ray portions of the electromagnetic spectrum. This part of the spectrum is invisible to us at the surface of the Earth because the atmosphere is opaque to the entire electromagnetic spectrum, except for 'windows' in the optical, infrared and radio portions of it.

The invisibility of ultraviolet sources has only recently become a problem in astronomy. The vast majority of stars broadcast at wavelengths near that of the Sun, and astronomers have had enough to do understanding these 'normal' stars. Increasingly, however, it is the atypical stars — stars of incredible densities, temperatures and turbulence, that interest astronomers. This is the realm of quasars, pulsars, neutron stars, and all the other exotics of modern astronomy. Substantially, this is an ultraviolet universe, since fundamental physical laws dictate that as temperature increases, so wavelength shortens.

Tantalising glimpses

To date, astronomers have had tantalisingly brief glimpses of this high-energy universe. The British and Americans have fitted small ultraviolet telescopes to a number of satellites, and for several years sounding rockets have been carrying experiments above the atmosphere for brief exposure to the space environment. But the equipment available has been miserable compared to that available at a proper ground observatory.

With the advent of the Space Shuttle, the constraints that have hampered space astronomy have disappeared, or at least been alleviated. NASA's space telescope is due to fly in the shuttle next year, and it will revolutionise astronomy. It is designed to take full advantage of the space environment: no clouds, no atmospheric distortion and no scattered light.

The problem with the space telescope is that it will have no power at ultraviolet wavelengths. Since ultraviolet photography requires its own special techniques, NASA had proposed to supplement the space telescope with a purpose-built UV telescope. That was in the good old days when the agency was awash with funds; when the money dried up, the UV telescope died, along with many other imaginative projects.

A golden opportunity

In 1979, Australian astronomers realised that a golden opportunity was lying around NASA's back door. The proposition was simple: if NASA could provide space in the shuttle, Australia would build the telescope.

By 1980 the specifications for the basic design were completed. The project had grown to include Canada, a highly sophisticated one-metre telescope and a very state-of-the-art device called a Photon Counting Array (PCA).

During 1981, NASA and the Canadians managed to obtain funds for their parts in the project. Astronomers at the Australian National University, however, were still trying to convince the Federal government that funds should be set aside for the construction of the Australian part of the project, the PCA. Plans at the moment call for all the research and development work to be completed by 1984. Building should commence soon afterwards and, if all goes well, the world's first large
Model mock-up of the Starlab telescope.

A ultraviolet satellite will lift off from Cape Canaveral some time in 1989.

Although the physics of Starlab is well understood, building it will still be a complex operation. Much of the design will stretch the state of the art to the limits.

**Design**

Ultraviolet light imposes special constraints on the design of a telescope. Because of the very short wavelength it is difficult to reflect ultraviolet waves, and impossible to refract them using conventional quartz lenses. As a result, the optics of Starlab will consist entirely of mirrors made of lithium or magnesium fluoride. These materials can be made extremely smooth, far more so than the surfaces of conventional mirrors. This smoothness is necessary, since reflecting surfaces must be machined and positioned with tolerances that are small compared to the wavelength of the incident radiation. Since Starlab is designed to operate with wavelengths just 900nm long, its mirrors will have to be smooth indeed!

This requirement of miniscule dimensional errors in the optics affects every facet of the telescope’s construction. It must be light enough from space use, yet rigid enough to withstand the rigours of launch. It must not expand or contract with changes in temperature as it moves from unshielded sunlight to frozen darkness, as it will do on every orbit. Finally, it must be insensitive to the layer of micrometeoroid dust that covers all exposed surfaces in space.

To be of any practical benefit, when a ray of light has passed through the telescope’s optics, the information it contains must be presented to the waiting astronomer. Conventionally, this is done by an eyepiece or a photographic plate. On Starlab, the job is performed by the photon counting array (PCA). It turns an incoming ray of light into an electronic event that can be communicated to Earth.

The first step in this process is to amplify the light. This is done in an image intensifier, which essentially consists of a plate covered with myriad holes 10 um across. Single photons of ultraviolet wavelength are admitted by these holes. A potential difference applied across the plate accelerates the photo onto a phosphor screen, causing a cascade of photons to fly off the other side. The process is effective enough to ensure that every incoming photon causes a million to be ejected from the screen.

This photon cascade is now ducted down fibre optics to an array of charged couple devices (CCD). A CCD is a device that will emit electrons when struck by photons. The current from the CCDs activates an on-board memory, which stores the information until directed to transmit it by a groundstation.

As with an audio amplifier, the main criterion by which a light amplifier is judged is its level of distortion. In the case of a light amp, however, what is at stake is not the shape of an input curve, but the position of input photons. The correct term for this is “resolution”. It is defined in angular measure as the ability of an imaging system (telescope, PCA) to differentiate between two point sources (stars) very close together.

In Starlab’s PCA, the stage of maximum distortion is the phosphor screen. We may expect that a single highly energetic photon will hit the screen in precisely the same relative position as it entered the system. However, the cascade that this impact causes will be widespread, and...
may be expected to illuminate a number of CCDs.

The solution is to statistically examine the distribution of the photon cascade across the CCDs. This has proved extremely effective experimentally, since the cascade is distributed symmetrically about the point of impact of the original photon. Using a statistical system like this, it is possible to make extremely fine distinctions in the visual field with only 43 CCDs.

The engineers and astronomers who are now designing the PCA for Starlab believe they will be able to achieve greater resolution with their device than will be achieved in the telescope optics. They already have a two-dimensional PCA working at Siding Spring Observatory so their optimism has some foundation, but the space environment places special strains on any electronic system.

For a start, Starlab's orbit will take it through the Van Allen radiation belts, where ionised particles in the Earth's magnetic field provide a constant radiation background to all the electronic events on board Starlab. Even when not in the Van Allen belts themselves, Starlab must still be immune to the output of the Sun and other cosmic ray sources.

Another problem will be heating. In a vacuum, with no convection to remove waste heat, all the components have to either radiate or conduct. Thus a great deal of attention has to be paid to the adequate heat-sinking of every component on board.

Perhaps the most serious problem of all is that the space platform will only have 12 kW of power available to drive all Starlab's instruments. Since this includes a 50 megabyte memory, it is very possible that Starlab will demand large-scale integration of much of its circuitry, this would reduce both power and heating problems.

What to look at?

So, what will Starlab see? Plans at the moment call for an extensive study of Cepheid variables — a type of star that varies in size and brightness in a well-understood manner. They can be used as distance markers, and because they can be resolved as discrete stars in galaxies some considerable distance away, a study of Cepheids will give astronomers a valuable new aid to measuring the distances of galaxies.

Supernovae, exploding stars, will be another target. It seems to be one possible fate of very massive stars that at a certain time in their lives, when all their atomic fuel has been used up, they undergo a massive explosion. Such is the violence of this event that fully 90% of the mass of the star may be blown away. At maximum intensity, it is not unusual for a supernova to outshine the rest of its galaxy, i.e.: for one star to outshine 10^11 stars, albeit for only a few days.

But not only the drama of a supernova explosion appeals to astronomers. They believe the cores of supernovae are the birthplace of all the metals heavier than iron. In this maelstrom of heat and energy atoms of successively greater atomic mass undergo atomic fusion, building elements all the way to uranium and beyond. Studying this process in the ultraviolet may be very instructive.

Black holes

Closely allied to the supernovae are black holes. Some researchers hold that a very massive star, for reasons... Continued on page 40
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Features in the Queue:
Articles planned for upcoming issues

- Survey of 50 microcomputer systems
- TROG: a video game for the Apple
- The 'C' language
- Bulletin boards
- Metaprograms (such as Quick 'n Easy)
- The Apple 'clone' industry update
- Introduction to word processing
- A play with Prestel
- Survey of printers
- Peripherals for CBM micros
- Introducing your child to computers
- Micro BBS for the Vic-20
- Z80 assembler programming
- Spread-sheet programs (such as VisiCalc)
- Computers in medicine
- Legalities of software copyright
- Computer music
- Japanese computers
- Apple space tablet
- The true capacities of systems
- Computer terms explained
- Survey of word processing software
- ZX81 peripherals
- Disk hardware
- Advanced capacities of BASIC
- Hand-held computers — how good are they
- Why do some monitors look so nice
- What is UNIX?
- Disaster insurance for business
- Ultra-high resolution graphics
- What is CP/M?
- Intro to 6502 machine language programming
- Survey of file management software
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(The features mentioned here are planned for the first few issues; circumstances may result in changes).

Two years ago, owning a microcomputer made you one of a very elite group of people. Two years from now, the group of people not using micros may be about as small. You can’t escape them... systems are getting cheaper every month and vastly more powerful, and the thought behind them is making them easier to use. The language of the micro, while a bit forbidding to the uninitiated, is actually so simple as to permit a complete novice to begin writing working programs within an hour of first unpacking a machine. Useful, powerful computers with a vast range of capabilities are available now for what a four function calculator cost ten years ago.

However, while the computer is becoming available to a greater number of new users, its complex capacities are also developing. The decreasing cost of powerful systems and the widespread use of microcomputers in business have brought about the development of some pretty ingenious software for higher level functions.

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not clearly understood, may either blow itself up in a supernova or collapse into a black hole. Others hold that it does both, that the outer parts of the star explode, while its core implodes until it reaches so small a size and so high a density that light cannot escape. Whatever, for a long time part of the mystery of these singular objects was that they were, by definition, impossible to see. More recent work, however, has shown that black holes might be quite bright in the ultraviolet.

It is argued that if any gas or dust was in the vicinity of a black hole it would be sucked into the hole. In doing so it would be accelerated to near the speed of light, which would cause the dust to radiate strongly in the ultraviolet. Early X-ray and ultraviolet satellites have already picked up one likely candidate: the source Cygnus X-I consists of a bright, massive star, and a dark, equally massive companion.

The idea that black holes are not quite so black is fuelled by current models of those enigmatic markers of deep space, the quasars. These hold that a quasar is simply a galaxy too big or too dense for its own good! The galaxy has formed a black hole at its centre and is now swallowing entire stars, releasing prodigious amounts of energy as it does so. Once again, Starlab should be able to test these theories by viewing the UV liberated close to the black hole.

Other work

Although not as dramatic, other aspects of the work planned for Starlab are potentially as rewarding. Starlab will make sky surveys down to very faint magnitudes with unparalleled accuracy. It will study clouds of interstellar dust and gas that flow brightly in the UV, but are invisible visually. It will be used to study the planets, and astronomers hope that the new view of these familiar objects will answer some of the oldest questions.

But perhaps the most interesting work will be the testing of various cosmological models. Modern cosmology takes Einstein's theories as its starting point, and fortunately it can be demonstrated that there are only a few alternative models of the universe that fit the master's theorems. Broadly speaking, the universe must either have started in a big bang and be expanding into eternity, or it must be oscillating from extreme density to extreme rarity, and back again.
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N-EL
Zenith Z-100

Steve Rimmer puts the Z-100 and its operating systems to the test. If only they'd let us keep the review models...

IT REMAINS UNCLEAR to me why, in the general metaphysical order of the universe, I should not have been born into some sort of situation where I could have a few computers like this one. I don't mean vast wealth, of course; a few tawdry millions would be fine. After all, I like the computer. It's fairly heavy and substantial and we get along well. I know how to use it. I can't understand why I should be denied one just because I'm about seven thousand dollars shy of the purchase price.

I know, the Earth says not why she spins.

The Zenith Z-100 is a very nice computer. Not without its flaws, it is both powerful and friendly nonetheless and a perfect trip of a system in the high end of the market. It has two processors, an eight bit 68085 and a sixteen bit 8088 with up to 192 kilobytes of RAM on board. There is a full colour, very high resolution graphics screen with 640 by 225 pixels to mess with, plus vast reams of options, bells, whistles and infernal doo-dads to amuse the mind and absorb with the senses. All of this is wrapped up in either of two packages, one with a built-in monitor and one with a flat space on top to use the tube of your choice. We got the latter version to have a play with.

Diskredited

The Z-100 comes with quite a bewildering array of options and choices. Primary among these is the choice of disk operating systems. You could take both, of course... the configurations are all in software, and which DOS you are running at any given time is purely a function of which disk is in the drive when you boot the system. However, the two are incompatible, and there does not seem to be any easy way to switch files from one to the other. As is to be expected, neither is clearly superior.

In the left corner we find CP/M 85. It is a pretty standard implementation of CP/M for the processor. The 8085 will run 8080 Z-100. The disks we got had things like Wordstar and Supercalc on them, and their operations were just like we've all come to know and love. There were also the usual CP/M utilities. The merits and features of CP/M have probably been bandied about enough by now... suffice it to say that there is a whole zoo of the all time best software available for CP/M based beasties, much of it free, and a large number of good things like languages and other programming friendlies, including Digital Research's own Z-80 mnemonic assemblers, are available for this system.

On the other hand, Zenith have not gone to a great deal of trouble over the Z-100 implementation of CP/M... clearly, they'd rather sell you their own DOS. As such, the CP/M based BASIC is just regular old MBASIC, without any kind of fancy colour drivers or whatever. There are no CP/M programs to read the clock or use any of the other fancy bits that make this system more than just another box with drives. Using the Z-100 under CP/M is a bit like using a TRS-80 Model II. It's not nearly as much fun as it could be.

There is also CP/M 86 available for the Z-100, taking advantage of the faster sixteen bit processor also available in the system. Zenith's own disk operating system is called ZDOS. Now, it is tempting to suggest that the Z actually stands for Zenith, although nothing could be farther from the truth. It is actually the first initial of Zoltan DiRevalso, a three eyed nether troll software engineer from Oil Sludge, Alberta who offered to write the package in exchange for three sheep and a pack of Maxell gold labels because he was poor. Being a troll, he was actually pretty stupid too and... well, it sounds like a believable tale if you read it fast.

ZDOS is actually a bit of a drag. Not that it isn't a good disk operating system... old Zoltan was a turkey at horse trading but he could write code... but it is so CP/M-like that it is clearly around just to feed Zoltan and muddy the waters in terms of systems. It has no inherent superiorities in its architecture... it is better for some things only because it comes with programs and...
utilities that nobody has bothered to
develop for CP/M. However, CP/M
software is not directly compatible
with ZDOS. Choosing CP/M will make
many of the system's features inac-
cessable to you unless you write the
required dedicated code (as, ahem,
the manufacturers should have).
Choosing ZDOS will put all those
neat programs available for CP/M
based systems into the fourth dimen-
sion. Choosing both will prove con-
fusing for the beginner, as ZDOS has
been set up using different keywords.
Not the CP/M's keywords are par-
cularly intelligent ... they are
however, convenient and fairly
widespread.

The common functions in ZDOS
are as follows.

-COPY Moves files around on the
disks. The COPY routine is part of the
CCP (or whatever ZDOS calls it),
rather than being a transient.
-CREF Creates a cross reference for
the assembler.
-DATE Reads the internal calendar
and prints the results on the screen.
-DEBUG is a run time environment
for debugging code, similar to the
CP/M DDT. It's almost identical.
-DIR is the directory command.
Some things never change. However,
this DIR gives a single column direc-
tory which cheerfully scrolls quickly
while forming into a square board-
er. Circle, predictably, does circles.

-ZBASIC has a full house of
graphics commands. There are eight
colours, and none are intensively
unpleasant to look at if you don't
mind everything being super
saturated. There are three
parameters to play with at any given
time, these being the border,
background and foreground colours.
There are a number of commands
that will change these things,
simplest of which is COLOR (in Yank,
of course), which will do an initial set
up. One useful aspect of this state-
ment is that, if you choose not to
specify one or more of its three
parameters it simply leaves those
functions unchanged rather than flip-
ing them back to the initial defaults.

There are two ways to draw pic-
tures on the screen. The first is fairly
fast in operation, using the draw com-
mmand. It is also unspeakably tedious
to set up, requiring the compilation of
long strings of command primitives
which, once gotten together, are real-
ly meaningless to the naked eyes.
Furthermore, this sublanguage
features virtually no error messages
of its own, meaning that you have to
spot any glitches in the string by pure
stealth and cunning.

The other way to draw is using
the standard high resolution graphics
commands ... LINE for straight bits
and CIRCLE for the curvies. These,
while not so fast as DRAW, are
brilliantly simple to use. As is typical
of most of the BASIC, they have many
options for getting fancy with but it is
possible to ignore the ones that
aren't applicable without gorging up
the syntax.

-LINE specifies lines between any
two points, or between the last plot-
ted point and a new point, in any col-
our. Circle, predictably, does circles.
However, the aspect ratio of the cir-
cle is adjustable ... it's set arbitrarily
to look round on a Zenith monitor ...
and you can, as such, create ellipses.
You also need not do a full circle;
arches are cool, and you can specify
starting and stopping points for the
plot. The number jumbling required to
use the CIRCLE command is, in fact,
a bit complex, but it can be mastered
with a bit of effort.

There is also a PAINT command
available, which makes doing solid
blocks of colour pretty painless. To
fill in a shape on the screen, one
simply picks a point within it as a
starting point for the painting, gives
the little beast a colour to paint with
and the colour of the border of the
shape and lets it get on with its ex-
istence. PAINT is reasonably fast and
amusing to watch while it's working.
However, it creates a fairly huge
pseudo-stack for itself when it works
to store delineation co-ordinates and
programs that call for PAINTing com-
plex figures may find that PAINT
wants more than the available
amount of RAM.

The BASIC also has a large
number of other exotic, if less ex-
iting, features available. These in-
clude all manner of disk handling
functions ... if you don't like the
several file techniques provided you
could probably devise your own.
There are also time and date routines,
lots of boring math stuff and while-
wend loops.

The Z-100's keyboard has twelve
programmable keys on it which the

Continued on page 72
SPEAKER KITS SALE!

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• One 2x5" Horn Tweeter
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• Crossover network
• Terminal, plan wire
• Frequency Resp. 22-32,000Hz.
• Size 14" W, 43" H, 14" D
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K1206
150 Watts ea. System included
• Two 12" woofers
• Two 5" midranges
• One 2x5" Horn Tweeter
• Two controls
• Crossover network
• Terminal, plan wire
• Frequency Resp. 20-32,000Hz.
• Size 18" W, 43" H, 14" D
• Enclosures are not included.

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K1810
175 Watts ea. System included
• One 18" woofer
• Four 5" midranges
• One 2x6" Horn Tweeter
• Four 2'/r" Horn Tweeters
• Crossover network
• Terminal, plan wire
• Frequency Resp. 16-32,000Hz.
• Size 24" W, 38 1/2" H, 16" D
• Enclosures are not included.

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K1510
300 Watts ea. System included
• Two 15" woofers
• Four 5" midranges
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• Terminal, plan wire
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ETI—MARCH—1983—45
Sooner or later, every computer owner wants hard copy from his or her machine. If you have a low-cost machine, printout need not be high-cost — thought Clive Sinclair. So he produced the ZX printer, and at a price to suit the ZX owner.

THE ZX PRINTER, as befits the machine it is designed to team with, is compact, functional and simple to operate. It plugs directly into the ZX81 or the ZX80 with 8K BASIC ROM. It provides metallised paper, obtainable from the suppliers at $16.95 for a three-roll pack. You can print nine lines to the vertical inch (25.4 mm) at a speed quoted as 50 characters per second. The 20 m roll allows you to print over 250 screens—worth of text (about 6500 lines!)

Putting it to use

The ZX printer is extremely simple and quick to put into operation. It takes longer to put a mains plug on the power supply lead than it takes to plug in the printer and learn the use of the one control available — the paper feed. The plug on the printer lead has an integral socket to accept the add-on 16K RAM pack. The 17-page instruction book gives a clear description of how to load a fresh roll of paper, use the feed button, tear the paper neatly off the roll (!), clean the printer and, of course, the general principle of operation. There is also a selection of programs aimed at giving you the pleasure of seeing your new acquisition work, while at the same time showing the use of those BASIC statements associated with the ZX printer. Strange as it may seem, these BASIC statements are neither explained nor described in the text; instead we are directed to read chapter 20 of the ZX81 instruction book.

It would amuse me to report that the ZX81 instruction book then referred you to the ZX printer instructions; however, although it does tell you that the printer will have instructions with it, it has a short chapter to quite clearly explain the function of the three relevant BASIC statements. These are LLIST, LPRINT and COPY. The first two are just like LIST and PRINT except that they direct the display to the printer instead of to the television screen or monitor. The third statement, COPY, enables you to print out a copy of whatever is displayed on the screen at the time.

General theory of operation

Normally when reviewing equipment or books it is not the ‘done thing’ to quote more than a sentence or two from any supplied text, but in this instance the ZX printer instruction book gives us a very simple and concise description of the basic workings of the printer:

‘the printer functions in rather the same way as a TV picture, i.e. by scanning from left to right. A conductive stylus is pulled across the paper at high speed, and where a black dot is wanted a pulse of current is passed through the stylus. This evaporates the aluminum coating on the paper, and allows the black backing to show through. To avoid the need to return the stylus quickly to the left-hand edge of the paper, there are in fact two styli, mounted on a moving belt, which follow each other in quick succession. The belt and the paper feed roller are both driven continuously whilst printing, so that when the next stylus comes round, the paper has been moved up ready for the next line.’

Having only three major print statements to consider, the ZX printer is very easy to use. Formatting the display to the printer can be carried out using the TAB and AT @ statements, albeit when using the AT statement line commands are ignored and only column commands in
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It's almost as good as Bobby Fischer, and it has a personality to boot. An amazing servo-computer chess player. Bill Markwick reports.

I MUST ADMIT that I started out to try the Novag Chess Robot with a somewhat jaded view; it might have turned out to be just another glorified calculator. I couldn't have been more wrong!

Evan Efston, of Efstonscience, 3350 Dufferin St., Toronto, sat me down in front of the chess set with the robot arm. "There are an estimated four million chess players in Canada," he said, "and this robot solves the problem of having to learn the complexities of computer programming." He pressed the "demonstration" button on the front panel, and the robot arm extended with a gentle whir. It began to pick up the pieces and set them down again quickly and accurately, moving them from a storage area at the side of the chessboard to a regulation chess setup, and then began to play both sides, all without hunting or noticeable overshoot.

We cancelled the demonstration mode, and pressed "new game". The arm reset the pieces, and pointed to Level 0, the easiest of 10. Mr. Efston pressed an intriguing button marked "Emotions". The robot suddenly changed from a well-behaved servomotor to a chess player. It scanned back and forth in front of my pieces, reaching for one or another and then retreating before making a choice. Mr. Efston pressed "Sound", and it started humming a tuneless melody. It set down its piece, and as I pondered my move, it began to emit a raucous series of squawks and tootles. "It'll try to distract you unless you cancel the emotions," said Mr. Efston with a grin.

With my limited knowledge of chess, I had no trouble sacrificing the game and, when the robot won, it squealed with electronic joy, loudly clicking its little fingers together and swinging the arm back and forth. It isn't just user-friendly - it's absolutely endearing! It also goes berserk if it loses; wouldn't you like to be able to switch off a friend's tantrum at the touch of a button?

Besides playing chess from beginner's level to tournament, the robot has 5500 opening moves, a TRACE mode which allows you to review your entire game, a HINT mode which suggests moves, and an optional printer (at $165.50) which prints all moves in standard chess notation. There's also a quartz Chess Clock ($129.50) for tournament-style timing. If that isn't enough, it has a memory that will store your game for up to three months with the power off, a black/white interchange which lets the robot play your side and extricate you from a mess, and 16 of the world's classic chess games which the arm will replay. Another 64 games are available with an optional memory module. Two people can also play while the robot keeps a watchful CPU on illegal moves.

The unit is very well made and didn't exhibit any of the idiosyncrasies you might expect from a servo-computer of this complexity. The one drawback is the price: $1995.00. This puts it out of reach of the average chess fan, but it's reasonable to assume that chess clubs will be lining up for it once they check out its performance. (There are more computerised but non-robotic chess boards at Efstonscience from $94.50.)

The Novag Chess Robot pondering its next move.
Sound Track

Play it again (and again, and again), SAM! When you feel like working off your aggressions, try to zap the nasties as they fly past. Design and development by Phil Walker.

THE ETI Sound Track is an 'arcade' game you can carry in your pocket. It requires no special displays as all the cues are sounds. The object of the game is to intercept all 15 of the attackers with your own armament. In order to do this you have to judge the best moment to fire from the simulated sound of the attacker. It is made more realistic by the fact that both volume and frequency changes due to Doppler shift are included. As the game progresses the speed of the attack increases to prevent you getting too used to one pace. Also there are three levels of skill which determine how difficult it is to hit the attackers at all.

At the end of the game, if enough of the attackers have been intercepted, an LED will light up to give an assessment of your performance. As an option, an aiming control can be fitted, if space permits, which will allow multiple shots if you are quick enough. To start the game, press the reset button and wait for the first attack. Now it's up to you. Bear in mind that your shots are effective only at the end of the shooting noise and while the target light is on.

The Circuit

The circuit for this project uses standard op-amps, CMOS counters and gates and a special sound effects IC. This allows us to make fairly realistic sounds to simulate an object flying past, some sort of weapon being fired and an explosion if a successful interception has been made. In order to make the completed project handheld, the PCB is fairly crowded but quite a lot has been put onto it.

The heart of the system is a voltage controlled oscillator operating at a frequency of less than 0.2 Hz. This provides two outputs; one is an asymmetrical triangle wave which controls the attack sound effect and simulates the position of the target while the other output is a logic signal to drive the score counters. The VCO frequency is modified by the attack counter such that the attacks proceed more rapidly as the game progresses.

The fire control section of the circuit produces two signals. The first of these is a long pulse which causes the shooting sound to be made by the sound generator. The second, immediately after, is a short pulse which enables the hit detector. If at the same time the ramp from the VCO is within the limits of the window discriminator in the hit detector, then a HIT will be registered and the HIT counter updated. At the same time the sound generator will be switched to provide an explosion effect.

The sound select logic and analogue control switching (in the absence of any other demand) will assume an attack sequence and configure the sound generator to give a mixture of white noise and a tone. As the ramp voltage from the VCO falls, simulating an attack, the volume will increase to a maximum and then decrease again. Simultaneously, as the volume reaches its peak, the pitch of the tone will decrease rapidly and stabilise at a lower level to simulate Doppler shift. While the ramp voltage returns to its starting level the sound generator is inhibited.

If either shooting or explosion effects are demanded, these will take precedence over the attack sound. The explosion is produced by envelope-shaping the white noise source in the chip while the shooting sound is given by an audio frequency VCO, frequency-modulated by a much lower frequency triangle wave.

The display given by the LEDs is to give some indication of the number
of successful interceptions made in a game. The first LED will light when eight out of the 15 attacks have been stopped. The next will light at 12, then 14, and finally 15. There is one other LED which flashes each time a HIT is possible, but note that the shoot button usually has to be pressed before it lights.

Construction

No major problems should be encountered in making this project; care must be taken when soldering the board as there are many places where tracks run between IC pins. Make sure that all the links are in place and that diodes, ICs and polarised capacitors are the right way round. Low profile IC sockets may be used but the case we used may then be a little tight.

SW1, R6 and R7 were mounted so that they fitted beside the battery compartment on one side while PB1 and PB2 went the other side. The LEDs are mounted on the front of the box so that they poke through the panel; use a little glue to hold them in place. Some interconnection work and components have to be put on to these (D7-10) and this should be kept as close to the panel as possible. If there is room, fit RV1 and R7 but this will only be possible if a very small potentiometer is available or a different box is used.

All interwiring should be carried out using thin flexible wire and kept as short as practicable. When fixing the loudspeaker check first that it will fit in the desired position and adjust fixing pillars etc. to ensure this. It is intended that it fits with part of the cone overlapping the battery compartment so a little shaving with a sharp knife may be required. When the speaker position is known, drill a series of holes in the panel and glue it into position.

The wiring may now be completed and the box assembled to finish the project. Fit a 9V battery to the connectors and it should be ready.

Fig. 1 Component overlay for the Sound track hand-held 'arcade' game. Note that some components are mounted off-board; see the photographs.

The parts list:

<table>
<thead>
<tr>
<th>Resistor (all 1/4W, 5%)</th>
<th>Value</th>
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<tr>
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<td>R7,15</td>
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<td>2u2 16V tantalum</td>
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<td>100u 10V PCB electrolytic</td>
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<td>IC4</td>
<td>4520B</td>
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<td>IC5</td>
<td>4012B</td>
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<th>Miscellaneous</th>
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<td>SW1</td>
<td>3-position slide switch</td>
</tr>
<tr>
<td>PB1,2</td>
<td>3-position push-to-make push-button</td>
</tr>
<tr>
<td>SW2</td>
<td>3-position slide switch (on/off)</td>
</tr>
</tbody>
</table>

Case 9V battery and connector; knob for pot; loudspeaker.
Fig. 2 Circuit diagram for the Sound Track.
IC1a buffers the voltage at the junction of R1 and R2 to give a reference at half the supply. IC1b and IC2c form a very low frequency voltage controlled oscillator. R20-23 make a simple D-to-A converter which varies the VCO frequency by a small amount as the game progresses. The timing for the whole game is derived from the VCO and provision is made by D1-3 to stop the circuit oscillating when the required 15 attacks have been counted by IC5a.

IC2a and IC2d form a window comparator whose position and width can be varied by RV1 and SW1. IC3a and IC3c are connected as a monostable and are triggered by PB1 being closed. C3 ensures that the period of the monostable is not affected by further closures of PB1. When the monostable time ends, IC3b is enabled for a short time determined by R31 and C4. This signal is inverted by IC8b and is applied with the outputs from the window comparator circuit to IC6a. If all the inputs to this IC are high at the same time this signifies a "HIT" and the output of IC6a will go low. This action causes the latch formed by IC7c and IC7d to be set with IC7c output high. The resulting low on IC4b clock input increments that counter, increasing the score, while further counting with the outputs from the window comparator circuit to IC6a. If all the inputs to this IC are high at the same time this signifies a "HIT" and the output of IC6a will go low. This action causes the latch formed by IC7c and IC7d to be set with IC7c output high. The resulting low on IC4b clock input increments that counter, increasing the score, while further counting with the outputs from the window comparator circuit to IC6a.

The analogue control signals for the sound generator chip IC10 are produced in three parts and switched into circuit when required by IC9. The control signals for IC9 and IC10 are derived by IC8a, 8c, 8d and an AND gate made up of D6, D5, and R37.

Another effect required to simulate an object passing is that the noise produced by it will first increase and then decrease. This is accomplished by the circuit around Q6. At high voltages Q6 will be on and the output is low. At low voltages Q6 will be off but the output will again be low. As the voltage applied to the circuit increases, the time at which Q6 is sufficient to make it conduct) the output voltage will be the same as the input. When, however, Q6 starts to conduct, the junction of R38, R41, and R43 will stay at a constant potential. The reason for this is that as the input voltage rises, more current will flow into the circuit via R38. A small amount of this will go through R41 to drive Q6 further into conduction, drawing the rest out via R43. This action will continue until the voltage across Q6 is virtually zero again. The output from Q6 drives the volume control pin of IC10 via IC9a.

The last effect is of a decaying explosion, while IC10 will produce the noise of the explosion, the decay envelope has to be generated by Q3 and Q4. Most of the time the base of Q3 is held at 5V by the output of IC7d (part of the "HIT" latch). In the event of a "HIT" being registered, the base of Q3 will now be driven low. C6, which previously was held at about 5V by Q3, will now start to discharge via R35. The voltage on C6 is buffered by Q4 and fed to IC10 by IC9a. Also for the explosion effect, R44 is connected into circuit by IC8b. This changes the noise slightly to give a more realistic sound. C11 and R48 are included in the amplifier circuit feedback to give more prominence to the mid-frequencies and cut down on the hiss effect of the digital generation of the various noises.

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Computers (Hardware)

The Essential Computer Dictionary and Speller

A beginners' guide to computers and microprocessors — with projects

BP73: A Microprocessor Primer

BP74: Practical Computer Experiments

HANDBOOK OF MICROPROCESSOR APPLICATIONS

An introduction to microprocessors — experiments in digital technology

Computers (Software)

The Art of Programming the 1K ZX81

Beginner's Guide to Computer Programming

The BASIC Cookbook

Pet Basic — Training Your Pet Computer

Pet Games and Recreation

Brain Ticklers

Programs for Beginners on the TRS-80

A complete book of practical and interesting programs for home use that can be understood and used immediately by the beginner. It includes step-by-step instructions for 20 desk calculator programs, 104 games, 128 business programs, and a unique MatriexStar matrix index will enable you to locate other programs using the same BASIC commands and statements.

The Joy of Minis and Micros: Data Processing With Small Computers

A collection of pieces covering technical and management aspects of the use of small computers for business or science. It introduces the use of microcomputers and good systems design for every computer project. Because a strong technical background is not necessary, the book is easy to read and understand. Considerable material is devoted to the question of what size computer should be used for a particular job, and how to choose the right machine for you.

Using Microcomputers in Business

Here's a plain English introduction to the world of microcomputers — it's simplicity, parts and functions, and how you can use one. Numerous projects demonstrate operating principles and lead to the construction of an actual working computer capable of performing many useful functions.

Designing Microcomputer Systems

A "Learn by doing" guide to the use of integrated circuits programmed in BASIC. The book covers computer fundamentals, basic electronics, and the principles of the computer. It then describes how to use the computer to meet the objectives of the reader, who is interested in building a computer or peripheral device. The book covers computer fundamentals, basic electronics, and the principles of the computer. It then describes how to use the computer to meet the objectives of the reader, who is interested in building a computer or peripheral device.
PASCAL
TAB No.1205
$ 9.45
Aimed specifically at TRS-80 users, this book discusses how to load, use and write PASCAL programs. Graphic techniques are presented along with actual programs.

PASCAL PROGRAMMING FOR THE APPLE
AR86
$ 17.45
A book to upgrade your programming skills, this book is the UCSD Pascal as implemented on the Apple II. Statements and techniques are discussed and there are many practical and ready-to-run programs.

APPLE MACHINE LANGUAGE PROGRAMMING
AB89
$20.45
The best way to learn machine language programming on the Apple II in no time at all. The book combines colour, program text and machine language in an easy-to-read format. It is designed for the beginner to help him learn quickly and effectively.

USER'S MANUAL
AR86
$ 21.45
The Z80 MPU can be found in many machines and is generally used as one of the most powerful 8 bit chips around. This book provides an excellent 'right hand' for everything you have programmed in the application of this popular processor.

HOW TO PROGRAM YOUR PROGRAMMABLE CALCULATOR
AB86
$ 12.45
Calculator programming, by its very nature, often is an obstacle to effective use. This book endeavours to show you how to use a programmable calculator to its full capabilities. Exercises and answers included with each chapter.

BASIC COMPUTER PROGRAMS IN SCIENCE AND ENGINEERING
GILDER
$ 19.85
Save time and money with this collection of 114 ready-to-run BASIC programs for the hobbyist and engineer. There are programs to do such statistical operations as means, standard deviation averages, curve-fitting, and interpolation. There are programs that design antennas, filters, attenuators, matching networks, plotting, and histogram programs.

GAME PLAYING WITH COMPUTERS SECOND EDITION
SPRACKLEN
HB89
$ 31.25
Newly published, this book can sharpen programming skills through a relaxed approach. Completely devoted to computerized games playing, this volume presents over 70 games, puzzles, and mathematical recreations for a digital computer. It is fully illustrated and includes more than 25 game-playing programs in FORTRAN or BASIC complete with descriptions, flowcharts, and output.

MICROCOMPUTERS AND THE 3R'S
DB89
$ 15.85
This book educates educators on the various ways computers, especially microcomputers, can be used in the classroom. It describes microcomputers, how to organize a computer program, how to use the computer to enhance classroom applications (with examples from subjects such as the hard sciences, life sciences, and music). It includes a list of vendors and resources listings of today's products. The book includes programs written in machine language, how to start up a microcomputer program, while chapters on responsible use present guidelines that direct the reader to useful additional information. All programs are written in the BASIC language.

GAME PLAYING WITH BASIC
SPENCER
HB10
$ 15.25
The writing is non-technical, allowing almost anyone to understand computerized game playing. The book includes the rules of each game, each game works, illustrative flowcharts, and the output produced by each program. The last chapter contains 26 games for reader solution.

SARGO: A COMPUTER CHESS PROGRAM
SPRACKLEN
HB89
$ 25.00
A computer chess program that won first place in the first chess tournament at the 1976 West Coast Computer Faire. It is written in Z 80 assembly language, using the TDL macro assembler. It comes complete with block diagram and sample printouts.

A CONSUMER'S GUIDE TO PERSONAL COMPUTING AND MICROCOMPUTERS, SECOND EDITION
MANGER AND CHEW
HB14
$20.00
The first edition was chosen by Library Journal as one of the 100 best books of 1978. Now, there's an updated second edition! This book introduces to the principles of microcomputers that assumes no previous knowledge on the reader's part, this second edition updates all developments in microcomputer technology, and a review of over 700 microcomputer products from over 60 manufacturers.

THE BASIC CONVERSIONS HANDBOOK FOR APPLE, TRS-80, AND PET USERS
BRAIN BANK
HB17
$11.75
Convert a BASIC program for the TRS-80, Apple II, or PET to the form of BASIC used by any other one of those machines. This is a complete guide to converting Apple II and PET programs to TRS-80, TRS-80 and PET programs to Apple II. This book can be used by students and engineers to translate their programs. The instructions are listed for TRS-80 (Basic I, Model I), Apple II Basic, and Apple II Plus Basic, as well as variations for the TRS-80 (Model II) Basic and Apple Integer BASIC.

SPEAKING PASCAL
BOWEN
HB16
$ 17.25
An excellent introduction to programming in the Pascal language, this book will help you learn how Pascal's more powerful name is something. Well written, examples included. New for each new edition and the reader is encouraged to construct programs in an organized development.

1033: ELECTRONIC CALCULATOR USERS HANDBOOK
M.B. BAKKE (Ed.)
$ 4.25
An invaluable book for all calculator users whatever their age or occupation, or whether they have the simplest or most sophisticated of calculators. Presents Foremats, data, methods of calculation, conversion factors, etc., with the calculator circuits and gives examples showing how to use them. Includes the way to calculate using only a simple four function calculator. Trigonometric Functions (Sin, Cos, Tan), Hyperbolic Functions (Sinh, Cosh, Tanh) Logarithms, Square Roots and Powers.

THE MOST POPULAR SUBROUTINES IN BASIC
Tab No.105
$ 10.45
An understandable guide to BASIC subroutines which would enable the beginner to write his own subroutines for faster and more efficient program development.

BP19: ELECTRONIC PROJECTS FOR BEGINNERS
F.G. RAYER, T.Eng.(CEI), Assoc.IRE
$ 5.90
BP3: ELECTRONIC PROJECTS FOR BEGINNERS
F.G. RAYER, T.Eng.(CEI), Assoc.IRE
$ 5.90
Another book written by the very experienced author — Mr. RAYER — who is the designer of electronics, will find a wide range of easily made projects. Also, there are a considerable number of different components and wiring diagrams, to aid the beginner.

Furthermore, a number of projects have been arranged so that they can be constructed without any need for soldering. and, as a result, fitting is simple and therefore the scope of projects which the newcomer can build and use.

220: 20 TESTED TRANSISTOR PROJECTS
R.TORREN
$ 5.50
Mr. Richard Torrens is a well experienced electronics development engineer and has designed, developed, built and tested the many useful and interesting circuits included in this book. The projects themselves can be split down into simple building blocks, which are shown separated by lines in the circuits for ease of description, and also to enable any reader who wishes to examine the main circuit from different points to realize ideas of his own.

BP49: POPULAR ELECTRONIC PROJECTS
R.A. PENFOLD
$ 6.25
Includes a collection of the most popular types of circuits and projects which, we feel sure, will provide a number of designs to suit most electronic constructors. The projects selected cover a very wide range and are divided into four basic types: Radio Projects, Audio Projects, Household Designs to interest most electronics constructors. The projects are constructed component by component, and the author who wishes to combine boxes from different projects can build and use.

EXPERIMENTER'S GUIDE TO SOLID STATE ELECTRONIC PROJECTS
BP87: ELECTRONIC PROJECTS FOR BEGINNERS
R.A. PENFOLD
$ 10.45
An ideal sourcebook of Solid State circuits and techniques with many practical circuits. Also included are many useful types of experimental gear.

BP71: ELECTRONIC HOUSEHOLD PROJECTS
R.A. PENFOLD
$ 7.70
Includes all of the most popular and useful electronic construction projects that are found in the home. The circuits range from such things as '2 Tone Door Buzzer', Intercom, through Smoke or Gas Detectors to Baby and Fire Alarm. Twenty useful projects which can all be built on a 24 x 10 hole matrix board with copper strips. Includes Door buzzer, Low-voltage alarm, AM radio, Signal Generator, Timer, Intercom and Headphone Amp, Transistor Checker and Infrared Headphone Amp, Transistor Checker and more.

BP73: ELECTRONIC PROJECTS FOR CARS AND BOATS
R.A. PENFOLD
$ 8.10
Projects, consisting in all, which use a 12 volt supply are the basis of this book. Included are projects on Windscreen Wiper Control, Component Tester, Battery Monitor, Cartridge Power Supply, Lights Timer, Vehicle Immobiliser, Gas and Smoke Alarm, Depth Warning and Shaver Inverter.

BP89: ELECTRONIC GAMES
R.A. PENFOLD
$ 7.55
In this book Mr. R.A. Penfold has developed and designed a number of interesting and unique electronic model integrated circuits. The text is divided into two sections, the first dealing with simple games and the latter dealing with more complex circuits.

BP95: MODEL RAILWAY PROJECTS
$ 8.10
Electronics projects for model railways are fairly recent and have made possible a new form of realism. The projects covered include controllers, signals and sound effects, and are provided for each project.

BP93: ELECTRONIC TIMER PROJECTS
R.G. RAYER
$ 8.00
Wind-up clock, wireless receiver, alarm clock and many intricate circuits have been featured on this pack. A simple clock to a really complex circuit are covered in this pack.

BP107: 30 SOLDERLESS BREADBOARD PROJECTS
R.A. PENFOLD
$ 8.10
Twenty useful projects which can all be built on a 24 x 10 hole matrix board. Includes Door buzzer, Low-voltage alarm, AM radio, Signal Generator, Timer, Intercom and Headphone Amp, Transistor Checker and more.

BP103: MULTICIRCUIT BOARD PROJECTS
R.A. PENFOLD
$ 8.10
This book allows the reader to build 21 fairly simple electronic circuits, all of which can be constructed on the standard printed circuit board. Wherever possible, the components are used in each design so that with a relatively small number of components and hence low cost, it is possible to make any one of the projects by reusing the components and P.C. boards.

BP107: 30 SOLDERLESS BREADBOARD PROJECTS
R.A. PENFOLD
$ 8.10
"A Solderless Breadboard" is simply a special board on which electronic circuits can be built and tested. The components used are just plugged in and unplugged as desired. The 30 projects featured in this book have been specially designed to be built on a "Vendoc" breadboard. Wherever possible, the components are used in each design so that with a relatively small number of components and hence low cost, it is possible to make any one of the projects by reusing the components and P.C. boards.
ELECTRONICS

BP10: HOW TO GET YOUR ELECTRONIC PROJECTS WORKING
R. A. PENFOLD
$8.10

We have all built circuits from magazines and books only to find that nothing works correctly, or at all, when first switched on. The aim of this book is to help the reader overcome just these problems by indicating how and where to start looking for many of the common faults that can occur when building up projects.

CIRCUITS

BP30: POPULAR ELECTRONIC CIRCUITS - BOOK 1
R.A. PENFOLD
$8.25

Another by the very popular author, Mr. R.A. Penfold, who has designed and developed a large number of circuits. There are grouped under the following general headings: Audio Circuits, Radio Circuits, Test Gear Circuits, Music, Project, Circuits, Household Project Circuits and Miscellaneous Circuits.

BP90: POPULAR ELECTRONIC CIRCUITS, BOOK 2
R.A. PENFOLD
$9.35

70 plus circuits based on modern components aimed at those with some experience.

The GIANT HANDBOOK OF ELECTRONIC CIRCUITS
F.G. RAYER, T.Eng.(CEI),Assoc.IERE
$8.10

About as twice as thick as the Webster's dictionary, and having many more circuit diagrams, this book is ideal for any experimenter who wants to keep amused for several centuries. If there isn't a circuit for it in here, you should have no difficulty in starting one, as you don't really want to build it.

BP39: (SF) FIELD EFFECT TRANSISTOR PROJECTS
R. N. SOR
$5.50

Field effect transistors (FETs). Fifteen application in a wide variety of circuits. The projects described here include radio frequency amplifiers and converters, test equipment and receiver aids, tuners, receivers, mixers and tone controls, as well as various other useful devices which are useful in the home.

This book contains something of particular interest for every class of enthusiast - short wave listener, radio experimenter or audio devotee.

BP76: SIMPLE LED. CIRCUITS
R.N. SOAR
$5.90

Since its first appearance in 1907, Mr. R. N. Soar's book has proved very popular. The author has developed a further range of circuits and these are included in book 2. Projects include a Transistor Tester, various Voltage Regulators, Testers and so on.

BP42: SIMPLE LED. CIRCUITS
R.N. SOAR
$3.55

The author of this book, Mr. R. N. Soar, has compiled 50 interesting and useful circuits and applications, covering many different branches of electronics, using one of the most inexpensive and freely available components - the Light Emitting Diode. This book will be of particular interest to the beginner and more advanced enthusiast alike.

BP82: ELECTRONIC PROJECTS USING SOLAR CELLS
OWEN BISHOP
$5.50

This project covers a wide range from a bicycle speedometer suitable for being powered by a small array of silicon cells. There is now a vast range of ICs available to the amateur market, the majority of which are not necessarily designed to operate at very low levels, and the few that are often designed to operate with the simplest power supply available. The book has been divided into preamplifiers and a variety of circuits which are based on the IC or transistor. A few projects described here include radio frequency amplifiers and converters, test equipment and receiver aids, tuners, receivers, mixers and tone controls, as well as various other useful devices which are useful in the home.

BP90: PROJECTS
M.K. BERRY
$5.50

The purpose of this book is to introduce the LM3900 to the Technician, Engineer and the Hobbyist. It provides the grounds work for further developments and more advanced uses, and is not only a collection of simple circuits or projects as in the basic electronic project book, but an introduction to this IC which is the only active device used. The LM3900 can do much more than is shown here, this is just an introduction. The circuit is the only limitation with this simple and versatile device. But first the reader must know the basics and that is what this book is all about.

BP22: 50 PROJECTS USING IC 45130
R.A. PENFOLD
$5.50

In this book, the designer has developed and included a number of interesting and useful projects which are divided into five general categories; 1. Audio Projects 2. R.F. Projects 3. - Transistor Equipment 4. - Household Projects - Miscellaneous Projects.

BP24: 50 PROJECTS USING SCPR'S. SCR'S & TRIPS
F.G. RAYER, T.Eng.(CEI),Assoc.IERE
$5.50

Relays, silicon-controlled rectifiers (SCR's) and Bi-directional triodes (TRIPS) have a wide range of applications in electronics today. This book gives tried and practical working circuits which should present the minimum of difficulty for the enthusiast to construct. In most of the circuits there is a wide latitude in component values and types, allowing easy modification of circuits or ready adaptation to suit your individual needs.

BP14: IC 555 PROJECTS
E.A.PARK, R.E.G., M.I.E.E.
$7.55

Every so often a device appears that is so useful that one wonders how life went on before without it. The 555 timer is such a device. Included in this book are Basic and General Circuits, Motor Car and Model Railway Circuits, Alarms and Noise Makers as well as a section on the 556, 558 and 559 timers.

BP24: 50 PROJECTS USING IC741
BLISH & LIVER REDMILE
$4.25

This book, originally published in Germany by TCP, has been printed in Great Britain by the Continental and Babun, and, in view of the fact that the integrated circuit used in this book is inexpensive to buy, to make this unique book available to the English speaking reader, Translated from the original German with copious notes, data and circuits, a "must" for everyone whatever their interest in electronics.

BP37: 50 PROJECTS USING RELAYS.
SCR'S & TRIACS
F.G.RAYER, T.Eng.(CEI),Assoc.IERE
$5.50

The ACTIVE FILTER HANDBOOK
TAB No.1133
$13.45

This book is intended for the constructor with a few basic ideas of electronic design. It includes practical and simple methods of constructing the basic active filters which can be used for a wide variety of applications. If 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.

BP55: ELECTRONIC MUSIC AND CREATIVE TAPE RECORDING
M.R. BERRY
$5.90

Electronic music is the new music of the Twentieth Century. It is played large scale on dedicated electronic music equipment, and, in fact, there is scarcely a group without some sort of synthesizer or other electromagnetic devices.

This book sets out to show how electronic music can be made at home with the simplest and most inexpensive of electronic equipment. What counts is your imagination, and there may be many who have already built their own home made synthesizer.

BP84: ELECTRONIC MUSIC PROJECTS
R.A. PENFOLD
$7.10

Although a few of the more recent branches of amateur electronic music have now become extremely popular 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, such as a Fuzz Box, Waa-Waa Pedal, Sustain Unit, Reverberation and Phaser Units, Tremolo Generator etc.

BP81: ELECTRONIC SYNTHESIZER PROJECTS
M.K. BERRY
$7.30

One of the most fascinating and rewarding applications of electronics is electronic music and there is hardly a group today without some sort of synthesizer or effects generator. Although an electronic synthesizer is quite a complex piece of equipment, it can be broken down into much simpler units which may be built individually and these can then be used or assembled together to make a complete instrument.

BP54: ELECTRONIC MUSIC SYNTHESIZERS
M.K. BERRY
$3.55

This book is an ideal reference for active filter design. The book introduces filters and their uses. The basic math is discussed so that the reader can tell where all design equations come from. The book also presents many practical circuits including a graphic equalizer, computer interface and more.

DIGITAL IC'S - HOW THEY WORK AND HOW TO USE THEM
TAB No.801
$11.45

An excellent primer on the fundamentals of digital electronics. This book explains the nature of gates and related concepts and also deals with the problems inherent to practical digital circuits.

MASTER HANDBOOK OF 1001 PRACTICAL CIRCUITS
TAB No.800
$20.45

MASTER HANDBOOK OF 1001 MORE PRACTICAL CIRCUITS
TAB No.804
$19.45

These three books are a treasury of ideas and hints for the engineer, technician or hobbyist. Circuits are classified according to function, and all sections appear in alphabetical order.

THE MASTER IC COOKBOOK
TAB No.1139
$16.45

If you've tried to find specs for a so called "standard" chip, then you'll appreciate this book. C.L. Hallmark has compiled specs and pinout for most of the IC's that you'd ever want to use.

ELECTRONIC DESIGN WITH OFF THE SHELF INTEGRATED CIRCUITS
TAB No.916
$13.45

This technical handbook gives you much to help you approach the vast range of applications possible by close inspection of the many problems that can occur when building up projects.

THE HANDBOOK OF IC PRE-AMPLIFIER AND POWER AMPLIFIER CONSTRUCTION
TAB No.35
$5.90

This book sets out to show how electronic music can be made at home with the simplest and most inexpensive of electronic equipment. What counts is your imagination, and there may be many who have already built their own home made synthesizer.

OUT OF PRINT

205: FIRST BOOK OF HI-FI LOUDSPEAKER ENCLOSURES
S.B. BABAN
$3.55

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

BP35: HANDBOOK OF IC AUDIO PRE-AMPLIFIERS AND POWER AMPLIFIER CONSTRUCTION
F.G. RAYER, T.Eng.(CEI)
$5.90

This book covers a wide range of audio equipment, from scratch. Includes practical and simple methods of constructing the basic active filters which can be used for a wide variety of applications. If 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.

BP25: HOBBYIST'S HANDBOOK
M. R. BERRY
$5.90

This book contains a variety of practical circuits and a reference book for design calculations. The approach has been made as non-mathematical as possible.

BP24: MULTIPLE DISCO THEQUE HANDBOOK
COLEN CARSON
$5.90

The vast majority of people who start up "Mobile Discos" know very little about their equipment or even what to buy. Most mobile "Discos" are "in the money" all the time, that is, they are fortunate, unnecessary or badly matched apparatus.

The aim of this book is to give you enough information to enable you to have a better understanding of many aspects of "disco" gear.

HOW TO BUILD A SMALL BUDGET RECORDING STUDIO FROM SCRATCH
TAB No.1166
$16.45

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

BP75: ELECTRONIC TEST EQUIPMENT

$7.30

F.G. RHEE, T. Eng (CEI), Assoc. IEEE

This book covers in detail the construction of a wide range of test equipment. The essential principles of the Electronics Hobbyist 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 does it provide a wealth of information, but the finished projects can also be usefully utilized in the further development of the hobby.

99 TEST EQUIPMENT PROJECTS YOU CAN BUILD

TAB No. 905

$14.45

An excellent source book for the hobbyist who wants to build up his own test equipment. Projects range from a simple signal tracer to a 50 MHz frequency counter. There are circuits which extend the range of the amateur's test equipment. Whether you wish to receive distant stations at only moderate audio levels, or record and analyze on frequency modulation (f.m.) receivers will appeal to those who desire high fidelity reception.

BP22: ELECTRONICS SIMPLIFIED - CRYSTAL SET CONSTRUCTION

$7.30

F.A. WILSON

Aimed at those who wish to get into construction without much theoretical background. The circuits are used and all projects are very inexpensive to build.

REFERENCE

THE BEGINNER'S HANDBOOK OF ELECTRONICS

THE POWER SUPPLY HANDBOOK

$10.45

A complete guide on how to read and understand schematic diagrams. The book teaches how to handle basic circuits and identify component functions. Useful for technicians and hobbyists who want to avoid a lot of headscratching.

COMPLETE GUIDE TO READING SCHEMATIC DIAGRAMS

$12.45

Completely updated by a "block" explanation of how control-device and components function. A practical guide from the beginner to the hobbyist. The book will commence by dealing with the conditions that are allowable for such electronic equipment. This is followed by an introduction to electronics and the concept of how components function. The book is divided into sections for easy reference, making it an ideal guide for the amateur and the hobbyist.

RADIO AND COMMUNICATIONS

BP77: RADIO CONTROL FOR BEGINNERS

$7.30

F.G. RAY, T. Eng (CEI), Assoc. IEEE

The aim of this book is to act as an introduction to Radio Control systems for beginners. The book is designed for individuals who wish to learn about the possibilities of radio control and how to apply it to their hobby. It covers the basics of radio control, including the theory and practical aspects of controlling objects remotely.

RADIO TELEGRAPHY AND TELEPHONE HANDBOOK

$12.45

A complete guide on how to read and understand schematic diagrams. The book teaches how to handle basic circuits and identify component functions. Useful for technicians and hobbyists who want to avoid a lot of headscratching.

COMPLETE GUIDE TO READING SCHEMATIC DIAGRAMS

$12.45

Completely updated by a "block" explanation of how control-device and components function. A practical guide from the beginner to the hobbyist. The book will commence by dealing with the conditions that are allowable for such electronic equipment. This is followed by an introduction to electronics and the concept of how components function. The book is divided into sections for easy reference, making it an ideal guide for the amateur and the hobbyist.

BASIC TELEPHONE SWITCHING SYSTEMS

$13.45

A practical work about interference causes and cures that affect TV, radio, hi-fi, CB, and other devices. Provides all the information needed to stop interference. Schematic wiring diagrams of filters for all types of receivers and transmitters are given. Also includes charts and graphs to help eliminate radio and TV interference caused by noisy home appliances, neon lights, motors, etc.

INTERRELATED INTEGRATED ELECTRONICS CIRCUITS FOR THE RADIO AMATEUR, TECHNICIAN, HOBBYIST AND CONSTRUCTION

$11.35

This book provides a variety of appealing projects that can be constructed by anyone from the hobbyist to the engineer. Construction needs to stop interference. Schematic wiring diagrams of filters for all types of receivers and transmitters are given. Also includes charts and graphs to help eliminate radio and TV interference caused by noisy home appliances, neon lights, motors, etc.

MISCELLANEOUS

BP80: CHOOSING AND USING YOUR HI-FI

$7.35

MAURICE L. JAY

The philosophy of this book is to provide the reader with the fundamental information necessary to enable him to make a satisfactory choice from the many hi-fi equipment now on the market. This is the book for you. The author discusses how to maximize the usefulness of cheap nothing to measure it with, this is the book for you. The variety is endless and includes just about anything you could wish for!

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THE APPLE II was originally designed in 1976 by two guys (in a garage). It was neat for its time, but technology has long since outstripped it. Among its limitations are an on board RAM space of only 48K...a king's ransom in '76 but available for less than thirty dollars at today's prices. Then there's the video display, which is forty columns wide and upper case only. The on-board BASIC is the pits, and, in fact, most of the ensuing architecture leaves a lot to be desired.

However, the main concept behind the hardware design remains sound. The bus structure is fiendishly versatile and it is frequently noted, as a credit to its designers, that it is forever being turned to tasks its designers never even dreamed it could do. There is more third party hardware and software available for the Apple II than for almost any other microcomputer in existence.

Even at present, despite the ravages of time and pirates, the Apple II sells fairly well.

The limitations of the Apple can be corrected. You can plug in a Videx card to provide 80 column lines of characters, and a keyboard enhancer to permit the keyboard to handle lower case. A soft card will allow the Apple to run CP/M and MBASIC. A language card will add another 16K of RAM. Clearly, though, it is still an old system.

This January Apple introduced a revised version of the system, the Apple Ile at a press conference in Toronto. It looks a lot like the Apple II, although its keyboard, with a number of enhancements like shift lock and two programmable keys, more resembles that of the Apple III. As one might expect, the keyboard generates lower case characters now, and the screen can display them. The screen still only has forty characters to a line, although there is a plug in card available that will expand this to eighty.

The Apple Ile still uses a 6502 processor and the same general architecture as the Apple II. However, the board has been depopulated quite a lot, chopping the chip count from 110 small scale deals to 31 complex beastsies. This includes two custom LSI chips which, at least for the time being, should keep anyone from pirating this fruit.

It is also possible to add a second 64K of RAM to the system in a bank switched arrangement, which is a good trip for VisiCalc models and other applications that use a lot of storage.

Asking the Apple heavies at the press conference about software compatibility was a bit of an exercise in translation. The system's software and structure is close to, but not identical with the Apple II. As such, most software for the older system will probably run on the Apple Ile. However, it was hard to pry from them the nature of the changes wrought and what could be expected to take exception to them. Some appear to be in the graphics section, which may mean that high resolution games will prove uncool.

Inasmuch as commercial Apple software is very deliberately made difficult to back up and get into, doing patches, even simple ones, on these things is probably all but impossible. As such, owners of Apple Ile's will have to wait for the manufacturers of the software they want to come up with compatible versions in the event of a mismatch.

The Apple Ile still sports what appears to be the original Applesoft BASIC. The uninitiated should be aware that, by 1976 standards, Applesoft was sort of okay. Pity, what.

The beast costs $1995.00 Canadian, slightly less than an Apple II. All told, it's not a bad choice for a computer, although, if you are thinking of
using a lot of the existing Apple II compatible stuff it will want a heavy scrutiny.

Lisa

And then there's Lisa, the other system that was announced at Apple's press conference. What a trip. Lisa is by far one of the shiniest toys I've ever seen since I got my first 8K PET.

The Lisa, is, first off, a heavily business-oriented system. It goes for about fourteen grand. It is, said the dudes in the suits, a system for knowledge workers, whatever they are. It is supposed to be ultra user-friendly, capable of doing all sorts of amazing things and will communicate with one in quasi-human terms. Aside from that, it's neat.

Lisa stands for Local Integrated Software Architecture. Do they dream up the names first and then come up with words to fill them in, do you think? It looks a bit like a DEC terminal. It has two floppy drives and a very high resolution screen with software allocatable characters and heavy graphics capabilities. It can be communicated with using its keyboard, but its software is highly menu driven, and a lot of the interacting one does with the Lisa is via a small trackball controller called the "Mouse." You roll this thing around on your desk top and a cursor follows suit on the screen.

The system is based on Motorola's 68000 32/16 bit processor... that's a thirty two bit Wide Internal bus with a sixteen bit data bus. It has a megabyte of RAM and two 5 1/4 inch floppies which can take 1.7 megabytes all told. There's also a five meg hard disk drive.

The main tube is black and white only, but supports 720 by 364 pixels or 40 lines of 132 characters. The screen can be dumped, graphics and all, to a dot matrix printer for complete reproduction. There are also communications facilities to be had and many other special purpose peripherals can be associated with the old girl through her several ports.

One may joke about the system being female but there was one Apple executive who referred to it as such quite seriously. I think he was in love.

The main trip of Lisa is unquestionably its software. The idea is for it to represent a desktop. There are little drawers of the things associated with one's desk on the bottom of the screen... a trash can, a clock, a calculator, a clip board, a file and so on. The several main functions of the system are similarly represented along the right hand side of the screen. Each of these things can be called up by moving the mouse cursor over its symbol and pushing its button. The software package is integrated, such that all menus are interactive with all other menus and one never has to actually run a program. You just leap from one bit to another as you see fit.

The programs themselves are heavily into menus. The menu pages appear upon command, growing out of the screen in a spray of concentric rectangles... a tad Star Wars, but attractive. Let the boys down in the software department have their fun. Menu entries are mouse-selectable. Most of the programs work in Lisa's first rate graphics in some way.

The main Lisa package consists of an integrated set of the most used business programs. It is by no means all that can be run on the system... there are lots of other packages available such as several higher level languages... and Apple expects a lot of stuff to come from third party suppliers. (Give me a Lisa and I'll write you a version of Camel Killer, Iads.)

The primordial Lisa's main menu selects between LisaCalc, which is, predictably, like VisiCalc, but with split pages and field formatting, LisaWrite, a word processor which, because of Lisa's high resolution screen, can display text in different character fonts, bold, italics, underlines, and so on, LisaGraph, a graphic display program for LisaCalc data, LisaDraw, a complete graphic page creation system, LisaList, a data base and, lastly, LisaProject. This final entry is actually fairly interesting, although you'll have to judge for yourself whether it's particularly useful. It allows one to construct these extensive spreadsheet-like flowcharts of the stages involved in multiple task projects and then to plan though them, editing the whole works, figuring out costs, timetabling and so on. It's fun to watch, of course... I feel ill equipped to evaluate such a tool; I only use VisiCalc to figure out how much wood I need to build guitars, and then only 'cause I feel like I should use it for something. Forecasting software threatens my carefully manged chaos.

Sitting With The Girls

I think that Lisa-like systems are a bit of a threat to overall computer literacy. So much work has gone into it to make Lisa accessible to the user with no computer related experience that he or she will never actually have to acquire any. This only becomes an issue the day he or she wants to ascend beyond the limits of the software. Peering over the edge one sees the gaping maw of the untamed machine that has been writhing beneath the well tended landscape all along.

However, this caveat aside, it's definitely a blast, and a nice implementation of the state of the art. While its software is dripping with gimmicks it is unquestionably well thought out and most powerful. One may question whether the gimmicks make it appreciably better than an eight disk banger running the generic versions of these programs but, hey, that is between you and your accountant. Probably a spiritually greater potential for the Lisa exists in other areas, most notably those of graphics and digital animation.

No home should be without one.
A new monolithic device which allegedly has the advantages of VMOS devices combined with the high current handling capability and low saturation voltage of a bipolar transistor has been developed by Supertex Inc of California, and is claimed to offer considerably better switching performance than existing products. By Brian Dance.

THE INTERNAL circuit of the Superfet, shown here, consists of a VMOS input device — which provides an extremely high input impedance, a current gain of perhaps a hundred million and a very fast switching capability — and a bipolar output transistor specially designed to preserve the fast switching ability.

A 10 ohm resistor is connected between the base and emitter of the bipolar output transistor to prevent the device from being turned on by spurious transient signals. In fact, this resistor consists of 32 separate resistors connected in parallel to preserve the fast switching capability, while the output transistor has many small emitter regions connected to two output pads. The input VMOS transistor occupies about 40% of the area of the 6.5 mm by 6.2 mm chip.

The Supertex XN01 was the first Superfet described in a paper given at the US Powercon Conference recently. It consists of an n-channel enhancement mode DMOS power FET and an npn high current, high voltage power transistor.

It is a really high power device, available with voltage ratings from 350 V to 500 V, and can pass a continuous drain current of 20 A (40 A when pulsed) with a power dissipation that can reach 150 W.

A particular feature of this device is that a drain-emitter voltage of only 6 V can be used to produce the maximum current of 20 A. It is claimed that the saturation voltage of the Superfet is lower than that of any comparable power MOSFET device. Resistive switching speeds are comparable with those of power MOSFET devices and more than twice as fast as those of a comparable 450 V, 20 A power Darlington device.

Incidentally, it is not possible to make a circuit with the performance of a Superfet by connecting a VMOS device to a high-power bipolar transistor. The switching speeds of the available VMOS and bipolar devices are similar to or worse than that of the Superfet, while parasitic lead inductances in the connections to the two devices would drastically limit the operating speed.

Supertex has stated that even if devices with a faster switching capability should become available, it will not be possible to use them to match the performance of the supply units for higher frequencies than can easily be handled by high-power bipolar discrete transistors. Devices which will operate at 200 kHz or more are required for this purpose. Another application is in the field of ac motor control.

<table>
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<th>Device Type</th>
<th>Max. Drain-to-Emitter Voltage BV&lt;sub&gt;DE&lt;/sub&gt;</th>
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We're down to the real nitty-gritty this month as Ian Sinclair describes how simple counting circuits work. As usual there are plenty of practical circuits for you to experiment with.

LAST MONTH, we spent some time making a J — K flip-flop toggle. In case you’ve forgotten, the J — K toggles when J = 1 and K = 1. This can be done by connecting each of these terminals to the +5V line or, if we’re using slow clock speeds, just by ignoring them — unconnected inputs will ‘float’ to logic 1. As we don’t want to encourage sloppy habits, we’ll use a wire link to make quite sure that these terminals are at +5V.

The toggling J — K, like any other toggling flip-flop, gives one complete pulse out for two clock pulses in. What about using two such flip-flops, with the Q output of the first flip-flop connected to the clock input of the next? Nothing like trying it, and we can use the board more or less as it was connected before. Figure 1 shows the circuit, including the clock pulse generator and switch arrangements, just in case you’ve stripped or changed the board since last month. We’re now making use of both of the flip-flops in the 74LS76 package.

Now in this circuit, LED1 indicates the clock pulses, LED2 shows the output of the first J — K and LED3 shows the output of the second J — K. The switches are still wired to control J, K, R and S, and so they have to be set with SW1 and 2 high, SW3 low and SW4 low. This resets both flip-flops (because we’ve connected both the R pins and both of the S pins to their respective control lines). When you’re ready, push SW3 high so that the set/reset lines are no longer used, and watch the LEDs. The flashing is not just at random because these LEDs are indicating a two-stage binary count.

**Binary Counting**

If you haven’t made friends with binary counting yet, then help is at hand. Instead of letting the clock pulse do the counting, we’ll use a switch, SW1, so that there is a count each time we switch up and down. Now since this is a mechanical switch, its contacts will bounce, so we’ll have to use a clock speed that is much faster than the bounce frequency. This calls for the 74LS132 to be used, and Fig. 2 shows the complete circuit. You won’t need to change the connections to the 74LS76 much, only the J and K pins need to be connected to +5V instead of to the switch. The new connections around SW1 are shown, SW2 is not used, and SW3 and 4 are unchanged.

Now try again, using a bit of table filling this time. One of life’s little confusions is that we show circuit diagrams with inputs coming from the left-hand side and outputs at the right-hand side. The input to a counter, however, goes to the counter unit which changes at each pulse, the units counter. When we write a number, though, we show the lowest value units on the right, J — K A is the units counter, its LED, LED2, is counting units, and its state (0 or 1) goes in column at the right of Table 1. The next J — K, B, is counting 2s and its state (0 or 1) goes in a column which is to the left of the first one.

**Table 1. Binary outputs from units and twos counters and their denary equivalents.**

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<thead>
<tr>
<th>BINARY</th>
<th>UNITS</th>
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<tr>
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<td>3</td>
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</table>

Did I say units and 2s? Yes, because these counters don’t use the familiar scale of ten, in which units up to 9 go into the units column, and each goes in the next column to the left (Fig. 3). Because J — K’s count in 2s, the columns don’t contain units, tens, hundreds, thousands, etc., but units, twos, fours, eights, etc. We’re
numbers.

Into Digital

Fig. 3 Comparing binary and denary numbers.

using two J — K sections, so we are counting units with F/F A and two’s with F/F B. Table 1 shows a counting sequence for two flip-flops, with the decimal numbers shown alongside.

With two flip-flops we can count only up to three (Q₁ = 1, a two, and Q₂ = 1, a one, making a total of 3) before the flip-flops go back to Q₁ = 0, Q₂ = 0.

Fig. 4 Connection changes for using the switch without the debounce circuit.

Before we move on, try the small modification which is shown in Fig. 4. This consists of moving the clock input connection of F/F A from the R — S to the switch, so that the debouncing circuit is no longer in use. Reset (SW3 down, then up again, with SW4 down), so that LEDs 2 and 3 are unlit. Use SW1 once, and see what happens. Keep using SW1, and you’ll find in all probability that at some stage the count goes haywire, jumps from 01 to 11 or 11 to 01 and so on. What happens is that each time the switch bounces, the pulse created by the bounce is counted as another clock pulse by the flip-flops. It’s for this reason that any switch which controls a pulse circuit needs to be debounced. Switches which simply set or reset don’t need this treatment.

Now to greater things. Suppose we add another two J — K flip-flops to our circuit, in the form of another 74LS76. We can now have LEDs which indicate a 4s column and an 8s column, and we can count up to the binary number 1111, which is decimal 15.

At this point, it’s convenient to introduce a method of numbering flip-flops and outputs which is used a lot in digital circuits. Instead of numbering 1,2,3… As usual, there’s a perfectly good reason. Numbers such as 2, 4, 8, 16, 32, 64 and so on, which are the values of the quantities in small number, raised higher than the 2 and on its right-hand side. A few hundred years ago, mathematicians agreed that the meaning of 2₁ would be simply 2, and 2² would mean 1. The columns for a four-digit binary number will be written as 2¹, 2², 2³, 2⁴, so we number the flip-flops F/F₁, F/F₂, F/F₃, F/F₄.

Having swallowed all that, have a go at the circuit of Fig. 6. It’s a four-stage binary counter, using two 74LS76 ICs, and with the 74LS132 used for debouncing SW1. As usual, we start by resetting, with switches 3 and 4 both low, then SW3 set high. After that, each complete up-and-down movement of SW1 will cause a single pulse to be counted. Fill in the count table (Fig. 7) for yourself — it’s a quite a long one with 16 entries.

Once you’ve satisfied yourself that the count is a regular binary sequence (translation — each binary number is one greater than the one before), switch off and reconnect the 74LS132 as a clock oscillator, and use SW1 in a gating circuit (Fig. 8) with one of the spare NAND gates of the 74LS132. The reset action is as normal, but now counting will take place only if SW1 is at logic 1. You can interrupt the count at any time, and the number of pulses which have entered the counter (at the clock input of F/F0) will have caused LEDs to light. They stay lit when the counting stops. If you don’t reset, switch off or start counting again. The number of pulses remains stored in the form of flip-flop outputs for as long as you like. You can use SW1 to count a few more pulses, then stop again just as you wish; this is one more step in the construction of a binary counter.

We’ll continue next month with the LS76 used in more counters and shift registers.
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[Diagram drawing]
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<tr>
<td>80 Column Card</td>
<td>18.00</td>
<td>125.00 N/A</td>
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<tr>
<td>Printer Card</td>
<td>18.00</td>
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<td>RAM Card</td>
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<tr>
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<td>95.00</td>
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Circle No. 2 on Reader Service Card.
Rotary Combination Lock
Chris Pearce

There are many circuits for push-button and rotary switch combination locks, but this circuit uses a potentiometer to enter the four-digit code (easily expanded to eight). LED1 flashes approximately every 2 seconds. To enter the code, the potentiometer must be turned to the first digit for the duration of one flash, then moved to the next digit, ready for the next flash, and so on until the code is entered. If a wrong number is entered at any time the lock will reset and the code must be re-entered.

RV1 should be set up so that it can point to a number between 1 and 10. As a 12 V supply was used, '1' corresponds to 2 V, '2 to 3 V, and so on. Circuit operation is as follows: IC1a and C1, R1, D1 form an oscillator which provides clock pulses for the circuit timing. This clock pulse drives IC2 and is also inverted to drive LED1 and the reset logic.

Assuming IC2 is reset and the code is '1234', a high will appear at IC2 pin 3, which corresponds to a count of 0. On receiving the next clock pulse, the high will move to count '1' (pin 2). This will drive PR1, and thus feed a voltage to the window comparator IC3. D9 sets the window width at 0V6. As the first digit of the code is '1', which corresponds to 2V, PR1 will be set to 2V9, allowing for 0V6 dropped across D3, and thus setting the upper window limit to 2V3 and the lower to 1V7. If, when the LED flashes, the potentiometer is set within the limits, the comparator output will be low and IC2 cannot be reset. On the next clock pulse IC2 will move to count '2' ready for the next digit and so on.

If the potentiometer is outside the limit if the wrong number, the comparator output will be high and IC2 will be reset when the LED flashes. If the correct code is entered the clock of IC2 will be inhibited via pin 13 and the output will be high. To set the lock the potentiometer is moved off the last digit.

C1 should not be electrolytic. C2 provides decoupling and should be placed near 103. The chance of breaking the four digit code in any one attempt is 1 in 10,000, and 1 in 100,000,000 for an eight digit code.

CMOS Sustainer for Electric Guitar
S.P. Giles, Edmonton

I believe this must be one of the simplest and cheapest sustainers for electric guitars around. IC1a and IC1b are both CMOS inverters, wired to act as op-amps. Any inverter will do the trick, such as 4009, 4049, 4069 or 4007.

The gain of IC1a is determined by the collector-emitter resistance of Q1 plus R2. If the output level is to remain constant while the guitar note decays away, the gain of IC1a must be increased by a corresponding amount. This is achieved by rectifying the output of IC1a through IC1b and D1 and passing the resultant DC voltage, which is smoothed by C4 and R7, to the base of Q1. This forces the collector-emitter resistance of Q1 to increase in proportion to the input level from the guitar. RV2 can be set to any desired level and when set high can easily overdrive the input stage of the guitar amplifier giving a tube-type of distortion.
BASIC can make use of. While running a program, it is possible to have the program accept input from these dudes. However, even more useful is that they can be programmed in quite a different way in the direct mode to assist in program development. Each key can store a string which, when the key is depressed, will be printed up on the screen in the next available cursor location. Thus, if key 1 had the string "LIST" + CHR$(13), hitting it would be all that would be required to list the current program.

The keys actually have default strings in them... actually uncharacteristically bad chosen for several of them (the LIST lacks a carriage return, for example) but they can be altered by the user. One innovation which would have been a trip would have been the capacity of storing all the key strings in a disk file so that each user could permanently define the keys in a useful way. I think I'd be tempted to patch this with the debugger if I owned a Z-100.

Finally, the BASIC possesses genuine pseudo-PET screen editing. Like the if 800, it makes scant mention of this, but, as with the CBM machines, editing a line of text requires nothing more than cursoring up to it, doing the changes and hitting a line return anywhere in the line to re-enter the modified line into RAM. This is manifestly easier than fighting with EDIT functions. 

Huge BASICS like this one are glacially slow and they do tie up an enormous amount of computing power and RAM for line returns. However, it is possible to make use of the system's extensive low level interrupt and device handling capabilities to speed things up. There are two serial ports out which can be used for simple data passing, and there is also a special monitor. RGB and composite video are available. 

The machine comes with two 5 1/4 inch disk drives in your choice of single or double sided configurations. Each drive can hold up to 640K of data formatted. The thing will also support a single external eight inch drive. If you don't like all of these permutations you can rip out one of the floppies and replace it with a little five inch Winchester, holding 5.3 megabytes. 

The system's documentation was extensive... huge three ringed binders full of stuff... and all right. The BASIC manual was a bit thin on examples and detail in a few places, but there was lots of low level hardware documentation, which is a lot harder to do without. There was not as much low level documentation on the ZDOS as one might like if one were to try writing programs for it, but it could be puzzled out.

Playing 'Til Dawn

As fiendishly expensive, splendidly functional computers go, the Z-100 is right up there. It's loaded with stuff, well constructed and its creators have only done a few things not entirely in the user's best interest, which is really pretty good. It will serve the needs of business applications very well, especially in situations wherein a computer is called on to perform a number of tasks, such as word processing, presentations, financial planning, and so on. There are few colour tubes which can equal the crispness of a decent black and white monitor, so in situations that call for the machine to be stared at a lot, such as in word processing, a second tube should be hung off the composite video port.

As alluded to before, with exception of its not having a built in printer, the Z-100 is almost identical to the if 800. If you were waiting for an if in a plastic box, here's your chance. On the other hand, the if, replete with printer, is fractionally cheaper. As for a home system to play with... if you can spring the bucks, go for it.

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Circle No. 23 on Reader Service Card.
ZX81 Printer
Continued from page 46
the range ±21 actioned. Although unlikely to cause much confusion, it must be remembered that the output from LPRINT is not printed immediately but stored in a buffer one line long. The computer will only print:
1) when the buffer is full
2) after an LPRINT statement that does not end in comma or semicolon
3) when a comma or TAB item requires a new line
4) at the end of a program if there is anything left unprinted.

In conclusion
The printout presented by the ZX printer was clear and readable with no disturbing fuzziness which occasionally has been seen with other systems. Graphic symbols can 'join up' from line to line, giving a clear, continuous picture. Keeping the printer clean is probably very important, and although the review model has been tested to some extent, long term reliability cannot be commented upon. As with the ZX81 and the ZX80 before it, the ZX printer offers something that, for the initial outlay, is quite remarkable, and can only add to the effectiveness of your ZX system.

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Circle No. 25 on Reader Service Card.

The internal workings of the printer. The belt carrying the two styli runs between the two white pulleys. Some examples of the printout are shown on this page.

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74—MARCH—1983—ETI
The Art of the ZX81
The ZX-81 is probably the most popular computer since the abacus. It's small, cheap and yet extremely powerful if you know all the tricks for getting the most out of the little beast. Even an unadorned 1K system can do some fairly amazing things with the right programming.

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Of course it's fun experimenting with 32 bit microprocessors on your breadboard. And there really is nothing like whipping out the old liquid helium and playing with a few Josephson Junctions. Build a deep space radio telescope? Sure you can. However, sometimes one simply wants to sit down and blast away with a few simple components and come up with a few projects the rabble without engineering degrees could understand. For these souls, discontented with the twenty first century, we present Modern Op-Amp Projects.

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<td>MX80, MX100111</td>
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<td>MX80111</td>
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Circle No. 19 on Reader Service Card.
Kitchen Scales
Continued from page 29

How it Works

The block diagram of Fig. 5 gives an overview of the circuit operation. Essentially, a Linear Variable Differential Transformer (LVDT) is used as a transducer, providing a voltage proportional to the displacement of its moveable core (a spring movement initially provides the linear displacement with weight). The circuitry generates the LVDT drive waveforms and uses a phase-locked detection technique to recover a stable voltage related to position (and thus weight). The voltage measurement obtained is displayed on a 3½ digit LCD DVM module to give a direct readout in kilograms.

Figure 3 illustrates the principle of the LVDT using an AC excitation signal. All the circuitry on the left of the LVDT shown in Fig. 1 is involved in supplying a stable 10 kHz sine wave to drive the primary coil. To achieve the required amplitude and frequency stability the sine wave is generated digitally using an even length walking ring counter based on IC2, the 4018 divide-by-2 synchronous counter. IC2 is configured as a 25 stage divide-by-10 counter by feeding back the Q5 output on pin 13 to the input on pin 1. The Q1-Q4 outputs are summed with selected resistors R5-8, thus approximating the sine wave. The counter is clocked at pin 14 from a 100 kHz astable oscillator formed from IC2a,b. Since the counter divides by 10 the sine wave generated will have one-tenth of the clock frequency, i.e. 10 kHz. The coil excitation frequency thus depends only on the C2/R9 astable time constant, and the amplitude only on the CMOS supply voltage.

The stability of the voltage levels is ensured by using a precision 5 V supply based on the bandgap reference diode D1. The op-amp used to regulate this supply (IC1a) actually powers itself from the 5 V output, thus stabilising its own power rails. A bias current of about 1.5 mA (also taken from the 5V rail) is fed to the reference diode through R2, to produce an extremely stable voltage of 1V2 at the non-inverting input of the op-amp. The other (inverting) input of the 5 V output is taken from the R3-R12 potential divider, the ratio of which sets the 5 V output due to negative feedback around the op-amp and series pass transistor Q1. ZD1, a 2V7 zener diode, allows the output of the op-amp to keep the base of Q1 at 5V6 while operating well below its own supply rail voltage.

The 5 V rail supplies all the circuitry but a separate digital ground is used for the logic ICs. This prevents digital noise from affecting the analogue signal measurement. C1 provides smoothing for the analogue supply rails, while C3 and C4 provide smoothing and decoupling for the digital circuitry.

Capacitor C6 filters the digital sine wave approximation from IC2, which is then attenuated to about 50 mV by the R14/C7 low-pass filter network. The resulting signal, a much better sine wave, is fed to the bandpass filter and coil driver amplifier based around IC3b. IC3b is configured as a standard 10 kHz active bandpass filter and gives a very pure sine wave on its output at pin 7 for driving the LVDT.

The LVDT primary coil has few turns and so its inductance changes due to the core displacement must remain constant as the primary coil input is varied. DC coupling is thus used between the coil and the op-amp output.

The sine wave swings ±50 mV about a reference level set at 50 mV above the analogue ground. This is only possible due to the ground sensing capability of the LM324 op-amp. Potential divider R13/R4 directly divides the precision 5 V supply by 100 to provide this reference level at the non-inverting input of pin 5.

The voltage output from the differential secondary of the LVDT (illustrated in Fig. 3) is amplified by IC1c. This op-amp is configured as a non-inverting DC amplifier with a high input impedance and a gain of around 20, the latter being determined by PR1. The 10 kHz sine wave signal is directly coupled from the coil and will be centred around the 2V5 reference rail provided by the potential divider R17, R18. The secondary is wired 'series opposing' such that there will be no signal when the ferrite core is centred.

The phase-locked detection is performed by multiplying the signal by +1 and -1 on alternate half-cycles of the sine wave to produce a bipolar signal centred about the reference level. IC1d, the last op-amp in the LM324 package, is configured as a straightforward inverter, AC-coupled to the sine wave signal. Two CMOS analogue switches, IC4a, 4b, switch the signal either directly (+1) or through the inverter (-1) on each separate half cycle. They are switched alternately, using logic inverter IC3c, from pin 4 of IC2, a square wave output of the digital sine wave generator. This produces the waveforms shown in Fig. 4 since the square wave edges correspond to the zero-crossing points of the sine wave after detection.

The resulting phase-detected signal is low-pass filtered by R28 and C12 to produce a ±100 mV DC voltage, linearly proportional to the displacement of the LVDT. A further voltage is provided by the 10-turn potentiometer RV1 in conjunction with the potential dividers R26 and R27. A reference of ±300 mV (relative to the 2V5 rail) is available at the slider of RV1. The two voltages are fed to the differential input of the LCD panel meter. This allows the digital scale to be returned to zero readout, allowing further measurements when, say, 1 kg is already being registered. The diagram of Fig. 2 shows how the LCD voltmeter is wired up for our application to give a 200 mV full scale deflection (corresponding to 2 kg).
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<td>Battery life 200 hrs. (included)</td>
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Multimeters

- Bench/Portable
- Frequency range 4½ digit 0.4" LCD
- Sensitivity 0.03% basic accuracy
- 8 digit Liquid Crystal Display

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<td>TM 451</td>
<td>Full auto-ranging or manual</td>
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<td>TM 351</td>
<td>Audible continuity test</td>
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<td>Complete with battery and test leads</td>
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- 10MHz (± 3dB) Bandwidth
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- Economy mode
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<td>Calibration Output</td>
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Generators

- Bench/Portable
- 1Hz to 100kHz Function Generator
- Sine, square, triangle waveforms
- External sweep mode
- Variable 600 ohm output

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<td>TG 100</td>
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A faint X-ray SNR is visible in the bottom right hand corner of this picture of a field of the Large Magellanic Cloud, taken with the 2D photon counting array fitted to the 1 m telescope at Siding Spring Observatory through a Hx filter in a 1000 second exposure.

Another view of the mock-up model of Starlab emerging from the instrument bay of the Space Shuttle.

Close Captioning T.V.
Continued from page 24

is arranged and the floppy discs sent by air to Toronto. The French language programming is done in Montreal. While the CBC has not yet quite fulfilled its undertaking to the Parliamentary Committee on the Disabled and Handicapped during the Year of the Disabled (1981) to provide five hours of close captioned material programming per week both in French and English, it has almost met this undertaking, of which only one hour (Barney Miller and Three's Company) are US imports.

A recent experiment, demonstrating the compatibility of Line 21 TeleCaptioning with the British VideoText and Teletext, involved WJLA-TV, Channel 7, Washington D.C. The purpose of the experiment was to prove the same captions can be seen at the same time on decoders built for either system. The difference between the system is that TeleCaptioning is specifically designed for telecaption programming for the hearing impaired while Teletext is designed as a large volume information system for many different television viewers, of which telecaptioning for the hearing impaired is only one use. The benefits of the compatibility between systems is that it means that a broadcaster can serve any audience easily and economically, without making any financial investment.

In Canada, there are some 200,000 severely hearing impaired persons. While the number of TeleCaption Adapters sold in this country is not known, up until November 1982 some 60,000 had been sold in North America as a whole. The expected cost to the CBC to provide the five hours of programming a week in the two official languages is approximately one million dollars a year, pro-rated at the American experience of $2,000 (US) per hour.

The main observable difference between the two models lies in the density of matter at extreme distances from Earth. Unfortunately, the present generation of Earth-based telescopes is incapable of seeing quite far enough.

Starlab will be able to see objects as faint as magnitude 24, considerably better than the best ground-based observatories. Scientists are guessing that this will enable them to view objects receding from us at a massive 80% of the speed of light. That is most of the way back to the big bang, and should certainly be sufficient to decide the shape of the universe we live in.

If the money is forthcoming, the first mission will be in 1989. Current plans call for the shuttle to retrieve Starlab some six to twelve months later. After servicing and possible reinstrumentation there will be a second and longer flight.

There is no reason why Starlab should not be used until it becomes so obsolete that no more worthwhile astronomy can be done with it. One would think that by then we would certainly have got our money's worth out of it!

Most astronomers would bet that it will have changed the way we look at the universe.
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Sinclair’s new ZX81 personal computer is a tremendous advance over the highly successful ZX80. It offers far more computer capability, yet Gladstone Electronics is able to offer the ZX81 at less than half the ZX80 price! How is this possible? Quite simply, by design. The ZX81 uses only 4 chips (as opposed to 21 in the original ZX80). The secret lies in the totally new Master chip. Designed by and custom-manufactured for Sinclair, this unique chip replaces 18 chips from the ZX80.

ZX81’s advanced capability.

The ZX81 uses the same fast microprocessor (Z80A), but incorporates a new, more powerful 8K BASIC ROM — the "trained intelligence" of the computer. This chip works in decimals, handles logs and trig, allows you to plot graphs, and builds up animated displays. And the ZX81 incorporates other operation refinements — the facility to load and save named programs on cassette, or to select a program off a cassette through the keyboard.

New, improved specification.

- Unique 'one-touch' key word entry: the ZX81 eliminates a great deal of tiresome typing. Key words (PRINT, LIST, RUN, etc.) have their own single-key entry.
- Unique syntax-check and report codes identity programming errors immediately.
- Full range of mathematical and scientific functions accurate to eight decimal places.
- Graph-drawing and animated-display facilities.
- Multi-dimensional string and numeric arrays.
- Up to 26 FOR/NEXT loops.
- Randomize function.
- Programmable in machine code.
- Cassette LOAD and SAVE with named programs.
- 1K-byte RAM expandable.
- Full editing facilities.
- Able to drive the new Sinclair ZX Printer.

Sinclair ZX Printer . . . 169.95

Designed exclusively for use with the ZX81 (and ZX80 with 8K BASIC ROM), the printer offers full alphanumerics and highly sophisticated graphics. COPY command prints out exactly what is on screen. At last you can have a hard copy of your program listing and results. Printing speed is 50 characters per second, with 32 characters per line and 9 lines per vertical inch. Connects to rear of ZX81 — using a stackable connector so you can use a RAM pack as well. A 65 ft paper roll, instructions included.

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