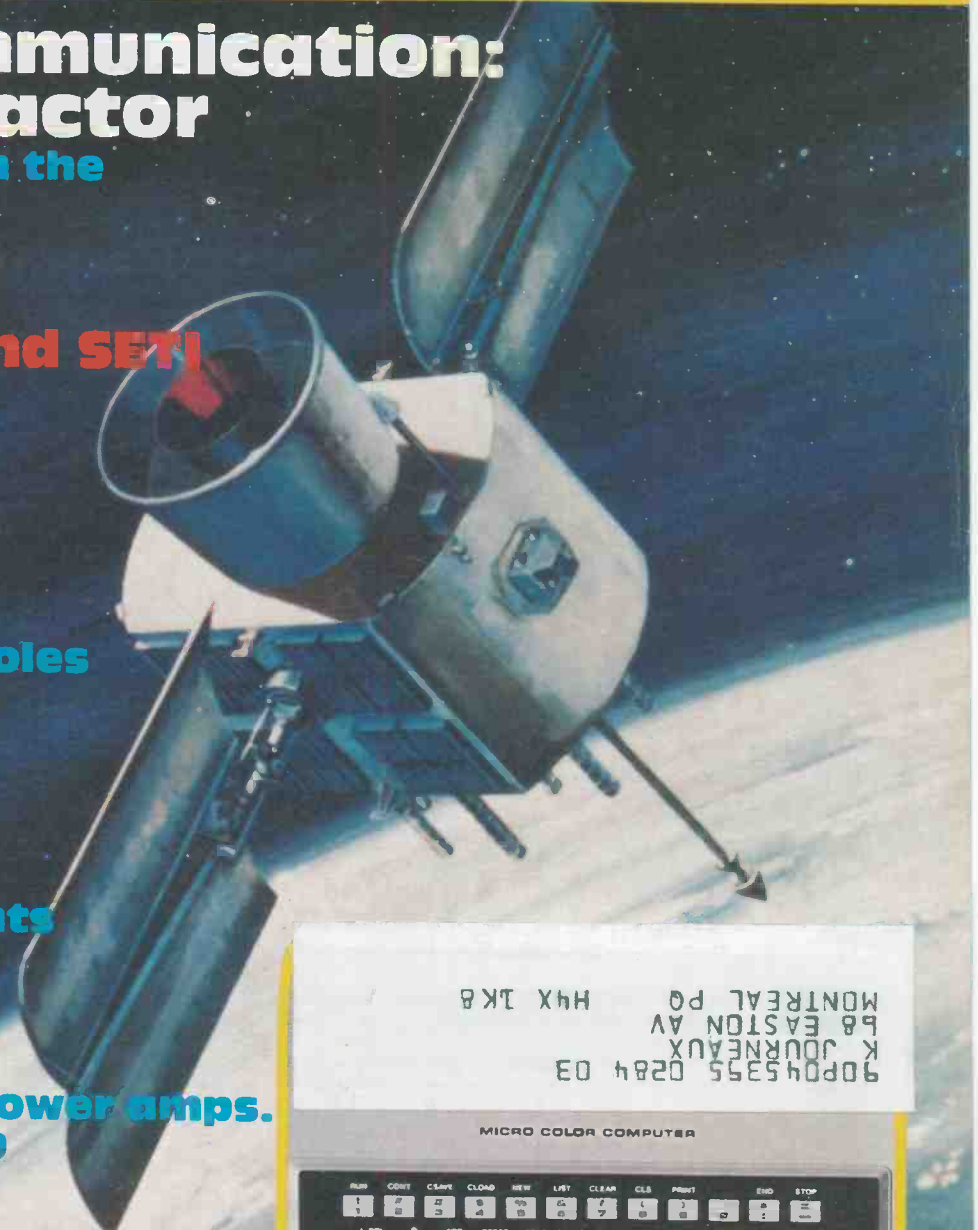
ETI for Electronics & Computing Enthusiasts

Inside Memory Systems

$2.25
MM70924

# Electronics Today INTERNATIONAL

August 1983



## Military Communication: The Chaos Factor
More unknowns from the unthinkable

## Bob Stephens and SETI
The Search for Extra-Terrestrial Intelligence

## Pay TV Piracy
Legalities and loopholes

## Automatic Sprinkler
PROJECT
A robot for your plants

## NDFL:
PROJECT
A new approach to power amps. Theory and 60 W amp




## TRS-80 MC-10 Review

0 57438 70924 08

# SURPLUSTRONICS

*we will not be undersold*

## 6502 System

*(Kit)*

**SAVE $300** on peripheral cards (approx.)

**Complete Kit: $649**

**Assembled & Tested: $748**

Includes PCB, complete set of parts (including blank EPROMS) power supply, case, keyboard and blank Z80 card PCB.

***There is simply no comparison between the obsolete 48K board & the new all Canadian designed and manufactured high quality 6502 board — read ETI May 83 review for details***

This 6502 board is a vast improvement on others available:

- 64K RAM (8-4164 chips)
- 80 x 24 video included on board
- Floppy Disk Controller included
- FIVE additional slots
- Z80 blank PCB included
- Powerful power supply (5V 5A, +12V 2 up to 3A peak, −5V 0.5A, −12V 0.5A)
- Superb quality plastic case
- Excellent keyboard including numeric keypad
- EPROMS (blank) included
- Full service facilities: normal maximum charge $50 on properly assembled kits as described in our service pamphlets.

**As Reviewed in ETI May 1983**

This board in all honesty far exceeds our original expectations and demand is spectacular. This board will also fit the older/cheaper cases and keyboards.

Mail Orders add $3.00 for handling. Ontario residents add 7% P.S.T. Visa, Mastercard and American Express cards accepted: send card number, expiry data, name of bank and signature. Send certified cheque or money order, do not send cash.

### Optional Extras

**5¼" Disk Drives**
Attractively packaged, ready to plug in. Extremely reliable.
**$279**

**12" Zenith Monitor**
Ready to use; switchable for 40 or 80 characters. 90 day warranty.
**$137**

**Parts for Z80 Card**
Fills up the supplied PCB; enables you to run CP/M software.
**$49**

**PCB only . . . . . . . . . . . . $57**
**Parts Complete . . . . . $255**
**Gemini 10X printer . . . $489**

**Surplustronics, 310 College Street, Toronto, Ontario, M5T 1S3 (416) 925-8603.**

*Circle No. 22 on Reader Service Card.*

The Magazine for Electronics & Computing Enthusiasts

# ETI Electronics Today INTERNATIONAL

August 1983
Vol. 7 No. 8
ISSN 0703-8984

Member ABC Audit Bureau of Circulations

## Features



## Projects



## Our Cover

An artist's concept of a satellite used in relaying military communications; the entire network could be paralysed by an EMP pulse. See Page 39 (Illustration courtesy U.S. Air Force.) At bottom: the Radio Shack MC10 is tested by Steve Rimmer. See page 36 (Photo by Bill Markwick.)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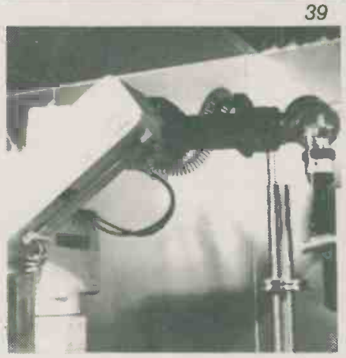

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## Columns, News and Information



## ADVERTISERS' INDEX



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We can supply photocopies of any article published in ETI Canada; the charge is $2.00 per article, regardless of length. Please specify both issue and article.

**COMPONENT NOTATION AND UNITS**
We normally specify components using an international standard. Many readers will be unfamiliar with this but it's simple, less likely to lead to error and will be widely used everywhere sooner or later. ETI has opted for sooner!
Firstly decimal points are dropped and substituted with the multiplier: thus 4.7uF is written 4u7. Capacitors also use the multiplier nano (one nanofarad is 1000pF). Thus 0.1uF is 100nF, 5600pF is 5n6. Other examples are 5.6pF = 5p6 and 0.5pF = 0p5.
Resistors are treated similarly: 1.8Mohms is 1M8, 56kohms is the same, 4.7kohms is 4k7, 100ohms is 100R and 5.6ohms is 5R6.

**PCB Suppliers**
ETI magazine does NOT supply PCBs or kits but we do issue manufacturing permits for companies to manufacture boards and kits to our designs. Contact the following companies when ordering boards.

Please note we do not keep track of what is available from who so please don't contact us for information on PCBs and kits. Similarly do not ask PCB suppliers for help with projects.

K.S.K. Associates, P.O. Box 266, Milton, Ont. L9T 4N9.
B—C—D Electronics, P.O. Box 6326, Stn. F, Hamilton, Ont., L9C 6L9.
Wentworth Electronics, R.R.No.1, Waterdown, Ont., L0R 2H0.
Danocinths Inc., P.O. Box 261, Westland MI 48185, USA.
Arkon Electronics Ltd., 409 Queen Street W., Toronto, Ont., M5V 2A5.
Beyer & Martin Electronic Ltd., 2 Jodi Ave., Unit C, Downsview, Ontario M3N 1H1.
Spectrum Electronics, 14 Knightswood Crescent, Brantford, Ontario M3R 7E6.

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Electronics Today International, Unit 6, 25 Overlea Blvd., Toronto, Ontario, M4H 1B1.

# for your information

## New Digital Multimeter

B&K-Precision have just introduced their 3½ digit, auto or manual ranging digital multimeter, model 2807. Meeting a wide variety of applications, the 2807 is a full function, handheld DMM that provides 0.5% DCV accuracy, overload & transient protection and convenient single rotary switch. Among other features, this DMM has a wide AC & DC voltage measurement range as well as a varied Ohm range.

B&K-Precision is represented in Canada by Atlas Electronics Limited, 50 Wingold Avenue, Toronto, Ontario, with branch offices in Montreal, Ottawa, Winnipeg, Calgary, and Vancouver.



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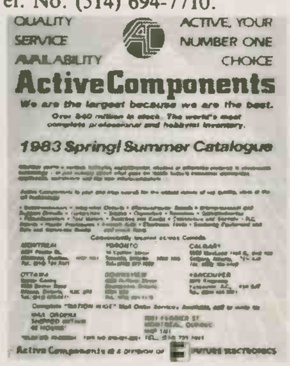
**LIABILITY**
While every effort has been made to ensure that all constructional projects referred to in this magazine will operate as indicated efficiently and properly and that all necessary components are available, no responsibility whatsoever is accepted in respect of the failure for any reason at all of the project to operate efficiently or at all whether due to any fault in the design or otherwise and no responsibility is accepted for the failure to obtain component parts in respect of any such project. Further no responsibility is accepted in respect of any injury or damage caused by any fault in design of any such project as aforesaid.

**Editorial Queries**
Written queries can only be answered when accompanied by a self-addressed, stamped envelope. These must relate to recent articles and not involve the staff in any research. Mark such letters ETI-Query. We cannot answer telephone queries.

## New Catalogue

Active Components newly revised and illustrated 80-page Spring/Summer catalogue is now available. In it you'll find the most complete selection of semiconductors, memories and microprocessors, passive electronic components and microcomputer systems and peripherals. For a free copy contact: ACTIVE COMPONENTS, 237 Hymus Blvd., Pointe Claire, Quebec H9R 5C7 Tel. No. (514) 694-7710.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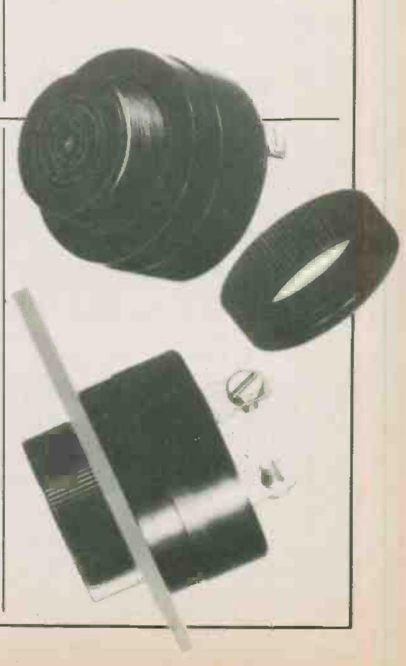
**Heathkit's Spring/Summer 1983 Catalogue has been released and is available from Heathkit Electronic and Computer Centres in Vancouver, Edmonton, Calgary, Winnipeg, Mississauga, Ottawa and Montreal or from Heath Company, 1020 Islington Ave., Toronto, Ont. M8Z 5Z3. Telephone (416) 232]2686.**

## Electronic Buzzers

Star Micronics announces a new series of panel-mount electronic buzzers. The FMB Series is available in two voltage ranges 4-9 Volts and 8-16 Volts. The FMB has a powerful 94 dB signal available either in continuous or pulsing tones. Terminations are .250" quick-disconnect tabs. The series FMB is ideal for any warning system such as security, process controls, computer peripherals and medical equipment.

For further information, request from Doug Pettifer, Lenbrook Electronics, 111 Esna Park Drive, Unit 1, Markham, Ontario. L3R 1H1. Telephone (416) 477-7722.



# Smith-Corona introduces the first printer with real character at the unreal price of $1095.*


## The Smith-Corona Daisy Wheel Printer

Until now, if you wanted to include a reasonably-priced printer as part of your computer or word processing system, you had to use a dot matrix printer. Daisy wheel printers were just too expensive.

Not anymore. Now Smith-Corona* offers a daisy wheel printer at such an incredibly low price, you can't afford *not* to include it. That means that even the smallest installation or business can now have letter quality printing capabilities at every work station.

The Smith-Corona printer operates with micro-processor-controlled daisy wheel technology, and is available with industry standard serial or parallel data interfaces.

Best of all, it produces results identical to those of our very finest office typewriters – printing with real character. So it can be used to create letters or documents that have to look perfect. As well as financial statements, inventory reports, direct mail campaigns – anything that requires quality printing.

And it's easy to use – just turn on the power, load the paper and away it goes. (It works equally beautifully with letterhead bond or fanfold paper.) There are drop-in ribbon cassettes and a choice of easy-to-change, snap-on daisy print wheels for a variety of fonts.

So why not get your hands on a real bargain: letter-perfect printing at an amazingly low price. Because, thanks to Smith-Corona, a printer with real character is no longer expensive.

Ask for it by name. **Smith-Corona**

DIVISION OF SCM® (CANADA) LIMITED

*suggested retail price

Please send me more information on the Smith-Corona daisy wheel printer.

Name__________________

Title__________________

Company Name__________________

Business Address__________________

City________ Prov.________ Postal Code________

Type of Business__________________

Mail coupon or call:
Education Director,
Smith-Corona
29 Gervais Drive, Don Mills, Ontario M3C 1Z1
(416) 449-0164

ETI

Circle No. 27 on Reader Service Card.

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# Sinclair ZX81 Computer Etc . . .

## Assembled $69.00

## ZX81

**The 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: 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 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 FOR/NEXT loops. *Randomize function. *Programmable in machine code. *Cassette LOAD and SAVE with named programs. *1K-byte RAM expandable to 16K. *Full editing facilities. *Able to drive the new Sinclair ZX Printer (to be available shortly).

**If you own a ZX80. . .**
The new 8K BASIC ROM as used in the ZX81 is available as a drop-in replacement chip. (Complete with new keyboard template and operating manual). With the exception of animated graphics, all the advanced features of the ZX81 are now available on your ZX80 — including the ability to drive the Sinclair ZX Printer.

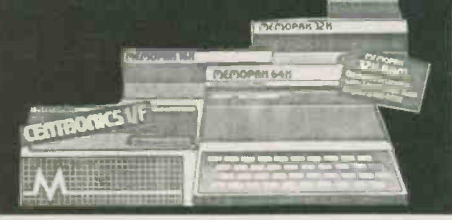
Sinclair's new 8K Extended Basic offers features found only on computers costing three or four times as much. *Continuous display, including moving graphics. *Multi-dimensional string and numerical arrays. *Math and scientific functions accurate to 8 decimals. *Unique one touch entry of "key words" (i.e. basic and system commands). *Automatic syntax error detection. *Randomize function. *Built-in interface for ZX Printer. *Connects to standard TV and cassette recorder. *164 page manual included. *Power supply (9V at 650 ma) optional for $14.95. *1K of memory is included.

## $149.00

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. Requires 9 volts, 1.2 amp power supply (option extra).

Printer Paper
Single Roll C751 per roll . . . . . . . . . . . . 6.95
Package of 3 . . . . . . . . . . . . . . . . . . . . 16.95
Power Supply (500 mA) . . . . . . . . . . . $9.95
Power Supply (650 mA) . . . . . . . . . . . $14.95
Power Supply (1 Amp) . . . . . . . . . . . . $19.95

# Etc . . .



### MEMOPAK 64K MEMORY EXTENSION

The 64K Memopak extends the memory of the ZX81 by 56K, and with the ZX81 gives 64K, which is neither switched nor paged and is directly addressable. The unit is user transparent and accepts commands such as 10 DIM A(9000).
Breakdown of memory areas . . . 0-8K Sinclair ROM. 8-16K-This area can be used to hold machine code for communication between programmes or peripherals. 16-64K-A straight 48K for normal BASIC use. **$199.00**

### MEMOPAK 32K $139.00 and 16K $69.00 MEMORY EXTENSIONS

These two packs extend and complete the Memotech RAM range (for the time being!) A notable feature of the 32K pack is that it will run in tandem with the Sinclair 16K memory extension to give 48K RAM total.

## Memopak . . .

### MEMOPAK CENTRONICS TYPE PARALLEL PRINTER INTERFACE

Main Features — ● Interfaces ZX81 and parallel printers of the Centronics type ● Enables use of a range of dot matrix and daisy wheel printers with ZX81 ● Compatible with ZX81 Basic, prints from LLIST, LPRINT and COPY ● Contains firmware to convert ZX81 characters to ASCII code ● Gives lower-case characters from ZX81 inverse character set **$149.00**

| | | |
|---|---|---|
| POWER SUPPLY | 500ma | $14.95 |
| POWER SUPPLY | 1A | $19.95 (FOR PRINTER) |

### MEMOPAK HIGH RES GRAPHICS PACK

HRG Main Features — ● Fully programmable Hi-Res (192 x 248 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 (each takes about 6.5K RAM) ● Instant inverse video on/off gives flashing characters ● Video pages can be superimposed ● Video page access is similar to Basic plot/unplot commands ● Contains 2K EPROM monitor with full range of graphics subroutines controlled by machine code or USR function **$199.95**

## Books

| | |
|---|---|
| COMPLETE ZX81 BASIC COURSE - Inc. 2 tapes | 39.95 |
| NOT ONLY 30 PROGRAMS: 1K | 16.95 |
| MACHINE LANGUAGE MADE SIMPLE | 19.95 |
| UNDERSTANDING ZX81 ROM | 19.95 |
| T/S 1000: PROGRAMS, GAMES and GRAPHICS | 16.95 |
| LEARNING T/S BASIC | 23.95 |
| THE BASIC HANDBOOK | 29.95 |
| 49 EXPLODING GAMES | 16.95 |
| COMPUTER FOR KITS SINCLAIR EDITION | 8.95 |
| MASTERING MACHINE CODE ON YOUR ZX81 | 24.95 |
| T/S 1000 USERS GUIDE (Vol 1) | 16.95 |
| EXPLORERS GUIDE TO THE ZX81 | 16.95 |
| ZX81 POCKET BOOK | 16.95 |
| GETAWAY GUIDE | 16.95 |
| GETTING AQUAINTED WITH YOUR ZX81 | 16.95 |

## Hardware

| | |
|---|---|
| ZX81 Ass. | 69.00 |
| ZX Print | 149.00 |
| 64K - RAM (Memotech) | 199.00 |
| 32K RAM (Memotech) | 139.00 |
| 16K RAM (Memotech) | 69.00 |
| 16K RAM (Sinclair) | 59.00 |
| 16K RAM (Kit no PC board) | 49.00 |
| Power Supply (650 M.A.) | 14.95 |
| Power Supply (1 AMP) | 19.95 |
| Keyboard (uncased) - 47 Keys, Assembled no soldering req. | 109.95 |
| Metal Case for above | 29.95 |
| Memopak High Res. Graphics Pack | 199.95 |
| Memopak Centronics Type Parallel Printer Interface | 149.00 |
| Memopak ZX81 Keyboard | 139.00 |
| Memo Calc | 79.95 |

* Interface for any serial printer & 4 cassette recorders; includes plugs, cords and a detailed manual.

## CP-100-A Seikosha Graphic Printer

## $450

- 5x7 Dot Matrix
- 8 Bit ASCII
- Parallel Printer
- 80 Columns

Interface Cards & Cable For Apple II . . . . . . . . . . . . . . . . . . . $119.00
Memotec Interface for Sinclair $149.00 Cable $35.00

## Electrohome Monitors & Accessories

| | | |
|---|---|---|
| EDM926/B&W | 9" Black & White monitor | $159.50 |
| EDM926/P31 | 9" P31 Green Monitor | $169.50 |
| EDM1226/B&W | 12" Black & White Monitor | $179.50 |
| EDM1226/P31 | 12" P31 Green Monitor | $189.50 |
| ECM1302-1 | 13" Color RGB Monitor | $389.00 |
| ECM1302-2 | 13" Color RGB Monitor Hi Rez. | $450.00 |
| I-1302 | NTSC Interface for ECM1302 for Apple II Computers (1 year warranty from Electrohome) | $ 69.50 |
| MP-1302-APL | RGB Card for Apple II or Franklin 100 | $199.00 |
| Zenith 12" Green | | $165.00 |
| A MDEC-1 Colour 13" | | $449.00 |

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## WOWIE! LOOK AT THIS! 6502 BOARDS & ACCESSORIES

**ABB-2** $55.00
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**AMB-1** $325.00
Mother Board, APPLE II Compatible, Assembled & Tested c/w Basic ROMS, 48K RAM, Made in Japan

**ABB-1** $ 45.00
APPLE II Compatible, Motherboard (no components)

**6502 Board Kit** $250.00
Includes all parts

**AEB-1** $119.00
EPROM Burner Card

**AIC-1** $99.00
Integer Card

**AEC-1** $99.00
80 Column Card

**AZC-1** $99.00
Z80A (CPM) Card

**APC-1** $99.00
Parallel Printer Card

**ASC-1** $99.00
Serial Printer Card

**ALC-1** $79.00
16K RAM (Language) Card

**AGC-1** $149.00
Graphics Parallel Printer Card

**AKB-1** $109.95
Keyboard; replacement for APPLE II

**AC-1** $79.00
Beige APPLE II Case (No keyboard)

**APS-1** $ 99.00
Switching Power Supply for APPLE II; +5V @ 5 amps, +12V @ 1 amp, −5V @ 1 amp, −12V @ 1 amp

**APS-2** $109.00
Switching Power Supply for APPLE II; +5V @ 3 amps, +12V @ 2 amps, −5V @ ½ amp, −12V @ ½ amp; c/w on-off switch & connecting wires

**AAA-2**
Disc Drive, 5¼", APPLE II Compatible, Excluding Controller Card ............................$349.00
with controller $398.00

**ADC-1** $75.00
Disc Drive Controller Card for two drives; Apple II Compatible

APPLE II is a registered trade mark of Apple Computer Inc.

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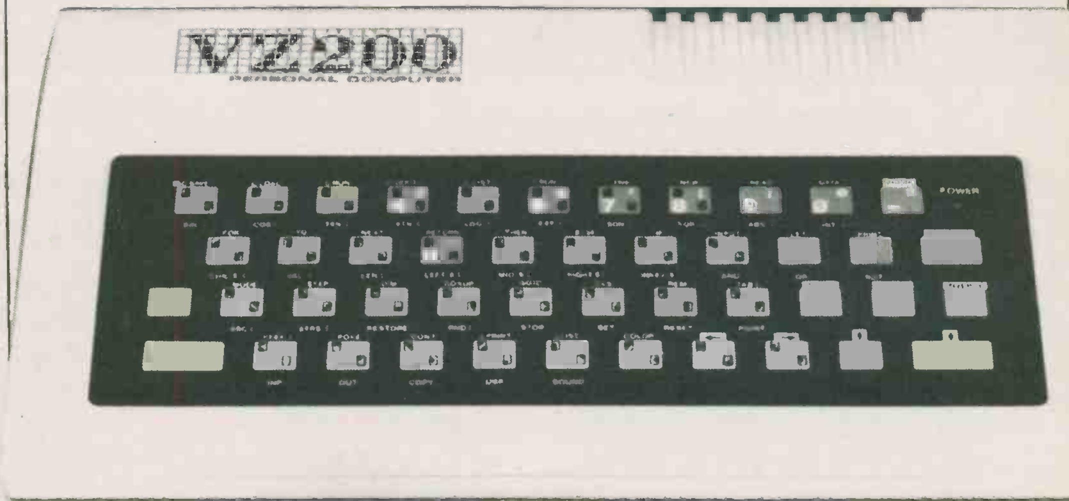
# for your information

## Low Cost Personal Computer

Video Technology introduces their new VZ200 microcomputer for under $200. It features 4K of RAM expandable to 64K, Microsoft Basic, a full-size moving-key keyboard, nine colours, single key word entry, full editing, and a peripheral expansion bus. The VZ200 is distributed in Canada by Rocelco Inc., 24 Viceroy Road, Unit 1, Concord, Ontario L4K 2L9 (416) 738-0737.




**If you're in the market for electronic components, hardware, books, computer parts, etc., a catalogue is available from J&J Electronics, P.O. Box 1437, Winnipeg, Manitoba R3C 2Z4. Send $1.00 to receive the current literature and to be placed on the mailing list for future publications.**

## Plug-In Transformers

A 20VA, plug-in, Class 2 transformer has been introduced by FROST. It plugs directly into a standard household outlet and supplies energy limited power via screw terminals. A brochure is available detailing the six most popular output voltages as well as other specifications and options. Please direct inquiries to:
Susan Blasko
L.H. FROST LIMITED
1130 8th Line
Oakville, Ontario
L6H 2R4.

## Communications Panels

From one communications panel you can dial, talk, and conference on POTS/Keyset lines, interbay trunks, and 4-wire test trunks. The new WILTRON 9820A and 9821 Communications Panels can outdial using dial-pulsing (DP), MF, or DTMF. The Model 9821, in addition, features a repertory dialer that stores sixteen 36-digit numbers and a 12-digit LED readout that displays the number dialed and the time of day.

Both the 9820A and 9821 provide the flexibility needed for test-position communications. A built-in speaker is included for monitoring test circuits or telephone lines. The 4x4 keypad provides all MF/DTMF tone pairs, including those used for coin collect/return and TSPS and CAMA trunks. For operator trunks, a fast-dial function provides 20 pps pulsing. Front-panel controls allow easy adjustment of MF/DTMF level, and the headset output has independent receive and transmit level adjustment. For additional information, contact: Wiltron Instruments Ltd., Suite 2, 880 Lady Ellen Place Ottawa, Ontario, K1Z 5L9. Telephone: (613) 725-1006.

# Designing NDFL Amps

PROJECT

**The use of nested differentiating feedback loops (NDFLs) is a new technique for reducing audible-frequency distortion in an amplifier to a vanishingly low level. As the name implies, NDFLs rely on negative feedback, but they use it in a new way. Edward M. Cherry explains the theory involved.**

IN ORDER TO understand just how far the new NDFL technique can improve an amplifier, we first need to know the fundamental limits to the reduction of distortion that can be achieved with conventional techniques. To begin with, we survey familiar negative-feedback theory.

Figure 1 is a block diagram of an amplifier with negative feedback. In this diagram, the forward path corresponds to the amplifier before feedback is applied, and its gain is traditionally designated by the Greek letter $u$. The feedback network returns a fraction $B$ of the output to the input circuit, where it is in some way subtracted from the true input to provide the actual input to the forward path.

In many practical amplifiers, the subtraction is accomplished by applying the input and feedback signals to the two inputs of a balanced differential first stage of the forward path. Figure 2 is an outline practical circuit. In this circuit the feedback factor $B$ is the attenuation of the network comprising $R_{F1}$ and $R_{F2}$

$$\beta = \frac{R_{F1}}{R_{F1} + R_{F2}}$$

A typical value for an audio power amplifier might be 1/20. The forward-path gain $u$ in Fig. 2 corresponds to gain from input to output when the feedback network is removed. A typical value for a simple audio power amplifier might be 1000.

For Fig. 1, the overall closed-loop gain A is given precisely by

$$A = \frac{\text{Output}}{\text{Input}} = \frac{\mu}{1 + \mu\beta}$$

The quantity $uB$ is called the loop gain. Physically, loop gain is the gain that would be observed if the feedback 'loop' in Fig. 1 was cut at some point, a signal was injected into one side of the cut, and the resulting signal at the other side of the cut was measured.

If the values of $u$ and $B$ are such that loop gain is small compared with unity, the closed-loop gain is very nearly equal to the forward path gain (that is, the gain without feedback)

$$A \to \mu$$
$$\mu\beta \ll 1$$

However, if loop gain is large compared with unity, the closed-loop gain approaches the reciprocal of the feedback factor and becomes almost independent of the forward-path gain

$$A \to 1/\beta$$
$$\mu\beta \gg 1$$

The quantity $1/B$ is often called the demanded gain, as it is the value the overall closed-loop gain would take in ideal circumstances.

As a numerical example, if we substitute the above values $u$ = 1000 and $B$ = 1/20 into Equation 2, the gain of our 'typical' audio power amplifier works out as A = 19.6. The approximate Equation 4 predicts A  20, within 2% of the correct answer.

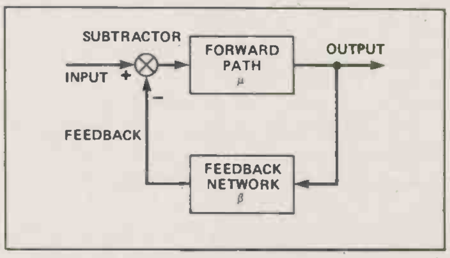



**Fig. 1 Block diagram of a feedback amplifier.**

The quantity $1 + uB$ occurs often in feedback theory. It is called the return difference F.

$$F = 1 + \mu\beta$$

Physically, return difference has the significance

$$F = \frac{\text{forward-path gain}}{\text{closed-loop gain}}$$

For values of loop gain greater than about 10, loop gain and return difference are almost equal — in our 'typical' example the values are 50 and 51 respectively.

Simplified treatments of feedback theory show that, if the distortion generated in the forward path (that is, the amplifier without feedback) at a particular output signal amplitude is $D_u$, then the resulting closed-loop distortion $D_A$ at the same output signal amplitude is

$$D_A = D_\mu/F$$

Distortion is improved when feedback is applied to an amplifier by a factor equal to the return difference. In our 'typical' amplifier, F = 51; if the distortion without feedback happened to be 10%, then feedback should reduce the distortion to 0.196%.

More rigorous treatments of feedback theory show that Equation 7 is no more than a poor approximation to the truth. In the first place, real amplifiers are far more complicated than Fig. 1 suggests, because several different feedback paths (not all intentional!) can be identified. For example, the collector-base capacitances of transistors inevitably provide some unintended feedback at high frequencies. There is a very real problem in interpreting just what loop gain and return difference mean when there is more than one feedback loop. Once the correct interpretation is established, return difference invariably turns out to be a function of frequency, and the reduction of distortion corresponding to Equation 7 depends on the value of return difference at the frequency of the distortion, not the frequency of the input. Feedback therefore, does not reduce all distortion components equally.

Finally, it is found that the closed-loop distortion of an amplifier can contain new components that were not present in the distortion that existed in the forward path before feedback was applied. These new distortion components initially increase as loop gain is increased, but they fall away again towards zero as loop gain is made large.

Despite all these complications, the fact remains that adequate negative feedback, properly applied, does reduce distortion. Why, then, do amplifier designers not simply apply some arbitrarily large amount of feedback and reduce amplifier distortion to the vanishing point?

## TIM, IIM, PIM, . . .

In the last 10 years or so, readers of audio magazines have been made aware of a conjecture that goes something like this:

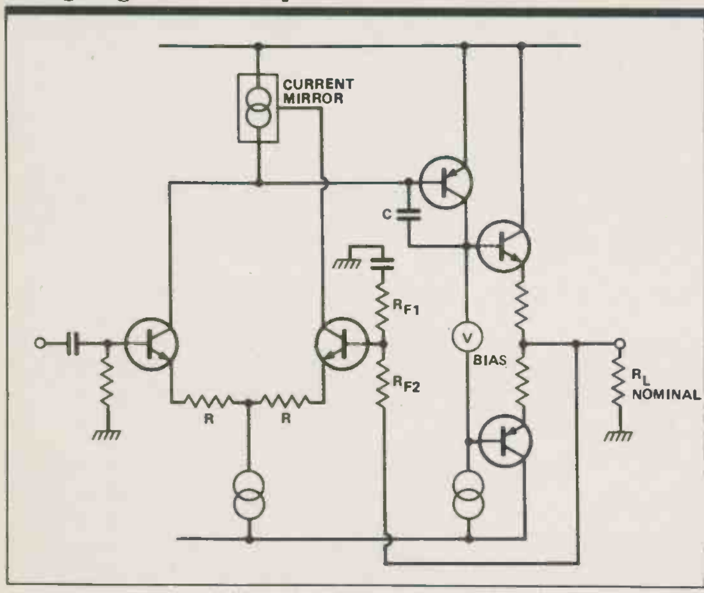



**Fig. 2 Outline circuit of an audio power amplifier.**

"Harmonic distortion and the usual intermodulation distortion decrease with increasing feedback. Transient intermodulation distortion (TIM) increases with increasing feedback, and is approximately directly proportional to the feedback. Therefore, there is an optimum value for the feedback at which the subjective distortion sensation is least. This optimum feedback is unlikely to exceed about 20 dB."

More recently, there has been conjecture that heavy overall feedback should be applied with caution if interface intermodulation distortion (IIM) is to be avoided. An amplifier should provide a low open-loop output impedance so that the need for feedback-generated loudspeaker damping is minimised.

There has also been conjecture that negative feedback, which reduces the usual intermodulation distortion, may increase phase intermodulation distortion (PIM) by converting amplitude non-linearities into phase non-linearities.

Unequivocally, none of these conjectures has any basis in the new NDFL amplifiers. As an aside, there is a substantial body of opinion that none of these conjectures has any basis, full stop.

## Instability And Oscillation

A fundamental limit to the amount of feedback that can be applied to an amplifier is set by the onset of instability and oscillation.

If the magnitudes of the forward-path gain and demanded gain of the idealised Fig. 1 are plotted versus angular frequency *w* (in radian/second) on logarithmic scales, the resulting graph looks something like Fig. 3. The 3 dB bandwidth of the amplifier without feedback is $1/r_u$, and the gain-bandwidth product (at which gain drops to unity) is $1/r_1$.

Because the graph is on logarithmic scales, the separation between the curves of forward-path gain and demanded gain is the loop gain (remember then, to divide two numbers, you subtract their logarithms; if you divide *u* by $1/B$, you get *uB*). The magnitude of loop gain falls to unity at the frequency $1/r_x$ where the curves intersect and their separation is zero (remember that the logarithm of unity is zero).

By a similar argument, return difference is the separation between the curves of forward-path gain and closed-loop gain, as indicated in Fig. 3.

We could make a similar graph to Fig. 3, showing the phases of *u* and $1/B$. Again, the phase of loop gain would turn out to be the separation between the two curves. However, there is a remarkable piece of mathematics due to Bode, who used a transformation evolved by Hilbert (1862-1943), which shows that there is a relation between the magnitude and phase of the response of any linear system. Subject to some qualifications, our proposed graph of the phases is completely predictable from Fig. 3 and contains no new information.

As an example, many readers will know that, if the forward-path in Figs. 1 and 3 has a high frequency cut-off rate variously described as single pole, 20 dB/decade, or 6 dB/octave, then its phase shift is 45° at the 3 dB cut-off frequency $1/r_u$, and is asymptotic to 90° at very high frequencies.

In 1932, Nyquist applied a theorem which dates back to Cauchy (1789-1857) to drive the condition for a feedback amplifier to be stable and free from oscillation. If a polar plot is made of the magnitude and phase of return difference as frequency is varied, a vaguely 'snail-shaped' curve results. Such a polar plot is called a Nyquist diagram. Subject again to some qualifications, the stability criterion for a feedback amplifier is that its polar plot of return difference should not enclose the origin. Figure 4 shows one example each of a stable situation and an unstable situation.

Because the phase of return difference can be predicted from Fig. 3 via Bode's result, a Nyquist diagram can also be constructed from Fig. 3 and the onset of instability can be predicted. In 1945 Bode showed that Nyquist's criterion could in fact be expressed in terms of the gradients of the curves in Fig. 3, thereby eliminating the work of finding the phase explicitly and plotting the Nyquist diagram. Bode's exact rule is complicated, but a useful paraphrase is

"If in graphs such as Fig. 3 the separation between the forward-path gain and demanded gain decreases toward zero at a rate not exceeding 30 dB/decade, the amplifier is unlikely to oscillate."

This paraphrase makes no allowance for the tolerances on components. It assumes, in effect, that everything about the forward path is well known and constant. In the audio context, the paraphrase takes no cognizance of the fact that the capacitance of the leads that connect an amplifier and loudspeaker is anything but well known. A more conservative rule, apllicable to the audio context, is therefore

In graphs such as Fig. 3, the separation between the forward-path gain and demanded gain should not decrease towards zero at a rate exceeding 20 dB/decade."

The practical consequence is that the forward path of an audio amplifier with

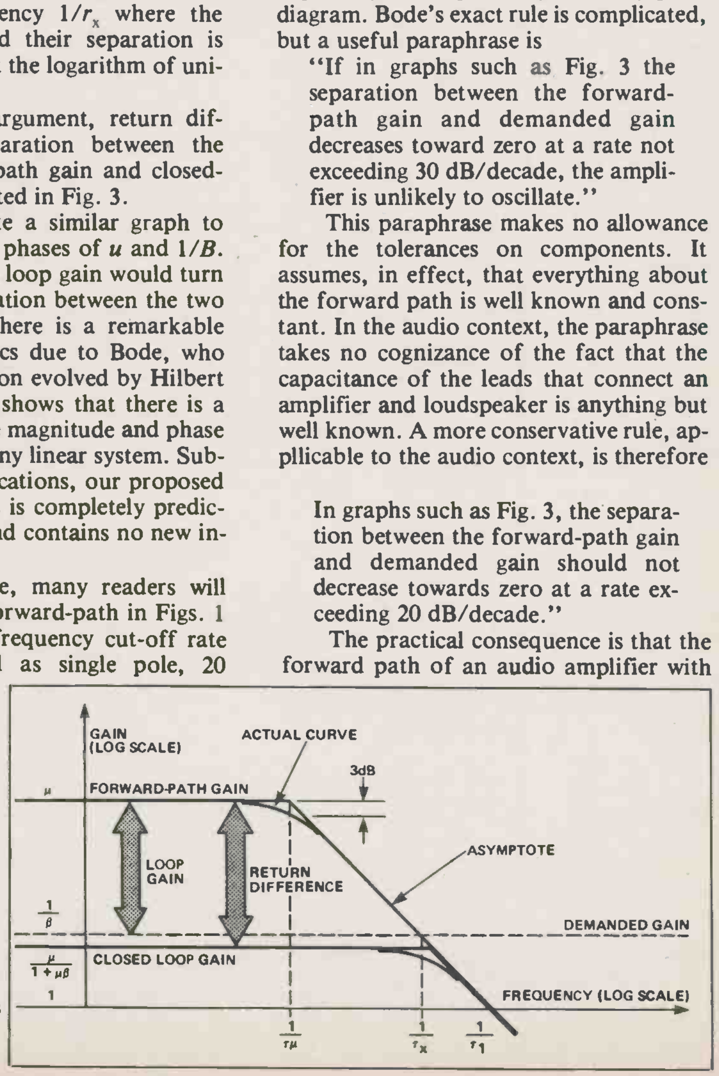



**Fig. 3 Logarithmic plots of gain versus frequency for Fig. 1.**

conventional resistive feedback should have a single dominant pole which sets the fall-off of gain at frequencies above $1/r_u$. The second and subsequent poles should lie at frequencies substantially above $1/r_x$ (the frequency where the separation reaches zero), because each pole contributes a 20 dB/decade downwards slope to the graph of forward-gain path.

## Maximum Available Feedback

In Fig. 2, the first stage is a differential amplifier with a current mirror at its output; the input and feedback signals are applied to the two bases to perform the subtraction process of Fig. 1. The second stage provides a large voltage gain, and the lag compensating capacitor C provides the dominant pole of the forward path corresponding to $1/r_u$ in Fig. 3. The third

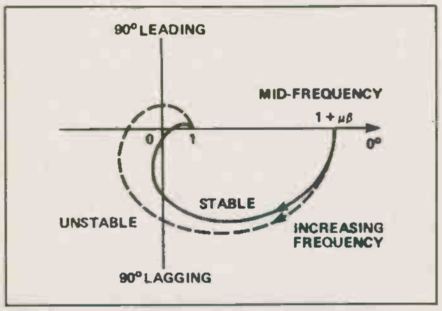



**Fig. 4 Nyquist's stability criterion. The curves are polar plots of return difference for changing frequency.**

stage is a complementary class-B emitter follower whose function is to transfer the output voltage from the second stage to the loudspeaker load. In practice, the transistors in the second and third stages are often Darlingtons, and the input transistors are often replaced by FETs.

In any similar amplifier, there is at least one pole associated with the finite transit time of electrons through each transistor. The transit time for typical small-signal transistors is a fraction of a nanosecond, but for power transistors of the ubiquitous 2N3055 class the transit time may be as long as a few tenths of a microsecond. Thus, the output stage of Fig. 2 may have a pole in the vicinity of 1 MHz.

As we saw in the previous section, the unity-loop-gain frquency $1/r_x$ in Fig. 3 must be substantially less than the frequency of all poles except the dominant pole $1/r_u$ if an amplifier is to be stable. If the power transistors are of the 3055 class, then no matter how fast the other transistors may be, there is going to be one pole at about 1 MHz. Therefore, $1/r_x$ must be chosen to correspond to something like 200 kHz. Even with more modern power transistors, $1/r_x$ is restricted to about 1 MHz. The art of designing a stable power amplifier involves choosing the lag compensating capacitor C such that $1/X_X$ is appropriate to the transistors actually used.

The geometry of Fig. 3 is such that, no matter how $u$, $B$ and $r_u$ are separately chosen, the return difference F($w$) at any angular frequency $w$ cannot exceed

$$F(\omega) \leqslant 1/\omega\tau_x$$

Thus, if $1/r_x$ is designed to correspond to 200 kHz, return difference at 20 kHz cannot exceed 10 (=20 dB), and cannot exceed 200 (=46 dB) at 1 kHz. An amplifier that boasts 80 dB of feedback (F=10,000 at low frequencies) must have $1/r_u$ corresponding to about 20 Hz; return difference must begin falling above 20 Hz, and the former values at 1 kHz and 20 kHz (46 dB and 20 dB) still apply.

Returning now to Equation 7, the effectiveness of feedback in reducing distortion is set by the frequency of the distortion, not the frequency of the input. The audible frequency range is generally reckoned to extend to about 20 kHz and, with the foregoing constraints, return difference at this frequency cannot exceed 10. Remembering that 20 kHz is the third harmonic of 6.667 kHz, we see that feedback cannot reduce offensive odd-harmonic distortion of mid-treble input signals by more than a factor of 10. Remembering too that 20 kHz is the seventh harmonic of 2.857 kHz, we see that feedback cannot reduce crossover distortion of mid-range input signals by more than a factor of 10.

Until recently there has been no way around this problem except to increase the unity-loop-gain frequency $1/r_x$, and this demands that the frequencies of the transistor poles must be increased if stability is to be preserved. Fragile, expensive power transistors, with narrow bases to achieve short transit times, become mandatory.

## The NDFL Approach

There is, however, another solution to the stability problem. If the forward-path gain has two dominant poles, so that its gain falls at 40 dB/decade, the rate of closure between the graphs of forward-path gain and demanded gain would still be 20 dB/decade provided the demanded gain itself were to fall at 20 dB/decade. In essentials, this requires that the usual frequency-independent resistive feedback factor $B$ should be replaced by something having a frequency dependence of the form $wr_F$ (remember that the demanded gain is the reciprocal of the feedback factor). Mathematicians tell us that a linearly rising frequency response corresponds to differentiation with respect to time and, in hardware terms, a capacitive feedback network will perform just this action.

Figure 5 shows the outline of an amplifier incorporating nested differentiating feedback loops. Notice first that the forward path has been separated into a number of stages, whose mid-frequency gains are $u_1$ to $u_N$ respectively. The variable s is what mathematicians call complex frequency; for sinusoidal signals its magnitude is equal to the angular frequency $w$ of the sinusoid. Factors of the form (1 + $sr_x$ represent a frequency response that rises proportional to frequency above the frequency $1/r_x$ — that is, they represent a zero. Similarly, factors of the form $1/(1 + sr)$ represent a frequency response that falls inversely proportional to frequency above the frequency $1/r_0$ — that is they represent a pole. Thus, the stages in Fig. 5 have special frequency responses: all stages except the first have a pole at $1/r$, and all except the first and last two have a zero at $1/r_x$.

Notice also that there are differentiating feedback networks, each denoted by $ST_F$, linking the output back to various points in the forward path. The resulting feedback loops are arranged one inside another, like a nest of Chinese boxes — hence the name nested differentiating feedback loops.

The amplifier is completed by an overall resistive feedback network $B$.

If we removed all the feedback from Fig. 5, the forward-path gain would be shown in Fig. 6: constant up to the frequency $1/T_O$, then falling at an N—1)-pole rate (20(N—1) dB/decade) up

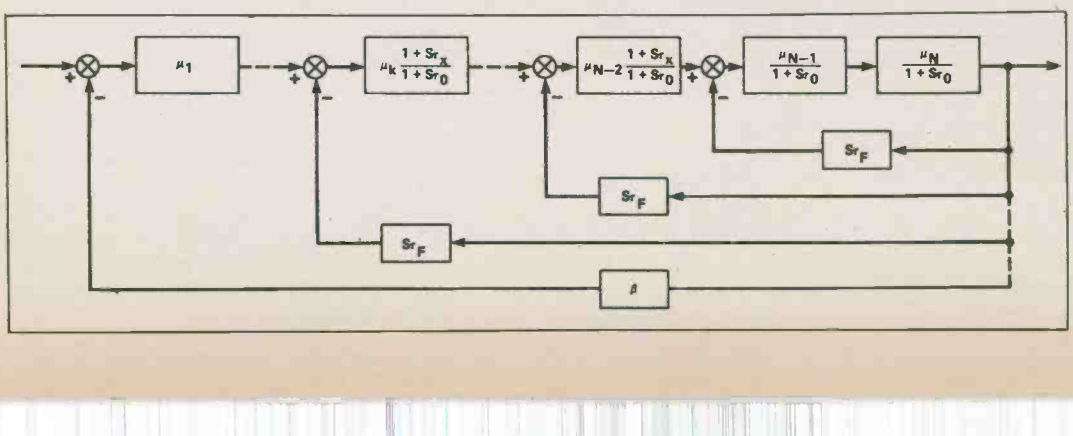



**Fig. 5 Block diagram of an NDFL amplifier.**

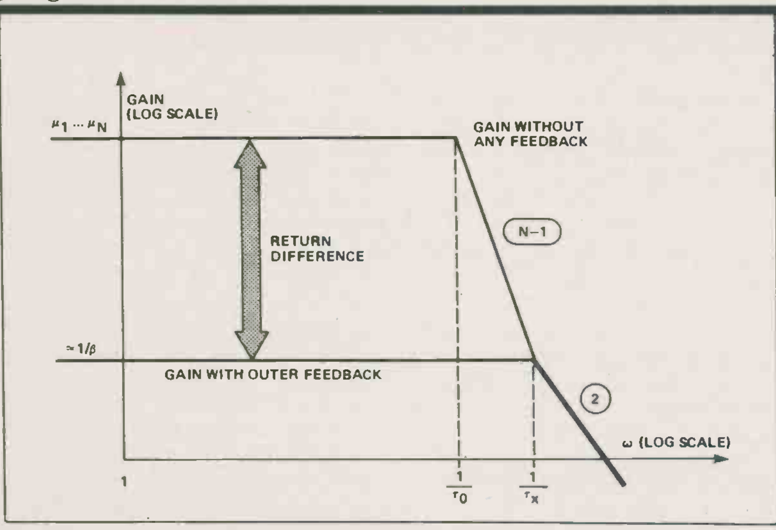



**Fig. 6 Logarithmic plots of gain versus frequency for Fig. 5.**

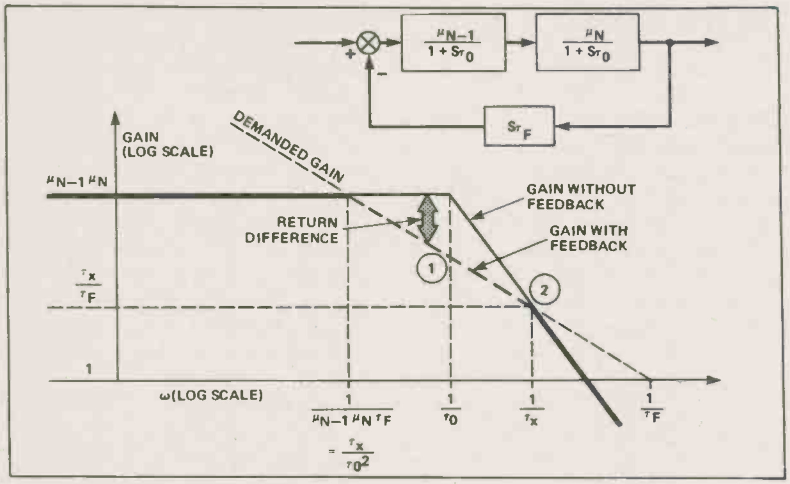



**Fig. 7 The inner loop of Fig. 5.**

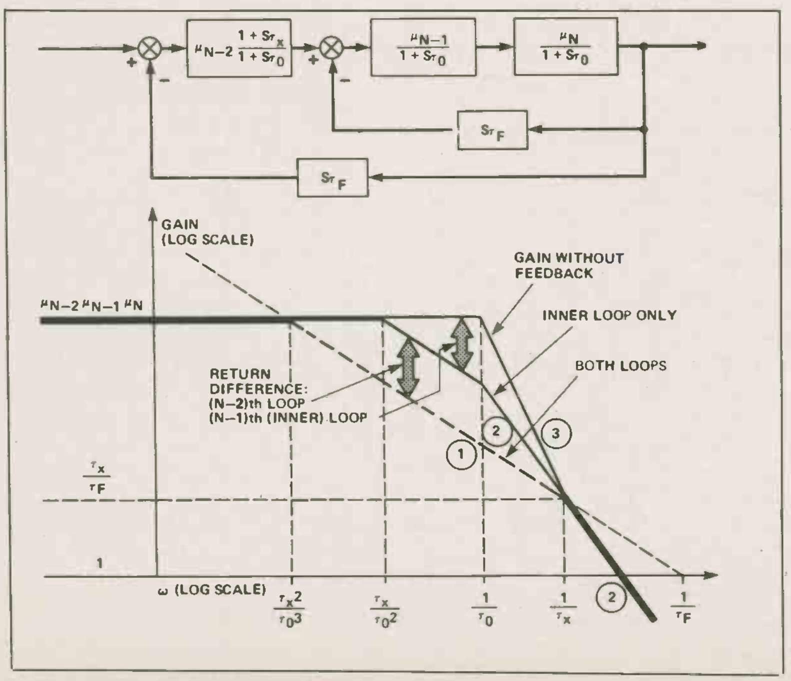



**Fig. 8 The (N-2)th loop of Fig. 5.**

to $1/T_X$, and finally levelling off somewhat to a two-pole rate (40 dB/decade).

If we now applied just the overall resistive feedback $B$, the return difference would be as shown in Fig. 6. Distortion would be reduced by a constant large amount, approximately $u_1$, $u_2 \ldots u_N B$, at all frequencies up to $1/T_O$. Choosing $1/T_0$ to correspond to 20 kHz would virtually eliminate audible-frequency distortion. But the amplifier would be unusable because of oscillation.

The rate of closure of the forward-path gain and demanded gain curves breaks the rule of 20 dB/decade. Let us see how inclusion of the nested differentiating feedback loops solves the problem.

Figure 7 shows just the last two stages and the inner differentiating feedback factor. This 'clump' is a feedback amplifier in its own right, and Fig. 7 shows its forward-path gain (that is, the gain of the last two stages without any feedback), the demanded gain, and the resulting closed-loop gain. Although the forward-path gain falls at a two-pole rate (40 dB/decade), the demanded gain falls at a one-pole rate (20 dB/decade), the demanded gain falls at a one-pole rate (20 dB/decade), and their rate of closure is 20 dB/decade. By itself, this 'clump' is stable.

Figure 8 shows what happens when we add the antepenultimate stage and another differentiating feedback factor. Again this 'clump' can be considered as a feedback amplifier in its own right. Provided we choose

$$\mu_{N-2} = \tau_0/\tau_X$$

the various gains line up as shown. The forward-path gain is the combined gain of stage (N—2) and stages (N—1) and N with their local feedback, and this is the middle solid curve in Fig. 8. The demanded gain is the dashed curve passing through $1/T_F$. Once again the forward-path gain and demanded gain close at 20 dB/decade, so the stability criterion is satisfied for this larger 'clump'.

And so it goes on. We can add more stages and differentiating feedback factors, and each time the curves line up as required for stability provided we choose

$$\mu_1\,\mu_{N-1}\,\mu_N B = (\tau_0/\tau_X)^2,$$
$$\tau_F = \mu_1\,\beta\tau_X,$$
$$\mu_K = \tau_0/\tau_X \text{ for } 2 \leq k \leq N-2.$$

Figure 9 shows the gain curves for the complete amplifier.

In designing an NDFL amplifier, the starting point is to choose the frequency $1/T_X$ so that the various transistor poles are sure to lie at substantially higher frequencies. Next choose the frequency $1/T_O$ up to which the return difference should remain constant; 20 kHz is a suitable value for audio amplifiers. After this, the circuit more or less designs itself via Equations 9-11 above.

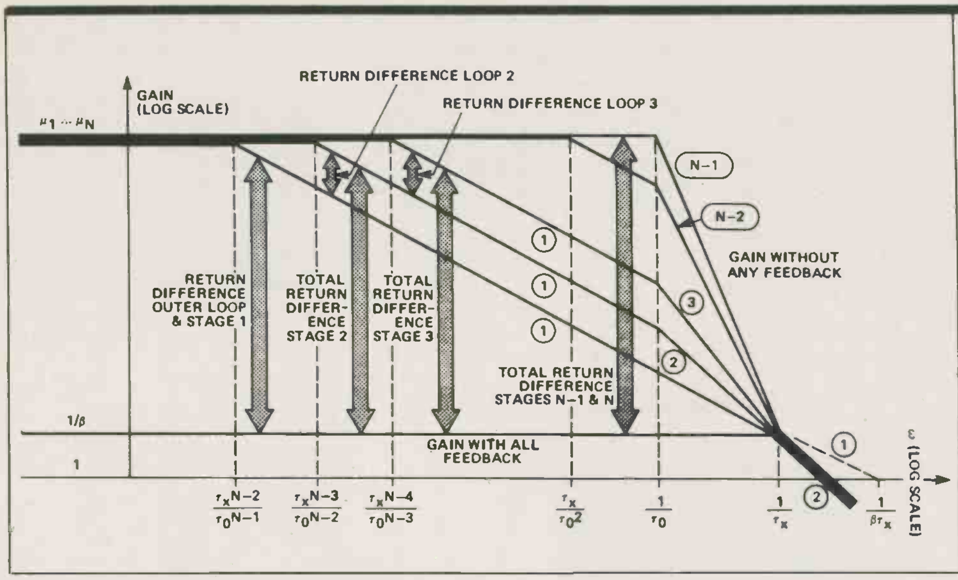



**Fig. 9 Complete plots of gain versus frequency for Fig. 5.**

## Outline Practical Circuit

Figure 10 shows how an amplifier of the basic topology of Fig. 2 can be modified to include two NDFLs.

Notice first that the lag compensating capacitor, C, in the penultimate stge of Fig. 2 has been removed in Fig. 10. In its place are two capacitors (C) linking the output back to various points in the forward path. These capacitors are the feedback networks of the nested differentiating feedback loops.

The output stage has been changed to include a modified form of Thiele's load-stabilising network. Some form of LRC filter is required to locate one of the poles correctly, and with the circuit shown we get double value from the components.

The input stage itself is unchanged, but an inexpensive small capacitor in the overall feedback network *B* can be used to correct the group delay and improve the reproduction of transient waveforms.

Another essential addition is an amplifying stage between the two nested differentiating feedback factors. This rather peculiar circuit (which dates back to Rush in 1964) seems largely to have been forgotten. It uses one NPN transistor and one PNP to provide a well-defined gain (13).

As already suggested, once the demanded gain $1/B$ and the critical frequency $1/T_X$ are chosen, the circuit almost designs itself. The equations are:

$$\frac{R_{F1}}{R_{F1} + R_{F2}} = \beta,$$

$$RC = \beta\tau_x\,,$$

$$R_Y C_Y = \tau_x\,,$$

$$\tau_L = (\sqrt{3} - 1)\tau_x\,.$$

All stage gains and poles and zeros automatically look after themselves.

Figure 11(a) shows the 5 kHz square-wave response of Fig. 10 as built from 5%-tolerance resistors, 20%-tolerance capacitors, and unselected production transistors. Evidently the circuit is 'designable'; Equations 12-15 really do predict component values for good transient response.

A nice feature of the modified Thiele circuit in Fig. 10 is that, when the load is made capacitive (a well-known source of high-frequency oscillation in amplifiers), the voltage waveform at the FEEDBACK POINT is the waveform the amplifier would have delivered into its nominal resistance load. Figures 11(b) and (c) illustrate this; the violent ringing in Fig. 11(b) is simply an LC resonance between the filter inductor and the load capacitance, and is in no way indicative of approaching instability.

Figure 12 shows details of the 1 kHz sinusoidal response under overdrive conditions. Note the quick, clean recovery.

An amplifier has been built in which the circuit can be switched from Fig. 2 to Fig. 10, to illustrate the improvement in performance of adding two NDFLs. Figure 13 compares the measured third-harmonic distortions of 1 kHz. Notice how the distortion of Fig. 10 drops away to below three parts per million at small signal amplitudes. Such behaviour is more typical of class-A amplifiers than class-B amplifiers, and may account for the clean sound of NDFL amplifiers.

Crossover distortion associated with incorrect bias of the output stage is one of the most audibly annoying forms of distortion. Audio amplifiers based on Fig. 2 sometimes have a type of crossover distortion that does not show up in normal measurements. Correct biasing of the output stage relies on close tracking of the thermally - compensated biasing device and the power transistors. At best the biasing device can be thermally bonded to the power transistor case. More usually it is bonded to the heatsink, but there is no way it can simultaneously sense the actual junction temperatures of all the power transistors. Under rapidly-fluctuating dynamic signal conditions, the junction

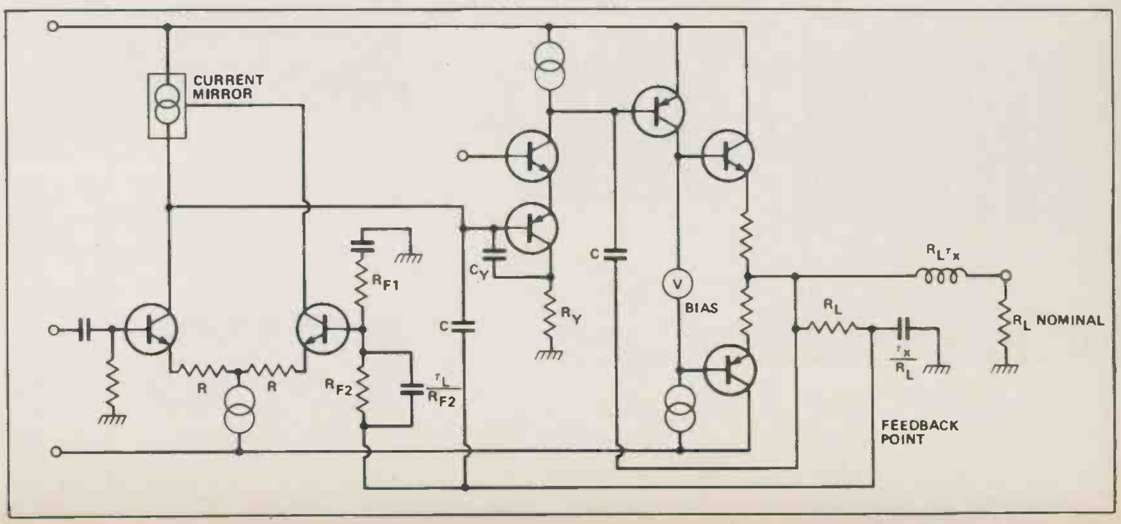
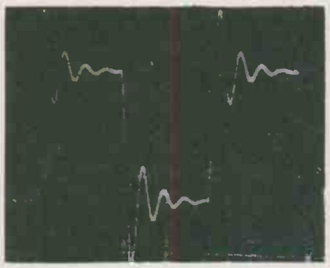
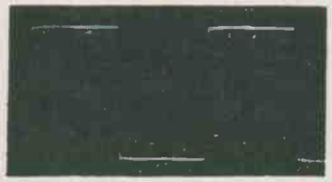



**Fig. 10 Outline circuit for an NDFL amplifier.**

(a) 8 ohm resistance load.



(b) 8 ohm and 2uF parallel load.



(c) waveform at feedback point for (b).

Fig. 11 5 kHz square wave response of Fig. 10.

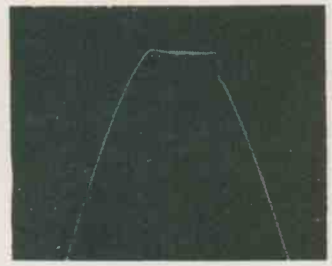


Fig. 12 Detail of output waveform from Fig. 10 under overdrive.

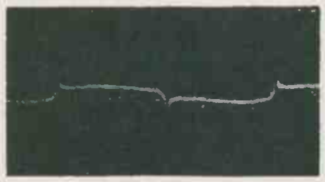
temperatures may be wildly different from each other and from the case or heatsink temperatures, and therefore the biasing may be wrong.

Figure 14 compares the static crossover distortion of Figs. 2 and 10 when the bias is deliberately set 0V5 too low. Dynamic mistracking of the biasing circuit should not introduce audible crossover distortion in an NDFL amplifier.

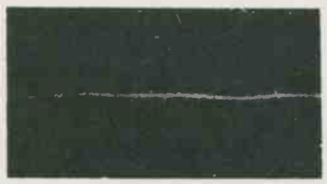
One final point. The NDFL technique maximises the return difference (and hence minimises distortion components) at frequencies up to $1/T_O$ Above this frequency the return difference falls away rapidly, and distortion rises. Choosing $1/T_O$ to correspond to 20 kHz minimises audible-frequency distortion, but does not minimise ultrasonic distortion.

For example, a common specification for audio power amplifiers is their THD at 20 kHz. The harmonics of 20 kHz lie at 40 kHz, 60 kHz, 80 kHz, and so on. All are ultrasonic (and hence inaudible) and the NDFL technique does not minimise them. A measurement of THD at 20 kHz may therefore give a quite misleading indication of an NDFL amplifier's audible performance. Valid objective tests include the SMPTE and CCIF tests for two-tone intermodulation distortion, the proposed IEC test for TIM, Cordell's proposed three-tone test for TIM and the proposed test for input-output intermodulation distortion IOD. The distinguishing feature of all these tests is that they measure the distortion at audible frequencies. ETI

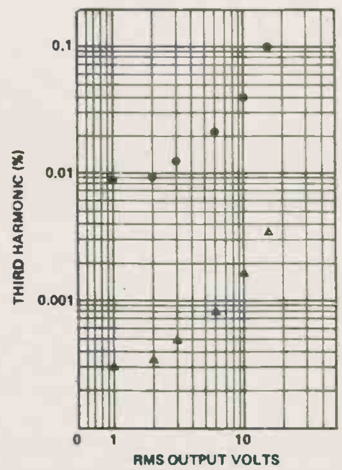
Fig. 14 2 kHz crossover distortion when bias is set wrongly.



(a) Fig. 2 (conventional amplifier).



(b) Fig. 10 (NDFL amplifier).




● FIGURE 2 (CONVENTIONAL AMPLIFIER)
▲ FIGURE 10 (NDFL AMPLIFIER)

Fig. 13 1 kHz harmonic distortion.

# 60W NDFL Amp

PROJECT

**To accompany the article on nested differentiating feedback loops, here is a practical amplifier design, presented as a module, with very low distortion. Design by Edward M. Cherry.**

THIS AMPLIFIER will perhaps be of most interest to home constructors who want to rebuild an existing system and upgrade its performance without the expense of new major components. The power output transistors employed are the well-known types MJ802 and MJ4502 which have been around for several years and have proved their reliability. Indeed, the whole design is mature and home constructors should have no difficulty in making it work.

## Grounding

In any amplifier where the basic distortion has been reduced to a few parts per million, several distortion mechanisms not ordinarily considered may become significant. One such mechanism is associated with currents circulating in the ground leads and power-supply wiring.

Figure 1 explains the origin of this distortion. The current in each power transistor of a class B stage is a half-wave rectified version of the output. The two currents, drawn alternatively from the positive and negative supplies, are equivalent to a circulating full-wave rectified current and this is basically an even-harmonic distortion of the signal output. If there is any mutual inductance between the power-supply wiring (including the grounds) and the signal wiring (also including the grounds), then an even-harmonic distortion is induced in the amplifier and feedback is powerless to correct it.

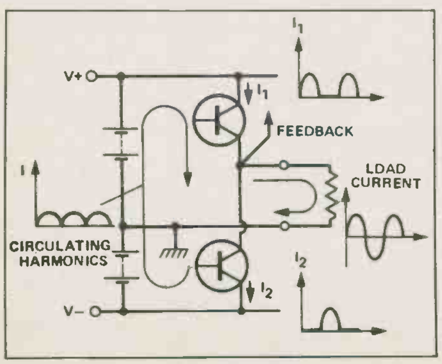



**Figure 1 Circulating even-harmonic current in a Class-B output stage.**

The circuit board has been laid out so as to minimise this effect. The areas enclosed by some tracks are critical, and home constructors making their own PCBs are cautioned to follow the layout exactly, using the accompanying foil pattern.

Note that the circuit uses three distinct ground symbols.

a)  is the *quiet ground* track on the circuit board (one per channel).

b)  is the *noisy ground* track on the circuit board (one per channel).

c)  is the metal chassis ground (there are six connections to the chassis in total).

Each channel is connected to chassis ground at two points. The input socket is connected to the chassis (rather than insulated from it), the input lead from socket to circuit board is shielded, and the quiet ground track is connected to chassis ground at the input socket via the screen. Similarly, the ground output terminal is screwed into the chassis, the leads from the circuit board to the output terminals are a twisted pair and the noisy ground track is connected to chassis ground at the output terminals via the ground output lead. The remaining two connections to chassis are in the power supply (Fig. 5).

Note that a 10 ohm resistor, R31, links the quiet and noisy ground tracks. This resistor is short circuited at low frequencies by the input shielding and neutral output wiring to chassis ground. However, the resistor takes over at high frequencies where wiring inductance become significant.

The 15*u*H filter inductors in the supply rails are also for suppressing circulating currents (R6 and R7 represent the winding resistances of L1 and L2).

This amplifier employs only two nested differentiating feedback loops and its distortion is not down to the ultimate limit. The benefit of including the filter inductors is therefore marginal. The author is not blessed with 'golden ears' and cannot hear the effect of removing the filters, although the difference is clearly measurable. The filters should certainly be included in amplifiers that use three or more NDFLs. As the inductors must be home-made, and therefore cost nothing but time, and as they do make a measurable (if small) improvement, most home constructors will probably wish to include them. Winding data is given in Table 1.

The precise values of inductance and resistance are not important — ±50% is good enough — but do not use the 1.25 mm wire from L3 as something like 0.1 ohm series resistance is essential. For a similar reason, do not parallel the 470*u*F bypass capacitors C9 and C10 with high-frequency types. Brass or steel mounting screws are perfectly satisfactory for the filter inductors, as linearity is not important.

## Critical Components

The majority of the components in this amplifier are not critical. Almost any small-signal diodes will do, such as the 1N914 and 1N4148. Q1 and Q2 should be high-gain, low-noise types — BC109 and BC549 are among the cheapest available. The others could be almost any small signal types: BC107 and BC547 are readily available NPN types, the BC177 and BC557 are suitable PNPs. The driver and output transistors should be the types shown: TIP29C and TIP30C for the drivers, MJ802 and MJ4502 for the power transistors. The biasing transistor, Q11, could be any NPN in a TO-126 pack that can be mounted on the heatsink: the TIP29C is a readily available type that would suit.

Unless the contrary is indicated on the Parts List, resistors can be standard ½ W types and the capacitors can be the lowest available working voltage. A few components, however, do require special mention. A feedback amplifier cannot be more linear than its feedback network, so the various components that constitute the feedback network should have small voltage coefficients.

Specifically:

a) The overall feedback resisitors R11 and R12 should be high-stability types, such as metal oxide or metal film;

b) C4,C6 and C8 should be NPO ceramics, not high-K types (NPO means negative-positive zero, a low-K capacitor with a very low temperature coefficient; metallised plate ceramics, for example. Silvered mica capacitors are also suitable);

c) C5 and C14 should be polycarbonate, polystyrene or polypropylene types, but not polyester (eg. mylar types);

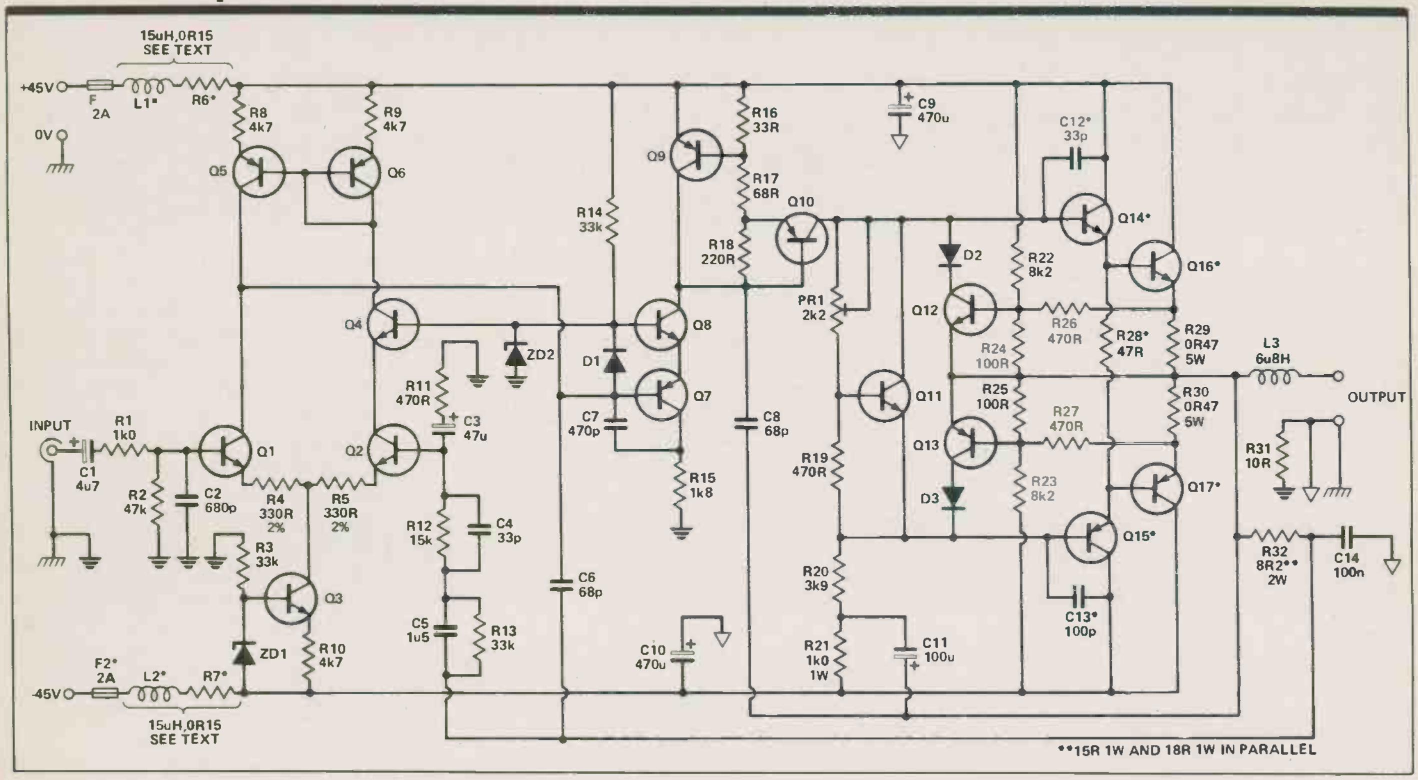



**Figure 2 Circuit diagram of the 60 W power amp. Components marked with a single asterisk are not mounted on the PCB.**

d) C3 should be an ordinary cheap aluminum electrolytic, definitely not one of the relatively expensive resin-dipped tantalum types (this is not a misprint!)

The 6*u*8 H inductor (L3) needs to be home-made. Winding data is given in Table 1. The bobbin should be mounted on the circuit board with a nylon screw; brass or steel must not be used, because of non-linear eddy current losses.

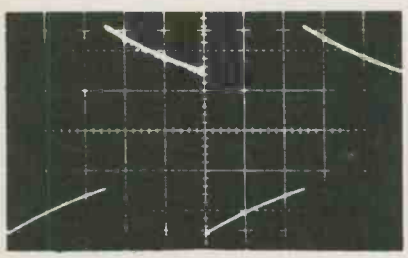


**Figure 3a Square wave response of the amp without group-delay compensation.**

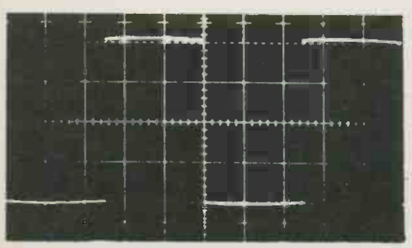


**Figure 3b Square wave response of the amp with group-delay compensation — note the improvement over Fig. 3a.**

## Construction

Assembly of the PCB is quite straightforward. It is probably best to commence by soldering all the resistors in place. Note that R32 could be either a 2 W type (not common) or two 1 W resistors (15R and 18R) in parallel. Note that the emitter ballast resistors of Q16 and Q17 (R29 and R30) should have very low inductance and if you have trouble with high frequency instability, these resistors are likely to be the culprit. The best solution may be several carbon resistors in parallel. Mount R29 and R30 a few millimeters above the board.

Assemble the diodes next, making sure you get them all the right way round. Install the links next. Follow with the capacitors. Note that C5 and C14 must be polycarbonate types and C4,6 and 8 must be NPO ceramics. None of the other ceramic capacitors should be hi-K types, as mentioned earlier. When mounting C9 and C11, see that there is three or four millimetres between the capacitor body and the adjacent 5 W resistors (R29 and R30)

The transistors may be mounted now. See that each is oriented correctly. Wind L3 next and mount it on the board. Details are given in Table 1. It is not necessary to strictly follow the former dimensions given, but the inductance needs to be close to 6*u*8 H and wound from 1.25 mm wire at least, for low resistance.

Assembly of the components mounted to the heatsink comes next. The heat-

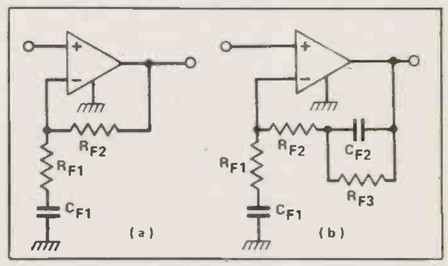



**Figure 4 Circuit for compensating low frequency group delay: (a) basic uncompensated circuit; (b) compensated circuit.**

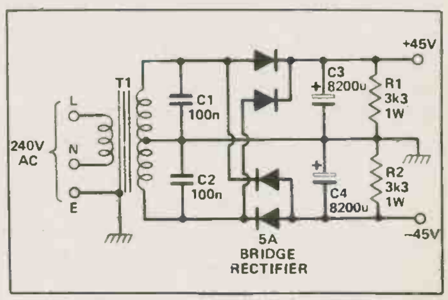



**Figure 5 Suggested PSU for the amplifier.**

sinks in the original were a standard type sold by many companies. Each heatsink has a thermal resistance to ambient of about 1°C/W, and other types could, of course, be substituted. The specified thermal resistance permits continuous operation at full power: smaller heatsinks (up to 2°C/W) could be substituted if the amplifier is to be used only for domestic sound reproduction. Use one heatsink per channel.

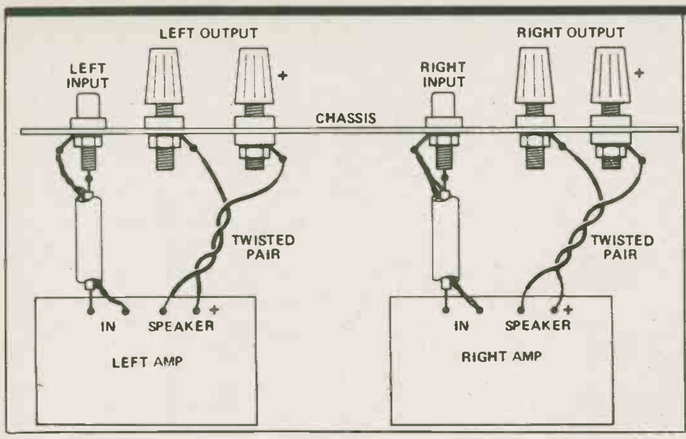



**Figure 6 Showing the general technique for connecting inputs, outputs and grounds to a stereo pair of modules.**

### HARMONIC ANALYSIS AT 6 kHz

| Harmonic | Rated output 21V9 60 W | -20 dB 2V19 600 mW |
|---|---|---|
| 2nd | 115 ppm | 40 ppm |
| 3rd | 100 | 25 |
| 4th | 32 | 15 |
| 5th | 40 | 9 |

Harmonics higher than the 3rd are ultrasonic and hence inaudible.

### TABLE 1

**Formers**
If a suitable type is not at hand, these may be turned from 25 mm diameter polystyrene rod to give 12 mm internal bobbin diameter with 7.5 mm winding space between cheeks.
**Wire & Winding L1,2**
Take two 1680 mm lengths of 0.75 mm diameter enamelled copper wire and wind onto each former leaving 20 mm or so lead length at start and finish.
**Wire & winding L3**
Take a 1190 mm length of 1.25 mm diameter enamelled copper wire and wind it onto the former. Leave 20 mm or so lead length at start and finish.

Three small components are mounted on the heatsink adjacent to the transistors to keep certain leads short: R28, C12 and C13. Construction is very much simplified if a 4-way terminal strip is installed under one of the collector mounting bolts of Q16 and a 5-way strip under one of Q17's mounting bolts. Figure 8 shows details.

The collector and emitter leads from each power transistor to the circuit board should be twisted. The base leads to Q14 and Q15 could be twisted in with the corresponding collector and emitter leads (although this is not necessary) and the base lead of Q11 can be kept separate. Note that all transistors must be insulated from the heatsink. Note also that the TIP30C specified for Q10 needs its leads dressed to fit the board.

Quiescent current in the power transistors should be set to 40-60 mA by PR1. *Be warned* that this quiescent current is almost zero until PR1 is about three-quarters of its maximum resistance, after which the current increases very rapidly; be sure that PR1 is set to *minimum resistance* when the amplifier is turned on for the first time.

A convenient way to check the quiescent current is by means of the voltage drop across R29 and R30; this should be 40-60 mV (total) for zero signal input to the amplifier.

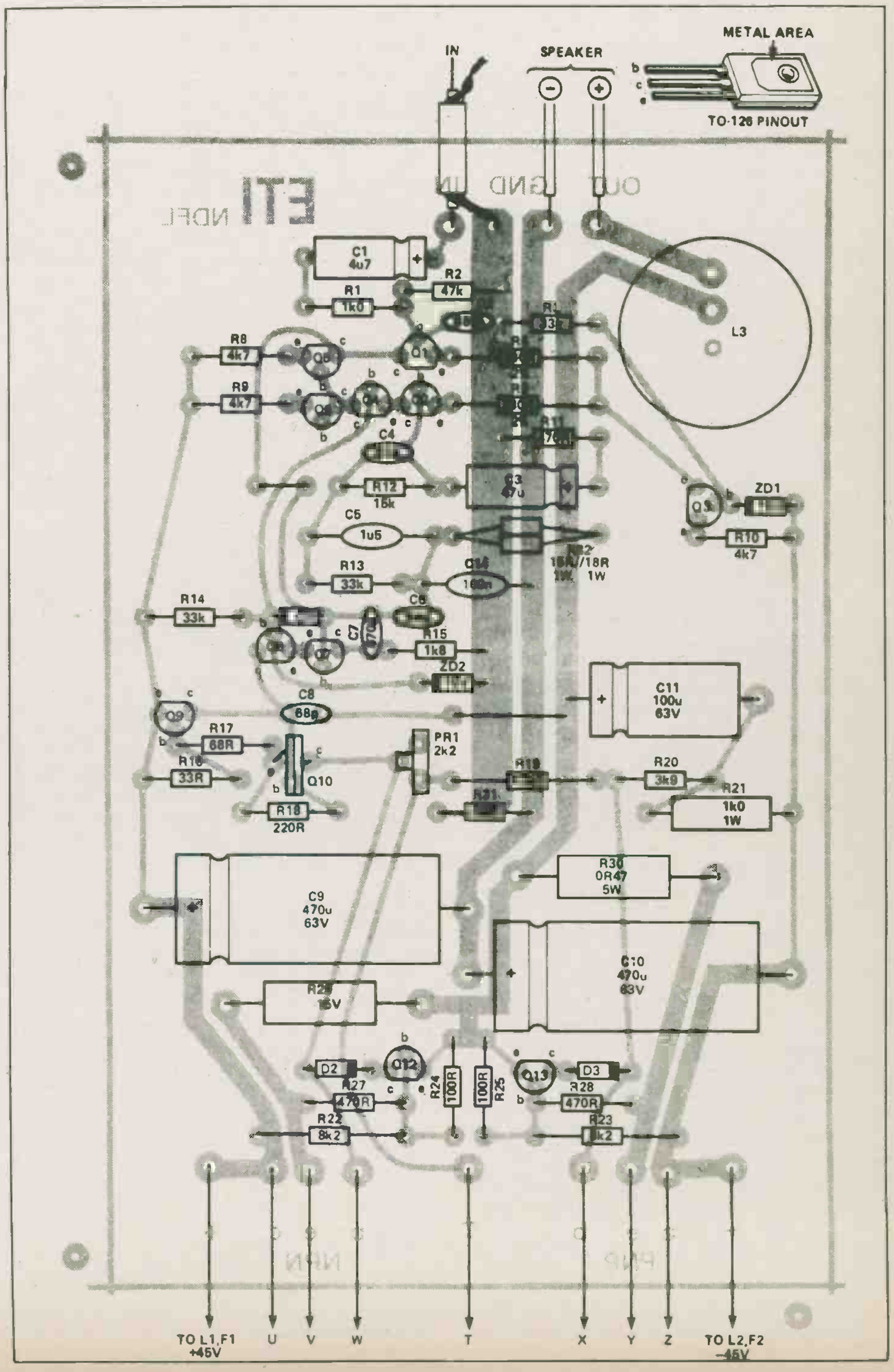



**Figure 7 Component overlay for the power amplifier.**

## PARTS LIST

**Resistors**

(all ½W, 5% except where stated)

| | |
|---|---|
| R1 | 1k0 |
| R2 | 47k |
| R3,13,14 | 33k |
| R4,5 | 330R 2% |
| R6,7 | see text |
| R8-10 | 4k7 |
| R11 | 470R metal oxide or metal film |
| R12 | 15k metal oxide or metal film |
| R15 | 1k8 |
| R16 | 33R |
| R17 | 68R |
| R18 | 220R |
| R19,26,27 | 470R |
| R20 | 3k9 |
| R21 | 1k0, 1W |
| R22,23 | 8k2 |
| R24,25 | 100R |
| R28 | 47R |
| R29,30 | 0R47, 5 W |
| R31 | 10R |
| R32 | 8R2, 2 W or 15R//18R, each 1 W |

**Potentiometer**

| | |
|---|---|
| PR1 | 2k2 miniature vertical preset |

**Capacitors**

| | |
|---|---|
| C1 | 4u7 axial electrolytic |
| C2 | 680pF ceramic |
| C3 | 47uF axial electrolytic |
| C4 | 33pF 100 V NPO ceramic |
| C5 | 1u5 polycarbonate |
| C6,8 | 68pF 100 V NPO ceramic |
| C7 | 470pF ceramic |
| C9,10 | 470uF 63 V axial electrolytic |
| C11 | 100uF 63 V axial electrolytic |
| C12,13 | 33pF 100 V ceramic |
| C14 | 100nF 100 V polycarbonate |

**Inductors**

| | |
|---|---|
| L1,2 | 15uH (see text and Table 1) |
| L3 | 6u8 H (see TAble 1) |

**Semiconductors**

| | |
|---|---|
| Q1,2 | BC109, BC549 etc. |
| Q3,4,8,12 | BC107, BC547 etc. |
| Q5-7,9,13 | BC177, BC557 etc. |
| Q11,14 | TIP29C |
| Q10,15 | TIP30C |
| Q16 | MJ802 |
| Q17 | MJ4502 |
| D1-3 | 1N4148, 1N914, etc. |
| ZD1,2 | 15 V 400 mW zener |

**Miscellaneous**

| | |
|---|---|
| F1,2 | 2 A standard fuse |

PCB; one 4-way and one 5-way terminal strip; heatsink to suit (see text); PCB stakes; bobbins for inductors; wire, etc.

## HOW IT WORKS

Figure 2 is the complete circuit of one channel of the amplifier; equations referred to in the explanation refer to last month's feature. The circuit is clearly based on Fig. 10 (in the theory article), with major parameters

$$1/B = 32.9$$
$$r_x = 800 \text{ nS}$$

The value of $B$ is set by the overall feedback resistors R11 and R12 (470R and 15k — see Equation 1). $r_x$ *is set by:*

*a)* *R4 and R5 (33R) plus C6 and C8 (68p) in conjunction with the chosen value of B* (see Equation 13);

b) R15 and C7 (1k8 and 470p — see Equation 14);

c) R32 and C14 (8R2 nd 100n) plus the 8 ohm nominal load and L3 (6u8 H);

d) R12 and C4 (15k and 33p) via the other constants in Equation 15.

The first stage requires little comment. Q1 and Q2 operate at 1.5 mA each, Q3 is a current source, Q4 is a common-base stage to equalise the quiescent voltages on Q1 and Q2; Q5 and Q6 constitute a current mirror. R1 and C2 form a 200 kHz low-pass filter against RF interference.

The current amplifier operates at 3 mA, set by R18, and it incorporates a catching diode (D1) to accelerate recovery from overdrive. The pre-driver, Q10, operates at 8 mA; Q9 protects the stage against damagingly large currents under fault conditions. Driver quiescent current is 25 mA, set by R28.

Transistors Q12 and Q13 provide short-term protection for the power transistors. Short-circuit current is limited to about 4 A, and peak signal current is limited to 7 A. Long-term protection is provided by 2 A fuses in each supply rail; these should be 'ordinary' types, rather than delay or quick-blow. In the unlikely event of transistor failure, these fuses limit the loudspeaker current to 2 A, corresponding to 32 W into 8 ohms.

The common alternative of a single fuse in the loudspeaker lead is less satisfactory: it provides less protection for the amplifier; it provides less protection for the loudspeaker as the fuse must be rated to carry the full signal current, and it introduces distortion on large-amplitude, low-frequency signals.

### Low Frequency Compensation

A feature of Fig. 2 not discussed so far is a low-frequency compensating circuit, R13 and C5.

Amplifiers of the basic circuit topology of Fig. 2 (theory article) have a group delay which is different for different signal frequencies. Some frequencies take longer or shorter times than others to pass through the amplifier. High-frequency group delay in NDFL amplifiers can be corrected, as described last month, by a small capacitor in the feedback network (See Equation 15). Errors in low-frequency group delay, in both Figures 2 and 10 (theory article) are associated with the input coupling capacitor and the capacitor in series with $R_{F1}$. Low-frequency square-wave inputs are reproduced with a 'tilt' as in Fig. 3a.

One approach to this problem is to use a truly direct-coupled amplifier, with no capacitors in series with the signal path; commercial audio power amplifiers of this type appeared in the 1970s. Unfortunately, such amplifiers are prone to drift. A significant DC voltage may appear at the output even when there is no input. Although it is possible to reduce drift in a power amplifier to an acceptable level, it is not possible with today's technology to build a system that is truly direct-coupled from pick-up input, through the RIAA network and the power amplifier.

In the last few years a generation of amplifiers has appeared which include some form of servo amplifier to correct the drift. All circuits known to the author reintroduce the problem of group delay, albeit in a lesser form.

The approach adopted in the design is to retain the coupling capacitors and thereby eliminate drift, but include a group-delay correcting circuit. Figure 4 shows the outline. Group delay is optimally compensated if:

$$R_{F3} = 2R_{RF2,} \qquad (16)$$

$$R_{F2}C_{F2} = R_{F1}C_{F1} \qquad (17)$$

Figure 3b shows the improvement in square-wave response.

Low-frequency group-delay compensation could well be included in audio power amplifiers and pre-amplifiers other than NDFL types.

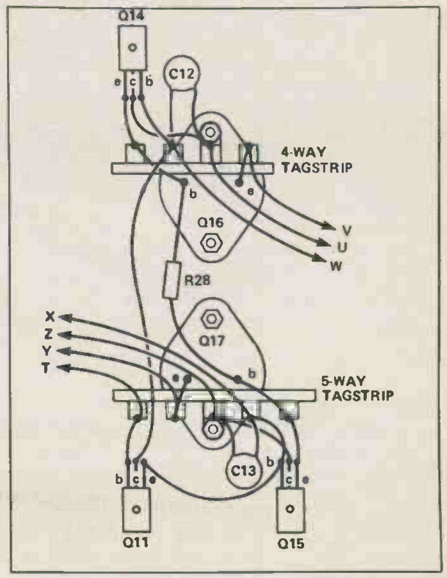



**Figure 8 Wiring diagram for the components mounted on the heatsink.**

HARMONIC ANALYSIS AT 1kHz

| Harmonic | Rated output 21V9 60 W | -20 dB 2V19 600 mW |
|---|---|---|
| 2nd | 19 ppm | 5 ppm |
| 3rd | 14 | 3.5 |
| 4th | 2.5 | 2.5 |
| 5th | 3.0 | 1.5 |
| 6th | 1 | 1 |
| 7th | 1.8 | 1.8 |
| 8th | 1 | 1 |
| 9th | 1.0 | 1 |
| 10th | 1.8 | 1 |

Notice how the harmonics drop away at small signal amplitude. In this regard a class-B NDFL amplifier is more like a conventional class-A amplifier than a class-B amplifier.

**1 ppm** = 0.0001%

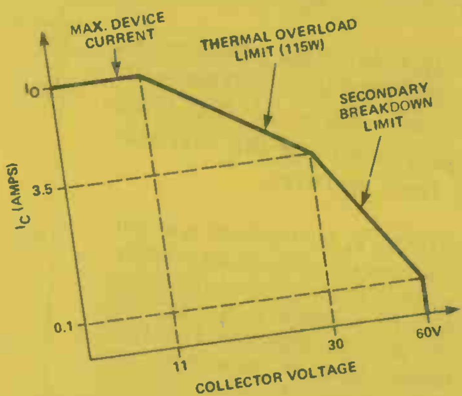
See page 68 for PCB

# ETI next month

At the time of going to press, the articles mentioned are in an advanced stage of preparation. However, circumstances may result in changes to the final contents of the magazine.

### Improving Your ZX-81

No, not putting it through a bandsaw. Solve loading and saving problems with an improved cassette operating system.


### Hi-Fi Power Supply Unit

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### Fuses

The lowdown on fuses and how to select them. How to have your pet project expire quietly instead of taking the house lighting with it.


### Cheap Printer Survey

A look at the various printers available for producing hard copy from your computer.

# Designer's Notebook: Thyristors

**And so to solid state switches. In this month's Designer's Notebook Ian Sinclair looks at the basic techniques involving the thyristor and its close relatives.**

TECHNICALLY, the thyristor is a four-layer diode, but as far as we are concerned, it's a silicon diode that is switched into conduction by a signal at a third electrode, the gate, as shown in Fig. 1. In many respects, however, the action is very much that of a normal silicon diode; for example, it will not conduct in the reverse direction (cathode positive), and it has about 0V6 forward drop across the anode-cathode terminal when it conducts. The distinguishing feature is that the start of forward conduction only occurs when the trigger pulse arrives at the gate and fires the thyristor. Whatever you subsequently do to the gate, the thyristor will continue to conduct until the forward current falls below a value known as the holding current, at which point the thyristor will turn off. However, while the thyristor is on, it is as fully conducting as a silicon diode would be.

## Triggers Fingered

One point that is not always sufficiently understood is that the triggering requirements can vary enormously from one type of thyristor to another. A lot of small thyristors will trigger for a gate current of only a fraction of a microamp, so that interference signals will trigger the thyristor if the gate terminal is not grounded to the cathode by a low-value resistor. A lot of false triggering of burglar alarms seems to be due to thyristor circuits in which the gate has too high a resistance to the cathode, making the gate circuit a very efficient aerial for any radiated energy! Even when quite low resistance values are used, thyristors can trigger in lightning storms or because of static discharges, so that some careful design of the gate circuit and extensive testing is needed if you are in the alarm business. The combination of low resistance and a suppressor ferrite bead placed at the gate terminal helps a lot! Large thyristors need rather more in the way of gate current, but even these can be triggered by a fraction of a milliamp.

Thyristors are most at home in circuits which use DC or unsmoothed (but rectified) AC. The use of rectified AC is particularly popular (Fig. 2) because the

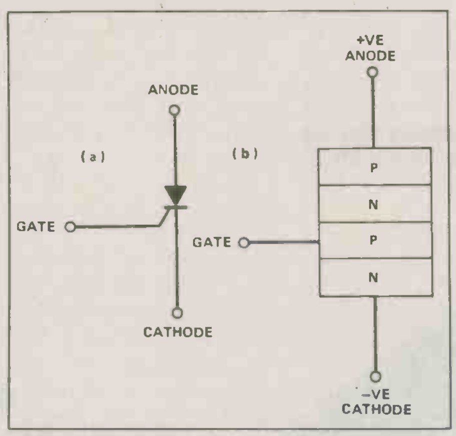



**Figure 1. The thyristor: (a) circuit symbol, (b) arrangement of semiconductor layers.**

thyristor will switch off each time the supply voltage reaches zero, and all that we need to concentrate our attention on is the triggering which switches it on again. Where a thyristor is used in a DC circuit, there is the extra complication of reducing the voltage across the thyristor to zero in order to switch it off (Fig. 3).

## A Passing Phase

Down to configurations. The most useful basic triggering circuit is the phase-controlled thyristor fed with rectified AC as illustrated in Fig. 4. The load can be placed in the leads to the bridge rectifier, in which case the thyristor will control the average power dissipated in the load, despite the fact that the load is working on AC and the thyristor is controlling a rectified supply. An interesting option is to place a reservoir capacitor on the cathode side of the thyristor, giving a low-cost and low-dissipation form of voltage regulation (Fig. 5). The gate control can be obtained from a charging capacitor, as demonstrated in Fig. 6, or from a zener diode as in Fig. 5 — remember that there is no triggering until the gate voltage is about 0V6 above the cathode voltage.

Simple triggering from a charging capacitor is never entirely satisfactory, because the thyristor cannot be relied upon to fire at exactly the same stage of charging in each cycle. To get round this, the simpler circuits make use of a trigger diode or diac which ensures more reliable triggering. The trigger diode has the curious characteristic that it will remain non-conducting while the voltage across it in either direction builds up, suddenly conduct at some voltage level which is determined by its construction, and remain fully conducting until the voltage across it has dropped almost to zero (Fig. 7). A diac wired between a charging

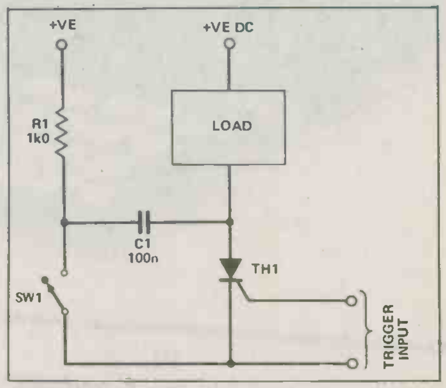



**Figure 3. Turning off a thyristor which is operated from DC. Pressing the switch will discharge the capacitor, pulsing the anode of the thyristor and so stopping the current. This is enough to prevent conduction until the gate is pulsed again.**

capacitor and the gate of the thyristor, with a load of a few hundred ohms connected between the gate and the cathode to avoid unwanted triggering will serve nicely to make the triggering much more reliable. What you then have to be sure of is that you have enough voltage around to operate the diac — depending on type, you may need up to 15 V across it before it starts to conduct.

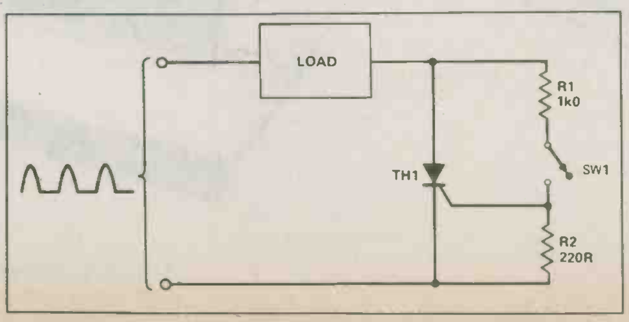



**Figure 2. Elementary switching circuit for use with rectified AC. When the switch is on, current will flow through the load.**

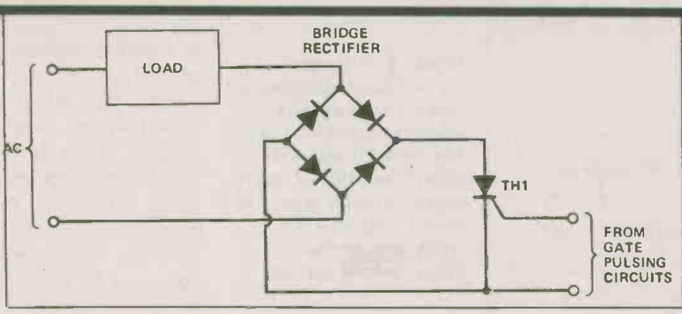



**Figure 4. Basic cicruit for thyrlstor control of an AC circuit, using a bridge rectifier to supply the thyristor. The load, however, operates from AC.**

The very simple phase-control system operates well enough for a lot of applications, particularly for light dimming, but more care is needed where electric motors are being controlled, mainly because of the back-EMF that motors of the AC/DC type will generate. When any motor of this type is spinning, it will act as a generator of DC (even if the supply to the motor is AC), and the thyristor must be capable of withstanding a reverse voltage which consists of the peak reverse AC plus this additional voltage generated by the motor.

The methods that are used for thyristor control of the larger motors, larger than your domestic power drill/food mixer motor, are a lot more specialised. For these circuits, charging capacitors are simply not precise enough as a method of triggering the thyristor at the correct point in the waveform: more elaborate trigger circuits, synchronised to the mains frequency, have to be used. These pulse-generating circuits can be coupled to the thyristor circuitry by using small pulse transformers, so that the timing circuits need not be connected to the circuits that the thyristor controls. This is particularly important when thyristors are used in high-voltage three-phase circuits, because the thyristors may be operating at voltages well above or below ground, yet the control box needs to be grounded.

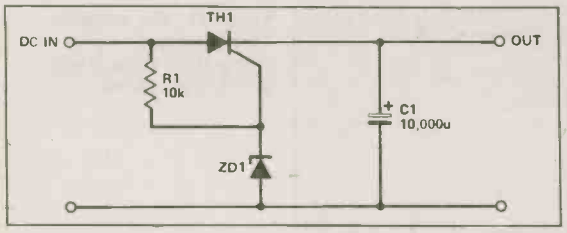



**Figure 5. A thyristor regulator. This makes a very useful pre-stabiliser circuit, or can be used as a stabiliser in its own right where very precise stabilisation is not needed.**

Radio interference is a continual problem for any thyristor circuit which makes use of phase control. Because the thyristor is being switched on when there is a substantial voltage across it, there are large current pulses which can be devastating for radio or TV receivers in the neighbourhood and which can also trigger other thyristors. It's essential, therefore, to design really effective pulse-transient suppression into the gate and anode circuits, and to ensure in the practical construction that the suppressors are placed as close as possible to the terminals of each thyristor. In general, small series inductors and parallel capacitors will do all that is needed, but they have to be capable of taking high peak currents, and must be wired close enough to prevent any wiring from acting as a radiating aerial.

## The Zero Option

The other way of controlling thyristors in energy-control circuits is seen much less in the small-scale circuits that we tend to be more familiar with. This alternative is zero-voltage switching, and it involves switching the thyristors on at the instant when the voltage between anode and cathode is zero. This has the advantage of generating no more interference than a silicon diode would, which is very much less than is generated by the phase-control circuit: but it can be used only with loads like water-heaters which have very long time constants. If you switch your electric drill motor on for 100 mS in each second, the speed will be rather erratic to say the least, but a water or room heater switched in this way does not cause noticeable fluctuations of temperature because the temperature does not shoot up rapidly when the heater is on, nor shoot down when the heater is off. Figure 8 shows an outline of a typical zero-voltage control circuit — there is an IC which can be used to govern the whole operation.

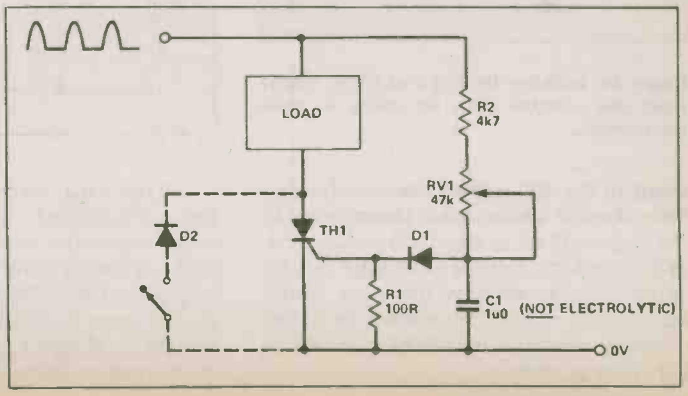



**Figure 6. A typical phase control circuit for AC. The thyristor will conduct on only half of the input wave, so that a 'power-doubler' circuit, which switches a diode across the thyristor in the reverse conduction direction may be needed for a larger range of power control (shown dotted).**

## For My Next Triac . . .

The triac is a two-way equivalent of the thyristor, with the main circuit terminals labelled MT1 and MT2 rather than anode and cathode, since current can flow in either direction through the triac. Like the thyristor, the triac remains non-conducting until it has been triggered by a pulse at its gate terminal; the pulse can be of either polarity, but the minimum amplitude for firing is not the same for the two possible polarities. Again like the thyristor, the triac ceases to conduct when the current through it becomes too low to sustain conduction. Triacs are extensively used to switch raw AC because a triac circuit represents a considerable saving on components as compared to a small thyristor circuit, even if the equivalent triac is more expensive than two thyristors. Figure 9 shows a typical triac circuit for AC use that can operate using a very small triggering input, such as from a microphone or photocell. The transformer supplies a low voltage for the gate circuit, and the rectifier bridge is arranged so that an unsmoothed full-wave rectified voltage is fed to the transistor amplifer circuit. When the transistor conducts, the current flowing in the bridge rectifier will also flow through the gate of the triac, triggering the triac on each half-cycle. The trigger current is AC because the gate is

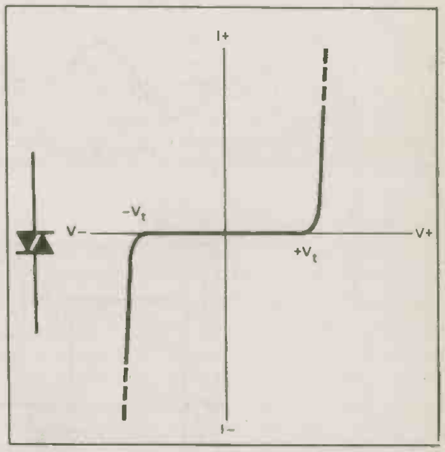



**Figure 7. The diac, and its typical characteristic.**

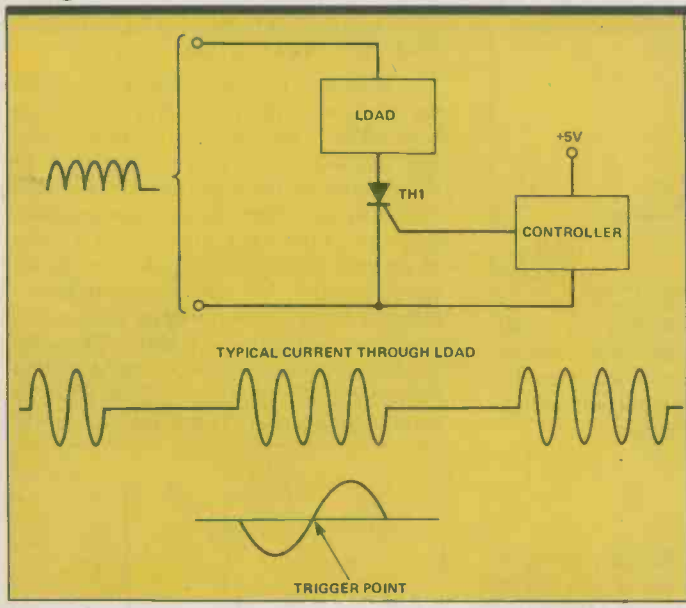



**Figure 8. Principles of zero-voltage switching circuits. The controller (usually an IC) will switch the thyristor on at the point when the AC wave passes through zero. This ensures minimal RF interference, unlike the phase-control method.**

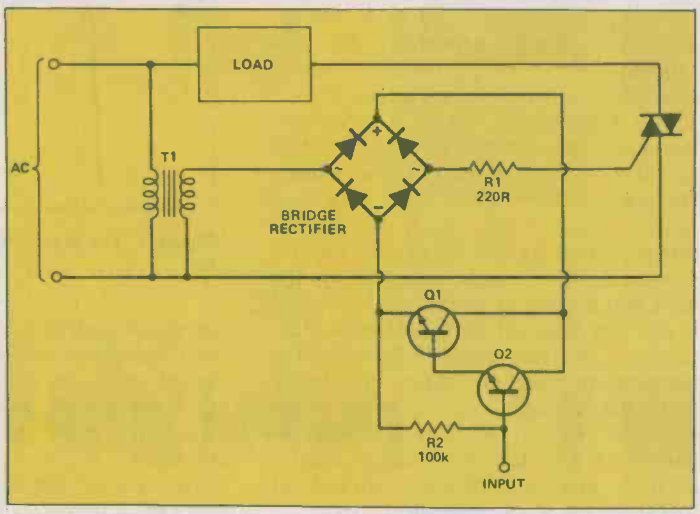



**Figure 9. Using a triac in a circuit where the switching signals are very small. Note that the whole circuit is live to the line.**

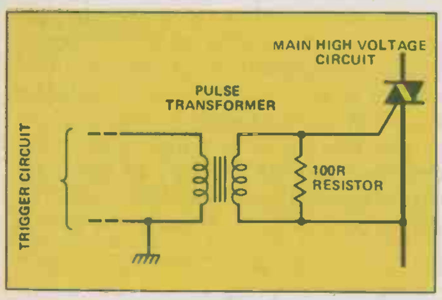



**Figure 10. Isolating the line part of the circuit from the control part by using a pulse transformer.**

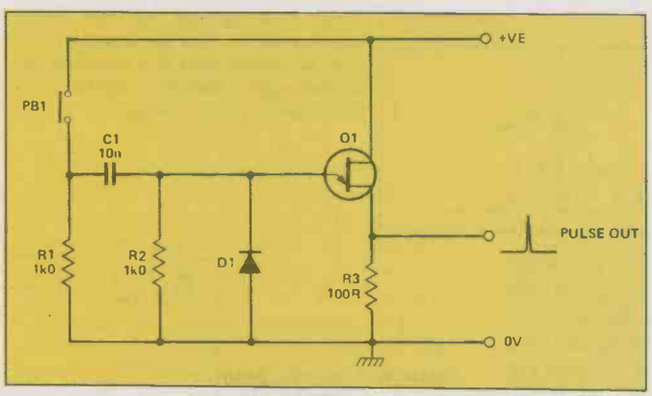



**Figure 11. The unijunction connected to provide a short pulse when a switch is pressed.**

wired in the AC side of the transformer. Note that the whole circuit is connected to the line — if an isolated low-voltage circuit is needed, then the gate must be triggered by a circuit using a pulse transformer rather than directly as in this example, and the part-circuit shown in Fig. 10 is needed.

Triggering thyristors or triacs via a pulse transformer needs a fairly sharp spike waveform, and one of the devices that has traditionally been used to provide this type of waveform is the unijunction. As the name suggests, this uses one junction on an N-type silicon base whose doping normally ensures that the conductivity is low (resistance high). The junction is placed so as to provide an emitter terminal, and when the emitter voltage is raised to the conducting level, the injection of holes into the bar will make it highly conductive. This is the triggered stage, which can be maintained only if a current continues to flow through the emittter. Unijunction circuits are arranged so as to prevent this continuous current, so ensuring a clean sharp pulse.

A unijunction 'one-shot' pulse generator is illustrated in Fig. 11. With the switch open, the emitter of the unijunction is grounded, and the device is non-conducting. Closing the switch contacts changes the voltage on one side of the capacitor from ground to the positive supply voltage, and the voltage on the other side will increase similarly, so triggering the unijunction. The conducting unijunction generates a positive-going spike at the grounded end of its circuit, and also charges the capacitor so that the end of the capacitor connected to the emitter is at about ground voltage. This process is very brief, and when the switch opens again, the emitter of the unijunction is protected from negative pulses by a diode.

The triggering voltage for a unijunction is a fixed fraction of the total voltage applied across the main terminals — the fraction is known as the 'intrinsic stand-off ratio,' and is usually around 0.6, implying that the device will trigger when the emitter voltage is about 60 per cent of the supply voltage. Because this ratio is fixed, changes in the supply voltage do not make much difference to the frequency of the output.



ETI

# Auto Greenhouse Sprinkler

**A summer plant-saver that works automatically, triggered by the falling moisture level in a plant pot.**

**by Owen Bishop**

THE HOT sunny days that we hope to be having from now until September can play havoc with plants in a greenhouse. You need only to forget to water them once, or forget to open the windows on a warm day, and the plants are soon in a sorry state. Last minute watering *might* revive them but, on the other hand, it might not! This device not only warns you when the plants are beginning to need some water, but actually does the watering for you. You might need to supplement its action each evening by using the old-fashioned watering-can, but it will take care of those times during the day when a light sprinkling makes all the difference to the health of the plants.

The circuit consists of two sections. One part is concerned with sensing the water state of the plants and sounding an alarm when it gets too low. The other part turns on the pump to sprinkle the water. If you simply need a warning and are prepared to do the sprinkling yourself, there is no need to build the pumping section. If you are going to include the pump, you will certainly want the warning device, too. This sounds for about 30 seconds *before* the pump is turned on. Should you or the family happen to be admiring the tomatoes as the soil goes dry, the warning gives you plenty of time to retreat — out of the range of the sprinkler. The warning period can be extended if 30 seconds is not long enough.

Anyone who has ever watered a potted plant knows that it is effective to water for a short period, and then stop and allow the water to soak in before repeating the watering. The sprinkler works in this fashion too. The pump is turned on for 30 seconds, off for 30 seconds, repeating until the soil has been moistened to the right degree.

## The Circuit

The amount of water in the soil is sensed by a circuit which measures the resistance of the soil between two metal rods buried

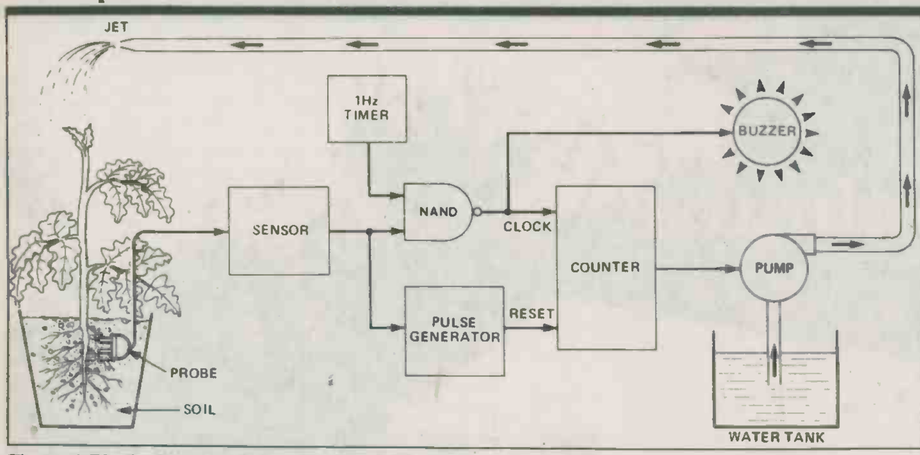



**Figure 1 Block diagram of the Auto Sprinkler.**

in the soil (the probe). If we pass a *direct current* through the soil, the water and dissolved salts in the soil act as an electrolyte. In a few minutes, polarisation occurs and the resistance changes. Instead, we use an *alternating current*, to avoid polarisation. This is generated by a 1 kHz oscillator (IC1) in the sensor circuit. The alternating potential is rectified by a diode (D1) and smoothed by a capacitor (C7) to give a steady potential. As the soil becomes drier, its resistance increases. This gives the alternating voltage greater amplitude and so the steady DC potential rises. This rising potential eventually triggers a Schmit trigger (IC3) causing its output to change abruptly from low to high (0 V to 12 V). The level at which this change occurs can be controlled by adjusting the 'Set Level' control, RV1.

The output of the sensor is combined with the output from the 1 Hz timer (IC2) by a NAND gate. When the output of the sensor is low (moist soil), the output of the gate is steady at 12 V. When the soil dries, the output begins to alternate between 0 V and 12 V at a rate of 1 Hz. These pulses switch an audible warning device on and off, providing a bleeping

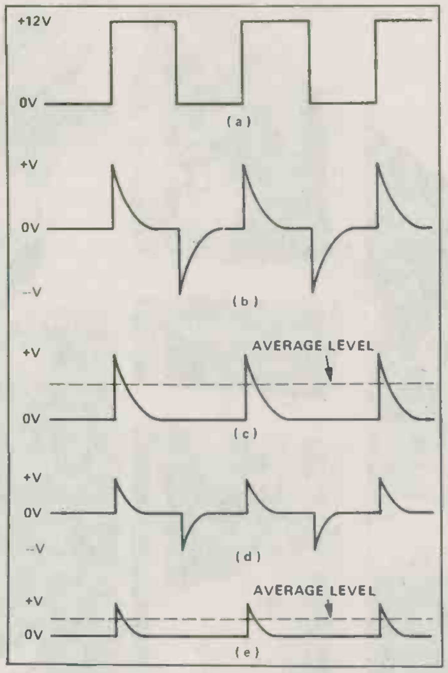



**Figure 2 The timing diagram shows: (a) Output from IC1; (b) Waveform at the 'live' pin of the probe; (c) Junctions of D1 and C7; (d) As (b) but with wetter soil; (e) As (d) with wet soil — the average level is lower so the alarm is not triggered.**

tone. The pulses are counted and, after a fixed number (say 32), the selected output of the counter goes to 12 V. This switches on the pump. The output alternates from 0 V to 12 V regularly at (say) 1/32 the rate of the time, giving periods of sprinkling followed by equal periods during which the water soaks into the soil.

When the soil is sufficiently wet, the reverse actions occur. As the soil resistance drops, the DC potential falls and the Schmitt trigger output (IC3, pin 10) goes low, stopping the alarm. The low-going edge triggers a pulse generator (two gates of IC4) which sends a single high pulse to the reset input of the counter. This makes all its outputs go low, so turning off the pump.

## Power Supplies

Before going on to constructional details, we must consider the matter of power supplies. The circuit uses an unregulated 12 V DC supply. This is best taken from a power-pack located indoors, with a light-duty lead to carry the current to the device in the greenhouse. The pump is a windshield-washer pump, which needs at least 2 A. A circuit for a suitable power-pack is given later. If you have decided to use this only as a warning device, the power requirements are much less. Without the pump and its relay, the circuit uses only about 45 mA and almost any small power-pack can be used to provide this. Then it would be more suitable to locate the circuit indoors, with a lead running to the *probe* in the greenhouse. A low-current power supply could easily be fitted into the case.

## Construction

The circuit is best built and tested stage by stage, beginning with the sensor circuit. The 1 kHz oscillator based on IC1 is the

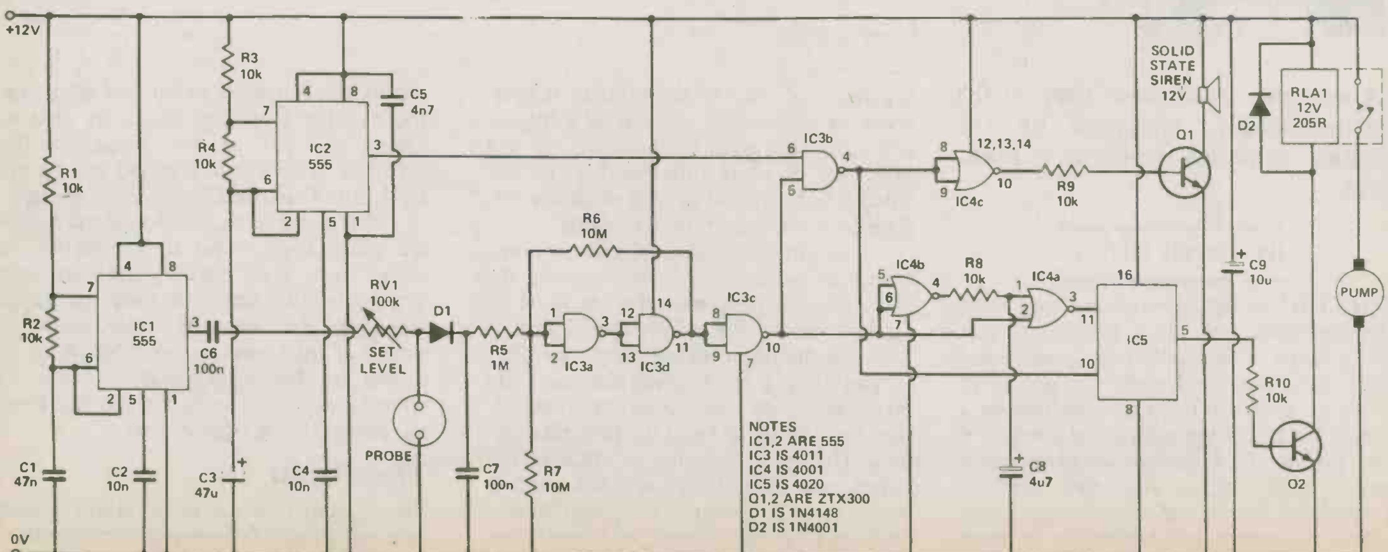



**Figure 3 Complete circuit of the Auto Greenhouse Sprinkler. The power supply unit is shown over the page.**

first part to assemble, including C6. If an earphone is connected between the free terminal of C6 and the 0 V line, a high-pitched tone should be heard, indicating that the oscillator is working. If all is in order, wire up RV1, D1, C7 and the probe. In the prototype, the probe is a 2-pin 5-amp mains plug of the old type, which was found in the scrap box. The essentials are two stout metal rods, preferably of brass or some other corrosion-resistant metal or alloy. They should be about 1.5 cm long and mounted on an insulating base about 1.5 cm apart. Connect these to the circuit board with ordinary lighting wire. While testing, you need a potted plant, or at least a pot of moist potting compost or good loamy soil. The probe can be simply pushed into the soil when testing. Later, when the system is in use, it is better to bury the probe one to 2 cm deep in a pot of soil or the greenhouse bed. Place it on its side, so that the base does not prevent water from reaching the soil surface directly above the rods.

If you have an oscilloscope or FET voltmeter, the rectifying stage can be tested by connecting the probe of the scope to the junction of D1 and C7. As RV1 is turned, the voltage should range from about 1 V to about 10 V. Pulling the probe slightly out of the soil (simulating drying out) results in a rise in output voltage. Incidentally, the circuit does not work unless there is at least some conduction across the probe, so remember to water the plant occasionally, or your tests (and the plant) will probably fail.

Next build the Schmitt trigger circuit (IC3). Its output should flip neatly from 0 V to 12 V as RV1 is turned from one extreme to the other (with the probe in the plant-pot).

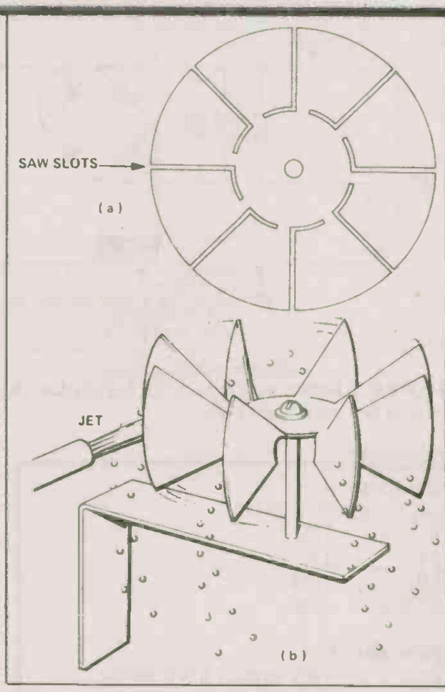



**Figure 4 A simple turbine sprinkler: (a) cutting the wheel from a disc of sheet aluminum; (b) the turbine in operation. Note that the jet should be quite narrow or the plants will be flooded.**

The next stage is to build the 1 Hz timer, based on IC2. Unless there is effective decoupling of the supply line between IC1 and IC2, the timer is triggered by noise from IC1. Decoupling capacitor (C5) was therefore placed as close as possible to the terminals of IC2. Too large a capacitor affects the operation of the sensor circuit, so keep to the value specified. The remaining gate of IC3 may now be wired in. With RV1 at one extremity (minimum resistance), the output of pin 4, IC3b, should be 12 V. At the other extremity it should alternate from 0 V to 12 V at approximately 1 Hz (the exact frequency does not matter).

One gate of IC4 simply inverts the output from IC3, so there should be no problems here. The other two gates form the reset pulse generator. This is not needed if you want only a warning, and no water pump. The pulse generator should normally have a low output which goes high very briefly when the output from IC3 goes low (i.e. when the soil has been watered enough). This pulse can be detected as an upward kick of the needle of a voltmeter connected to pin 3, IC4a.

The pump is controlled by the counter (IC5). First check the connections from IC3 and IC4. The output from IC5, pin 4, has 1/64 the frequency of the input and with a 1 Hz input, the output is low for 32 S and high for 32 S. This gives 32 S warning — to evacuate the greenhouse. If you think this is more than enough, take the output from pin 5 (as in Figure 3), which gives a 16-second warning. Since your timer may not be running at 1 Hz anyway, the best thing is to test the output from the various pins — dotted lines on the component overlay — and find the one which gives the timing you prefer. Mount the relay with its protective diode, D2, and the switching transistor Q2. Join the base of Q2 to the selected output pin of IC5 by way of R10. The tracks to which the relay switch terminals are soldered were made as short as possible but, since they are to carry heavy current, it is advisable to run a thick coating of solder

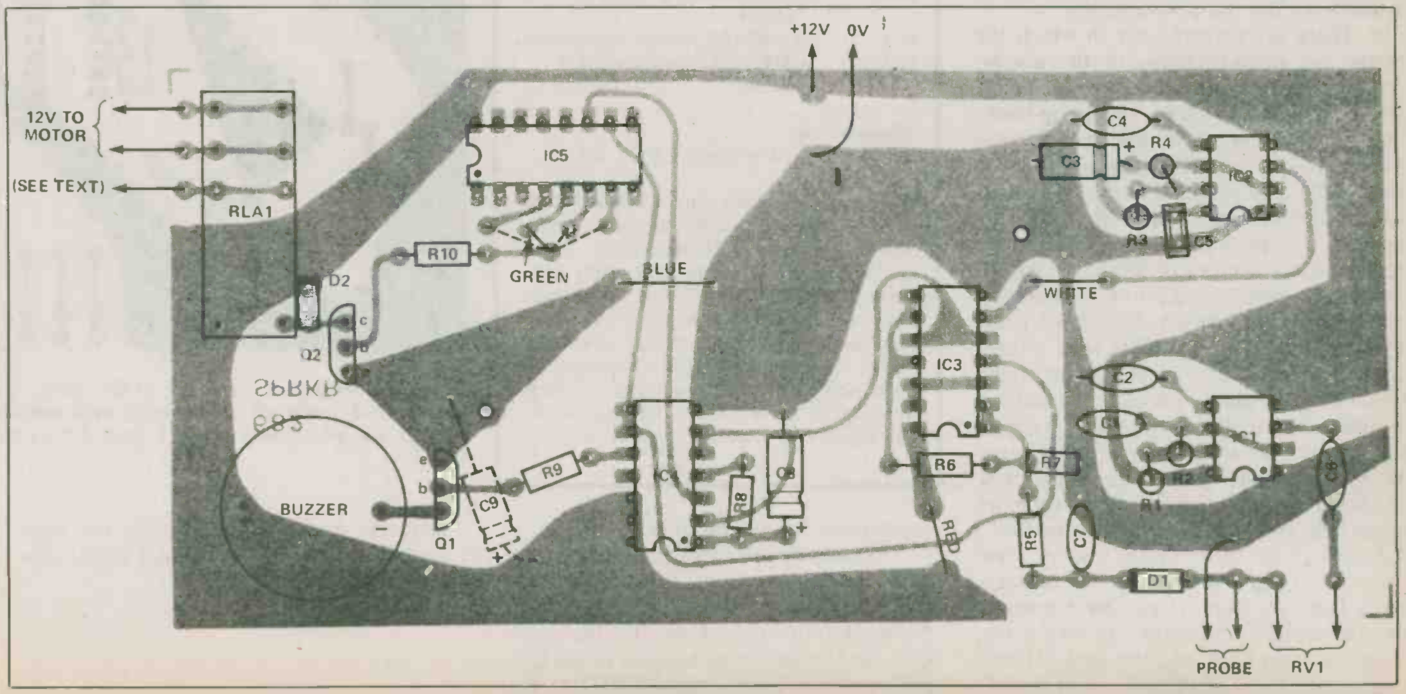



**Figure 5 The component overlay. C9 may be included to damp out surges in the power supply caused by the operation of the relay. PCB links are colour-coded for convenience; the green link sets the warning time, as described in the text.**

along them to aid conduction. Finally, mount the circuit board, RV1 and the pump in the case.

## Installing The Sprinkler

The case housing the circuit should be sited well away from any area of the greenhouse which is to be sprayed or dripped on. A few trials may be needed to establish optimum operating conditions and methods, so perhaps it is best to mount the case temporarily, to begin with. The probe should be buried in a pot of soil. Preferably, this should have a plant in it too, to ensure that the soil loses water at the same rate as the soil in other pots. The probe can be buried in a bed if preferred, but it should be placed where it will receive an average amount of water and where it is likely to lose water at an average rate (i.e. not in the sunniest or shadiest part of the greenhouse).

The pump needs a supply of water. This is best held in a tank inside the greenhouse, so that the water is at the correct temperature. The tank should be covered, if possible, to exclude light, which encourages the growth of algae, and to exclude soil and dead leaves, which might clog the pump. Alternatively, the pump may be fed from a covered rainwater barrel or other tank outside the greenhouse. There could be an application here for those 'water level detector' devices which are so often featured in books of simple electronic projects. Mount one in the tank to warn you when the tank needs topping up!

WARNING: do not run the pump unless it has a supply of water. Without water, it draws excessive current, which could burn out the power supply.

There are several ways in which the water can be distributed to the plants. You may prefer to irrigate from below, in which case the tube from the pump branches to the trays or troughs in which the plants are standing. The trays are flooded repeatedly until the soil becomes saturated to the right amount. If you are using this system, it is advisable to bury the probe nearer to the bottom of its pot. Another method of distribution is to run lengths of tubing above the bench, suspended from the frame of the roof. The tube is perforated at intervals, so that water rains down on the plants beneath. A turbine sprinkler like that illustrated in the drawing scatters the water over a wider area. With all methods, you will probably need to use fine jets on the end of the tube, or screw clips on the tube to restrict the flow. Another point to be considered is what becomes of the water after it has drained away from the pots. If you have troughs on your bench, you could arrange for the water to drain back into the tank. This is more economical of the water and useful, should you want to leave the greenhouse unattended for several days.

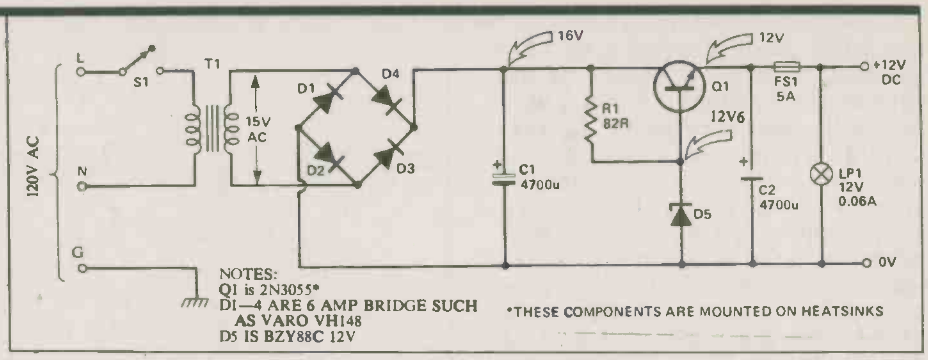



**Figure 6 A power supply suitable for driving the complete unit, including the pump. Note that the output is a *nominal* 12 V.**

**PARTS LIST**

**Resistors**
(all ¼ W, 5% carbon)

| | |
|---|---|
| R1,2,3 | 10k |
| R5 | 1M |
| R6,7 | 10M |
| R8,9,10 | 10k |

**Potentiometers**

| | |
|---|---|
| RV1 | 100k carbon track, linear |

**Capacitors**
(all polyester, except where indicated)

| | |
|---|---|
| C1 | 47n |
| C2 | 10n |
| C3 | 47*u* 16 V electrolytic |
| C4 | 10n |
| C5 | 4n7 polycarbonate |
| C6,7 | 100n |
| C8 | 4*u*7 16 V electrolytic |
| C9 | 10*u* 16 V electrolytic |

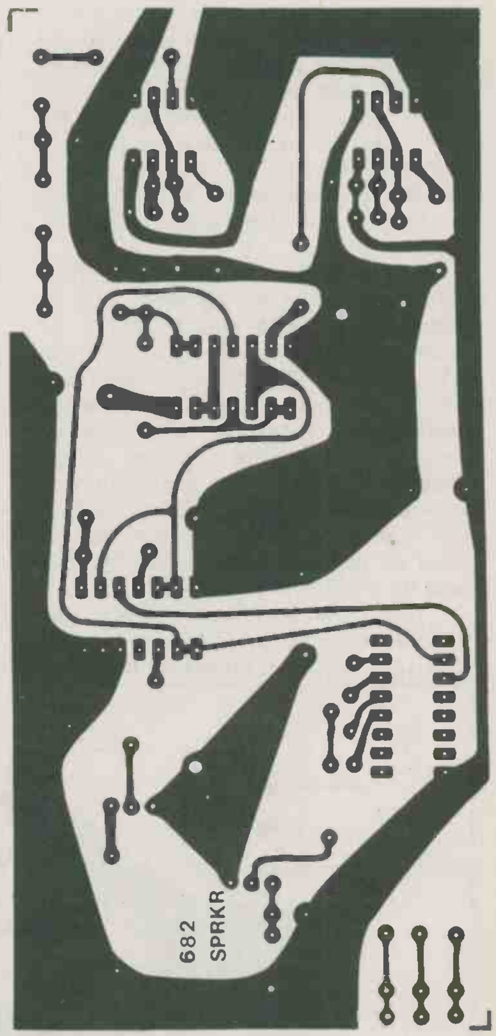
**Semiconductors**

| | |
|---|---|
| D1 | 1N4148 |
| D2 | 1N4001 |
| Q1,2 | 2N3904 or other general purpose transistor |
| IC1,2 | 555 timer |
| IC3 | CD4011BE quad 2-input NAND |
| IC4 | CD4001BE quad 2-input NOR |
| IC5 | CD4020BE 14-stage binary counter |

**Miscellaneous**

| | |
|---|---|
| RLA1 | 12 V miniature PCB relay |

PCB; 1 mm terminal pins; Knob for RV1; 12 V audible warning device such as Radio Shack 273-065; PCB mounting; 12 V automobile washer pump unit; ABS case, approx. 180 mm x 110 mm x 50 mm; materials for making the probe (see text); bolts and nuts for mounting board and pump; plastic tubing and t-joints (standard 5 mm aquarium aerator tubing is suitable); water tank; materials for making the irrigating devices; connecting wire, solder.

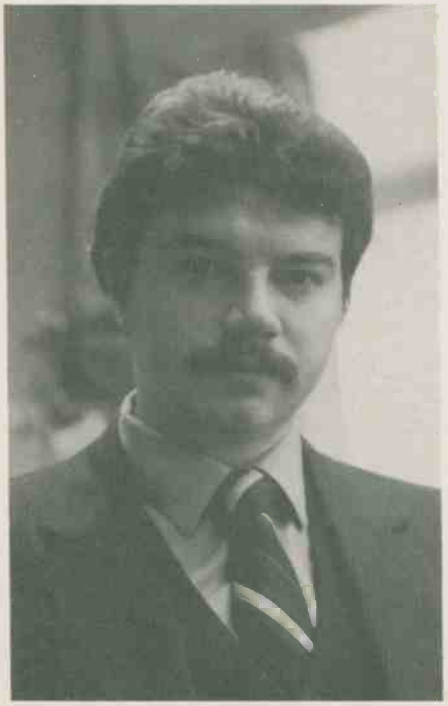



**The Auto Greenhouse Sprinkler PCB pattern. The large ares of copper are present to improve stability — they can be omitted if you include C9 on the board.**

Whatever methods you adopt, you will need to experiment with the distributing system to get it just right. You will need to find out which is the best position for the sensor and which is the best setting of the level control (RV1) of the sensor. Eventually you should be able to arrive at just the right system for your greenhouse and the particular plants you are growing.

# Bob Stephens And SETI

## The Search For Extra-Terrestrial Intelligence



Bob Stephens. Photo by Bill Markwick.

**Tilting at the windmills of bureaucracy, Bob Stephens hopes to rejuvenate an astronomical observatory and continue a serious scientific quest.**

by **Roger Allan**

ONE OF THE oldest questions in intellectual history, dating no doubt as far back as man's first conscious thoughts about the night sky, is "is there life out there?" Nowadays, in part due to the recent popularization of the subject by the media and successful feature films, and in part due to astrophysicists' recognition that there is in fact no logical reason to believe that we are the only intelligent life form in the universe, the subject of SETI, the Search for Extra-Terrestrial Intelligence, has taken on something akin to a new respectability — a transition from the fuzzy-minded wide-eyed fringe to something akin to peripheral mainstream, if highly underfinanced, scientific thought. After all, even NASA has a SETI project, as do the Russians and Australians and goodness knows who else. Everyone seems to have an opinion, one way or another, as to whether or not there is extra-terrestrial life.

It is a reality in contemporary science, unfortunately, that the knife edge of scientific advancement is undertaken only by specialists, who by the very nature of their specialization, in the words of one wag, "learn more and more about less and less, until they know absolutely everything about nothing." SETI, seemingly, should be no exception. The search involves astrophysics, the mathematics of which is abstruse even by university standards. It involves physical plants, the antennae, computers, coding, engineers, specialists of a refined and rarefied breed. Any attempt by an amateur would seemingly be doomed to failure by the very nature of the problem to be solved — if not because they do not have the time, then because they do not have the training; if not the training, then lack of the necessary equipment; if not the equipment, then lack of the running finances — they are not specialists with all that that implies.

Yet every once in a while, the dynamics of society spins off an individual who seemingly runs counter to the accepted realities of the "way of doing things", and while not always achieving success, nonetheless comes sufficiently close to the mark that the individual's very efforts are remarkable in themselves. Fools though they may be called, even by their fathers in this case, or Don Quixote tilting at windmills by the more literary-minded spectators, their very attempt is worthy of a cheer. It is therefore even more remarkable and worthy of consideration when one of these societal spin-offs actually appears to be "pulling it off", as it were, and while still far from achieving success, appears to have as good a chance as any specialist of answering the millenia-old question of "is there life out there".

The name of the man in question is Bob Stevens, age 29, unmarried, based in Edmonton, middling height, shortish hair, reasonable build, though he looks as if swimming a few laps might do him good; three piece business suit, non-smoker, soft spoken. Wide-eyed fanatic is one label which would not stick to him, though upwardly-mobile CPA might. Education: largely self taught, though there were a few courses some years ago at the Northern Alberta Institute of Technology in video electronics, and a motley collection of night courses. Personal finances and income: currently none.

About two years ago, Stevens, then working for CN Telecommunications, became interested in optical astronomy. Within six months his interest led him to radio astronomy, particularly to the question of extra-terrestrial intelligence. Recognizing that in Canada there was no SETI project, Stevens decided that he would set one up — not just a little backyard job, but a proper, long term project with the right equipment. Rather an ambitious plan, fully steerable, decent-sized 20 to 30 meter radio dishes costing what they do. But nonetheless-

The first thing Stevens needed was some practice, so he obtained two radio dishes which he set up in his backyard.

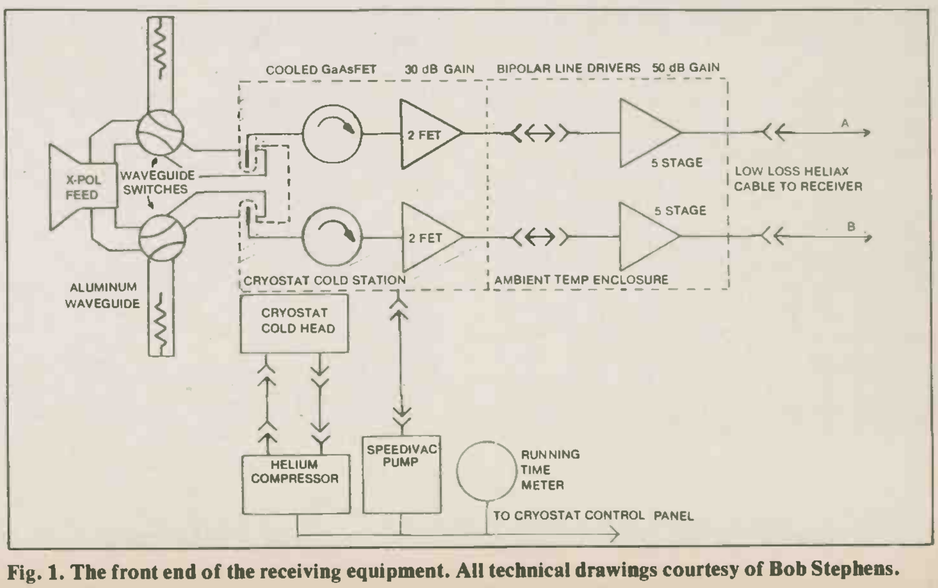



**Fig. 1. The front end of the receiving equipment. All technical drawings courtesy of Bob Stephens.**

One is a six ft. steerable dish on a north-south axis, automatically covering five minutes of arc per sweep. It is connected to an eight channel Beckman Type-R Dynograph ink-type strip chart recorder, which he uses for continuous analog monitoring of receiver inputs. It is in combination with a 40 GHz Polarad spectrum analyzer forming the back-end monitoring for his home observatory. It operates on the 21 cm line. Further, he has erected a ten ft. horn wave guide operating at the hydrogen emission line of 1420 mHz. This, plus a basement full of bits and pieces provided him with some hands-on experience.

But six footers aren't sufficient for a decent SETI search; one needs professional quality and size equipment located in a quiet area, which suburban Edmonton certainly is not.

Mark Twain once remarked that he always found it surprising how lucky those people were who worked the hardest. Stevens worked hard.

The background: In the 1940s and 50s the American armed forces erected a series of large radar stations across northern Canada as their Distant Early Warning System (DEW Line). To get the signals south to their command structure required a series of repeater stations — big ones, four in number, at three locations, known as the DEWDROP Line. The southernmost end of DEWDROP, where it interfaced with ground lines, is at Hay River, North West Territories (NWT). It consists of two 60 x 60 foot troposcatter, S-Band parabolic antennas. They had been turned over to CN Telecommunications some years ago when the southern end of DEWDROP was no longer needed, a point to point microwave system having been installed. CN had now found them redundant and they were slated for demolition. Enter Stevens and a purchase price: $1. CN agreed, with the proviso that they be removed within a year, subject to monthly extensions. Hay River is located at the terminus of the only rail line in the NWT, so removal and shipment south would not be a major problem if Stevens had the money, which he hasn't. He has arranged two temporary storage sites, one in Edmonton and one in Calgary, but other than stripping the antennas of their feedhorns and associated waveguides, the antennas just sit there — owned and essentially ready for use by an amateur radio astronomer, but currently just gathering rust. An attempt was made to raise some money through Alberta's New Employment Expansion Development Program (NEED) which would provide some $200 a week for the hiring of workers and $125 a worker for tools, but the application was turned down. Apparently, the Alberta government will not spend such monies on hiring Alberta residents if the money is to go out of province, such as the southern end of the North West Territories.

It was about this time that Stevens created the Amateur Radio Astronomy Observatory, a non-profit, charitable organization to get the SETI project off the ground and viable. The first step was to apply to the Canada Council for a grant — not a large one, but enough to pay the postage, Steven's finances having fallen (since he'd quit his job to devote himself full time to the project) to the level of selling off the video test equipment used when he was in business. The application was denied. Apparently, if ARAO had been interested in painting egg shells with goose quills, or covering bridges with Saran Wrap, he'd have had a chance, but not if his project involved some creativity and potential usefulness. A second application to the National Research Council is pending. They are not quite sure what to do with it, as it is the first time that an amateur has applied for help. Hardly surprising, as it is also the first time that an amateur radio astronomer has two 60 x 60 foot antennas ready

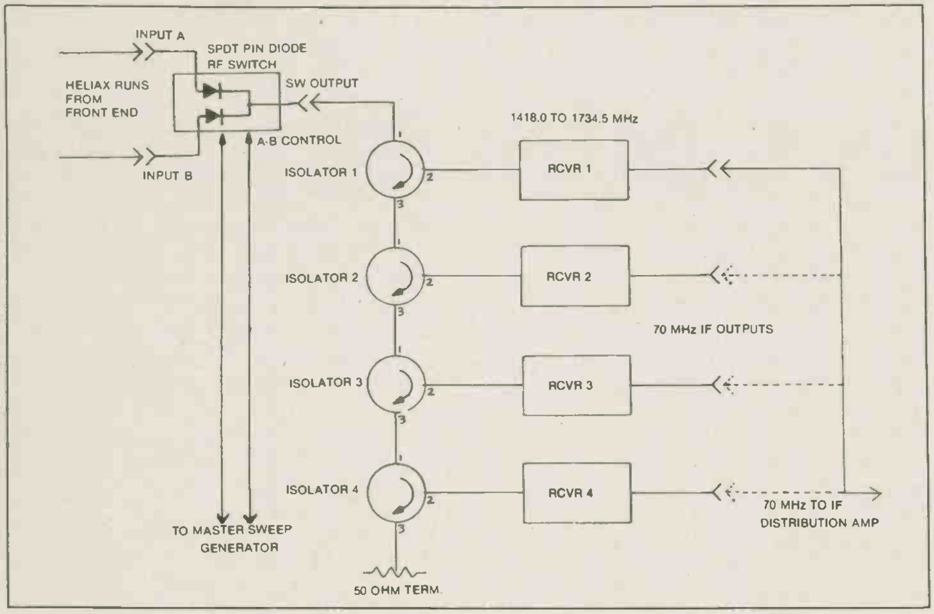
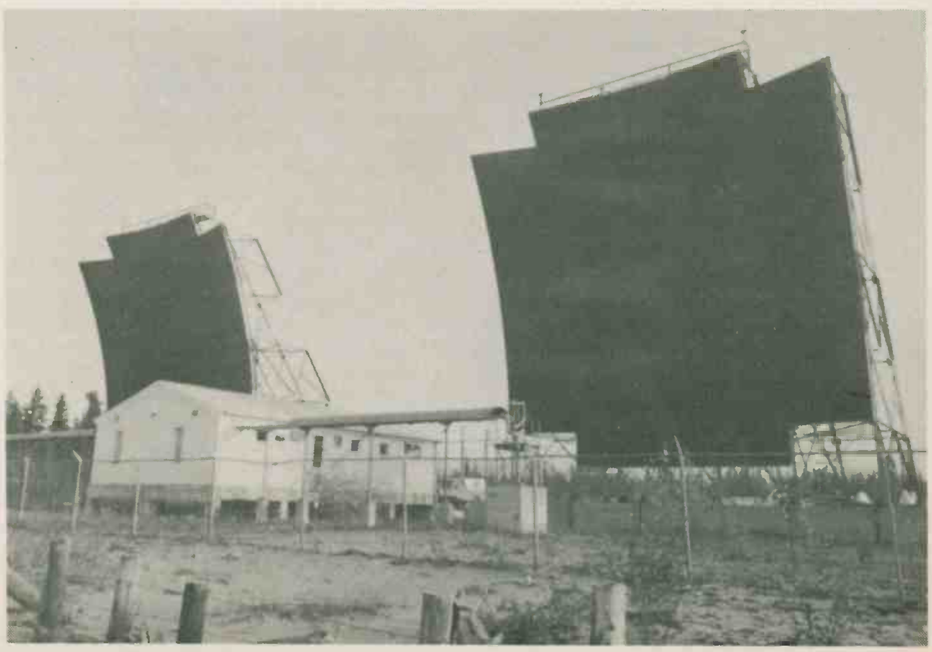



**Fig. 2. The block diagram of the receiver bay.**



**The antenna array at Hay River, NWT, donated to the project by CN.**

to be fitted together into an enormous troposcope for use by amateur radio astronomers.

Enter Mark Twain's dictum again. In Algonquin Park is found the Algonquin Radio Observatory, consisting of the well known 46 meter single dish facility. Stevens found that a mile away is a sixty foot dish owned by the University of Toronto. It is a fully steerable azimuth-elevation (AZ-EL) facility with hydraulic control. Curvature is accurate for use up to 3 GHz. Electric motors and pumps are intact, and all that is required is the fabrication of a controller. Some minor repairs are required on the building, as well as the installation of a tub or shower stall and kitchenette. The antenna needs some minor sandblasting and a fresh coat of paint.

The point of all this is that the antenna had been declared redundant and had been slated for demolition. With a little help from friendly sources at the National Research Council, who would prefer that the dish be used rather than torn down, ARAO, through Stevens, was able to make a deal with U of T whereby they would donate the dish to ARAO. Even CN, with their $1 charge, hadn't been that generous. Alongside the facility is provision for a second dish, complete with a pedestal base and official permission, dating back a few years, for the erection of a second dish.

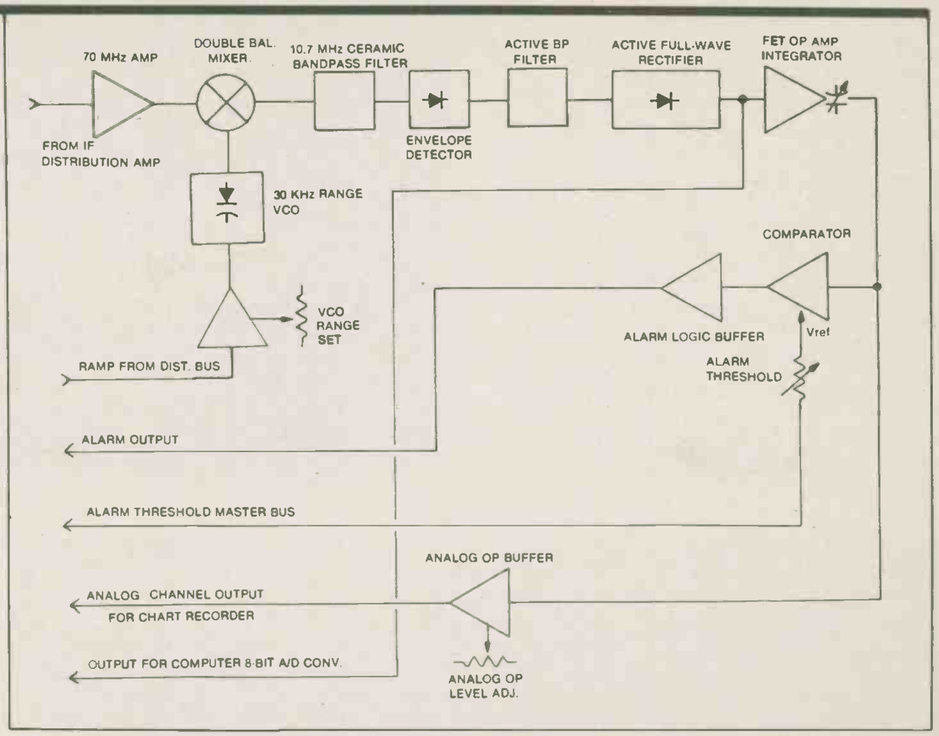
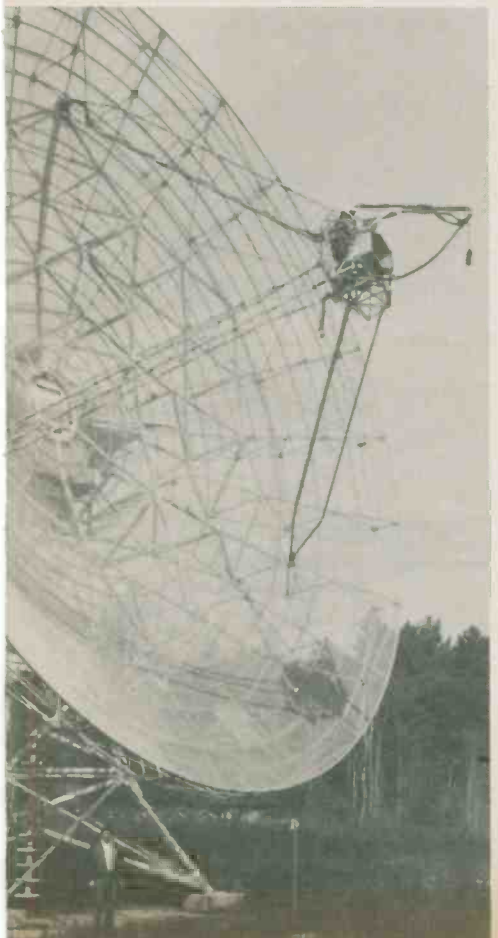



**Fig. 3. The 30 KHz filter/detector and various outputs.**

**The steerable dish antenna at the Algonquin Park site.**



The current rub is what to do with it. The agreement between the various authorities is that the dishes, including the Algonquin Radio Observatory, may only stay there for a few more years, when everything will have to be torn down and the land reverted to park. What ARAO wants is permission to ship the troposcopes there, erect them on the already existing second pedestal and, in combination with the 60 ft. dish, to set up an amateur radio observatory until such time as the general agreement, including the Algonquin facility has to move. While there appears to be some sympathy, particularly from Mr. Norm Broten, the Director of Astronomy at the Herzberg Institute of Astrophysics, National Research Council, no decision has been made.

So there the subject currently stands — a well meaning, hard working, totally dedicated, non-fanatic, all but personally bankrupt amateur radio astronomer, who in eighteen months from a standing start, has succeeded in obtaining two 60 x 60 foot troposcopes and a 60 foot fully steerable dish. All slated for demolition, all in place, with no money to run them or break them down and transfer them, or set up the research projects for amateurs by amateurs — the first in the world, and very well equipped it would be, if it could get off the ground.

But what does ARAO want to do with all this equipment, presupposing that the bits and pieces, permissions and monies came through? A lot of things, as it turns out.

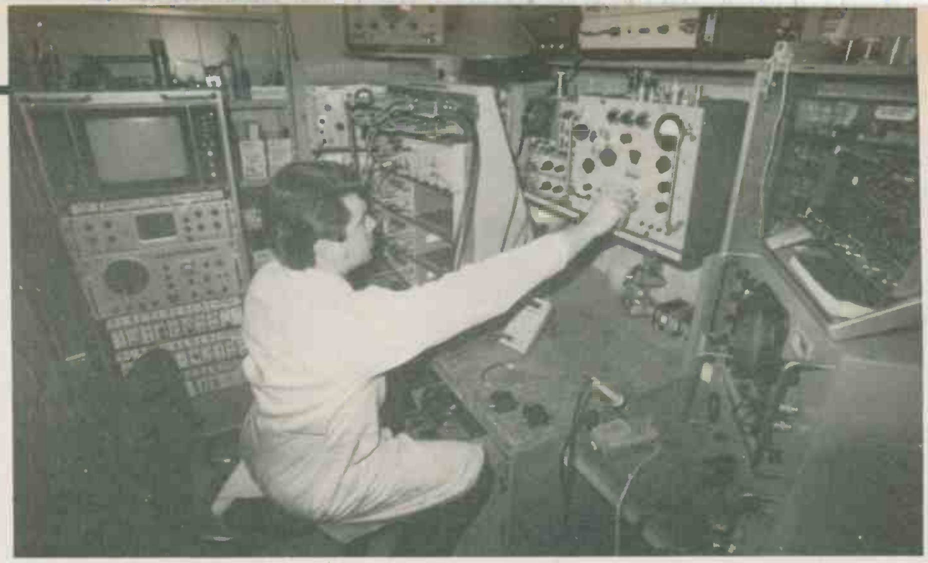
First and foremost is a SETI search — the first major one in Canada. ARAO proposes that the AZ-EL 60 foot dish be utilized immediately in the all-sky meridian transit search mode as soon as "waterhole" low-noise front end receivers and data processing equipment are installed. This is not far fetched. The equipment has either been obtained or is readily available for relatively small sums.

After the completion of the first set up, ARAO proposes the installation of a tracking computer and antenna guidance system, whereby the 60 foot AZ-EL may undertake a target star SETI search with subsequent increased sensitivity due to the increased integration times available. This target search would be directed at known F,C and K spectral class stars (similar to our own) complementing existing target star searches planned or underway by facilities such as the one at NASA/Ames in California or the one at Green Bank, Ohio. This target star SETI search would be continued until such time as the Hay River troposcopes could be installed as a single, large, meridian transit antenna. At this point, the waterhole receivers and SETI instrumentation would be transferred to the larger meridian-transit antenna, and a more comprehensive all-sky waterhole SETI search begun.

But while a SETI search is Stevens', and therefore ARAO's, primary concern and driving force, there are a number of other things that a **amateur** radio astronomy observatory could and would be used for by amateurs. One of the areas where they can and would do good work is in the mapping of optical masers, and area of "donkey work" in astronomy which has to be done, but which isn't too terribly glamorous and as such, while necessary, is low on the professional astronomer's priority lists.

Further, there is an outside possibility of some sort of summer school, as well as the rental of the facility to universities or professional astronomers for research or training purposes.

But perhaps the most interesting non-SETI use is that members of ARAO would be able to come to the site and do their own projects — making the site the only one in the world where amateurs can get their hands on professional-sized and quality equipment to run their own experiments, record their own data, and, as with the optical maser mapping, make a real contribution to professional astronomy.



**Bob Stephens and some of his equipment. Except as noted, all photographs are courtesy of Bob Stephens.**

Stevens' motivation for devoting his life over the past eighteen months to this project is two-fold. On the one hand, the terrestrial microwave window is filling up, primarily through the military communication net's signals, such that a SETI search with the passage of time is becoming increasingly difficult. Everything is getting cluttered. If a major project, such as this one, is not launched soon, the only way that the search could be undertaken would be by the placing of an antenna on the far side of the moon. Expensive and unlikely. Secondly, and more personally, Stevens is concerned about the longevity of the human race. With the huge expenditures on arms which he believes will one day be used, the success of the search and recognition that we are not the only life form in the universe might encourage us to take better care of ourselves.

So there it stands: a dedicated radio astronomer, who in eighteen months has amassed one-half million dollars worth of surplus equipment, is personally bankrupt and lacks the support required to get the project over its final hurdle and working. It is a professional-quality project by and for amateurs, and is presently stranded in bueaucratic officialdom.

It is the dream of answering a millenia-old question, hamstrung for the sake of a few dollars.

**The address of ARAO, the Amateur Radio Astronomy Observatory, is 10516-132 Avenue, Edmonton, Alberta T5E 0Z4. Membership is $30.00 per year, and includes the ARAO newsletter. Any donations towards projects would be gratefully accepted.**

## ARAO SETI Signal Processing
### Theory of operation

The parabolic antenna is fed with a cross-polarised, horn/waveguide feed. Two cryogenically cooled front end GaAs FET RF preamplifiers and bipolar transistor coaxial line drive amplifiers supply the entire 1.4 to 1.7 GHz "waterhole" band as two simultaneous, orthogonal linear polarisations, to the receiver bay. ("Waterhole" refers to the frequency of resonance of hydrogen, and is one of the least noisy areas of the electromagnetic spectrum; it would be a natural frequency for interplanetary communications). At this location a PIN diode switch alternately connects the receiver bay to first one, then the other polarisation. This switching is performed by a pulse generated for such purposes by the master sweep ramp generator.

The 70 MHz I.F. output of a user-selected receiver (one of four waterhole receivers in the receiver bay) is amplified and split into 256 equal I.F. taps. Each I.F. tap connects to a 30 KHz wide Filter/Detector module, each of which contains a voltage controlled local oscillator to supply a second conversion to 10.7 MHz. Each of these 256 local oscillators are swept simultaneously by the master sweep ramp detector. The PIN diode RF switch is toggled between polarisations with each successive sweep.

In each Filter/Detector module, the local oscillator is swept over a 30 KHz range, converting adjacent 30 KHz segments of the overall 7.68 MHz receiver passband at 70 MHz down to a 10.7 MHz second I.F. At 10.7 MHz, the signal is bandpass limited with a narrow ceramic filter. The signal is then envelope detected with a high efficiency square-law detector.

At this point, any energy appearing within the 30 KHz passband will appear as a recurring "pip" in the detector output at the rate of the local oscillator sweep. Energy of a wideband nature and in excess of the 30 KHz passband will not produce a recurring "pip", however, and will merely result in a higher DC level being present in the detector output. This DC level will not pass through the following stage of processing, and in this manner one achieves some amount of discrimination against signals that are wideband and obviously not SETI in nature.

This "pip" may be more easily thought of as an audio tone whose frequency will always be that of the master sweep generator repetition rate, regardless of the detected signal's frequency location within the 30 KHz passband or its width, as long as it is less than 30 KHz.

This tone is applied to an extremely narrow, multi-active bandpass filter whose passband center frequency is precisely that of the master sweep generator repetition rate. The output of the filter, including enhancement by nature of its "ringing", is second-detected in a full-wave active rectifier and applied to a FET op amp integrator.

A simple comparator monitors the DC level in the integrator in relation to a master reference. When this reference is overcome, a SETI alarm will instantly summon the system computer to this particular 30 KHz channel.

The system computer continuously monitors all 256 comparator outputs. When a channel alarm is tripped, the computer addresses that particular module's second detector output through a FET cross-point switch arranged to be easily digitally addressed in a 16 x 16 configuration.

That channel's analog output is applied to the computer's 8-bit high speed "video" A to D converter, which has a dynamic range of 256 steps. With this digitized information representing source brightness, and 4096 step frequency identification obtained from a 12 bit A to D converter continuously driven by the master sweep generator, a digital integration and Fourier transformation is produced.

Data will be presented via a hard copy on a high speed printer, displayed as energy detected in each of 4096, 7.62 Hz wide bandwidths available.

One advantage to this design is its lateral expansion capabilities without obsoleting any present hardware, or requiring any significant re-working of the computer hardware or software. The initial prototype will consist of a single, 16 output I.F. distribution block and 16 Filter/Detector modules of 30 KHz each, monitoring a total of 480 KHz of receiver passband.

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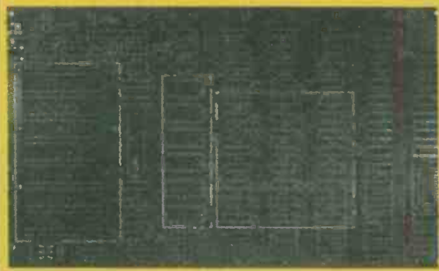

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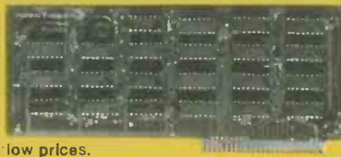

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# Computer Review
# TRS-80 Model MC10

**The original Colour Computer was small enough . . . the Micro Colour is the runt in a litter of dwarfs. However, there's real mean power in that diminutive exterior.**

**by Steve Rimmer**


IF YOU'VE been following the low cost computer world, this thing may remind you of some other computer. If you have been waiting in drooling anticipation for the Sinclair Spectrum to become available . . . well, it may have arrived in disguise.

The Radio Shack MC-10 Micro Colour Computer is a little white box about the size of one of those seven dollar jumbo size paperback novels. It has a switch type keyboard, albeit a ginchy small one, rather than a membrane type. As one might expect, it can render images in living computer-colours . . . in fact, there are nine of them available, if you include black and white. It has a sound generator which can emit single voice bleeps in any of 256 pitches through the speaker of the TV set it looks at the world through. There is a really compact Microsoft BASIC in there somewhere, an RS-232 port to serve as a printer interface and no end of sophisticated . . . and very cost effective . . . high tech all in that tiny little case.

However, the bit that will surely attract your eye is the price. All of this splendour costs a mere two hundred dollars.

## Microbe

The MC-10 is a total beginner's system. This is cool, though . . . you will definitely outgrow it, but it's cheap enough to give to the dog as a chew toy when boredom sets in. It's based on a 6803 micro-processor, a cousin of the 6809 found in the larger Colour Computer, and a 6847 video controller to handle the screen. It has a little over three thousand bytes of useable memory.

The first thing you'll probably notice when you attack one of these things is the keyboard. As these things go, it is not too shabby in its operation. The keys feel all right . . . a bit like a moderately decent calculator. Each key can type a letter in its normal mode. Some can do graphics characters if hit in conjunction with the shift key. You can also use the keys for single stroke keyword entry if you mash the CONTROL key. What this means is that, for example, instead of typing the word PRINT, you could do a CONTROL 9 and the word PRINT would appear on the screen.

This last thing is extremely handy if you're up for doing extensive programming. While the keyboard is decidedly better than that of a ZX-81, it is still a chore for doing a lot of typing on.

On the other hand, there are some scraps of relatively poor design involved in the keyboard as well. The major one of these is that the shift key is on the right side of the keypad . . . only. The position usually taken up by the left hand shift key is occupied by the control. As such, if one is used to using a typewriter and goes for the normal position of the primary shift, one gets a long string of single stroke keywords one may not have been expecting. The first time I tried to get the beast to print my name I got "READSETRNDSET". It ignored the "S", which is the letter it uses for "cursor move right."

The layout wants some getting used to . . . I think it might be easier if one were left handed.

The BASIC is fairly neat for a small machine. It has a number of really clever

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A useful handbook for computerists interested in using their machines in linear applications. Topics discussed include voltage references, op-amps for data conversion, analogue switching and multiplexing and more.

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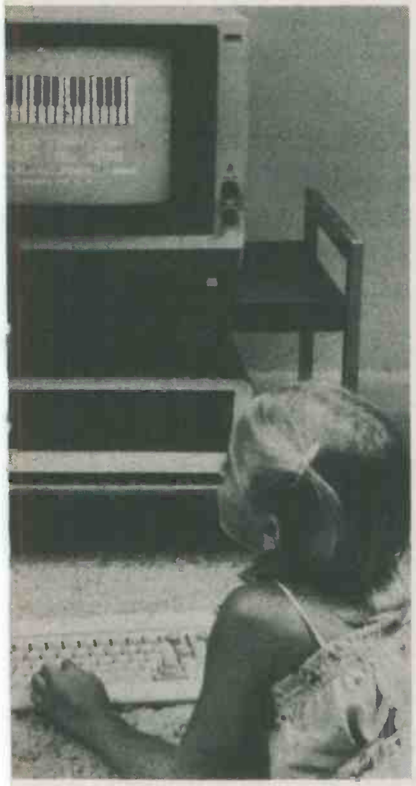
Helps you learn to exchange information and access data bases all over the world, using a system based on the Z-80, or almost any other 8- or 16-bit microprocessor. Includes a portable communications software package with complete instructions, plus many portable programs in BASIC and Z-80 assembly language.

**SB21888: STD BUS INTERFACING** **$20.45**
Now you can interface your STD system when there's no commercial interface card available! Gives you all information and circuitry needed to use your STD bus computer system for controlling instruments or processes, or for acquiring data from an electrical device. Contains immediately usable assembly language software for Z-80, 8080/8085, 6502, and 6800-based microcomputers.


**See back page of catalogue for ordering details. Prices include shipping. No taxes apply to books.**



# BASIC

**SB21836: ADVANCED 6052 INTERFACING** $19.00
Numerous examples of the 6502 and 6800 families, plus fundamental concepts help teach you design of interface circuits, understanding of LSI devices, and solutions to typical problems of ground noise, isolation, and transient and lightning damage. Contains many techniques valuable in the field of machine control.

**BRAIN TICKLERS**
**AB005** $9.00
If the usual games such as Bug Stomp and Invaders From the Time Warp are starting to pale, then this is the book for you. The authors have put together dozens of stimulating puzzles to show you just how challenging computing can be.

**BASIC COMPUTER PROGRAMS IN SCIENCE AND ENGINEERING**
**GILDER**
**HB08** $18.00
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 BASIC**
**SPENCER**
**HB10** $17.45
The writing is nontechnical, allowing almost anyone to understand computerized game playing. The book includes the rules of each game, how each game works, illustrative flowcharts, diagrams, and the output produced by each program. The last chapter contains 26 games for reader solution.

**PH179: BASIC PROGRAMS FOR HOME FINANCIAL MANAGEMENT**
**W. GOLDSMITH, Jr.** $17.45
This book is a 33 program home financial management system written in BASIC. It includes descriptions, listings, and sample runs and programs that are adaptable to TRS-80, Apple II, and other home computers.

**SB22047: 26 BASIC PROGRAMS FOR YOUR MICRO** $17.45
Features 26 previously unpublished, simple-to-complex games you can run on almost any brand of microcomputer as long as you have enough RAM on board. Most take between 500 and 5000 bytes, with the highest taking 13K. Conversion charts that let you key them into your Radio Shack, TRS-80, Apple II, Timex/Sinclair 1000 (ZX81), Spectrum, Atari, or PET are included. Also features notes on program techniques and structures.

**Tab1380: 30 COMPUTER PROGRAMS FOR THE HOMEOWNER IN BASIC** $16.45
Programs include a telephone timer, decor redesign, chequebook program, a "coupon" organiser, menu planner and calorie planner.

**Tab1533: GRAPHICS PROGRAM IN MICROSOFT BASIC** $19.75
Generate computer art including mathematically defined art and animated graphics; draw still pictures — realistic and abstract; create an interactive space shuttle simulation; plot architectural and landscape drawings with both high and low resolution graphics; construct a 3-dimensional model of a function; plot 2-dimensional graphics, statistical relations, maps and diagrams. All these are written in Microsoft BASIC that is adaptable to just about any BASIC micro system.

**SB21941: BASIC: FUNDAMENTAL CONCEPTS** $33.00
Introduces the BASIC language and compares its two major dialects by Microsoft and Digital Equipment Corporation. Teaches you the elements you need to convert programs from one BASIC dialect to another and helps you understand what happens when your computer tries to run a program in a dialect it can't understand. Third in Sam's computing series.

**SB21841: BASIC PROGRAMMER'S NOTEBOOK**
**E. SAVAGE** $21.45
A valuable book that provides you with many timesaving BASIC sub-routines and programming practices usually known only to highly experienced programmers. Also contains several debugged and easily modified program samples you can use.

**SB21942: BASIC: ADVANCED CONCEPTS** $33.00
Last in Sams' special four-volume series on computers and computing. Uses BASIC as a tool to help you study program storage within the computer, explore the limitations of floating-point arithmetic, and examine number systems commonly used in computing. Complements and adds to the fundamental commands and concepts of No. 21941, the preceding volume.

**THE MOST POPULAR SUBROUTINES IN BASIC**
**TAB No.1050** $10.45
An understandable guide to BASIC subroutines which enables the reader to avoid tedium, economise on computer time and makes programs run faster. It is a practical rather than a theoretical manual.

**PROGRAMMING IN BASIC FOR PERSONAL COMPUTERS**
**AB015** $13.45
This book emphasizes the sort of analytical thinking that lets you use a specific tool — the BASIC language — to transform your own ideas into workable programs. The text is designed to help you to intelligently analyse and design a wide diversity of useful and interesting programs.

**COMPUTER PROGRAMS IN BASIC**
**AB001** $15.45
A catalogue of over 1,600 fully indexed BASIC computer programs with applications in Business, Math, Games and more. This book lists available software, what it does, where to get it, and how to adapt it to your machine.

**BP86: AN INTRODUCTION TO BASIC PROGRAMMING TECHNIQUES** $8.25
**S. DALY**
This book is based on the author's own experience in learning BASIC and in helping others, mostly beginners, to program and understand the language. Also included are a program library containing various programs, that the author has actually written and run. These are for biorhythms, plotting a graph of Y against X, standard deviation, regression, generating a musical note sequence and a card game. The book is complemented by a number of appendices which include test questions and answers on each chapter and a glossary.

**THE BASIC COOKBOOK.**
**TAB No.1055** $10.45
BASIC is a surprisingly powerful language . . . if you understand it completely. This book, picks up where most manufacturers' documentation gives up. With it, any computer owner can develop programs to make the most out of his or her machine.

**BASIC FROM THE GROUND UP**
**SIMON**
**HB15** $19.45
Here's a BASIC text for high school students and hobbyists that explores computers and the BASIC language in a simple direct way, without relying on a heavy mathematical backbround on the reader's part. All the features of BASIC are included as well as some of the inside workings of a computer. The book covers one version of each of the BASIC statements and points out some of the variations, leaving readers well prepared to write programs in any version they encounter. A selection of exercises and six worked out problems round out the reader's experience. A glossary and a summary of BASIC statements are included at the end of the book for quick reference.

**AHG2: UNDERSTANDING BASIC**
**PEDDICORD** $4.45
BASIC is the universal microcomputer language and Understanding Basic teaches the novice to write programs right from the beginning. Emphasizes fundamental programming concepts and covers most features common to all popular versions of BASIC.

**PH166: IMPLEMENTING BASICS: HOW BASICS WORK**
**W. & P. PAYNE** $20.45
Shows the reader how to write progressively more complex and advanced programs. Uses the stack-oriented method, tells how to develop table-driven software, and gives techniques for writing programs.

**PH167: MAKING BASIC WORK FOR YOU**
**C. DeROSSI** $12.45
Learn to program with BASIC, one of the most useful computer languages around. Whether you are entering a computer-related field or simply have access to a computer and would like to use it more effectively, this book has everything you need to know.

**PH168: PROGRAMMING IN BASIC FOR PERSONAL COMPUTERS**
**D. HEISERMAN** $13.45
This complete guide to BASIC computer programming, adaptable to the TRS-80, Apple II, and PET computers, covers a wide range of topics, from programmable video games to engineering and business programs.

**SB22014: BASIC PROGRAMMING PRIMER (2nd EDITION)** $25.45
Improved and expanded version of the 5-year Sams/Waite best seller, now featuring keywords, statements, and functions usable with any computer running a variation of Microsoft BASIC, including the IBM PC. Advanced BASIC coverage shows use of special statements, professional-style program coding, and more! New game-program listings include Rubik's Cube, Microspace Invaders, and Word Scrambler! New self-tests and answers help you learn and check your BASIC programming progress as you go! Still user-friendly to beginners and more advanced users, regardless of occupation.

**HB125: INTRODUCTION TO TI BASIC**
**INMAN, ZAMORA, ALBRECHT** $19.25
Written by three of the foremost microcomputing programming experts in the country, this comprehensive work teaches you BASIC for use with the Texas Instruments Home Computer. The authors have carefully constructed this introduction so that you will soon be writing BASIC programs and exploiting all of the excellent features of the TI machine. Covers all the essential programming statements and machine features.

**HB108: PROGRAMMING IN BASIC: A COMPLETE COURSE**
**McRITCHIE** TBA
Suitable for use in both data processing and business courses, this introduction to BASIC provides foundation instruction in the use of the computer terminal, flowcharting, and programming concepts. Since it presupposes no previous experience with computers, McRitchie is accessible to a wide range of students with varying reading abilities. It teaches programming through hands-on student work, and reinforces basic principles through numerous examples and assignments.

**HB101: I SPEAK BASIC TO MY TRS-80**
**HB102: I SPEAK BASIC TO MY APPLE**
**HB103: I SPEAK BASIC TO MY PET**
**JONES** ea. $12.75
I SPEAK BASIC A field-tested computer literacy course that introduces students (and teachers) to BASIC language programming. NO PREVIOUS COMPUTER EXPERIENCE IS REQUIRED. This complete 15-session course is machine specific for Apple™, PET™, and TRS-80™ microcomputers and provides a complete understanding of the machine's operations and functions. The Student Text begins each lesson with learning objectives, followed by definitions of key terms, programming examples, in-class exercises, assignments, a summary, programming practices, and a quiz. Special annotations and suggestions in the Teacher's Manual aid in lesson planning and teaching methods, including answers to all quizzes and practices. Exam Set provided on spirit duplicating masters.

**PH237: COMPUTER PROGRAMS IN BASIC**
**P. FRIEDMAN** $15.45
Covering six major discipline fields of Business/Finance, Games, Math, Science/Education, Personal Interest and Utility, this directory provides program reviews in over 173 categories and briefly describes what the program does, tells where it can be found, and lists the equipment needed to make the program run.

**HB121: BASIC WITH STYLE: PROGRAMMING PROVERBS**
**NAGIN and LEDGARD** $13.20
Covers structured BASIC programming. Essential and surprisingly simple principles help BASIC programmers upgrade the quality and efficiency of their work. Each proverb is accompanied by discussion, explanations, and sample programs demonstrating the techniques.

**HB117: BASIC BASIC: AN INTRODUCTION TO COMPUTER PROGRAMMING IN BASIC LANGUAGE, 2nd Ed.**
**COAN** $19.25
". . . An excellent introduction to the use of BASIC . . . clearly written and well organized." COMPUTING REVIEWS. "It is a well written book . . . there are many good examples, complete with results." COMPUTER WORLD. Over 100 sample programs present the essential statements of BASIC. Each new language statement or capability is clearly explained at the time it is first used in a sample program. Every section is followed by practice problems; solutions to even-numbered problems appear in the text; the remainder in the separate Teacher's Guide.

**HB118: ADVANCED BASIC: APPLICATIONS AND PROBLEMS**
**COAN** $19.00
". . . a useful textbook to the student in a follow-up course, or the programmer acquiring BASIC as his second or third language . . . well above average." DATA PROCESSING DIGEST. Advanced techniques and applications, including coordinate geometry, area, sequences and series, polynomials, graphing, simulations, and games.

# Computing — Languages & Operating Systems

## ASSEMBLY LANGUAGES

**Z-80 AND 8080 ASSEMBLY LANGUAGE PROGRAMMING**
**SPRACKLEN**
**HB05** **$16.00**
Provides just about everything the applications programmer needs to know for Z-80 and 8080 processors. Programming techniques are presented along with the instructions. Exercises and answers included with each chapter.

**HB126: Z-80 AND 8080 ASSEMBLY LANGUAGE PROGRAMMING**
**SPRACKLEN** **$16.10**
Provides just about everything the applications programmer needs to know for Z-80 and 8080 processors. Programming techniques are presented along with the instructions. Exercises and answers included with each chapter.

**Tab1389: MACHINE AND ASSEMBLY LANGUAGE PROGRAMMING** **$15.45**
This book assumes no prior programming knowledge and starts by explaining the advantages of ML. Several sample programs are included and each chapter ends with a quiz to check your understanding of that section.

**SARGON: A COMPUTER CHESS PROGRAM**
**SPRACKLEN**
**HB12** **$26.00**
"I must rate this chess program an excellent buy for anyone who loves the game." Kilobaud.

Here is the computer chess program that won first place in the first chess tournament at the 1978 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.

## FORTH

**PH174: STARTING FORTH**
**L. BRODIE, FORTH, INC.** **$24.45**
Here is valuable reading material for anyone interested in computer programming. "Starting Forth" presents a clear and complete guide to FORTH — the revolutionary approach to computer programming.

**SB21842: INTRODUCTION TO FORTH**
**K. KNECHT** **$16.00**
Most complete book you can find on the MMS FORTH version of FORTH, and also a fundamental approach to programming in all versions of that language. Many programming examples are provided with direct comparisons to the Microsoft Level II BASIC version of the same program.

**AHG17: UNDERSTANDING FORTH**
**REYMANN** **$4.45**
An introduction and overview of this highly flexible programming language that is enjoying increasing interest.

**SB22007: FORTH PROGRAMMING**
**L. SCANLON** **$24.45**
Only book on the market that shows you the differences between FORTH-79 and fig-FORTH, and how to write or modify software using either dialect! Teaches you how to manipulate the stack and add new operations. Lists all FORTH commands. Includes more than 50 fast-acting, useful programs that will execute with little or no modification on any FORTH system.

## FORTRAN

**HB119: BASIC FORTRAN**
**COAN** **$16.40**
This book will enable novice programmers to write FORTRAN programs immediately. The author has developed more readable programs by taking you step by step through the programming process. Short, complete programs are developed into longer, more comprehensive ones. Over 80 program examples are included.

**HB123: FORTRAN WITH STYLE: PROGRAMMING PROVERBS**
**LEDGARD and CHMURA** **$14.95**
This FORTRAN 76 style guide is intended for programmers who want to write carefully constructed, readable programs. Provides simple rules of style that enable the programmer to focus creatively on the deeper issues in programming.

**AHG4: UNDERSTANDING FORTRAN**
**LUDWIG** **$4.45**
FORTRAN is the most widely used language for engineering, scientific, and economic forecasting applications. Understanding FORTRAN acquaints the reader with this type of programming and covers the essential features of the language.

## COBOL

**Tab1398: COBOL** **$16.45**
Cobol for Common Business Orientated Language is a high level language which has gained high acceptance as the language for expressing business data processing procedures in standrad English. This title answers the questions you may have on purpose, use, environment, data and procedures.

**AHG5: UNDERSTANDING COBOL**
**PEDDICORD** **$4.45**
COBOL is the most commonly used language in large, business computers. Understanding COBOL is the ideal introduction for the beginning programmer or curious business manager.

## PASCAL

**PH169: THE FIRST BOOK OF JOSEF: AN INTRODUCTION TO COMPUTER PROGRAMMING USING PASCAL**
**I. TOMEK, ACADIA UNIVERSITY** **$17.45**
Who said learning programming principles has to be dull? Now there's an entertaining and enjoyable way to learn! Readers learn and apply fundamental programming concepts by manipulating a simulated robot, Josef, via a simple programming language consisting of ordinary words governed by simple rules.

**PH170: UCSD PASCAL: A CONSIDERATE APPROACH**
**D. PRICE** **$17.45**
For anyone who wants to learn how to write programs in UCSD Pascal, this book offers the simplest, most effective way to write programs that are easy to read and easy to use. Written specifically for the novice programmer, it offers a solid, low-level introduction and focuses on basic, essential programming skills without going into unnecessary technical detail. Includes many simple programs.

**PH171: UCSD PASCAL: A BEGINNER'S GUIDE TO PROGRAMMING MICROCOMPUTERS**
**J. HUME & R. HOLD** **$20.45**
Everything beginners need to know for effective use of the "hot" new computer language, UCSD Pascal, is readily available in this exciting introduction to programming microcomputers.

**PH172: THE UCSD PASCAL HANDBOOK**
**R. CLARK & S. KOEHLER** **$21.45**
The UCSD Pascal Handbook contains language description organized especially for quick and easy reference. Built around example programs that demonstrate common and useful techniques.

**PH173: PASCAL: A CONSIDERATE APPROACH**
**D. PRICE** **$13.45**
Here is a straightforward introduction to the programming language Pascal. The emphasis is on "considerate programming," using an easy-to-follow approach that aims to ease the learning process by using simple programs.

**AHG3: UNDERSTANDING PASCAL**
**LEDIN** **$4.45**
PASCAL is available on most microcomputers and is one of the newest and most popular of all programming languages. By teaching this ideal "learning language," Understanding Pascal helps the novice develop good programming methods and understand the main programming structures.

**HB120: PASCAL WITH STYLE: PROGRAMMING PROVERBS**
**LEDGARD, NAGIN, and HUERAS** **$14.25**
A style guide specifically written to help Pascal users write more accurate, error-free programs the first time. Offers rules or guidelines that stress overall program organization and "Logical thinking." Special chapter on how to use the top-down approach with Pascal.

**PASCAL PROGRAMMING FOR THE APPLE**
**AB008** **$20.45**
A great book to upgrade your programming skills to the UCSD Pascal as implemented on the Apple II. Statements and techniques are discussed and there are many practical and ready to run programs.

**PASCAL**
**TAB No.1205** **$16.45**
Aimed specifically at TRS-80 users, this book discusses how to load, use and write PASCAL programs. Graphic techniques are discussed and numerous programs are presented.

**SPEAKING PASCAL**
**BOWEN**
**HB16** **$19.45**
An excellent introduction to programming in the Pascal language! Written in clear, concise, non-mathematical language, the text requires no technical background or previous programming experience on the reader's behalf. Top-down structured analysis and key examples illustrate each new idea and the reader is encouraged to construct programs in an organized manner.

## CP/M

**PH175: CP/M ASSEMBLY PROGRAMMING**
**K. BARIER** **$17.45**
This book is a self-teaching manual that will enable readers to learn the details of microcomputer hardware, its operating system, and assembly language programming. These three topics are integrated in a learn-by-doing environment of the most popular microcomputer operating system.

**PH176: SYSTEM PROGRAMMING UNDER CP/M-80**
**L. HUGHES** **$21.45**
How to use and program under the CP/M operating system. How to install and modify the CP/M o.s.

**HB106: CP/M REVEALED**
**DENNON** **$20.45**
This book is intended for CP/M users to improve their skills. It is a guide to the CP/M operating system: the console monitor (CCP), the system manager (BDOS), and the input/output driver package (CBIOS). In addition to providing a clear understanding of the data structure of the CP/M disk and other essentials to using CP/M effectively, this text fills many of the information gaps left by the Digital Research CP/M manuals. Coverage includes buying CP/M, booting up, logging in, changing memory size, mapping disk space, calling all programs, interfacing I/O devices, and more.

**HB109: INSIDE CP/M: A GUIDE FOR USERS AND PROGRAMMERS, WITH CP/M-86 AND MP/M 2**
**CORTESI** **$33.45**
This guide and reference manual for CP/M (an operating system for small computers) is divided into two sections. The Tutorial presents the basics of the management, use, and programming of a small computer and CP/M. In the Reference section, CP/M information is organized for quick access by programmers and users. The answer to any question about the day-to-day use of CP/M can be found in a few seconds in the reference section. Most of this text applies correctly to most CP/M systems; however, the book was developed on, and for, CP/M 2.2.

**SB21791: CP/M® PRIMER**
Helps microcomputer veterans and novices alike find the answers about CP/M in a complete, one-stop sourcebook that's a Sams best-seller! Gives you complete CP/M terminology, hardware and software concepts, startup details, and more for this popular 8080/8085/Z-80 operating system. Helps you begin using and working with CP/M immediately, and includes a list of compatible software, too.

**PHS15: A PROGRAMMER'S NOTEBOOK: UTILITIES FOR CP/M-80**
**D. CORTESI** **$46.50**
This book/disk package, designed from the professional programmer's point of view, offers the nuts and bolts of programming in 8080 assembly language. With it, the user will be able to build an impressive software library that would cost a fortune if bought elsewhere. Book/Disk Package.

## UNIX

**PH177: USING THE UNIX SYSTEM**
**R. GAUTHIER** **$21.45**
The book provides computer professionals with an excellent handbook that shows how to handle everything from specific commands to files to overall system design for new applications.

**SB22028: UNIX PRIMER PLUS** **$28.45**
This newest Sams/Waite Primer introduces you to the powerful UNIX operating system. Perfect for students, office workers, home-computer owners, new computer users and others learning about or starting on a UNIX-based system.

## MISCELLANEOUS

**PHS14: COMAL HANDBOOK**
**L. LINDSAY** **$39.50**
COMAL (COMmon Algorithmic Language) takes the simplicity of BASIC and the power and structure of Pascal and combines them into one language that's easy to learn and powerful to use. Includes 100 sample programs and procedures. Book/Disk Package.

**AHG18: UNDERSTANDING LOGO**
**McLEAN** **$4.45**
LOGO is easy to learn, but capable of great sophistication. This Handy Guide is an introduction for the beginner and an overview for the advanced programmer.

**HB124: MY MICRO SPEAKS BASEX (AND LOVES IT!)**
**WARME** **$14.95**
An in-depth examination of BASEX, a versatile language for 8080 and Z-80 type microcomputers, which combines the best features of BASIC and executable machine code. The major advantage of BASEX is speed — programs run up to ten times faster than similar programs in BASIC.

**AHG11: UNDERSTANDING APL**
**BRYSON** **$4.45**
APL, rapidly growing in popularity, is one of the most concise computer languages, particularly well-suited to the efficient solution of mathematical and business problems. This Handy Guide is a concise introduction to the terms and functions of this language. For the beginning to advanced programmer.

**AHG12: UNDERSTANDING LISP**
**GLOESS** **$4.45**
LISP is the most widely used language in the Artificial Intelligence community, an area of growing importance in the computer world, and is available on a growing number of personal computers. This Handy Guide is a detailed introduction to this language. For the reader with at least some programming experience.

# BUSINESS (GENERAL)

**PH180: 1983 CANADIAN BUSINESS GUIDE TO MICROCOMPUTERS**
**K. DORRICOTT** **$9.45**
Written by the managing director of Deloitte, Haskins & Sells, a Canadian partnership of public accountants and other professional advisors to management, this book is one of the most complete comprehensive guides to microcomputers available. Starting with a general overview of microcomputers and their business applications, the author helps you assess your computer needs, compares and evaluates computer systems and application packages, and gives you tips on "doing it right". A must for anyone thinking of purchasing a microcomputer for business.

**PH183: HOW TO BUY A BUSINESS COMPUTER AND GET IT RIGHT THE FIRST TIME**
**CROSS** **$21.45**
246 pages

**THE JOY OF MINIS AND MICROS: DATA PROCESSING WITH SMALL COMPUTERS**
**STEIN AND SHAPIRO**
**HB03** **$18.00**
A collection of pieces covering technical and management aspects of the use of small computers for business or science. It emphasizes the use of common sense 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.

**SB21890: UNDERSTANDING AND BUYING A SMALL BUSINESS COMPUTER** **$14.45**
A lively, practical guide intended primarily for small-business owners but equally usable by any businessperson considering purchase of a micro- or minicomputer for business use. Presented in a careful, nontechnical style and filled with examples, diagrams, and case studies of other business-users to help build your knowledge and confidence. Not a shopping guide. Helps you avoid hidden costs, spot reliable suppliers, and ask intelligent questions.

**PH190: HOW TO BUY AN OFFICE COMPUTER OR WORD PROCESSOR**
**B. DONOHUE** **$12.45**
A single-source of detailed instructions on how to find and contract the right computer or word processor, this book lays out a step-by-step procedure for selecting a system and for protecting one's self with a solid contract.

**PH191: HOW TO SELECT YOUR SMALL COMPUTER ... WITHOUT FRUSTRATION**
**H. SEGAL & J. BERST** **$20.45**
Presents the latest tested and proven techniques to help the prospective computer buyer avoid the most common pitfalls that plague new users. Includes 18 worksheets leading the reader through each step of the way and "shopping lists" of features to look for in the most popular hardware and software.

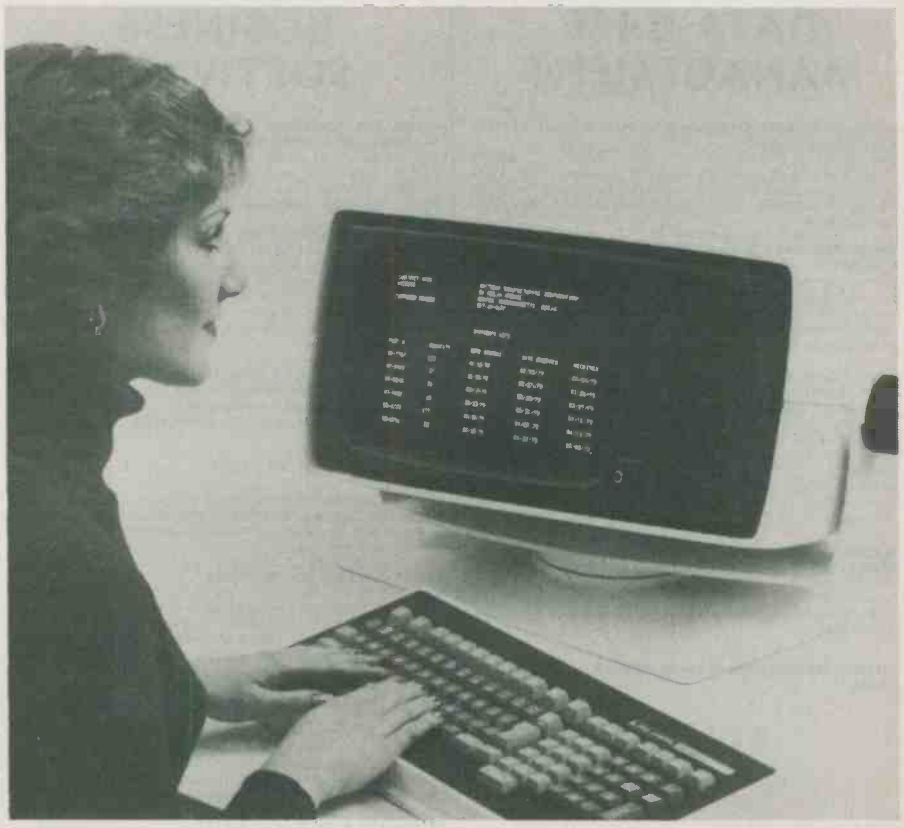
**PH182: THE ELECTRONIC OFFICE**
**N. FINN** **$17.45**
Specific suggestions on how to implement office automation, as well as the factors to consider in computer contract negotiations, selection of hardware, database input and management, and 'ergonomics' of computer design.

**PH184: MICROCOMPUTERS IN SMALL BUSINESS**
**R. RANDALL** **$12.45**
Written specifically for the business-person with little or no experience with computers. Provides a basic, detailed introduction to the use of microcomputers in the small business environment.

**PH185: A GUIDE FOR SELECTING COMPUTERS AND PROGRAMS FOR SMALL BUSINESS**
**P. ENOCKSON** **$20.45**
An overview of all the aspects of the selection of a computer, including software and the installation of the entire system in any small business.

**PH187: THE COMPLETE BOOK OF WORD PROCESSING AND BUSINESS GRAPHICS**
**W. SIKONOWIZ** **$20.45**
Designed as an introduction to word processing and business graphic systems, this easy-to-understand guide features comparisons between dedicated machines and general purpose computers configured for these same applications.

**PH188: A MANAGER'S GUIDE TO LOCAL NETWORKS**
**F. DERFLER, Jr. & W. STALLINGS** **$20.45**
Informative, yet easy to understand, this book explains how business managers and corporate decision-makers can improve productivity with a better understanding of local network systems.



**PH198: TAMING YOUR COMPUTER: A GUIDE FOR BUSINESS AND PROFESSIONAL PEOPLE**
**J. KANTER** **$12.45**
'Taming Your Computer' will show you how to use your computer to reach peak efficiency in your daily functions as businessman or professional. Perfect for businessmen who want to streamline their production.

**PH200: MICROCOMPUTERS FOR BUSINESS**
**SUMMER & LEVY, editors** **$11.45**
Just about everything the small business operator or manager should know when considering the cost efficiency of microcomputer systems. Includes comparisons of various systems, cost evaluation, choosing the right system, much more. 40 case studies.

**PH201:COMPUTER POWER FOR THE SMALL BUSINESS**
**C. SIPPL & F. DAHL** **$11.45**
Explains how computers work in simple terms. Step-by-step instructions tell how to develop a plan for an individualized computer system.

**PH202: HOW TO COMPUTERIZE YOUR SMALL BUSINESS**
**J. COHEN & C. McKINNEY** **$11.45**
A complete guide to selecting data processing equipment and services, this book shows how to plan a computer system tailored to the needs of any small business.

**HOW TO PROFIT FROM YOUR PERSONAL COMPUTER: PROFESSIONAL, BUSINESS, AND HOME APPLICATIONS**
**LEWIS**
**HB01** **$19.45**
Describes the uses of personal computers in common business applications, such as accounting, managing, inventory, sorting mailing lists, and many others. The discussion includes terms, notations, and techniques commonly used by programmers. A full glossary of terms.

**PH192: HOW TO MANAGE YOUR SMALL COMPUTER ... WITHOUT FRUSTRATION**
**H. SEGAL & J. BERTS** **$20.45**
Readers will learn how to guarantee a hassle-free installation; how to overcome the staff's computer phobia; how to hire, train and motivate DP personnel, and how to sell excess computer capacity for bonus profits.

**PH193: DEVELOPING COMPUTER SOLUTIONS FOR YOUR BUSINESS PROBLEMS**
**H. PETERSOHN** **$20.45**
A computer expert shows managers how to effectively implement, and evaluate automation alternatives. Written specifically for managers in both large and small business environments, it guides the reader in defining problems explaining them to data processing people, and finding the fastest and least expensive installation method.

**PH194: MICROCOMPUTERS IN LARGE ORGANIZATIONS**
**T. MADRON** **$17.45**
Here is the first — and only — book that discusses planned implementation of microcomputers in large organizations. Written specifically for business and data processing managers, it provides a complete description of software for the development of the Executive Workstation. Also included are implementation techniques on the IBM-PC and the Osborne 1.

**PH195: SO YOU ARE THINKING ABOUT A SMALL BUSINESS COMPUTER**
**R. CANNING & N. LEEPER** **$15.45**
Specially designed for the business person with little or no knowledge of computers, this book gives practical step-by-step guidelines for successfully selecting a small computer system and using it in daily office routines. It describes the benefits of having a computer system, how computers work, hardware and software characteristics, and how to use the services of a consultant.

**PH189: THE COMPUTER IN YOUR LEGAL PRACTICE**
**M. MARCUS & L. BROWN** **$26.50**
At last — here's the answer every lawyer has been waiting for! A complete, authoritative guide to computerizing a legal practice, this book will help readers better understand how computers work — and how to use them for increased efficiency and productivity in a business. Applications include law office management, accounting, finance, word processing, database and research, document control, records management, electronic mail, administration, and more.

**PH186: MICROCOMPUTERS FOR ACCOUNTANTS**
**T. NEEDLEMAN** **$20.45**
Written by a consultant who specializes in the financial application of microcomputers, this book shows accountants how to make their business more profitable by implementing microcomputers for better practice management, improved client support, and such new services as tax accounting, modelling, budgeting, and forecasting.

**PH196: THE PHYSICIAN'S GUIDE TO DESKTOP COMPUTERS**
**M. SPOHR, M.D.** **$29.50**
Designed for medical practitioners-doctors, dentists, nurses — who use or plan to use microcomputers in their practice. Written for the uninitiated computers user, the book covers the special capabilities of the desktop computer that make it valuable in a medical office/clinic.

**USING MICROCOMPUTERS IN BUSINESS**
**VEIT**
**HB04** **$16.45**
An essential background briefing for any purchaser of microcomputer systems or software. In a fast-moving style, without the usual buzz words and technical jargon, Veit answers the most often asked questions.

# Computing — Business

## DATA BASE MANAGEMENT

**PH199: DATA BASE SYSTEMS: DESIGN, IMPLEMENTATION AND MANAGEMENT**
**R. ROSS** **$29.50**
Here's a practical, comprehensive resource that covers Data Base Management Systems. Examines CODASYL, inverted DBBMs, mini-DBMS, the relationship model and physically-linked DBMS.

**PH181: THE DATA BASE GUIDE**
**C. BENTON** **$26.50**
Complete step-by-step book detailing the necessary elements for selecting, organizing, and implementing database systems for micocomputers. Presents material at a beginner's level yet thorough enough to aid the professional data processing person.

**SB21875: MICROCOMPUTER DATA BASE MANAGEMENT** **$19.00**
A practical guide for anyone who needs to control and access large amounts of data with a microcomputer. Complete tutorial shows routines you can use to write and implement your own data-base programs. Also explains step-by-step operation of WHATSIT, SELECTOR, and PROFILE, just 3 of many data-base packages on the market, and evaluates their performance. If you know the fundamentals of BASIC programming, you'll do fine with this book.

**AHG10: UNDERSTANDING DATA BASE MANAGEMENT**
**FREILING** **$4.45**
This Handy Guide explains how data bases are created, maintained and utilized, and surveys the latest techniques, providing an easy overview for businesss managers and programmers alike.

**PH230: EVERYMAN'S DATABASE PRIMER**
**BYERS** **$20.45**

## BUSINESS SOFTWARE

**PH203: THE POWER OF MULTIPLAN™**
**MANAGEMENT INFORMATION SOURCE** **$20.45**
Covers: Accounts receivable, invoicing, cost recovery, production scheduling, estimating, checkbook, and engineering problem solving, accounts payable, payroll, monthly sales report, inventory and financial forecast.

**PH204: THE POWER OF VISICALC: REAL ESTATE**
**MANAGEMENT INFORMATION SOURCE** **$20.45**
Residential income property analysis, amortization schedule, condominium conversion or tract home development cash flow analysis, project operating case flow analysis, property-tenant income revenue calculations, construction disbursements, construction loan draw, project cost analysis, cash flow analysis.

**PH205: THE POWER OF VISIPLOT — VISICALC — VISIFILE:**
**MANAGEMENT INFORMATION SOURCE** **$20.45**
Line graphs, Bar graphs, Area graph, Pie and Hi-Lo overlaying plots, storage management, VisiCalc data plotted, VisiFile data plotted.

**PH206: dBASE II USER'S GUIDE**
**A. GREEN** **$38.50**
This instructional handbook for novices and experienced users alike presents a simple, highly effective approach to learning how to use this powerful software program avialable for microcomputers.

**PH207: SUPERCALC! THE BOOK**
**D. BEIL** **$23.45**
This practical programming guide is designed to help users of a SuperCalc system discover its real power! It teaches readers how to design the right "model" so that they can examine every step of their business operation and includes practice problems to help along the way.

**PH208: THE VISICALC APPLICATIONS BOOK**
**J. GRUSHCOW** **$23.45**
Designed for both the novice and advanced VisiCalc user, this practical guide explains WHY VisiCalc should be used as well as HOW to use it in six key business areas: credit control, financial statement analysis, forecasting, budgeting cost management, and portfolio management.

**PH209: THE POWER OF VISICALC**
**R. WILLIAMS & B. TAYLOR** **$13.45**
A must for anyone who owns — or is thinking about getting — a microcomputer, this instructional handbook presents a simple and effective approach to learning how to use the most powerful software program available for personal size computers. It demonstrates the use of VISICALC features through specific examples in a wide range of applications.

**PH210: THE POWER OF SUPERCALC**
**R. WILLIAMS & B. TAYLOR** **$13.45**
Here is the first book that demonstrates the use of SUPERCALC features through specific application examples. Written for business owners, accountants, teachers, students, and homeowners, it presents several easy-to-follow exercises for developing and expanding problem-solving skills with SUPERCALC.

**AHG8: HOW TO USE VISICALC/SUPERCALC**
**SHRUM** **$4.45**
A step-by-step, detailed guide to the two best-selling software for personal computers, used to make budgeting and forecasting easy. This Handy Guide clearly and simply explains all VisiCalc/SuperCalc functions and helps the reader creatively solve problems. For the complete novice.

**HB104: BASIC COMPUTER PROGRAMS FOR BUSINESS (Vol. 2)**
**STERNBERG** **$20.45**
A must for small businesses and entrepreneurs using micros. Over 60 practical business applications, each documented with a description of its functions and operation, a listing in BASIC, a symbol table, sample data, and one or more samples.

**PH197: SIMPLE: BASIC PROGRAMS FOR BUSINESS APPLICATION**
**J. ALONSO** **$20.45**
This book includes BASIC programs that even a new user can use with as little as 3 minutes of instruction! And for experienced users, these programs can be easily modified to better suit particular needs. Covers a wide range of statistical, business, and mathematical techniques.

**BASIC COMPUTER PROGRAMS FOR BUSINESS:**
**STERNBERG (Vol. 1)**
**HB13** **$18.45**
A must for small businesses utilizing micros as well as for entrepreneurs, volume provides a wealth of practical business applications. Each program is documented with a description of its functions and operation, a listing in BASIC, a symbol table, sample data, and one or more samples.

## WORD PROCESSING

**PH211: WORD PROCESSORS AND INFORMATION PROCESSING**
**D. POYNTER** **$16.45**
A clear, readable word processing book that provides business and lay people with the means to effectively evaluate word processing equipment and choose the appropriate machine for their specific needs.

**PH212: CHOOSING A WORD PROCESSOR**
**P. GOOD** **$17.45**
Provides a head-to-head comparison of 157 features of the 21 leading word processing systems, plus extensive checklists to help pick the system that is most flexible and most cost efficient for the work that must be done.

**PH213: WORD PROCESSING SIMPLIFIED AND SELF-TAUGHT**
**J. CHRISTENSEN** **$7.45**
Illustrates how word processing functions in a typical office environment and explains the basic components and applications that all potential users need to know, whether for business or personal use.

**PH214: THE WORD PROCESSING HANDBOOK**
**R. STULTZ** **$12.45**
Convenient and easy to use, this handbook is designed for the business manager responsible for the operation of high technology word processing systems. It is written in a style which cuts through the usual technical doubletalk to give the reader a better understanding of word processing systems — what they are, what they do, and which one to select, as well as the bottom line cost of owning and operating a system.

**SB21929: WORD PROCESSING FOR SMALL BUSINESSES** **$17.45**
Tells you about doing practical word processing on a personal computer, how word-processing software works, what benefits you can expect from W/P, and what you should avoid. Compares micro- and minicomputer W/P systems, discusses W/P software and its documentation, points out the effects of different hardware designs, and presents details for more than 50 word-processing systems, including applicable hardware and W/P software.

**AHG7: HOW TO BUY A WORD PROCESSOR**
**SCRIVEN** **$4.45**
A buying guide and short course on word processing wrapped into one book; covering electronic typewriters, personal computers, and specialized word processing systems. Includes a comparison chart of the most popular systems and software.

## GENERAL

**DESIGNING MICROCOMPUTER SYSTEMS**
**HB18:** **$18.00**
**POOCH AND CHATTERGY**
This book provides both hobbyists and electronic engineers with the background information necessary to build microcomputer systems. It discusses the hardware aspects of microcomputer systems. Timing devices are provided to explain sequences of operations in detail. Then, the book goes on to describe three of the most popular microcomputer families: the Intel 8080, Zilog Z-80, and Motorola 6800. Also covered are designs of interfaces for peripheral devices, and information on building microcomputer systems from kits.

**S-100 BUS HANDBOOK**
**HB19:** **$26.00**
**BURSKY**
Here is a comprehensive book that exclusively discusses S-100 bus computer systems and how they are organized. The book covers computer fundamentals, basic electronics, and the parts of the computer. Individual chapters discuss the CPU, memory, input/output, bulk-memory devices, and specialized peripheral controllers. It explains all the operating details of commonly available S-100 systems. Schematic drawings.

**THE BASIC CONVERSIONS HANDBOOK FOR APPLE, TRS-80, AND PET USERS**
**BRAIN BANK**
**HB17** **$13.45**
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, TRS-80 and Apple II programs to PET. Equivalent commands are listed for TRS-80 BASIC (Model I, Level II), Applesoft BASIC and PET BASIC, as well as variations for the TRS-80 Model III and Apple Integer BASIC.

**AHG6: UNDERSTANDING ARTIFICIAL INTELLIGENCE**
**GLOESS** **$4.45**
This Handy Guide surveys current developments and applications of artificial intelligence and explains them in easy-to-understand language. Readers need not know programming.



See back page of catalogue for ordering details. Prices include shipping. No taxes apply to books.

# Computing — General

**HB116: THE BASIC CONVERSIONS HANDBOOK FOR APPLE™, TRS-80™, and PET™ USERS**
**BRAIN BANK** **$13.45**
A complete guide to converting Apple II and PET programs to TRS-80, TRS-80 and PET programs to Apple II, and TRS-80 and Apple II programs to PET. Equivalent commands are listed for TRS-80 BASIC (Model I, Level II), Applesoft BASIC, and PET BASIC, as well as variations for TRS-80 Model III and Apple Integer BASIC. Also describes variations in graphics capabilities.

**SB21927: MICROCOMPUTER MATH**
**W. BARDEN** **$17.45**
A step-by-step introduction to binary, octal, and hexidecimal numbers, and arithmetic operations on all types of microcomputers. Excellent for serious BASIC beginners and intermediates as well as assembly-language programmers. Treats addition and subtraction of binary, multiple-precision and floating-point operations, fractions and scaling, flag bits, and more. Many practical examples and self-tests.

**PH240: THE COMPUTER COOKBOOK™**
**W. BATES** **$17.45**
A guidebook to putting together microcomputer systems from various components available on the market. Offering factual and specific information (not a lot of jargon), it explains how to integrate assorted "ingredients" into finished systems.

**HOW TO TROUBLESHOOT AND REPAIR MICROCOMPUTERS**
**AB013** **$13.45**
Learn how to find the cause of a problem or malfunction in the central or peripheral unit of any microcomputer and then repair it. The tips and techniques in this guide can be applied to any equipment that uses the microprocessor as the primary control element.

**TROUBLESHOOTING MICROPROCESSORS AND DIGITAL LOGIC**
**TAB No.1183** **$16.45**
The influence of digital techniques on commercial and home equipment is enormous and increasing yearly. This book discusses digital theory and looks at how to service Video Cassette Recorders, microprocessors and more.

**HOW TO DEBUG YOUR PERSONAL COMPUTER**
**AB012** **$13.45**
When you feel like reaching for a sledge hammer to reduce your computer to fiberglass and epoxy dust, don't. Reach for this book instead and learn all about program bug tracking, recognition and elimination techniques.

**PH178: INCOME FROM YOUR HOME COMPUTER**
**E. LIAS** **$17.45**
Presents 30 ways to earn income with a home microcomputer. One third of the innovative ideas are applicable to the novice, and much of the text appeals to game players as well as skilled system designers. Includes names and addresses of software agents, microcomputer manufacturers, journals, user clubs, microcomputer directories, workshop resources, and publishers who buy software.

**HOW TO PROGRAM YOUR PROGRAMMABLE CALCULATOR**
**AB006** **$12.45**
Calculator programming, by its very nature, often is an obstacle to effective use. This book endeavours to show how to use a programmable calculator to its full capabilities. The TI 57 and the HP 33E calculators are discussed although the principles extend to similar models.

**BP33: ELECTRONIC CALCULATOR USERS HANDBOOK** **$4.25**
**M.H. BABANI, B.Sc.(Eng.)**
An invaluable book for all calculator users whatever their age or occupation, or whether they have the simplest or most sophisticated of calculators. Presents formulae, data, methods of calculation, conversion factors, etc., with the calculator user especially in mind, often illustrated with simple examples. 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.

**SB21960: COMPUTER PROGRAMS FOR MACHINE DESIGN** **$31.45**
Aids mechanical and material engineers, machinists, technicians, and students in solving the day-to-day problems that come up in their involvement with various facets of machine technology. Organized by major subject area in a logical, problem-solving order that features a statement of the problem, the formula used for solution, and a working example. You can manipulate data repeatedly to observe specific design variables. Programs are in BASIC.

**AHG16: UNDERSTANDING DATA COMMUNICATIONS**
**BUCKWALTER** **$4.45**
A non-technical introduction to all aspects of communications between computers. Emphasizes the practical requirements of electronic mail, networking, and shared systems.

**SB21896: INTRODUCTION TO ELECTRONIC SPEECH SYNTHESIS**
**N. SCLATER** **$13.45**
Helps you understand how a human "voice" is electronically created, explains the three current digital synthesis technologies used, and tells you what you can expect in speech quality as it relates to data rate and the cost of memory devices. Also evaluates complexity and cost of commercial voice-synthesis subsystems.

**PH220: MICROCOMPUTER DATA COMMUNICATIONS SYSTEMS**
**F. DERFLER, Jr.** **$17.45**
This guide explains microcomputers as data communications terminals and electronic message systems. Covers TRS-80, Apple II, Heath H-89, and other systems.

**PH221: CAI SOURCEBOOK**
**R. BURKE** **$16.45**
CAI stands for Computer Assisted Instruction, and this step-by-step introduction to the systematic development and validation of CAI includes a complete set of forms and procedures for implementing the systems approach to computer assisted instruction.

**PH222: THE ABC's OF MICROCOMPUTERS: A COMPUTER LITERACY PRIMER**
**L. CHRISTIE & J. CURRY, Jr.** **$11.45**
An invaluable collection of informative discussions on applications, equipment, programming, and operations of microcomputers. Focuses on those topics essential for the novice to know, and defines all technical terms as they appear.

**PH223: COMPUTERS AND DATA PROCESSING SIMPLIFIED AND SELF-TAUGHT**
**R. STRACKBEIN & D. STRACKBEIN** **$7.45**
Shows in non-technical language how computers work, what their applications are, and how these applications are being utilized in the everyday world.

**PH224: SIMPLIFIED GUIDE TO MICROCOMPUTERS**
**W. BOCCHINO** **$26.50**
Features 10 model programs (worth hundreds of dollars) for business and personal use, a special glossary of microcomputer terms, and dozens of photos, diagrams, charts and checklists.

**PH225: MICROCOMPUTERS GRAPHICS**
**D. HEARN & M. BAKER** **$25.45**
Provides the reader with a solid grasp of the graphic capabilities of microcomputers and the variety of uses to which they can be put. Graphics methods are illustrated with programs written in BASIC.

**PH226: COMPUTER ANATOMY FOR BEGINNERS**
**M. OUVERSON** **$15.45**
Specifically written for the thousands of readers who simply want to know what the microcomputer revolution is all about and how it might affect, or even benefit them.

**PH227: SOFTWARE ENGINEERING FOR SMALL COMPUTERS: A PROGRAMMER'S COMPANION**
**R.B. COATS** **$23.45**
For more advanced programmers who want to extend their skills beyond simple programming, this reference guide takes the reader from analysis to design, through construction and implementation.

**PH228: PROGRAMMING A PERSONAL COMPUTER**
**P. HANSEN** **$25.45**
Describes a software system powerful enough to support the development of new operating systems, compilers, and text processing programs on a small, personal computer, yet is simple enough to be studied in detail at all levels of programming. The software system is written in the programming language Edison — a Pascal-like language that supports program modularity and concurrent execution on microprocessor. 11 line illustrations.

**PH229: VIDEOTEXT: THE MESSAGE IN THE MEDIUM**
**P. STORFER** **$20.45**
Here is a complete, authoritative guide to videotext services. It explores their potential impact on: advertising, personal computer use, banking and financial services, libraries, publishing, and broadcasting.

**PH231: MICROS AND MODEMS**
**J. NILLES** **$30.50**

**MICROCOMPUTERS AND THE 3 R'S**
**DOERR**
**HB09** **$16.45**
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-based program, the five instructional application types (with examples from subjects such as the hard sciences, life sciences, English, history, and government), and resources listings of today's products. The book includes preprogrammed examples to start up a microcomputer program; while chapters on resources and products direct the reader to useful additional information. All programs are written in the BASIC language.

**PH232: MATHEMATICAL PROBLEM SOLVING WITH THE MICROCOMPUTER: PROJECTS TO INCREASE YOUR BASIC PROGRAMMING SKILL**
**S. SNOVER & M. SPIKELL** **$12.45**
Whether it is for educational or recreational purposes, this collection of programs is written with BASIC instructions that are general enough to work on virtually every computer that uses BASIC language.

**PH233: A 60-MINUTE GUIDE TO MICROCOMPUTERS**
**L. HOLLERBACH** **$10.45**
Specifically designed for beginners who want a quick course in personal and business computing, this book provides a solid, low-level introduction to microcomputers. It gives a lucid presentation of microcomputer use in both business and personal spheres and clarifies all the technical buzz words in a simple and entertaining fashion.

**PH234: EXPLORING THE WORLD OF THE PERSONAL COMPUTER**
**J. NILLES** **$17.45**
"Exploring the World of the Personal Computer" takes this technology to the individual and societal level, examining the positive and negative aspects of the present and future widespread use of low cost microcomputers.

**PH235: BIG THINGS FROM LITTLE COMPUTERS**
**D. PETERSON** **$17.45**
Written in a non-technical style, this book will appeal to the increasing number of people interested in personal computing — whether or not they have a professional background in the area. Computer enthusiasts will learn about such topics as how a computer works, and what can actually be done with a computer.

**PH236: THE PRENTICE-HALL CONCISE BOOK OF COMPUTERS**
**M. FRANK** **$14.45**
"The Prentice-Hall Concise Book of Computers" explains clearly what computers are, how they operate, and the sort of work they perform. It examines every aspect of this fascinating subject, from the simplest type of machine to the most sophisticated, which are astoundingly fast, and shows that, far from being the mystery that most people consider them, computers are useful, comprehensible tools of benefit to all of us, whether we use one directly or not. Over 150 illustrations in colour and black and white.

# CONSTRUCTIONAL

**Tab1491: 101 PROJECTS FOR THE Z80** **$30.45**
Gives you hands-on experience in interfacing fundamentals plus a thorough grounding in creative programming. There are hardware and software applications and several that combine both.

**Tab1449: COMPUTER PERIPHERALS YOU CAN BUILD** **$20.45**
Shows you how to build A/D and D/A converters, cassette interfaces, light pens, disk drives, AC and DC control mechanisms, music boards and much more.

**HOW TO BUILD YOUR OWN WORKING MICROCOMPUTER**
**TAB No.1200** **$16.45**
An excellent reference or how-to manual on building your own microcomputer. All aspects of hardware and software are developed as well as many practical circuits.

**BP78: PRACTICAL COMPUTER EXPERIMENTS** **$7.30**
**E.A. PARR, B.Sc., C.Eng., M.I.E.E.**
Curiously most published material on the microprocessor tends to be of two sorts, the first treats the microprocessor as a black box and deals at length with programming and using the "beast". The second type of book deals with the social impact. None of these books deal with the background to the chip, and this is a shame as the basic ideas are both interesting and simple.

This book aims to fill in the background to the microprocessor by constructing typical computer circuits in discrete logic and it is hoped that this will form a useful introduction to devices such as adders, memories, etc. as well as a general source book of logic circuits.

# KIDS

**PH215: KIDS AND THE APPLE**
**E. CARLSON & DATAMOST** **$26.50**
Written primarily for 10 to 14 year-olds, this book helps kids (as well as parents and teachers) become pros at writing Applesoft Basic Programs for home computers. Through a series of 33 sequential, easy-to-follow lessons, examples and exercises, learn how to program Apple computers, to play board games, word games, action games, store and recall personal data, debug, edit, create graphics, even create a program.

**PH216: KIDS AND THE VIC**
**E. CARSON & DATAMOST** **$26.50**
Written primarily to 10 for 14 year-olds plus parents and teachers, this new guide offers sequential, easy-to-follow lessons, examples, and exercises that illustrate how to program the VIC personal computer to play board games, word games, and action games, store and recall personal data, debug, edit, create graphics, and more!

**PH217: BASIC COMPUTER PROGRAMMING FOR KIDS**
**P. CASSIDY & J. CLOSE** **$16.45**
Fully illustrated with photographs and drawings, this book teaches the reader the history of computers and computing and gently introduces binary mathematics and the basic theory of how computers work. Written in an easy, conversational tone.

**PH218: COMPUTER GRAPHICS AND GAMES FOR KIDS: APPLE II**
**P. CASSIDY & J. CLOSE** **$16.45**
An entertaining, educational approach to teaching kids to use computers, this book explains the principles of programming through computer graphics and games. Readers are given a series of simple, easy-to-follow graphics problems to solve for quick, effective mastery over the material and over the machine. Readers are then encouraged to create and modify their own computer games.

**PH219: BASICALLY SPEAKING: A YOUNG PERSON'S GUIDE TO COMPUTING**
**COHEN** **$17.45**

# Computing Systems

## APPLE

**ARCP3: 101 APPLE COMPUTER PROGRAMMING TIPS & TRICKS**
**F. WHITE** **$13.00**
Practical ready-to-type-and-run software. 96 pages.

**HB105: BASIC APPLE™ BASIC**
**COAN** **$19.25**
A complete guide to Applesoft BASIC. Takes you from beginning concepts, such as entering data and obtaining output and planning programs, to more advanced topics, such as numeric and string arrays and sequential and random-access files. Alternate techniques for programming in Apple Integer BASIC are also covered. Discusses Lo-Res and Hi-Res graphics.

**HB107: GRAPHICS COOKBOOK FOR THE APPLE**
**WADSWORTH** **$14.95**
Learn how to use your Apple II to "paint" shapes, objects, and letters in low-resolution graphics. The author provides a library of microcomputer graphics including such multicoloured illustrations as robots and flying saucers, trees, sailboats, and colourful picture backgrounds. Contains complete annotated Applesoft BASIC programs to draw all the pictures described in the book as well as suggestions for improving programming techniques.

**HB110: APPLE PASCAL: A PROGRAMMING GUIDE**
**TUCKER** **$27.45**
This class-tested text offers a complete, self-contained introduction to programming using the Apple UCSD Pascal language. Tucker's accessible coverage introduces Pascal via a subset language (Eight Statement Pascal) to orient and involve students from the start. He teaches Apple editor and filer commands early and provides extensive examples, exercises, and lab problems keyed to a variety of fields from business to science. Structured programming is used throughout.

**SB21959: THE APPLE® II CIRCUIT DESCRIPTION** **$33.00**
Provides you with a detailed circuit description of the Apple II motherboard, including the keyboard and power supply. Comes complete with timing diagrams for major signals and discussion of differences between the various revisions. Good for technicians, serious hobbyists, and others with some knowledge of digital hardware.

**SB21889: INTERMEDIATE LEVEL APPLE® II HANDBOOK**
**D. HEISERMAN** **$24.45**
Hands-on aid for exploring the entire internal firmware of your Apple II and finding out what you can accomplish with its 6502 microprocessor through machine- and assembly-language programming. Good introduction if you're ready to move out of BASIC but don't want to buy more hardware.

**PHS1: PASCAL FOR THE APPLE**
**IAIN MacCALLUM** **$34.20**
A step-by-step introduction to Pascal for Apple II and Apple II Plus users. The package of text and software diskette provides readers with worthwhile and interesting programs which can be run immediately and the results studied. Includes over 200 exercises with full solutions. Book/Disk Package.

**PHS2: APPLE GRAPHICS GAMES**
**PAUL COLLETTA** **$33.50**
Contains 10 arcade-style games written especially for the Apple II, including Spider, Piano, Pairs and Poker, as well as education, math, and designing games. Book/Disk Package.

**PHS17: MULTIPLOY (APPLE II)**
**P. COLETTA** **$30.45**
"Arithmetic can be fun?"
"YES!" Simply slip MULTIPLOY into an Apple II and you're under attack; math problems come down the screen and unless you answer them correctly — WHAM! — you're a goner. Four math operations — three levels of play. Software Package.

**PHS18: WORDWORX (APPLE II)** **$60.50**
WordWorx consists of two fantastic word games — "Myspellery" and "Sentence Builder." Each game can be played competitively or solo, and at a variety of difficulty levels. They're both challenging learning tools for kids and brain-teasing fun for adults. Software Package.

**Tab1513: APPLE II BASIC** **$23.45**
Does far more than teach you BASIC vocabulary. Includes a library of subroutines that form the cornerstone of this unique programming approach. Other topics include formatting hard copy, PEEKs, POKEs, CALLs and other output techniques, sequential text files; random access files; sorting routines; number crunching, etc.

**SB21846: ENHANCING YOUR APPLE® II — VOLUME 1**
**D. LANCASTER** **$23.00**
Who but Mother Nature or Don Lancaster could successfully enhance an Apple? YOU can, with help from Volume 1 in Don's newest series for Sams. Among other things, you'll learn (1) to mix text, LORES, and HIRES together anywhere on the screen in any combination, (2) how to make a one-wire modification that will open up whole new worlds of 3-D grpahics and other special effects, plus (3) a fast and easy way to tear apart and understand somebody else's machine-language program. Other goodies abound!

**SB21863: CIRCUIT DESIGN PROGRAMS FOR THE APPLE® II** **$23.00**
A series of ready-to-run Applesoft programs that show you "what happens if" and "what's needed when" as they apply to periodic waveform, rms and average values, the solution of simultaneous equations, and more. Ideal for electronics design engineers and others faced with solving problems related to plotting and simple verification of experimental data.

**SB21862: APPLE® INTERFACING** **$16.00**
Describes the internal Apple II control signals available for I/O interfacing and shows you how to use them with Applesoft BASIC to control devices and communicate with other computers, modems, serial printers, and more. Furnishes real, tested interfacing circuits that work, plus complete breadboarding to help you check out your own interfacing ideas.

**SB21864: MOSTLY BASIC: APPLICATIONS FOR YOUR APPLE® II, BOOK 2** **$19.00**
A second goldmine of fascinating BASIC programs, including two dungeons that test your math and history abilities and another one that's strictly for fun, eleven household programs, a monthly savings plan and six more on money or investment, two that test your level of ESP, and more — 32 in all! Excellent for beginning or advanced computerists.

**SB21911: APPLE® FORTRAN** **$21.45**
Gives you full programming details on Apple FORTRAN 77, plus an introduction to Apple's Pascal language card, the use of FORTRAN on single or multiple disk drives, and several programs in FORTRAN that you can use immediately! Excellent for any Apple II owner who uses or would like to use FORTRAN, including beginning or advanced programmers, businessmen, and other professionals.

**SB21894: APPLE® II ASSEMBLY LANGUAGE** **$23.00**
Specifically directed to the beginning programmer who has no prior experience with assembly language. Shows you how to use the 3-character, 56-word assembly language vocabulary of Apple's 6502 microprocessor to create powerful programs that bring you inside the brain of the Apple itself! Can be read by Apple owners in all walks of life simply as a learning experience or used in a conscientiously applied assembly language study program.

**SB22026: POLISHING YOUR APPLE®** **$7.45**
Clearly written, highly practical, concise assembly of all procedures needed for writing, disk-filing, and printing programs with an Apple II. Positively ends your searchs through endless manuals to find the routine you need! Should be in the hands of every new Apple user, regradless of experience level. Ideal for Apple classrooms too!

**APPLE MACHINE LANGUAGE PROGRAMMING**
**AB009** **$20.45**
The best way to learn machine language programming the Apple II in no time at all. The book combines colour, graphics, and sound generation together with clear cut demonstrations to help the user learn quickly and effectively.

**PH101: ELEMENTARY APPLE**
**W. Sanders & Datamost (1983)** **$20.45**
For new owners of the Apple Personal Computer, this entertaining guide is like having a friendly, cheerful teacher at the user's side — clearly explaining everything the beginner wants to know — and carefully leading him from point to point.

**PH102: HOW TO WRITE AN APPLE PROGRAM**
**E. FAULK & DATAMOST (1983)** **$20.45**
Proven-successful, simple techniques for programming the Apple personal computer in BASIC. The authors develop an actual program with the reader to provide a simple set of examples for the topics discussed.

**PH103: PROGRAMMING THE APPLE: A STRUCTURED APPROACH**
**J. CAMPBELL & L. ZIMMERMAN (1983)** **$26.50**
Offers a unique, structured approach to programming by presenting the BASIC language as a problem-solving tool. This book unravels the intricacies of programming — where to start, what to do, and how to write code more effectively.

**PH104: ACCOUNTANT'S BASIC PROGRAMMING FOR THE APPLE II**
**A. PARKER & J. STEWART (1983)** **$20.45**
Shows the reader how to program the Apple II to perform a variety of accounting functions, such as payroll, accounts payable, accounts receivable, tax, inventory, customer statements, and more.

**PH105: APPLE COMPUTER GRAPHICS**
**K. WILLIAMS (1983)** **$26.50**
Offers a complete, clear, state-of-the-art explanation of the graphic capabilities of the Apple II — and how to use them. Requires only a knowledge of BASIC; no assembler or machine language skills are required.

**PH106: PROGRAMMING TIPS AND TECHNIQUES FOR THE APPLE II**
**J. CAMPBELL (1983)** **$23.45**
An advanced exploration of the Intricacies of structures programming. Further develops the skills necessary to solve programming problems. Special chapter on sound and graphics which discusses both high and low resolution graphics for the Apple II.

**PH107: APPLE LOGO PRIMER**
**G. BITTER & N. WATSON (1983)** **$17.45**
A pictorial starter book that will make LOGO easy for anyone. Includes easy to follow examples and reference tables. Also Included is a workshop outline for teachers and leaders who want to train others.

**PH108: THE ACADEMIC APPLE**
**R. MOWE (1983)** **$15.45**
Written for parents and teachers using the Apple II in the education process. Topics discussed include choosing commercial software, educational software, sample programs and teaching BASIC programming.

**PH109: APPLE II PROGRAMMER'S HANDBOOK**
**R. VILE (1982)** **$23.45**
Written specifically for the beginning programmer, here's a hands-on approach to programming. It includes tips and techniques for Integer BASIC, APPLESOFT BASIC, APPLE PASCAL, and 6502 Assembly Language on the APPLE II computer and gives complete programs — each tested and ready to use — for applications in graphics, education, utilities, languages, and entertainment.

**PH110: THE APPLE PERSONAL COMPUTER FOR BEGINNERS**
**S. DUNN & VALERIE MORGAN (1982)** **$18.45**
Written for those who have no experience in computers, this informative book teaches the fundamentals of BASIC and computing, using the Apple computer system.

**PH111: BASIC FOR THE APPLE II**
**L. GOLDSTEIN & M. GOLDSTEIN (1982)** **$20.45**
A new start-to-finish "hands-on" guide covering BASIC programming and practical real-life applications for the Apple II. Includes detailed information for setting up and using a computer system with discussions of such diverse applications as games, graphics, file management, and word processing.

**PH112: APPLE FILES**
**D. MILLER (1982)** **$20.45**
Aimed at the Apple user who is familiar with BASIC and wants to set up or expand files for home or business. Includes programs for mailing lists, a medical records system, home inventory and more.

**PH113: THE VISICALC BOOK: APPLE EDITION**
**D. BEIL (1982)** **$20.45**
A helpful and informative guide to using VISICALC, the "electronic spreadsheet" software program that's perfect for pricing/costing estimates, profit/loss forecasting and hundreds of other business "what if" questions. Specifically written for Apple computer systems.

**PH114: APPLE BASIC**
**R. HASKELL** **$17.45**
Gives the beginner a thorough introduction to BASIC programming using the Apple computer. Includes home financial management, games, graphics, math programs and more. Appropriate for classroom use or self instruction.

**PH115: APPLE BASIC FOR BUSINESS/FOR THE APPLE II**
**A. PARKER & J. STEWART** **$21.45**
Shows how to use BASIC and the Apple II system to solve practical business problems quickly and efficiently. Contains flowcharts and sample programs.

**PH116: APPLE MACHINE LANGUAGE**
**D. & K. INMAN** **$20.45**
Allows Apple users to move from BASIC to the more powerful machine language programming quickly and easily.

**PH117: PASCAL PROGRAMMING FOR THE APPLE**
**T. LEWIS** **$20.45**
This manual provides easy-to-follow instructions on programming with Pascal. The author begins with the basics: the shell of a Pascal program, type casting the data, simple sequences, choice and looping. He then moves on to subjects of greater complexity and challenge.

**PH118: INTERFACE PROJECTS FOR THE APPLE II**
**R. HALLIGREN** **$17.45**
Provides Apple II users with a series of interface projects that are easily built and enable the user to discover the computer's capabilities through project construction.



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# IBM P.C.

**PH150: IBM BASIC**
**D. PAYNE, Ph.D** **$21.45**
Focusing on developing the proper attitudes, techniques and skills for good problem-solving, the book's approach facilitates the reader's understanding of computing by presenting procedural reasoning problems accompanied by programs written in BASIC.

**PH151: IBM PC ASSEMBLY LANGUAGE PROGRAMMING**
**L. SCANLON** **$30.50**
An introduction to the fundamental principles of microprocessors, numbering systems, and assemblers for those with little or no experience with microcomputers or assembly language programming. Focuses on a "real" assembler that will probably become the de facto standard of the IBM PC.

**PH152: PASCAL PROGRAMMING FOR THE IBM PC**
**K. BOWYER & S. TOMBOULIAN** **$24.45**
Here's the "first of its kind" book that brings Pascal programming and the IBM Personal Computer together. Working interactively, this book is perfect for users who want to move beyond BASIC but don't know where to start. It emphasizes graphics and sound applications with reference to both the IBM Personal Computer and UCSD p-system Pascal.

**PH153: SCIENCE AND ENGINEERING SOURCEBOOK FOR THE IBM PERSONAL COMPUTER**
**C. LEWART** **$17.45**
Designed for the electronic and communication engineer, programmer, student, and advanced electronic hobbyist, this collection of 20 programs covers the areas of electronic engineering, number theory, computer program design, data communication, probability, statistics, operations research, and applied math.

**PH154: SYSTEMS MADE SIMPLE ON THE IBM PC**
**R. FLANDERS & D. FLANDERS** **$26.50**
Now the techniques used to design major computer systems have been reduced to terms that average personal computer users can apply. Through Structured Analysis and Structured Programming approaches, the user is taken step-by-step through the design and implementation of the systems.

**PH155: HOW TO WRITE AN IBM-PC PROGRAM**
**E. FAULK & DATAMOST** **$20.45**
Assuming only a minimal knowledge of the computer, coverage includes everything from where to get programming ideas to fixing the bus the easy way. Illustrated.

**PH156: BUSINESS APPLICATIONS FOR THE IBM PC**
**S. ZIMMERMAN & L. CONRAD** **$24.45**
Designed for the first-time business user of the IBM PC. Offers step-by-step instructions on the use and customization of existing business software programs. Provides actual programs that are essential to many business functions.

**PH157: INTRODUCTION TO CICS PROGRAMMING**
**L. MILLER & L. VIANDS** **$33.50**
Presents a step-by-step, easy-to-follow introduction to the practical use of CICS — an IBM software product for data communications and the development of on-line computer applications. All examples shown are independent of the operating system, but they assume a basic knowledge of COBOL.

**PH158: IBM FILES**
**D. MILLER** **$20.45**
Shows how to access your IBM-PC's full potential. Takes the mystery and misery out of creating your own files. Written for both the beginning and advanced programmer.

**PH159: BASIC FOR BUSINESS FOR IBM-PC**
**PARKER**
**$26.50**

**PH160: USING THE IBM PERSONAL COMPUTER**
**T. LEWIS** **$20.45**
A guide to general use of the IBM Personal Computer, covering BASIC commands, how to use word processing software, the use of VISICALC and creating new programs.

**PH161: IBM BASIC FOR BUSINESS & HOME**
**R. FUNKHOUSER** **$20.45**
Without the ponderous detail of the manufacturer's manual, this book shows the new micro user how to write programs for the IBM PC. No prior knowledge of computers or electronics is necessary to understand and use the information.

**PH162: THE VISICALC BOOK FOR THE IBM PERSONAL COMPUTER**
**D. BEIL** **$21.45**
This book is designed to help the user to get more out of VISICALC (an extremely useful "electronic spreadsheet" software program) on the IBM Personal Computer.

**Tab1540: 100 READY TO RUN PROGRAMS AND SUB-ROUTINES FOR THE IBM PC** **$28.45**
Includes programs for Business (Text Editor, Mailing List, Alphabetizing and Sorting, Checking Account); Mathematics (Functions Analysis, Complex Number Math, Simultaneous Equations, etc.); Education (Spelling Bee, Trig lesson); Electronics (Colour Monitor Alignment, Ohms Law Equations, Circuit and Component Graphics); Graphics (Hi-Res Designs, Animated Graphics, Painting); Games (Several) and lots more. You'll learn how to use advanced programming features and how to start tailoring programs to your own special needs.

**HB111: PROGRAMMING THE IBM PERSONAL COMPUTER: BASIC**
**GRAHAM** **$24.45**
An introduction to programming in BASIC language. Users can apply material directly to their machine, with no adapation neeessary. An ideal introductory text to be used informally, or in classroom or training situations. Covers the unique features of the IBM Personal Computer, elements of BASIC and programming, and various applications (text editor programs, program for storing and retrieving information from random files, etc.).

**HB112: PROGRAMMING THE IBM PERSONAL COMPUTER: UCSD PASCAL**
**POLLACK** **$24.45**
"The Portable IBM PC Pascal!" Emphasizes the syntax of UCSD Pascal and good program design. An ideal introductory text to be used informally, or in classroom or training situations. Includes full coverage of the system and its uses, basic and advanced UCSD p-System™ functions. Easy to understand, user-oriented, reinforces working knowledge and application.

**HB113: YOUR IBM PERSONAL COMPUTER: BASIC AND APPLICATIONS**
**CORTESI** **$24.45**
Intended to get the first-time user over the hurdle of the initial introduction to the new machine. Provides a non-threatening, "confidence-building" introduction to the Personal Computer and to computing, BASIC language and software. (VisiCalc®, word processing, etc.). An ideal introductory text to be used informally, or in classroom or training situations. Focuses on central programming concepts, emphasizing IBM's version of MICROSOFT BASIC.

**AHG14: HOW TO USE THE IBM PERSONAL COMPUTER**
**NOLAN** **$4.45**
A simple introduction to one of the fastest selling personal computers. Filled with clear instructions and tips on set-up, expansion, specific applications, and maintenance.

**SB22000: USING YOUR IBM® PERSONAL COMPUTER** **$24.45**
Here's the most practical, most thorough guide on the market for computing with the IBM PC! Part One helps you get started with off-the-shelf programs, and shows you how to use the PC's system unit, keyboard, display screen, disk drives, and printer. Part Two teaches you to program in PC BASIC, with scores of examples to help you learn quickly. Fully explains all commonly used PC BASIC commands, including those for grpahics, music, sound effects, and more.

**PHS3: IBM PERSONAL COMPUTER: AN INTRODUCTION TO PROGRAMMING AND APPLICATIONS**
**L. GOLDSTEIN & M. GOLDSTEIN** **$46.50**
Specifically designed for the computer novice. Offers immediate applications to business graphics, games and word processing. Book/Disk Package.

**PHS4: EXECUTIVE'S GUIDE TO THE IBM PERSONAL COMPUTER: BASIC PROGRAMMING AND VISICALC**
**A. PARKER** **$60.45**
Designed to give the business executive an introduction to BASIC programming. Demonstrates business programs for accounts receivable, general ledger, VisiCalc, and more. Book/Disk Package.

**PHS5: CROSS REFERENCE UTILITY (CRF): A PROGRAMMING AID FOR THE IBM PC**
**J. HART, D. MAHAN, G. REYNOLDS, & THE SUMAR CORPORATION** **$45.45**
Specifically designed to help the IBM PC programmer improve the quality of programs, this utility software provides a complete reference listing of variables in a BASIC program in order to review, analyze, and modify software. Software Package.

# ATARI COMPUTERS

**ARCP8: 101 ATARI COMPUTER PROGRAMMING TIPS & TRICKS**
**A. NORTH** **$13.00**
Learn-by-doing instruction, hints, secrets, shortcuts, techniques, for models 400/800/1200XL, includes 101 ready-to-run programs. 128 pages.

**ARCP9: 31 NEW ATARI COMPUTER PROGRAMS FOR HOME, SCHOOL & OFFICE**
**A. NORTH** **$13.00**
Practical type-and-run software for models 400/800/1200XL. 96 pages.

**AHG9: UNDERSTANDING ATARI GRAPHICS**
**BOOM** **$4.45**
The popular Atari computers are ideal for writing graphic programs, such as games, charts, or object representations. This Handy Guide works the reader through the logic and mechanics of developing good graphics. For the beginning to advanced programmer.

**AHG15: HOW TO USE THE ATARI COMPUTERS**
**BOOM** **$4.45**
A simple introduction to these fast-selling personal computers. Filled with clear instructions and tips on set-up, expansion, specific application, and maintenance.

**PHS16: PAINT (48K ATARI WITH JOYSTICK)**
**CAPITAL CHILDREN'S MUSEUM** **$52.50**
Users actually create their own computer "paintings". The PAINT diskette provides access to hundreds of colour textures, allowing a virtually limitless number of artistic patterns. Book/Disk Package.

# OSBORNE

**PH163: USING THE OSBORNE 1 COMPUTER**
**T. LEWIS** **$20.45**
The Osborne 1 is fast beoming one of the hottest selling personal/business computers on the market. This informative book shows the reader how to use it with word processing, databasing, VISICALC and programming.

**PH164: OSBORNE USER'S GUIDE**
**L. GOLDSTEIN** **$20.45**
The "applications handbook" that boosts the personal computer to full potential. This book uses the Osborne to guide readers to an understanding of BASIC. Using a relaxed, informal style, it explains programming, applications, peripheral devices, and software.


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# Computing Systems

## TRS-80

**PH119: HOW TO WRITE A TRS-80 PROGRAM**
**E. FAULK & DATAMOST (1983) $20.45**
The authors develop an actual program with the reader to provide a simple set of examples for the topics discussed, and to add to the user's library of subroutines.

**PH120: TRS-80 COBOL**
**R. GRAUER (1983) $23.45**
Written specifically for the Radio Shack Model II and III computers, here is a learn-by-doing introduction to ANS-74 COBOL as implemented on the TRS-80. Includes many programs and exercises.

**PH121: HARDWARE INTERFACING WITH THE TRS-80**
**J. UFFENBECK (1983) $19.45**
TRS-80 Model I and Model III owners now have a book to help them understand how to use their personal computers to monitor and control electronics interfaces between the computer and the home or industrial environment. Contains 14 hands-on experiments using BASIC.

**PH122: TRS-80 EXTENDED COLOR BASIC**
**R. HASKELL (1983) $17.45**
Suitable for both classroom use and home self-instruction, this comprehensive, hands-on approach to BASIC programming on the TRS-80 colour computer comes complete with illustrated examples for the computer's video screen.

**PH122B: EXPLORE COMPUTING WITH THE TRS-80 (AND COMMON SENSE): WITH PROGRAMMING IN BASIC**
**R. & J ANDREE (1982) $16.45**
The guide teaches the keyboard, programming, and how to solve problems using the computer. Different starting points are provided so that complete beginners — as well as more advanced enthusiasts — can find material suited to their level of study.

**PH123: TRS-80 DISK BASIC FOR BUSINESS MODEL II AND MODEL III**
**A. PARKER (1982) $20.45**
An introductory guide for the popular TRS-80 computer and the BASIC Language that's sure to answer all the questions with chapters on how to use a computer, why use BASIC, writing and running a program, entering data from a keyboard, report writing by computer, using canned programming, and more!

**PH124: THE TRS-80 PROGRAMS AND APPLICATIONS FOR THE COLOR COMPUTER**
**A. BAKER (1982) $20.45**
Al Baker shows how to use the TRS-80 colour computer to best advantage for storing important data, balancing the cheque book, playing games, and much more — while sharpening programming skills.

**PH125: INTRODUCTION TO TRS-80 BASIC AND COMPUTER PROGRAMMING**
**M. ZABINSKI $15.45**
Designed for use with the Radio-Shack TRS-80 computer this book discusses all the important concepts and applications of computer programming. Illustrated with many flowcharts, the book contains over 200 exercises.

**PH126: TRS-80 MODEL III: PROGRAMMING AND APPLICATIONS**
**L. GOLDSTEIN $20.45**
A top-notch introduction to computer programming using the TRS-80 Model III. Quickly brings the neophyte to near-professional levels.

**PH127: TRS-80 ASSEMBLY LANGUAGE**
**H. HOWE, Jr. $13.45**
Now for the first time user as well as the experienced user of the TRS-80 microcomputer, here is a book that explains assembly language programming in a thorough, yet easy to understand style.

**PH128: TRS-80 ASSEMBLY LANGUAGE SUBROUTINES**
**W. BARDERN, Jr. $25.45**
Easy-to-use "precanned" routines that can be run as is, modified, or simply studied. Requires minimum effort from the user, all programs ready-to-run, covers the widest possible range of applications.

**PH129: INTERFACE PROJECTS FOR THE TRS-80**
**R. HALLIGREN $17.45**
Provides TRS-80 users with a series of interface projects that are easily built and enable the user to discover the computer's capabilities through project construction. Projects are primarily hardware oriented but have programs supplied to support the hardware.

**SB22009: TRS-80® MODEL I, III, AND COLOUR COMPUTER INTERFACING PROJECTS $21.45**
A unique book for beginning interfacers which includes 14 simple, useful, and easy-to-build construction projects to help you make use of your TRS-80 computer in the real world. Presents an easily understood, complete tutorial with full documented, debugged software written specifically for the TRS-80 models I and III, and the Colour Computer.

**SB21865: MOSTLY BASIC: APPLICATIONS FOR YOUR TRS-80® , BOOK 2**
**H. BERENBON $19.00**
Another goldmine of ready-to-run BASIC programs — 32 in all! Includes two dungeons that test your ability in history and math, a Dungeon of Danger that's strictly for fun, eleven household programs, seven on money and investment (three of which are on the stock market), two that test your ESP level, and more! Complete with an explanation, sample run, and listing for each program.

**SB22046: TRS-80® FOR KIDS FROM 8 TO 80, VOL.1**
**M. ZABINSKI $14.45**
An enjoyable, easy to follow, and amazingly effective book suitable for beginning TRS-80 programmers of any age, especially youngsters. No special background is needed. Same principles used at National Computer Camp help you quickly begin writing computer programs and encourage you to try many examples. Excellent as a classroom text or for self-study.

**PHS6: TRS-80 MOD III ASSEMBLY LANGUAGE TUTOR**
**H. HOWE, Jr. $39.45**
A book/software tutorial that makes it easy to learn assembly language programming and interfacing with the TRS-80 Model III. Requires only a basic knowledge of level II BASIC. Book/Disk Package.

**ARCP5: 101 COLOUR COMPUTER PROGRAMMING TIPS & TRICKS**
**R. CLARK $11.65**
Learn-by-doing instructions, hints, secrets, shortcuts, techniques, insights, includes 101 ready-to-run programs. 128 pages.

**ARCP6: 55 COLOUR COMPUTER PROGRAMS FOR HOME, SCHOOL & OFFICE**
**R. CLARK $14.45**
Practical ready-to-run software with colourful graphics. 128 pages.

**ARCP7: 55 MORE COLOUR COMPUTER PROGRAMS FOR HOME, SCHOOL & OFFICE**
**R. CLARK $14.45**
Handy companion volume packed with different useful type-and-run software. 112 pages.

**SB21893: TRS-80® COLOUR COMPUTER INTERFACING $21.45**
Teaches you the interfacing techniques, inner workings, and operation of the TRS-80 Colour Computer as well as its high-performance 6809 microprocessor. Find out how to control and monitor various equipment and events by means of the Computer's expansion connectors. Excellent info for budding electronic and computer engineers and technicians at all levels.

## TIMEX/SINCLAIR

**BP109: THE ART OF PROGRAMMING THE 1K ZX81 $8.10**
**M. JAMES and S.M. GEE**
This book shows you how to use the features of the ZX81 in programs that fit into the 1K machine and are still fun to use. Chapter Two explains the random number generator and uses it to simulate coin tossing and dice throwing and to play pontoon,. Chapter Three shows the patterns you can display using the ZX81's graphics. Its animated graphics capabilities, explored in Chapter Four, have lots of potential for use in games of skill, such as Lunar Lander and Cannon-ball which are given as complete programs. Chapter Five explains PEEK and POKE and uses them to display large characters. The ZX81's timer is explained in Chapter Six and used for a digital clock, a chess clock and a reaction time game. Chapter Seven is about handling character strings and includes three more ready-to-run programs—Hangman, Coded Messages and a number guessing game. In Chapter Eight there are extra programming hints to help you get even more out of your 1K ZX81.

**BP114: THE ART OF PROGRAMMING THE 16K ZX81 $10.40**
**M. JAMES & S.M. GEE**
The book starts by introducing the 16K RAM pack and the printer. It continues by explaining how the extra storage is used and presents a memory test program to check that the 16K RAM pack is operational. Chapter Three covers some utilities that you will find useful in writing longer programs. Chapter Four is an interlude from serious applications, presenting four games programs that make the most of the extended graphics capabilities now available to you. Chapters Five to Eight deal with writing and debugging large programs, storing them on cassettes and printing out both programs themselves and their results. These chapters also introduce programs for editing data bases and statistical analysis for financial management and covers text and graphics printing. Chapter Nine takes a look at randomness. Chapter Ten introduces machine code and explains why you might like to use it.

**SELF-TEACHING SOFTWARE FOR THE ZX81 AND TIMEX SINCLAIR 1000: MATHEMATICS I-VI**
**J. GLADSTONE**
**Software Package:**

- **I. PHS8, $45.45**
- **II: PHS9, $45.45**
- **III. PHS10, $45.45**
- **IV. PHS11, $45.45**
- **V. PHS12, $45.45**
- **VI. PHS13, $45.45**

Designed to give children ages 5-12 the learning advantage! Each program contains 4 cassette tapes with 32 lessons, games, and activities, and a 32 page activities book, all packaged in a handsome vinyl binder. Written by a leading Canadian educator.

**SB21957: TIMEX SINCLAIR 1000/ZX81 BASIC BOOK**
**R. NORMAN $19.45**
A practical, usable book that neatly and effectively teaches ZX81 BASIC language and programming techniques to owners of the ZX81 personal computer. Includes many programming tips to help make your ZX81 programs more efficient. Ideal for the novice computerist as well as any new owner of the ZX81.

**ARCP1: 101 TIMEX 1000/SINCLAIR ZX-81 PROGRAMMING TIPS & TRICKS**
**E. PAGE $11.65**
Secrets, hints, shortcuts, learn-by-doing instructions, techniques, includes 101 ready-to-run programs. 128 pages.

**ARCP2: 37 TIMEX 1000/SINCLAIR ZX-81 COMPUTER PROGRAMS FOR HOME, SCHOOL AND OFFICE**
**E. PAGE $13.00**
Practical type-and-run software. 96 pages.

**PH139: FIFTY 1K/2K GAMES FOR THE TIMEX/SINCLAIR 1000 AND THE ZX-81**
**A. GOURLAY, J. WALSH & P. HOLMES (1983) $15.45**
The most complete selection of games ever assembled for the Sinclair ZX-81 and Timex 1000 personal computers. Dogfight, Breakout, Outlaw, Galaxian, Roadracer, Alien Invasion, and dozens more!

**PH140: THE EXPLORER'S GUIDE TO THE ZX81 AND THE TIMEX SINCLAIR 1000**
**M. LORD (1983) $17.45**
Coverage includes features of BASIC not found in beginner's guides, as well as machine code programming, 30 games and other programs, application routines, programming utilities, and more.

**PH141: 30 PROGRAMS FOR THE TIMEX-PC 1000**
**MELBOURNE HOUSE PUBLISHERS (1983) $13.45**
Presents a collection of 30 interesting and varied programs for the Timex-PC 1000/ZX81. Complete with fully explained programs, scores of programming hints and space-saving techniques.

**PH 142: PROGRAMMING YOUR TIMEX/SINCLAIR 1000 IN BASIC**
**M. EISENBACHER (1983) $13.45**
A simple, straightforward introduction to BASIC programming on the TIMEX/Sinclair 1000 written specifically for those with no previous computer experience.

**PH143: BASICS OF TIMEX SINCALIR BASIC**
**WALACH $15.45**

**PH144: MAKING THE MOST OF YOUR ZX-81**
**T. HARTNELL $15.45**
This handbook focuses on all the additional features of the ZX-81. There are new games and useful learning tricks, plus instructions on how to write programs that really work. It guides the reader form start to finish using each feature of the computer.

**PH145: THE ZX-81 POCKET BOOK**
**T. TOMS $15.45**
This handy manual teaches how to create new programs and helps the creator understand why they work. Here's what the ZX-81 can do . . . which extras will enable it to do even more . . . how to use ZX-81 BASIC in the best ways . . . and, for ZX80 owners, how to convert their system into the advanced ZX-81.

**PH146: 49 EXPLOSIVE GAMES FOR THE ZX-81**
**T. HARTNELL $15.45**
Galactic Intruders, Breakout, Checkers, Death Maze, Star Trek, Smugglers Mold, and forty-three other favourites are all here and especially adapted for the ZX-81. This fascinating gamebook gives programming instructions for all 49 marvelous games PLUS complete and easy-to-understand rules.

**PH147: PET BASIC I**
**R. ZAMORA, et al $20.45**
Filled with many examples, do-it-yourself exercises, and thought provoking explorations, this concise yet complete guide encourages readers to experiment with the machine's numerous features and capabilities.

**PH148: PET GAMES AND RECREATION**
**M. OGELSBY, et al $17.45**
Easy-to-understand directions included for each game provide: a game description and the objective — a summary of instructions for both player and computer — the level of difficulty — strategy hints — and more!

**PH149: MASTERING MACHINE CODE ON YOUR ZX-81**
**T. BAKER $17.45**
This comprehensive, easy-to-understand handbook is virtually the first material available on ZX machine code. It includes the ins and outs of machine code translation, the secrets of the ZX-81, how to adapt the code to the ZX-80, and language translation between BASIC and ZX machine code.



'PHS Codings Include software disk or cassette'

# PET/CBM/VIC

**PH130: PET/CBM: AN INTRODUCTION TO BASIC PROGRAMMING AND APPLICATIONS**
**G. STREITMATTER & L. GOLDSTEIN (1983) $20.45**
Includes an introduction to BASIC as well as a survey of applications, peripheral devices, and software. Immediate applications for business, graphics, games, and word processing make this book a useful tool for any PET owner.

**PH131: ZAP! POW! BOOM!**
**ARCADE GAMES FOR THE VIC 20**
**T. HARTNELL & M. RAMSHAW (1983) $17.45**
Move through the maze eating dots with MAZEMAN. Sail through space zapping the ASTROIDS. Outshoot the fastest draw in town GUNFIGHT. Owners of the VIC 20 can now play these games — and more — simply by following the programs outlined in this handy guide.

**PH132: VIC BASIC: A USER-FRIENDLY GUIDE**
**R. ZAMORA, D. INMAN, R. ALBRECHT, & DYMAX $17.45**
This is a practical guide to the Commodore VIC, one of the first low-cost computers that allows the user to combine colour, sound, and graphics easily. Here, the reader will learn to write programs taking full advantage of all these capabilities.

**PH133: 25 ADVANCED GAMES FOR PET/CBM**
**HATCH (1983) $20.45**

**PH134: THE PET PERSONAL COMPUTER FOR BEGINNERS**
**S. DUNN & V. MORGAN (1982) $20.70**
Authors Dunn and Morgan have developed a learn-by-doing approach for using the popular, personal PET computer. The book is written not for the mathematician or computer specialist, but for the hobbyist, child, student and small business.

**PH135: PET/CBM: AN INTRODUCTION TO BASIC PROGRAMMING AND APPLICATIONS**
**L. GOLDSTEIN (1982) $20.45**
This well-written introduction to programming in BASIC for the popular PET computer is a must for the novice programmer. It includes an introduction to BASIC as well as a survey of applications, peripheral devices and software. Immediate applications for business, graphics, games, and word processing make this book a useful tool for any PET owner.

**PH136: PET/CBM BASIC**
**R. HASKELL (1982) $17.45**
Ideal for the beginning or advanced programmer, this book offers a step-by-step approach to top-down programming that can help students and business people apply fundamental concepts and program a computer with ease and expertise.

**PH137: STARTING WITH BASIC**
**ON THE COMMODORE VIC-20**
**D. MONRO/ill. B. TIDY (1982) $15.45**
Here's a real computer book for real people! It's designed for true beginners who own — or are considering purchasing — the Commodore VIC-20. It helps these novices learn to program the VIC in BASIC computer language, and goes on to teach them the unlimited capabilities of their machine.

**PH138: THE COMAL HANDBOOK**
**L. LINDSAY (1982) $25.45**
The COMAL Handbook is a reference to assist the COMAL (a language developed for use with Commodore computers that combines the best features of BASIC and PASCAL) use in learning by doing rather than strictly by reading.

**PHS7: START WITH BASIC FOR THE COMMODORE VIC 20**
**D. MONRO $33.45**
This book/cassette package shows the reader how easy it really is to create programs using the full capacillty of the machine. Includes helpful exercises and step-by-step instructions to put the full power of the VIC 20 at the user's fingertips. Book/Cassette Package.

**HB132: COMPUTE!'S FIRST BOOK OF VIC $20.45**
In the style of our First Books of Atari and PET/CBM, this book contains many of the articles and applications featured in past issues of COMPUTE! Magazine. Approximately 20-30% of the book is material that has not been previously published. An excellent resource book for Commodore VIC-20 owners.

**SB22056: COMMODORE 64 PROGRAMMER'S REFERENCE GUIDE $28.45**
A creative programmer's working tool and reference source, packed with professional tips and special information for getting the most out of your Commodore 64! Includes a complete, details dictionary of all Commodore BASIC commands, statements, and functions, followed by BASIC program samples showing how each item works. Also tells you how to mix machine language with BASIC, use hi-res effectively, and much more! By Commodore Computer, 486 pages.

**SB21948: VIC 20 PROGRAMMER'S REFERENCE GUIDE $24.95**
Provides a complete VIC 20 BASIC vocaulary guide, a section on machine-language programming, a programming tips guide with suggestions on how to improve your programming skills, and a special section on VIC 20 input/output operations. An easy-to-use, detailed manual that helps you program your VIC 20 like a pro! By Commodore Computer. 289 pages.

**SB22001: MOSTLY BASIC: APPLICATIONS FOR YOUR PET®, BOOK2**
**H. BERENBON $20.45**
A second collection of ready-to-run BASIC programs that includes a history dungeon, a math dungeon, a Dungeon of Danger that's strictly for fun, eleven household programs, seven on money and investment (three of which are on the stock market), two that test your ESP level, and more! Thirty-seven programs in all, each complete with an explanation, sample run, and listing.

**PET GAMES AND RECREATION**
**AB002 $17.45**
A variety of interesting games designed to amuse and educate. Games include such names as Capture, Tic Tac Toe, Watchperson, Motie, Sinners, Martian Hunt and more.

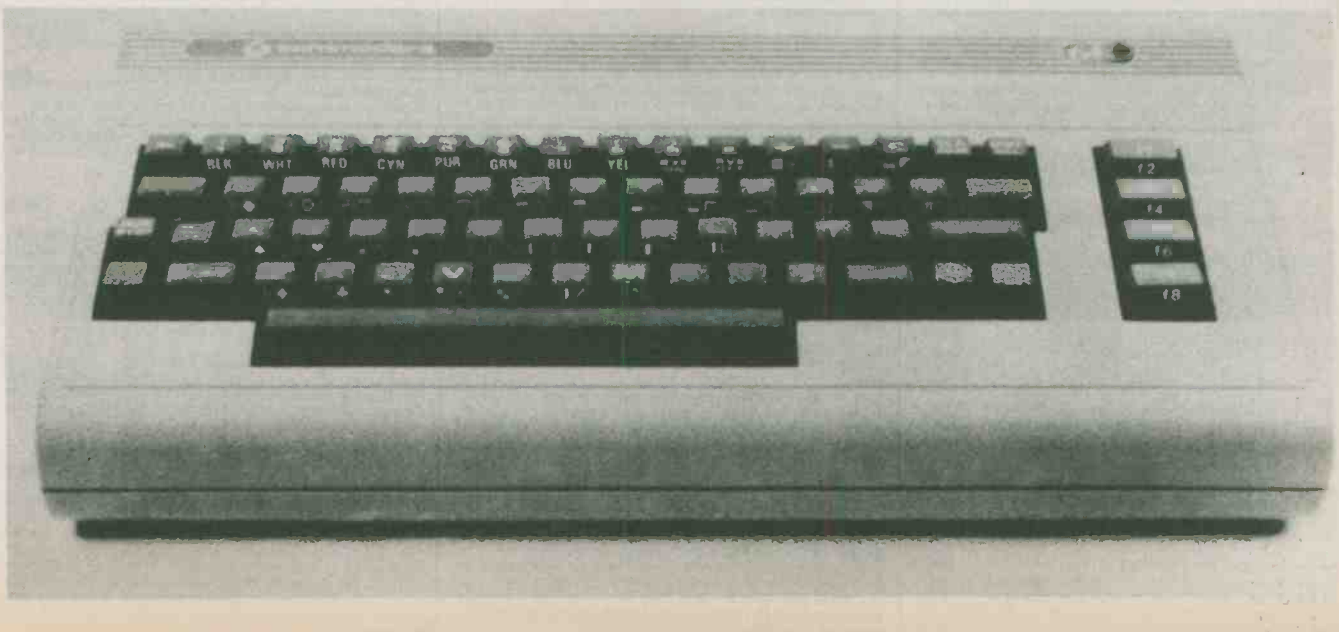
**PET BASIC — TRAINING YOUR PET COMPUTER**
**AB014 $20.45**
Officially approved by Commodore, this is the Ideal reference book for long time PET owners or novices. In an easy to read and humorous style, this book describes techniques and experiments, all designed to provide a strong understanding of this versatile machine.

**SB22010: COMMODORE 64 USER'S GUIDE $19.00**
The same book that comes packed with every Commodore 64 computer! Shows you how to set up, program, and operate your Commodore 64, including how to do arcade-type colour animation, music, and sound effects, how to interface with a host of peripherals, and how to use packaged programs from Commodore and other manufacturers. Helps you get into computing in a big way, even if you've never used a computer before. By Commodore Computer.

**SB21944: COMMODORE SOFTWARE ENCYCLOPEDIA (2nd EDITION) $14.45**
Most comprehensive directory you'll find of software for the Commodore PET. Lists materials in 10 categories, including personal aids, technical aids, and firmware. Ranges from business to education, to games, and shows Canadian and European PET software too. By Commodore Computer.

**PET™ GRAPHICS**
**HAMPSHIRE**
**HB127: $27.45**
**All subroutines available on PET disk,**
**HB128: $35.50**
Written to Instruct the PET user on how to program grid displays. Provides a collection of machine language subroutines, enabling the PET owner to write more efficient programs. Provides a wide range normally unavailable graphic functions. Includes fine resolution plotting, double density plotting, multiple screen page displays, interfacing a light pen with the PET, and appendices on circuit diagrams of PET Video Circuitry and ASCII codes used by the PET.

**LIBRARY OF PET™ SUBROUTINES**
**HAMPSHIRE**
**HB129: 24.45**
**All subroutines available on PET disk,**
**HB130: $35.50**
PET software designers will save considerable time writing applications programs with this book. Provides more than 53 proven subroutines as well as a logical framework to build new programs. Each subroutine is supported with complete information describing its purpose and the problems that may arise in its implementation.



# ELECTRONICS BEGINNERS

**PH255: COMPLETE GUIDE TO READING SCHEMATIC DIAGRAMS, 2nd Edition**
**J. DOUGLAS-YOUNG** **$10.45**
Packed with scores of easy-to-understand diagrams and invaluable troubleshooting tips as well as a circuit finder chart and a new section on logic circuits.

**PH251: BEGINNER'S HANDBOOK OF IC PROJECTS**
**D. HEISERMAN** **$17.45**
Welcome to the world of integrated circuit (IC) electronic projects. This book contains over 100 projects (each including a schematic diagram, parts list, and descriptive notes.)

**PH252: DIGITAL ICs: HOW THEY WORK AND HOW TO USE THEM**
**A. BARBER** **$11.45**
The dozens of illustrations included in this essential reference book will help explain time-saving test procedures, interpreting values, performing voltage measurements, and much more!

**PH249: THE BEGINNER'S HANDBOOK OF ELECTRONICS**
**G. OLSEN & M. MIMS,III** **$11.45**
In this basic book, the authors cover the entire spectrum of modern electronics, including the use of such components as integrated circuits and semiconductor devices in record players, radio receivers, airplane guidance systems, and many others.

**THE BEGINNER'S HANDBOOK OF ELECTRONICS**
**AB003** **$11.45**
An excellent textbook for those interested in the fundamentals of Electronics. This book covers all major aspects of power supplies, amplifiers, oscillators, radio, television and more.

# ELECTRONIC THEORY

**ELEMENTS OF ELECTRONICS — AN ON-GOING SERIES**
**F.A. WILSON, C.G.I.A., C.Eng.,**

| | |
|---|---|
| **BP62: BOOK 1. The Simple Electronic Circuit and Components** | **$8.95** |
| **BP63: BOOK 2. Alternating Current Theory** | **$8.95** |
| **BP64: BOOK 3. Semiconductor Technology** | **$8.95** |
| **BP77: BOOK 4. Microprocessing Systems And Circuits** | **$12.30** |
| **BP89: BOOK 5. Communication** | **$12.30** |

The aim of this series of books can be stated quite simply — it is to provide an inexpensive introduction to modern electronics so that the reader will start on the right road by thoroughly understanding the fundamental principles involved.

Although written especially for readers with no more than ordinary arithmetical skills, the use of mathematics is not avoided, and all the mathematics required is taught as the reader progresses.

Each book is a complete treatise of a particular branch of the subject and, therefore, can be used on its own with one proviso, that the later books do not duplicate material from their predecessors, thus a working knowledge of the subjects covered by the earlier books is assumed.

BOOK 1: This book contains all the fundamental theory necessary to lead to a full understanding of the simple electronic circuit and its main components.

BOOK 2: This book continues with alternating current theory without which there can be no comprehension of speech, music, radio, television or even the electricity utilities.

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

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

BOOK 5: A book covering the whole communication scene.

**PH241: DC ELECTRONICS** **$17.45**
Covers everything from voltage current, and resistance relationships to more advanced studies of electrical measurements, circuits, resistors, capacitors, and inductors.

**PH242: AC ELECTRONICS** **$17.45**
Covers AC fundamentals and theory. Includes discussions and experiments in resonance and reactance; RC, RL, and RLC circuits; and how to work with formulas to analyze the operations of AC circuitry.

**PH243: ELECTRONICS CIRCUITS** **$17.45**
Covers all of the most popular electronic circuits, with emphasis on integrated circuits.

**PH244: SEMICONDUCTOR DEVICES** **$17.45**
Covers semi-conductor fundamentals, diodes, zeners, bipolar transistor operation and characteristics, FETs, thyristors, ICs, and optoelectronics.

**PH247: DIGITAL TECHNIQUES** **$20.45**
Covers logic circuits, Boolean Algebra, flip-flops, registers, combinational logic circuitry, and digital design.

**Tab1531: CONCEPTS OF DIGITAL ELECTRONICS** **$22.45**
This book erases the mysteries surrounding digital electronics theory. Understand and use low-cost 7400 series IC's to produce working digital devices including a power supply and a breadboard experimenter.

# PROJECTS

**BP48: ELECTRONIC PROJECTS FOR BEGINNERS** **$5.90**
**F.G. RAYER, T.Eng.(CEI), Assoc.IERE**
Another book written by the very experienced author — Mr. F.G. Rayer — and in it the newcomer to electronics, will find a wide range of easily made projects. Also, there are a considerable number of actual component and wiring layouts, to aid the beginner.

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

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

**221: 28 TESTED TRANSISTOR PROJECTS**
**R.TORRENS** **$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 simpler building blocks, which are shown separated by boxes in the circuits for ease of description, and also to enable any reader who wishes to combine boxes from different projects to realise ideas of his own.

**BP49: POPULAR ELECTRONIC PROJECTS** **$6.25**
**R.A. PENFOLD**
Includes a collection of the most popular types of circuits and projects which, we feel sure, will provide a number of designs to interest most electronics constructors. The projects selected cover a very wide range and are divided into four basic types: Radio Projects, Audio Projects, Household Projects and Test Equipment.

**EXPERIMENTER'S GUIDE TO SOLID STATE ELECTRONIC PROJECTS**
**AB007** **$10.45**
An ideal sourcebook of Solid State circuits and techniques with many practical circuits. Also included are many useful types of experimenter gear.

**BP71: ELECTRONIC HOUSEHOLD PROJECTS** **$7.70**
**R. A. PENFOLD**
Some of the most useful and popular electronic construction projects are those that can be used in or around the home. The circuits range from such things as '2 Tone Door Buzzer', Intercom, through Smoke or Gas Detectors to Baby and Freezer Alarms.

**BP94: ELECTRONIC PROJECTS FOR CARS AND BOATS** **$8.10**
**R.A. PENFOLD**
Projects, fifteen in all, which use a 12V supply are the basis of this book. Included are projects on Windscreen Wiper Control, Courtesy Light Delay, Battery Monitor, Cassette Power Supply, Lights Timer, Vehicle Immobiliser, Gas and Smoke Alarm, Depth Warning and Shaver Inverter.

**BP69: ELECTRONIC GAMES** **$7.55**
**R.A. PENFOLD**
In this book Mr. R. A. Penfold has designed and developed a number of interesting electronic game projects using modern integrated circuits. The text is divided into two sections, the first dealing with simple games and the latter dealing with more complex circuits.

**BP95: MODEL RAILWAY PROJECTS** **$8.10**
Electronic projects for model railways are fairly recent and have made possible an amazing degree of realism. The projects covered include controllers, signals and sound effects: striboard layouts are provided for each project.

**BP93: ELECTRONIC TIMER PROJECTS** **$8.10**
**F.G. RAYER**
Windscreen wiper delay, darkroom timer and metronome projects are included. Some of the more complex circuits are made up from simpler sub-circuits which are dealt with individually.

**110 OP-AMP PROJECTS**
**MARSTON**
**HB24** **$13.45**
This handbook outlines the characteristics of the op-amp and present 110 highly useful projects—ranging from simple amplifiers to sophisticated instrumentation circuits.

**110 IC TIMER PROJECTS**
**GILDER**
**HB25** **$11.45**
This sourcebook maps out applications for the 555 timer IC. It covers the operation of the IC itself to aid you in learning how to design your own circuits with the IC. There are application chapters for timer-based instruments, automotive applications, alarm and control circuits, and power supply and converter applications.

**BP110: HOW TO GET YOUR ELECTRONIC PROJECTS WORKING** **$8.10**
**R.A. PENFOLD**
We have all built circuits from magazines and books only to find that they did not work correctly, or at all, when first switched on. The aim of this book is to help the reader overcome just these problems by indicating how and where to start looking for many of the common faults that can occur when building up projects.

**PH250: EXPERIMENTER'S GUIDE TO SOLID STATE ELECTRONICS PROJECTS**
**A. BARBER** **$10.45**
This book takes the mystery out of solid state electronics and enables the reader to build such useful devices as: series regulated power supplies, light dimmers, solar cell operated radios, hi-fi amplifiers, light indicators for battery operated equipment and much more.

**110 THYRISTOR PROJECTS USING SCRs AND TRIACS**
**MARSTON**
**HB22** **$13.45**
A grab bag of challenging and useful semiconductor projects for the hobbyist, experimenter, and student. The projects range from simple burglar, fire, and water level alarms to sophisticated power control devices for electric tools and trains. Integrated circuits are incorporated wherever their use reduces project costs.

**110 CMOS DIGITAL IC PROJECTS**
**MARSTON**
**HB23** **$11.75**
Outlines the operating characteristics of CMOS digital ICs and then presents and discusses 110 CMOS digital IC circuits ranging from inverter gate and logic circuits to electronic alarm circuits. Ideal for amateurs, students and professional engineers.

**BP76: POWER SUPPLY PROJECTS** **$7.30**
**R.A. PENFOLD**
Line power supplies are an essential part of many electronics projects. The purpose of this book is to give a number of power supply designs, including simple unstabilised types, fixed voltage regulated types, and variable voltage stabilised designs, the latter being primarily intended for use as bench supplies for the electronics workshop. The designs provided are all low voltage types for semiconductor circuits.

There are other types of power supply and a number of these are dealt with in the final chapter, including a cassette power supply, Ni-Cad battery charger, voltage step up circuit and a simple inverter.

**BP84: DIGITAL IC PROJECTS** **$8.10**
**F.G. RAYER, T.Eng.(CEI),Assoc.IERE**
This book contains both simple and more advanced projects and it is hoped that these will be found of help to the reader developing a knowledge of the workings of digital circuits. To help the newcomer to the hobby the author has included a number of board layouts and wiring diagrams. Also the more ambitious projects can be built and tested section by section and this should help avoid or correct faults that could otherwise be troublesome. An ideal book for both beginner and more advanced enthusiast alike.

**BP67: COUNTER DRIVER AND NUMERAL DISPLAY PROJECTS** **$7.55**
**F.G. RAYER, T.Eng.(CEI), Assoc. IERE**
Numeral indicating devices have come very much to the forefront in recent years and will, undoubtedly, find increasing applications in all sorts of equipment. With present day integrated circuits, it is easy to count, divide and display numerically the electrical pulses obtained from a great range of driver circuits.

In this book many applications and projects using various types of numeral displays, popular counter and driver IC's etc. are considered.

**BP73: REMOTE CONTROL PROJECTS** **$8.60**
**OWEN BISHOP**
This book is aimed primarily at the electronics enthusiast who wishes to experiment with remote control. Full explanations have been given so that the reader can fully understand how the circuits work and can more easily see how to modify them for other purposes, depending on personal requirements. Not only are radio control systems considered but also infra-red, visible light and ultrasonic systems as are the use of Logic ICs and Pulse position modulation etc.

**BP99: MINI—MATRIX BOARD PROJECTS** **$8.10**
**R.A. PENFOLD**
Twenty useful projects which can all be built on a 24 x 10 hole matrix board with copper strips. Includes Doorbuzzer, Low-voltage Alarm, AM Radio, Signal Generator, Projector Timer, Guitar Headphone Amp, Transistor Checker and more.

**BP103: MULTI-CIRCUIT BOARD PROJECTS** **$8.10**
**R.A. PENFOLD**
This book allows the reader to build 21 fairly simple electronic projects, all of which may be constructed on the same printed circuit board. Wherever possible, the same components have been used in each design so that with a relatively small number of components and hence low cost, it is possible to make any one of the projects or by re-using the components and P.C.B. all of the projects.

**Tab1431: DIGITAL ELECTRONIC PROJECTS** **$21.45**
Build a deluxe code oscillator, a digital game called Climb-the-Mountain, a clock with alarm, a metric measuring wheel, a modular decade counter, even a 14-note music generator. 17 projects in all.

**BP107: 30 SOLDERLESS BREADBOARD PROJECTS — BOOK 1** **$9.35**
**R.A. PENFOLD**
A "Solderless Breadboard" is simply a special board on which electronic circuits can be built and tested. The components used are just plugged in and unplugged as desired. The 30 projects featured in this book have been specially designed to be built on a "Verobloc" breadboard. Wherever possible the components used are common to several projects, hence with only a modest number of reasonably inexpensive components it is possible to build, in turn, every project shown.

**BP106: MODERN OP-AMP PROJECTS** **$8.10**
**R.A. PENFOLD**
Features a wide range of constructional projects which make use of op-amps including low-noise, low distortion, ultra-high input impedance, high slew-rate and high output current types.

# CIRCUITS

**BP80: POPULAR ELECTRONIC CIRCUITS — BOOK 1** **$8.25**
**R.A. PENFOLD**
Another book by the very popular author, Mr. R.A. Penfold, who has designed and developed a large number of various circuits. These are grouped under the following general headings; Audio Circuits, Radio Circuits, Test Gear Circuits, Music Project Circuits, Household Project Circuits and Miscellaneous Circuits.

**BP98: POPULAR ELECTRONIC CIRCUITS, BOOK 2** **$9.35**
**R.A. PENFOLD**
70 plus circuits based on modern components aimed at those with some experience.

**The GIANT HANDBOOK OF ELECTRONIC CIRCUITS**
**TAB No.1300** **$28.45**
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 convincing yourself you don't really want to build it.

**BP39: 50 (FET) FIELD EFFECT TRANSISTOR PROJECTS** **$5.50**
**F.G. RAYER, T.Eng.(CEI),Assoc.IERE**
Field effect transistors (FETs), find 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 miscellaneous devices which are useful in the home.

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

**BP87: SIMPLE L.E.D. CIRCUITS** **$5.90**
**R.N. SOAR**
Since it first appeared in 1977, 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: 50 SIMPLE L.E.D. CIRCUITS** **$3.55**
**R.N. SOAR**
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 (L.E.D.). A useful book for the library of both beginner and more advanced enthusiast alike.

**BP82: ELECTRONIC PROJECTS USING SOLAR CELLS** **$8.10**
**OWEN BISHOP**
The book contains simple circuits, almost all of which operate at low voltage and low currents, making them suitable for being powered by a small array of silicon cells. The projects cover a wide range from a bicycle speedometer to a novelty 'Duck Shoot'; a number of power supply circuits are included.

**BP37: 50 PROJECTS USING RELAYS, SCR's & TRIACS** **$5.50**
**F.G.RAYER, T.Eng.(CEI),Assoc.IERE**
Relays, silicon controlled rectifiers (SCR's) and bi-directional triodes (TRIACs) 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 of them to individual needs.

**BP24: 50 PROJECTS USING IC741** **$4.25**
**RUDI & UWE REDMER**
This book, originally published in Germany by TOPP, has achieved phenomenal sales on the Continent and Babani decided, 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 circuitry, a "must" for everyone whatever their interest in electronics.

**BP83: VMOS PROJECTS** **$8.20**
**R.A. PENFOLD**
Although modern bipolar power transistors give excellent results in a wide range of applications, they are not without their drawbacks or limitations. This book will primarily be concerned with VMOS power FETs although power MOSFETs will be dealt with in the chapter on audio circuits. A number of varied and interesting projects are covered under the main headings of: Audio Circuits, Sound Generator Circuits, DC Control Circuits and Signal Control Circuits.

**BP44: IC 555 PROJECTS** **$7.55**
**E.A. PARR, B.Sc.,C.Eng., M.I.E.E.**
Every so often a device appears that is so useful that one wonders how life went on before 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.

**BP65: SINGLE IC PROJECTS** **$6.55**
**R.A.PENFOLD**
There is now a vast range of ICs available to the amateur market, the majority of which are not necessarily designed for use in a single application and can offer unlimited possibilities. All the projects contained in this book are simple to construct and are based on a single IC. A few projects employ one or two transistors in addition to an IC but in most cases the IC is the only active device used.

**BP97: IC PROJECTS FOR BEGINNERS** **$8.10**
**F.G. RAYER**
Covers power supplies, radio, audio, oscillators, timers and switches. Aimed at the less experienced reader, the components used are popular and inexpensive.

**BP88: HOW TO USE OP AMPS** **$9.35**
**E.A. PARR**
A designer's guide covering several op amps, serving as a source book of circuits and a reference book for design calculations. The approach has been made as non-mathematical as possible.

**IC ARRAY COOKBOOK**
**JUNG**
**HB26** **$14.25**
A practical handbook aimed at solving electronic circuit application problems by using IC arrays. An IC array, unlike specific-purpose ICs, is made up of uncommitted IC active devices, such as transistors, resistors, etc. This book covers the basic types of such ICs and illustrates with examples how to design with them. Circuit examples are included, as well as general design information useful in applying arrays.

**BP50: IC LM3900 PROJECTS** **$5.90**
**H.KYBETT,B.Sc., C.Eng.**
The purpose of this book is to introduce the LM3900 to the Technician, Experimenter and the Hobbyist. It provides the groundwork for both simple and more advanced uses, and is more than just a collection of simple circuits or projects.

Simple basic working circuits are used to introduce this IC. The LM3900 can do much more than is shown here, this is just an introduction. Imagination is the only limitation with this useful and versatile device. But first the reader must know the basics and that is what this book is all about.

**223: 50 PROJECTS USING IC CA3130** **$5.50**
**R.A.PENFOLD**
In this book, the author has designed and developed a number of interesting and useful projects which are divided into five general categories: I — Audio Projects II — R.F. Projects III — Test Equipment IV — Household Projects V — Miscellaneous Projects.

**224: 50 CMOS IC PROJECTS** **$4.25**
**R.A. PENFOLD**
CMOS IC's are probably the most versatile range of digital devices for use by the amateur enthusiast. They are suitable for an extraordinary wide range of applications and are also some of the most inexpensive and easily available types of IC.

Mr. R.A. Penfold has designed and developed a number of interesting and useful projects which are divided into four general categories: I — Multivibrators II — Amplifiers and Oscillators III — Trigger Devices IV — Special Devices.

**THE ACTIVE FILTER HANDBOOK**
**TAB No.1133** **$14.45**
Whatever your field — computing, communications, audio, electronic music or whatever — you will find this book the 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 tape interface and more.

**DIGITAL ICS — HOW THEY WORK AND HOW TO USE THEM**
**AB004** **$11.45**
An excellent primer on the fundamentals of digital electronics. This book discusses 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** **$24.45**
Here are transistor and IC circuits for just about any application you might have. An ideal source book 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.1199** **$18.45**
If you've ever 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 types of ICs that you'd ever want to use.

**ELECTRONIC DESIGN WITH OFF THE SHELF INTEGRATED CIRCUITS**
**AB016** **$13.45**
This practical handbook enables you to take advantage of the vast range of applications made possible by integrated circuits. The book tells how, in step by step fashion, to select components and how to combine them into functional electronic systems. If you want to stop being a "cookbook hobbyist", then this is the book for you.

**BP117: PRACTICAL ELECTRONIC BUILDING BLOCKS BOOK 1** **$8.10**
Virtually any electronic circuit will be found to consist of a number of distinct stages when analysed. Some circuits inevitably have unusual stages using specialised circuitry, but in most cases circuits are built up from building blocks of standard types.

This book is designed to aid electronics enthusiasts who like to experiment with circuits and produce their own projects rather than simply follow published project designs.

The circuits for a number of useful building blocks are included in this book. Where relevant, details of how to change the parameters of each circuit are given so that they can easily be modified to suit individual requirements.

**PH253: ELECTRONIC DESIGN WITH OFF-THE-SHELF INTEGRATED CIRCUITS**
**Z. MEIKEIN & P. TACKRAY** **$13.45**
A real help for do-it-yourselfers, this handy guide tells professionals and hobbyists alike, how to take components off the shelves, arrange them into circuitry, and make any system perform its desired function.

# Electronics

## RADIO AND COMMUNICATIONS

**BP79: RADIO CONTROL FOR BEGINNERS** **$7.30**
**F.G. RAYER, T.Eng.(CEI),Assoc.IERE.**
The aim of this book is to act as an introduction to Radio Control for beginners to the hobby. The book will commence by dealing with the conditions that are allowable for such things as frequency and power of transmission. This is followed by a "block" explanation of how control-device and transmitter operate and receiver and actuator(s) produce motion in a model.

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

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

**BP96: CB PROJECTS** **$8.10**
**R.A. PENFOLD**
Projects include speech processor, aerial booster, cordless mike, aerial and harmonic filters, field strength meter, power supply, CB receiver and more.

**222: SOLID STATE SHORT WAVE RECEIVERS FOR BEGINNERS** **$5.20**
**R.A. PENFOLD**
In this book, R.A. Penfold has designed and developed several modern solid state short wave receiver circuits that will give a fairly high level of performance, despite the fact that they use only relatively few and inexpensive components.

**BP91: AN INTRODUCTION TO RADIO DXing** **$8.10**
This book is divided into two main sections one to amateur band reception, the other to broadcast bands. Advice is given to suitable equipment and techniques. A number of related constructional projects are described.

**BP105: AERIAL PROJECTS** **$8.10**
**R.A. PENFOLD**
The subject of aerials is vast but in this book the author has considered practical designs including active, loop and ferrite aerials, which give good performances and are reasonably simple and inexpensive to build. The complex theory and math of aerial design are avoided.

**BP46: RADIO CIRCUITS USING IC's** **$5.90**
**J.B. DANCE, M.Sc.**
This book describes integrated circuits and how they can be employed in receivers for the reception of either amplitude or frequency modulated signals. The chapter on amplitude modulated (a.m.) receivers will be of most interest to those who wish to receive distant stations at only moderate audio quality, while the chapter on frequency modulation (f.m.) receivers will appeal to those who desire high fidelity reception.

**BP92: ELECTRONICS SIMPLIFIED—CRYSTAL SET CONSTRUCTION** **$7.30**
**F.A. WILSON**
Aimed at those who want to get into construction without much theoretical study. Homewound coils are used and all projects are very inexpensive to build.

**PH245: ELECTRONIC COMMUNICATIONS** **$17.45**
Covers amplitude modulation, AM and FM transmitters, pulse modulation, and antennas. Includes discussions of applications.

**BP70: TRANSISTOR RADIO FAULT-FINDING CHART** **$2.40**
**CHAS. E. MILLER**
Across the top of the chart will be found four rectangles containing brief descriptions of various faults; vis: — sound weak but undistorted; set dead; sound low or distorted and background noises. One then selects the most appropriate of these and following the arrows, carries out the suggested checks in sequence until the fault is cleared.

## AUDIO

**BP90: AUDIO PROJECTS** **$8.10**
**F.G. RAYER**
Covers in detail the construction of a wide range of audio projects. The text has been divided into preamplifiers and mixers, power amplifiers, tone controls and matching and miscellaneous projects.

**205: FIRST BOOK OF HI-FI LOUDSPEAKER ENCLOSURES** **$3.55**
**B.B. BABANI**
This book gives data for building most types of loudspeaker enclosure. Includes corner reflex, bass reflex, exponential horn, folded horn, tuned port, klipschorn labyrinth, tuned column, loaded port and multi speaker panoramic. Many clear diagrams for every construction showing the dimensions necessary.

**BP47: MOBILE DISCOTHEQUE HANDBOOK** **$5.90**
**COLIN CARSON**
The vast majority of people who start up "Mobile Discos" know very little about their equipment or even what to buy. Many people have wasted a "small fortune" on poor, 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, F. 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 book. If you don't want your new four track to wind up sounding like one, though, you shouldn't be without it.

**BP51: ELECTRONIC MUSIC AND CREATIVE TAPE RECORDING** **$5.50**
**M.K. BERRY**
Electronic music is the new music of the Twentieth Century. It plays a large part in "pop" and "rock" music and, in fact, there is scarcely a group without some sort of synthesiser or other effects generator.

This book sets out to show how electronic music can be made at home with the simplest and most inexpensive of equipment. It then describes how the sounds are generated and how these may be recorded to build up the final composition.

**BP74: ELECTRONIC MUSIC PROJECTS** **$7.70**
**R.A. PENFOLD**
Although one of the more recent branches of amateur electronics, electronic music has now become extremely popular and there are many projects which fall into this category. The purpose of this book is to provide the constructor with a number of practical circuits for the less complex items of electronic music equipment, including such things as a Fuzz Box, Waa-Waa Pedal, Sustain Unit, Reverberation and Phaser-Units, Tremelo Generator etc.

**BP81: ELECTRONIC SYNTHESISER PROJECTS** **$7.30**
**M.K. BERRY**
One of the most fascinating and rewarding applications of electronics is in electronic music and there is hardly a group today without some sort of synthesiser or effects generator. Although an electronic synthesiser is quite a complex piece of electronic equipment, it can be broken down into much simpler units which may be built individually and these can then be used or assembled together to make a complete instrument.

**ELECTRONIC MUSIC SYNTHESIZERS**
**TAB No.1167** **$11.45**
If you're fascinated by the potential of electronics in the field of music, then this is the book for you. Included is data on synthesizers in general as well as particular models. There is also a chapter on the various accessories that are available.

**Tab1364: DESIGNING, BUILDING AND TESTING YOUR OWN SPEAKER SYSTEM . . . WITH PROJECTS** **$14.45**
Covers the theory of speaker construction and describes a variety of plans for speaker system projects ranging from simple setups to complex multi-driver systems. Enclosure design is covered in very good detail.

**BP68: CHOOSING AND USING YOUR HI-FI** **$7.25**
**MAURICE L. JAY**
The main aim of this book is to provide the reader with the fundamental information necessary to enable him to make a satisfactory choice from the extensive range of hi-fi equipment now on the market.

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

## TEST EQUIPMENT

**BP75: ELECTRONIC TEST EQUIPMENT CONSTRUCTION** **$7.30**
**F.G. RAYER, T.Eng. (CEI), Assoc. IERE**
This book covers in detail the construction of a wide range of test equipment for both the Electronics Hobbyists and Radio Amateur. Included are projects ranging from an FET Amplified Voltmeter and Resistance Bridge to a Field Strength Indicator and Heterodyne Frequency Meter. Not only can the home constructor enjoy building the equipment but the finished projects can also be usefully utilised in the furtherance of his hobby.

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**BP108: INTERNATIONAL DIODE EQUIVALENTS GUIDE**
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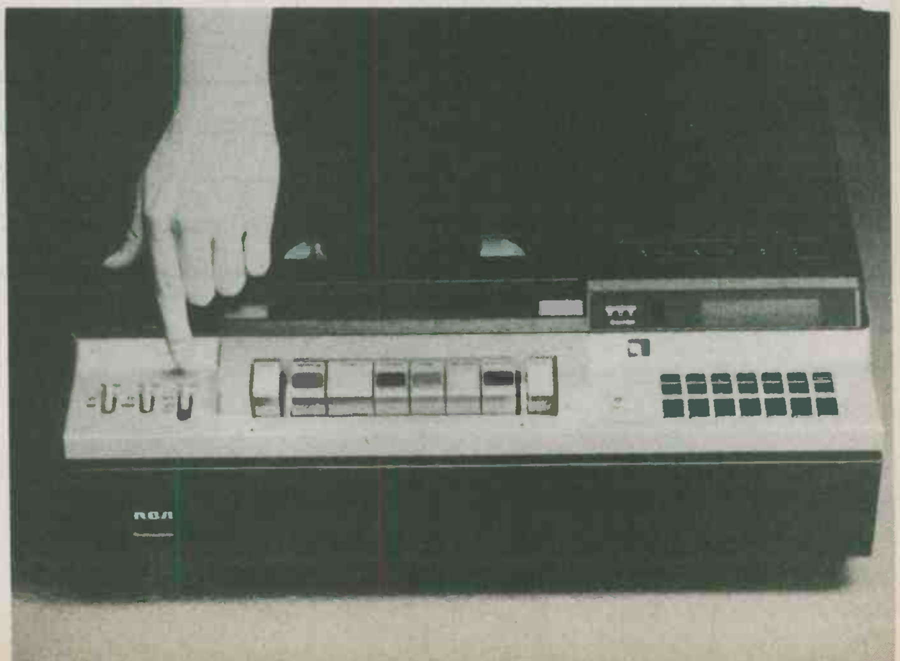


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Supplement to the August 1983 issues of Computing Now! and Electronics Today.

bits to make the best use of the MC-10's munchkin sized RAM allotment. For example, the GOSUB stack is dynamically allocated. To translate this into human-speak, whenever a program runs into a GOSUB it jumps to the number of the subroutine being called and stores the line number that it has to return to in memory. This memory is called a "stack". In some systems there is a bit of reserved RAM for the stack. The MC-10, however, just puts the stack in the user RAM, which means that you can use this memory for other things if your program has relatively few GOSUBs. On the other hand, a program with quite a number of subroutines will appear to gobble up an unusually large amount of space for variables when you run it.

The SOUND function of the BASIC is pretty good. It is of the form of SOUND followed by two variables for the pitch and duration. You can begin to approximate a tempered scale to do quasi-music, although the manual that comes with the system doesn't give you a table of pitch values that will do a scale . . . you have to figure them out for yourself.

The graphics on the system are actually a little disappointing. The 6847 can support bit mapped graphics, but the BASIC provided in the MC-10 doesn't want to put it into its high resolution modes. Presumably the designers of the little troll didn't want to include sufficient memory for a bit mapped screen. As such, the graphics that you can manage involve turning blocks on and off on the screen and doing up chunky images with the sixteen block graphics characters available.

There are a number of aspects of the MC-10's artistic abilities which are actually a bit perplexing. For example, you can alter the colour of the cursor by hitting CONTROL 0. Each time you do one of these it steps through one of its nine colours. However, the beast does not seem to be able to actually print in this range of colours. You can use the graphics blocks in colour by specifying which colour code you are up for when plotting them. The background colour is also adjustable.

The BASIC has most of the fundamental dull features a BASIC package wants, with a full range of functions, statements and commands, although some of them are of questionable use. One of the most profound examples of this is the array capacity. In fact, you can define arrays with as many as 256 elements in up to two dimensions. However, because array variables take quite a bit of memory overhead for each entry to begin with, and because there is very little RAM, you can barely get 256 elements in one direction. In fact, dimensioning an array of any real size cuts the computer's program memory down to a handful of bytes.

The MC-10's BASIC runs extremely fast . . . it's probably the speediest one I've come across . . . and it can manage


some fairly realistic looking on-screen animation within the limitations of the graphics.

## Doing It

Using the MC-10 is a lot better than trying to do programming on a rock. A rock has little or no documentation and fairly poor data retention capabilities. It is not so nice as using a more sophisticated system, and much of what you may have seen on TV as being fairly standard features of computers in general doesn't necessarily apply to the Micro Colour Computer.

To begin with, as with a rock, the BASIC text editing facilities available on the system are fairly rudimentary. If you try to edit the lines of a stored program on a rock, you will find that you are unable to do so. This is also true of the MC-10, which lacks all manner of BASIC editor. If you want to change a line you must retype it entirely. This is totally pitiful.

The system is also limited to text lines of 128 characters or less. This is a bit academic, actually . . . it would be somewhat mad to write lines approaching this length, lest one later finds they need editing and, as such, retyping. This, too, is a drag, as concatenating program lines is a good way to get more program in limited RAM.

The screen of the MC-10 will display dark letters against a light background no matter what you do with it. If you set the screen colour to something dark, the MC-10 will still print in dark letters . . . surrounded by light colour blocks to make them legible.

In fairness, using the single stroke BASIC keywords is a real joy, and you can get quite a lot of program into the little gnome in a short time once you get used to things. The error messages provided with the BASIC, while condensed into two-letter codes, are fairly helpful. There are no apparent BASIC bugs, and nothing unexpected happens even if you do untoward things.

Other niceties, like a RESET button that leaves the program text intact, will be appreciated as you get more advanced. On the other hand, there is no way to leave BASIC even if you want to, so machine language programming is probably impossible.

The serial port provided with the MC-10 is primarily intended for driving peripheral devices like printers and plotters. You may well question the validity of associating a two hundred dollar computer with a two thousand dollar plotter, but they seem to have thought it was a neat idea at Radio Shack. The BASIC has LLIST and LPRINT functions to support these external boxes.

All told, the Micro Colour Computer is a passing good trip at two bills. It will provide the beginner with a nice system to play with and learn about the rudiments of programming. I think that when you reach the limits of its capacities, you will have reached a brick wall . . . it does not look to be expandable in any useful way. However, with the decreasing cost of computer hardware at the moment, by the time one gets to the perimeter of the MC-10, two hundred dollars will probably buy a good "next step up" system.

On the other hand, there are systems costing in the area of two hundred dollars like the VIC-20, which are probably an all around better scene. While the MC-10 is not difficult to use, it hasn't got anything to recommend it in the areas of human engineering, while other systems, with full size keyboard screen editing and better graphics, really do.

The MC-10 appears to be extremely rugged, and would be a good choice for a younger user who might chance to bat it around a bit. It is also very easy to use if you can't type, something that can't be said of other systems. It's probably the best choice if you want to buy a computer for the kids.

Finally, the MC-10 is supported by a large and fairly visible organization . . . if you don't understand something or want some software or peripheral assistance, there is always a handy Radio Shack to go pound on.

Like several other machines sprouting from the silicon jungle recently, the MC-10 appears to have been the result of a frenzied R & D orgy bent on getting something on the shelves to capture a share of the mushrooming low end consumer computer market. While the results in this case aren't bad, I think that they could have been a lot better with a few bytes less frenzy.

*Argh, Billy, let's not buy a computer now. I be thinkin' that if'n we wait a couple more months they'll be a turnin' up in the cereal boxes . . .*

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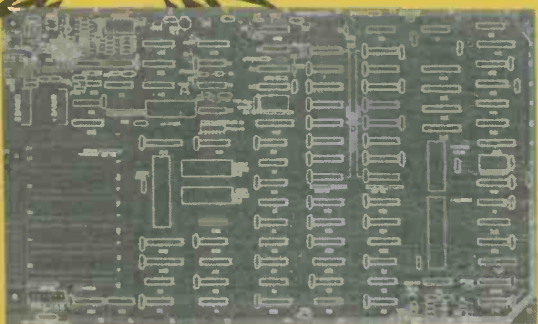

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# Military Communication: The Chaos Factor

**Detonation of a thermonuclear device in space over North American may interrupt the operation of electronic equipment and communications gear. The military could lose control over the many nuclear-equipped bases around the world.**

**by Roger Allan**

IN JULY, 1962, the U.S. Military detonated a 1.4 megaton hydrogen bomb 248 miles above Johnson Atoll in the Pacific. While the test was successful, and the military learned what they wanted about the effect of such blasts on radar and radio signals, there were a series of odd occurences which intrigued a number of physicists. 800 miles away in Hawaii, for instance, burglar alarms had rung, street lights had failed and circuit breakers had popped open in power lines. Investigation showed that similar unexpected side effects of the blast had occurred in a number of electrical systems on islands in a 1000 mile radius of the blast. While the blast was expected to momentarily upset the ionosphere, these sorts of occurences did not fit the presuppositions of the military scientists.

Today, after investigation, the cause is known as the electromagnetic pulse (EMP), and potentially is the most serious and grave danger to the U.S. military's command, control and communication ($C^3$) capability — forcing it into a situation whereby the military commanders would not have the system to communicate and hence to control the worldwide U.S. military forces, resulting in an all-out nuclear war or surrender: a Hobson's choice between "using it or losing it."

All nuclear explosions produce electromagnetic pulses. However, only high-altitude bursts produce pulses whose effects extend far beyond the radius of direct destruction. Because the high-altitude source region exists between 20 and 40 km, and because this source region can extend many thousands of kilometers in diameter, the area of EMP coverage on the ground in relatively large. Typically, the maximum effects occur in the source region at a burst height between 40 and 400 km.

At these high altitudes, gamma rays produced in the first few milliseconds of a nuclear explosion can travel hundreds of kilometers before encountering electrons in atmospheric molecules. For a 10 megaton burst at an altitude of 400 km, this region of collision is about 3000 km in diameter and 10 km thick. The Compton electrons — those scattered by the gamma rays and named for the discoverer of this effect, Arthur H. Compton — are accelerated by these collisions, encounter the earth's magnetic field and are deflected, producing a transverse electric current. This current in turn sets up the electromagnetic pulses, which radiate downward toward the earth as EMP's.

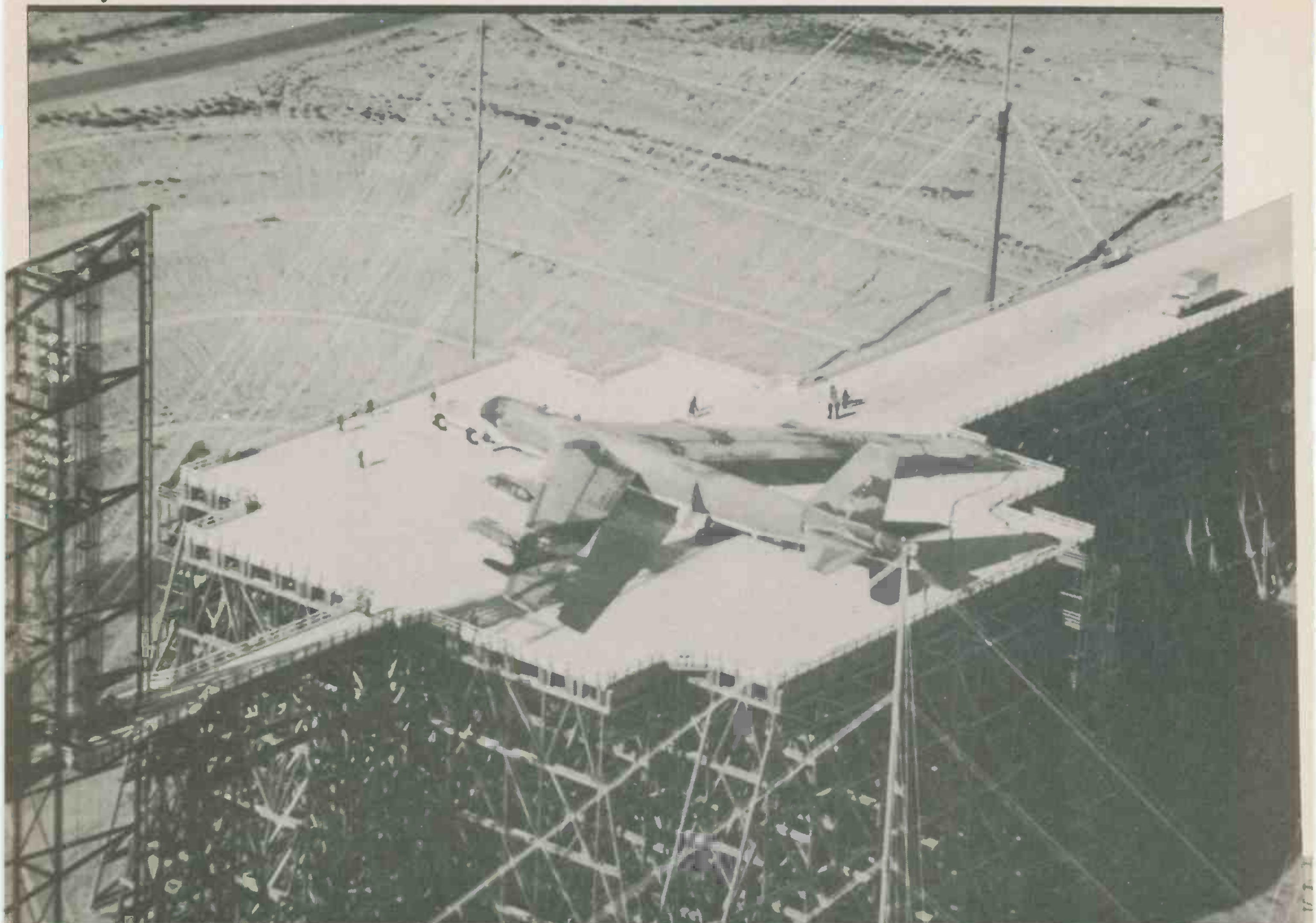
The EMP's rise very rapidly, reaching a peak field in only about 10 nS, then tail off in about 1 microsecond. As a result of this sharply peaked waveform, the power of the EMP's is spread over a broad band of frequencies.

EMP's may affect an area of 500 to 800 miles or more, depending on the height and yield of the burst. A typical one-megaton warhead can produce peak fields within this area of 50,000 V/m. The instanteous power density over this area is very high — typically about 6 MW/m$^2$, or 4000 times the radiation power received from the sun. However, since the pulse is of short duration, the total energy received is relatively small — about 0.6 J/m$^2$.

Any conductor within the very large area of EMP effects will act as an antenna to pick up the electromagnetic pulses. Long distance power transmission lines are particularly effective in picking up the lower-frequency components of the pulse. The magnitude of the current pulse induced in such power lines is highly variable, depending on the location and orientation of the line relative to the burst and the size and height of the burst. In a worst case scenario, peak voltages can be 3 MV, peak amperages 10 KA, and peak power 30,000 MW. This is two orders of magnitude above the design capabilities of virtually all power transmission lines and, thus, more than enough to trip current fault sensors and damage insulation. Despite these very high powers, total energy in a current pulse would not be extremely large (generally on the order of thousands or tens of thousands of joules) because of the microsecond duration of the induced pulse.

The voltage and amperage of such EMP-induced currents are comparable to those of the very largest lightning bolts, and the rise times of the currents (a few hundred nanoseconds) are considerably faster than those of lightning bolts. A far more significant difference between EMP's and lightning is that the EMP's are induced simultaneously throughout the entire grid and not just at a single locality.

Low frequency effects of EMP's can also induce large currents and voltages in long-distance communications and telephone links, while the high-frequency components would be picked up by circuits within electronic and electrical ap-



**An EMP test facility in Nevada. A B-52 bomber is supported on a wooden trestle held together by 250,000 wooden pegs. The electrical system produces very high power nanosecond pulses for testing the effect of EMP on aircraft. (Photo courtesy of U.S. Air Force).**

paratus of all sorts, even so far as destroying the microcomputers in automobiles and aircraft.

The significance of EMP was only slowly learned and accepted by the military. In the late 1950's, both the United States and the Soviet Union commenced a series of atmospheric nuclear tests. The U.S. launched two in 1958, one at a height of 27 miles, the other at 48 miles. As a prelude to arms negotiations, the U.S. and U.S.S.R., in 1959, agreed to a moratorium on atmospheric testing, pending conclusion of negotiations for a limited test ban treaty. In 1961 the Soviets broke the moratorium and launched a series of atmospheric tests. The U.S. was caught flat-footed, and it took some time before they were ready and able to follow suit. The explosion on 8 July, 1962, which gave the first indication of EMP as mentioned, was one of this U.S. series. By the time the U.S. had finished its series and was analysing its data, considering what to do next, the Soviets launched a second series of tests described with 20/20 hindsight as "far more elegant" *viz a viz* EMP than the immediately previous US series. By the time the US was in a position to launch a second series which included primitive EMP tests, the limited test ban treaty had been signed. No further atmospheric tests have been conducted by either side in the subsequent 19 years.

The importance of this little piece of historical chronology is two-fold. First, the US conducted its tests in the Pacific, miles from anywhere, where electrical systems in neighbouring islands (even Hawaii) were relatively primitive by EMP standards, depending primarily on vacuum tubes and a few transistors. These, it has subsequently been learned, are ten million times less susceptible to EMP than are integrated circuits. Further, the ships used by the US Navy to carry the test monitoring equipment were of WW II vintage — their radars and communication gear likewise being primarily vacuum tube dependent. As such the total body of available data, that is, equipment and facilities which were effected by the EMPs and available for study, was relatively sparse. The Soviets, on the other hand, undertook their testing over south/central Siberia. While the population of such areas is slight, there are a number of cities and factories which had transistors and elementary circuits for use in communication and industrial control, along with military bases and their "state of the art" equipment. It is felt, again with 20/20 hindsight, that due to the Soviet population density and industry over which the tests were conducted, the Soviets were aware of EMP far earlier than the Americans, and that part of the design of their second series of tests was predicated on learning more about it.

Secondly, there is political thought that the Soviets hastened the signing of the test ban treaty, conceding a number of points during negotiations, such that they would be placed in the position of knowing about EMP effects while denying the US the testing procedure necessary for them to find out about them. This is demonstrated by the Mig-25 (Foxbat), a pillar of Soviet aerial defences which, at the time one was flown to Japan in 1976 by a defector, was considered by the Americans to be the best fighter-interceptor in the world. Inspection of the aircraft showed a number of points which puzzled the investigators. While the engines were state-of-the-art, the fuselage was constructed of steel rather than titanium, and its electronic circuitry, while of good design, including in the words of **Jane's All the World's Aircraft** (1981), its "high quality airborne computer," depended on vacuum tubes for those circuits located near to the aircraft's skin, and only depended on integrated circuits buried deep in the mainframe. Steel and vacuum tubes are far more EMP resistant than titanium and integrated circuits. The debate around this aircraft concerns whether or not the Soviet knowledge of EMP is so advanced that they are deliberately designing their aircraft to be EMP resistant, or whether the use of steel is due to Soviet industrial difficulties and the use of vacuum tubes due to the slow dissemination of integrated circuit technology through the military/industrial complex.

A third interpretation is that the defection was faked — being an instance of deliberate "misinformation".

The American failure to properly understand EMP for so many years, coupled with the Pentagon's inherent unwillingness to accept that their $C^3$ system would collapse within two or three minutes of a Soviet submarine launching a warhead into the appropriate area above central United States, has already cost billions of wasted dollars.

An example of such wastage is the **Safeguard** anti-ballistic missile defense system consisting of some 100 nuclear-tipped **Spartan missiles** located in silos at 12 fields primarily in northern Dakota. Upon a Soviet missile onslaught, the **Spartan** missiles would be fired, and when approaching a Soviet missle at a height of 160 km, would dissolve into a silent ball of nuclear fire, destroying the missile. Unfortunately, the explosion would also bathe the United Sates in an EMP pulse, destroying the military's $C^3$ system. The silos now stand empty, quiety filling with ground water. It appears that the Bell System, which is the Pentagon's prime contractor for $C^3$ systems, and which was the prime design contractor for the **Safeguard** system, had designed one system in such a fashion that if it had been successful (**Safeguard**) it would have destroyed the second system ($C^3$). **Safeguard** was declared operational on April Fool's Day, 1975, and stood down as non-operational 10 months later. It cost $5.7 billion.

The Pentagon is now asking Congress for another anti-ballistic missile system, also to operate outside the earth's atmosphere, but dependent on non-nuclear warheads.

A further indication of the fuzziness surrounding EMP thinking is that the **Safeguard** system itself was EMP proof — continuous steel shields being wrapped around critical equipment including the radars, emplaced interceptors and computers.

While this is the most expensive EMP fiasco, there had been other, earlier, ones which during the late 60's had forced the Pentagon to admit, albeit grudgingly, that EMP was a subject worthy of research. Commencing in the late 1960's, the Nuclear Defense Agency, the Pentagon's prime research organization, started to upgrade EMP research priority, such that by 1971 it was running at about 250 million dollars per year. This rate slowly rose from that level until the early 1980's when, in an unprecedented request, the Pentagon asked Congress for 7.4 *billion* dollars to be directed over the next five years on EMP research. The request, at time of writing, is still pending.

**"There would be a thousand commanders of a thousand Minuteman silos not knowing what on earth is going on or what to do about it: to fire or not to fire."**

The urgency represented by the Pentagon's request lay in EMP's effect on the military's $C^3$ capability and hence its ability to wage war. Very little of it has been EMP proofed, primarily because of the number of connections involved. Customarily, lightning and surge arrestors do not work due to the fast rise times of the surges. Components can be designed such that a connection is EMP proofed, but this would require the retro-fit of Faraday shields around equipment and these special connections in every circuit throughout the entire command structure. Even so much as a single unproofed wire coming into, say, a computer could result in the destruction of that computer's entire memory. It is therefore not a question of "plugging" most holes and hoping the system will still have sufficient redundancy that it will continue to function, but rather the necessity of "plugging" every hole or the whole lot fails. The retro-fit cost has been conservatively estimated at 250 *billion* dollars spread over the remainder of the decade.

The rulebooks of war say that the President has 43 different ways of sending out what is known as an Emergency Action Message (EAM) to the strategic US nuclear forces. This is sometimes referred to as the "call to arms." Essentially, and in very broad generalities, the President faced with the reality of an incoming Soviet missile strike has two choices — to fight an instantaneously ordered, all-out, massive counterstrike involving every weapon at his disposal, or he can try to fight a limited, but protracted nuclear war, trying to keep the casualties down, trying not to end humanity: what the current Vice-President once described as a "winnable" nuclear war. An all-out strike is relatively easy to wage: a single order received by the various components of the world-wide strategic forces telling them to fire, which they then do. But a protracted war is a very different organizational problem. A monumentally vast number of orders have to be cut, transmitted, received coherently and executed within very tight time parameters. This requires a very wide array of totally secure and unjammable communication nets, operating within very tight time parameters and essentially error free. With the recognition of EMP, it appears that the US $C^3$ networks would cease to function in very short order (a matter of minutes), not only isolating the President from the military, but isolating each and every small unit of the military from each other. In other words, there would be a thousand commanders of the thousand Minuteman silos not knowing what on earth is going on or what to do about it: to fire or not to fire. Some would fire, some wouldn't. But the important point is that there would be no cohesion, no operational plan surrounding their actions — they'd be fighting a nuclear war blindfolded. A thousand little gods. It is this that has the military worried. In the light of this problem, in 1982, the Secretary of Defense, Caspar Weinberger, called together a high-level, service-wide "strategic connectivity executive review board" to "wrestle" with the problem of designing a communications system better able to survive the effects of nuclear war. To date, its major finding has been to support the Pentagon's request for EMP research money.

The most unreliable portion of $C^3$ is the ground-based communication links. For one thing, the amount of EMP picked up and delivered to sensitive electronic equipment depends on the length of the collector. The short antenna of an FM radio picks up hardly anything. A global communications web of copper wires, microwave towers, switching centres and command posts picks up a great deal. Moreover, the sheer size of such a network makes it almost impossible to test it exhaustively for hardness to the effects of EMP, and the few tests carried out have not been encouraging.

An example of this is the Autovon network, a high-priority system built by Bell Systems for the government. It is supposed to be "nuclear bombproof". In 1975 a section of it, specifically a switching centre, was tested as to its EMP resistant capabilities. It turned out it had none, stopped dead, and took four and a half days to get working again. Autovon, the Pentagon's major $C^3$ ground link, has hundreds of such switching centres.

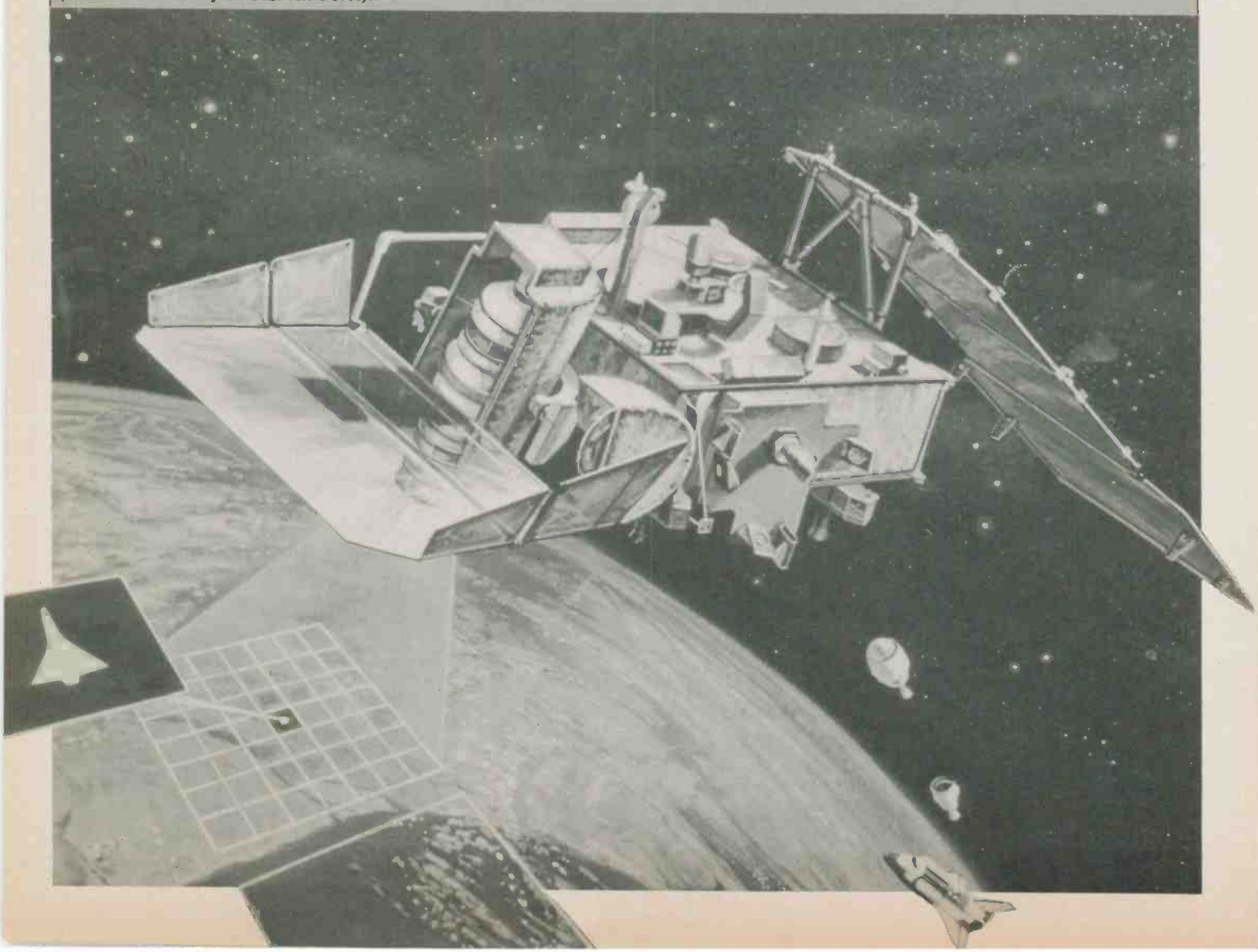
A second example of where EMP could destroy the US $C^3$ capability is at the Presidential/Pentagon interface. The Presidential airborne command posts are four specially designed Boeing 747s. Only one plane is EMP hardened. The other three, on call 15 days out of every month, have as many as 11,500 essential circuits that would fail if the planes were hit by an electric pulse from a nuclear burst thousands of kilometers away. The hull construction (windows, doors, cable connections) that would admit EMP will not be sealed until late 1983.

There are essentially four ways to harden the system. One, was mentioned above — retro-fit surge arrestors. The second is to increase the use of fibre optics which are unaffected by EMP. One of the reasons the Carter Administration cancelled the B-1 bomber was that its control and communications ability would be knocked out by EMP. A new bomber proposed by the Reagan Administration is to have as much of its system composed of fibre optics as possible. So also is the MX missile. Still, as mentioned in a previous article on integrated optics ("Light Memory", ETI, August 1982) no one has as yet designed an opto-electronic switch, and hence no fibre optic system can be considered EMP proof — the EMP affecting the system at the electrical-laser interface. None the less, the Pentagon is purchasing fibre optics in very large quantities and pressuring Bell Systems to hasten its fibre optic usage in main corridor telephone trunk routes such as the Washington to Boston corridor ("Fibre Optics", ETI, June 1982).

A third way is via the development of the Ground Wave Emergency Network (GWEN). The system, still under development, will consist of a grid of unmanned EMP hardened relay nodes operating at the LF Band. Network terminals will be located at major command centres, warning sensor sites and force element command posts. These terminals will have the capability to support two-way data communications in a nuclear environment.

A fourth way is to increase the use of satellite communication links in the military's total $C^3$ posture, and in fact the Pentagon relies on such satellite links for more than 70 percent of its long-haul communications. Half of this capacity is leased by the Pentagon from commercial vendors and half is provided by Pentagon-owned satellites such as those of the Defense Satellite Communications System. The Air Force is thinking of installing satellite ground stations at the phased-array radars just going into operation along the Massachusetts and California coasts. Plans are underway to equip the launch control centres of the 1000 *Minuteman* missile silos scattered across the American heartlands with satellite ground stations. At least 400 Navy ships have satellite links, and so on. While cost

**An artist's concept of the Space Test Program satellite used for survelllance. These satellites, while effective, are vulnerable to anti-satellite weapons. (Illustration courtesy of U.S. Air Force).**



is one of the reasons the Pentagon increasingly relies on satellites, a major reason is survivability. X-rays from a nuclear blast in space can produce a high voltage electric pulse in a satellite (called 'system generated EMP'). But unlike huge ground based networks, a satellite can be tested to ensure that EMP hardening procedures work. A factor against satellites is that they are vulnerable to Soviet satellite killers and the possibility of a direct nuclear hit. It is for this reason that the Strategic Satellite System proposed by the Air Force was scrapped. It was decided that a "proliferated" system was more survivable than a handful of "dedicated" emergency satellites which could be easily spotted and attacked. As such, dozens of US satellites whose primary mission lies elsewhere are equipped to send war messages. The Navstar Global Positioning Satellites, for example, carry an additional payload known as a single channel transponder for EAM signals.

Yet when all is said and done, executing an EMP attack against the United States with the chaos and pandemonium that would result, forcing the American President into a "use it or lose it" Hobson's choice, is simplicity itself. All that would be required is one thermonuclear bomb detonated high above the central United States, and the US power grid would shut down; all electrical appliances

**"Failure to properly understand EMP coupled with the Pentagon's unwillingness to accept that their communications network would collapse has cost billions of wasted dollars."**

without a separate power supply stopping, commercial telephone lines going dead, military channels going off the air. Yet this is a worst case scenario, based on the calculation of physicists who in the early 1960's looked at a few unanticipated events surrounding a 248 mile high weapons test in the Pacific and wove them into a theory that predicts catastrophic events. Perhaps they were wrong.

It is precisely due to this uncertainty that the Defense Nuclear Agency has, for funding purposes, latched so carefully onto what is known as the Jackson Safeguards. In 1963 when the Limited Test Ban Treaty was on the Senate floor, Senator Jackson proposed four conditions for the Senate's acceptance of the treaty. The third of these calls for the US to maintain an "atmospheric test readiness capability", such that should the Soviets break the treaty, the US would be instantly capable of commencing exoatmospheric nuclear testing. The Defense Nuclear Agency is empowered to fullfill this criterion, and does so in part by the maintennance of a 165-person force on Johnson Atoll in the Pacific. Under their direction is a missile launch site with a thermonuclear warhead ready for installation and firing. Three days after the Soviets broke the test ban treaty, the US would have fired the missile, detonated the bomb exoatmospherically and determined once and for all whether the EMP threat is as great as believed, and whether the hardening procedures work.

Until then, or until a nuclear war occurs, a slight question mark remains. But only a slight one. ETI

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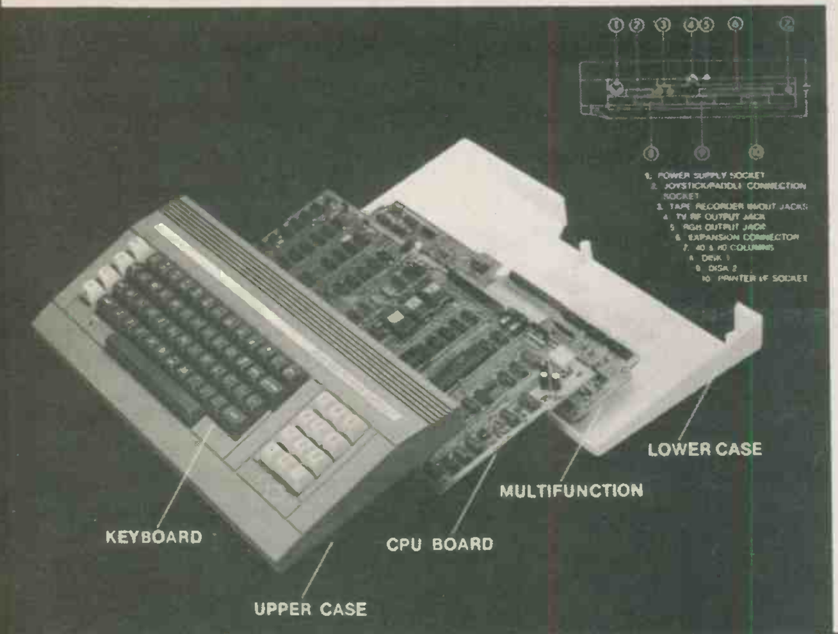


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# Inside Memory Systems

**A microscopic look at the brain cells of a computer. Gary Branscombe opens that black passage for a tour.**

REMEMBER WHEN data used to be stored in magnetic cores. These cores, or toroids, were like tiny donuts measuring approximately 20 mils in diameter. The cores were made of ferrite, and consequently they could easily be magnetised.

When a thin wire was wound around the core and a current passed through it, the core could be magnetized in either a clockwise or a counterclockwise direction. This is illustrated in Fig. 1a and 1b where "@" represents the direction of magnetization. This characteristic allows us to write a '1' or a '0' simply by feeding the core positive or negative current.

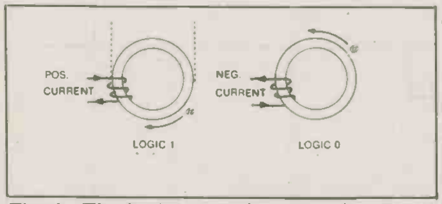



**Fig. 1. The ferrite core of a magnetic memory can store a "1" or a "0", depending on the direction of current flow.**

To prevent the computer from being illiterate, it must be able to read. This can be done by running a sense line through the center of the core. This sense line takes the data and passes it out to the data bus. Here we encounter a problem. Each time a read operation is performed the core would be reset to the '0' value. This is known as a Destructive Read Out (DRO), because the data is changed (and thus destroyed) when read. This was not nice, and to retaliate, one more wire was added. This was called an inhibit line.

The easiest way to overcome DRO was to always write a '1' into the core after each and every read operation, and here occurs the use of the inhibit line.

If we read a one, then the inhibit line lies dormant and the computer writes a one back into that cell. If we read a '0' then the inhibit line goes low. This opposes the writing current and the computer does not get to write a '1' into the core. Thus the core stays at the '0' level, and this is what we had to begin with. Now the memory is said to have a Non Destructive Read Out (NDRO).

## X's, Y's but no ZZZZzzz's

This system works nicely, yet has but one more problem. It is not practical when used with more than 10 bits, as each bit would require its own sense lines, inhibit lines, and write lines. To overcome this bulkiness, a very clever computer freak spent many sleepless nights developing what has come to be known as the X-Y coordinate scheme.

This allows each memory plane to use only 1 sense line, inhibit line, and of course the X,Y lines. A simple 4 x 4 matrix is shown in Fig. 2.

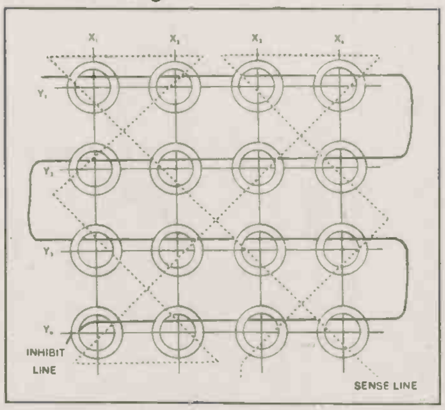



**Fig. 2. 4x4 core matrix**

To select the desired core, all you have to do is choose the corresponding X,Y coordinate. The required core will be at the intersection of these lines. A city is laid out in a similar manner. To find a computer freak, go to any city centre; a byte to eat can be found in the suburbs.

A core requires a certain amount of current to magnetize it in any one direction; one amp is a good approximation. Using the the X,Y scheme, we send .5 amps along each line, and this is not enough to change magnetic direction. However, the lonely core that sits on the intersection point will get hit with 0.5 amps from each direction. This adds up to one amp, and this can change the logic level.

## Some Plane Geometry

Obviously a 4 x 4 array is pretty useless as far as a practical memory system goes. To maximize its efficiency, the cores are arranged on a plane and the address lines are multiplexed.

Cores are assembled on a plane that usually contains a 32 x 32 array, or 1024

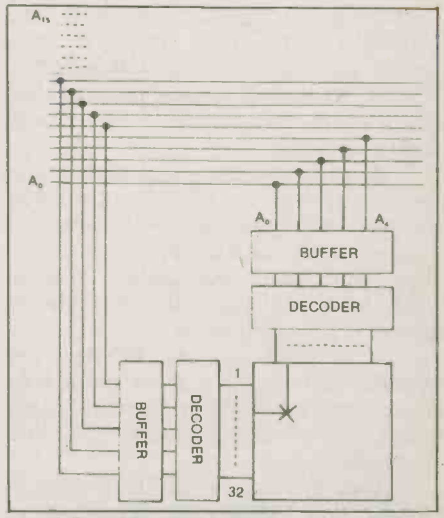



**Fig. 3 Simplified block diagram of a RAM circuit.**

bits. These planes are stacked in parallel to get a byte, a word, a long word, etc.

Since 1024 bits require 10 address lines, we send 5 lines to the X axis and 5 to the Y. These 5 lines pass through a buffer to a decoding matrix. This decoder will select one of 32 depending on the binary input. Fig. 3 shows a very simple diagram of a plane with the address bus, buffers, and decoders.

For a quick example, let's assume that the binary number 0000 0000 1010 0011 is on the address bus. We are only interested in the lowest 10 bits. These 10 bits will be divided evenly between the X and Y decoders. X gets the low 5 bits (00011) and this selects the 3rd column. Y gets the higher 5 bits (00101) and this decodes to the 5th row down on the Y axis. This is illustrated on the diagram (Fig. 3). We will gain access to the single bit where these lines intersect. We can read its value or write in a new one.

Magnetic cores did work, but they had many drawbacks. They were slow with access times of up to 10us, compared with today's memories at 150-250 nS. They were big, drew a lot of current and had to be hand wired, usually by some buggy-eyed, drooly-faced computer freak who threaded the cores with wires the diameter of human hair. Fig. 4 shows an actual size picture of a 1K x 1 RAM of magnetic core compared to today's 256K x 1 dynamic RAM chip. With increased efficiency in silicon manufacturing, it was no longer feasible to pay anybody to wire these things. The world turned its attention to semi-conductor memory.

## RAMSES AND ROMSES

So far we have looked only at core memory. This system is a member of the RAM family of memory devices. RAM means Random Access Memory. The name says it all. These little articles allow random access to any cell in the memory block for reading from it or writing to it.

RAMs are available in two technologies (bipolar transistors and MOSFETs) and two functional styles (static and dynamic). This is illustrated in Fig. 5. RAM is a volatile memory and, like alcohol, will evaporate on a power-down situation.

And now the mysterious ROM creeps into the picture. The ROM is a Read Only Memory and is the brains of the computer system. It tells the microprocessor (MPU) how to process the information. Without it the MPU may spend all its time playing games in the video RAM.

A derivative of the ROM is the PROM. This is not a dance but a User Programable Read Only Memory. Many quasi-Apple owners are familiar with this particular item.

Then comes the EPROM. This is similar to a PROM, but allows you to make mistakes because it is erasable with ultraviolet light. If an error crops up, just sit it in the sun for a year and the information will mystically disappear. Or else take it to an EPROM store and they will erase it overnight for a nominal charge.

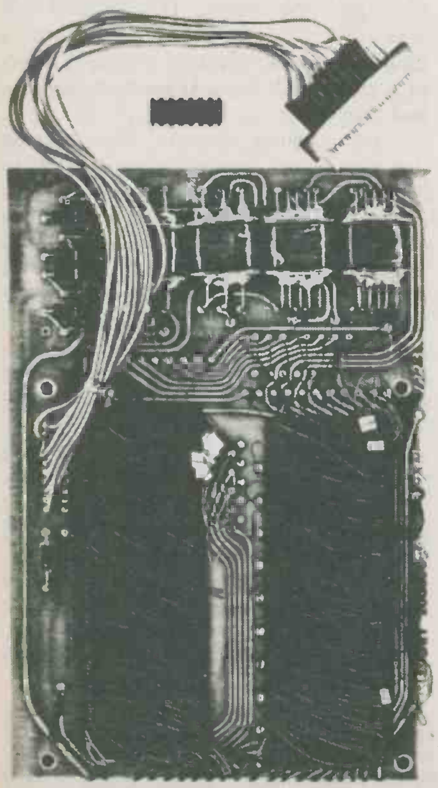


Fig. 4. Comparing size of a 1024 x 1 bit magnetic core memory to a 256K x 1 bit dynamic MOSFET memory (16 pin DIP) (MCM 6256)

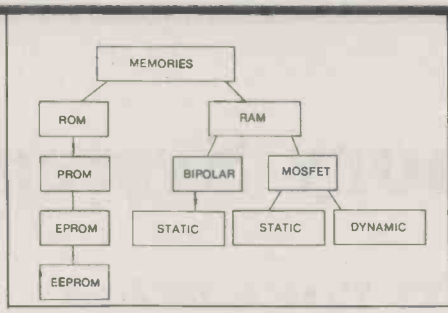



Fig. 5. Semiconductor memory families.

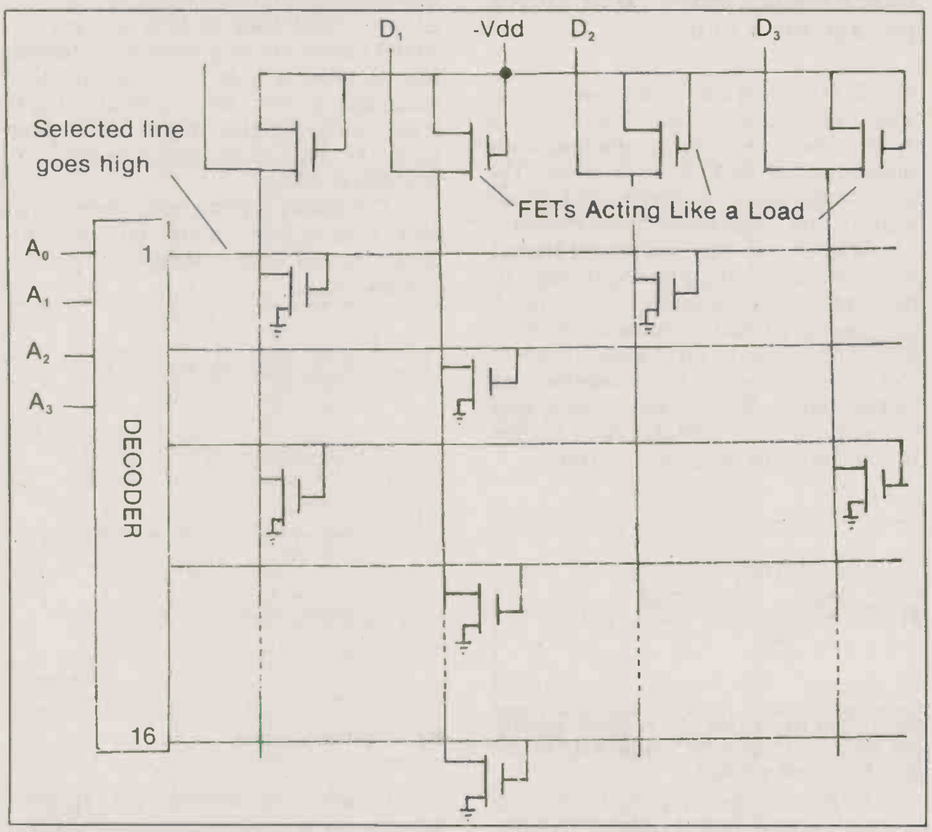



Fig. 6. 16x4 bit ROM circuit. A FET at any intersection will go high.

Finally there is the EPROM. This is an Electrically Erasable Read Only Memory. The information on this chip may be altered electrically while in the circuit.

## ROManticize

The ROM is mask programmed by the manufacturer. The mask is the machine language program that is etched into the ROM during the manufacturing process. It is a costly procedure that has to be done in large batches to make it economically feasible. A typical application may be a large appliance manufacturer who requires a specific ROM for a microprocessor controlled washing machine. Preprogrammed ROMs are also available. Examples may be:

*BCD to ASCII conversion
*Sin look up table
*Arc Tan look up table
*The quick brown fox . . .

The ROM is always structured using matrix organization regardless of the technology used. This is slightly different to the X,Y scheme in that it only uses one decoder. It is much simpler to manufacture than RAM and consequently, it can be used in Extremely Large Scale Integrated Circuits (ELSI). Fig. 6 shows a simple 16 x 4 bit ROM.

## LET'S GO TO THE PROM

The PROM is very similar in construction to the ROM. This chip can be programmed by anybody who has the need and/or desire to program his own memory. It is not erasable, so if a mistake is made, that $8.00 chip is reduced to junk. It is available in the form of all '1's and you zap in the '0's, or all '0's and you zap in '1's.

Each cell in the PROM array contains a fuse. This fuse can either hold the data lines high (all 1's) or low (all 0's). Zapping is the procedure of applying a short burst of current in order to blow the fuse. Don't get carried away or you may end up paying a visit to your friendly neighbourhood parts counter. If Fig. 6 were a PROM, it would be all 1's, the FETs representing an intact fuse and the spaces representing a blown fuse.

## EPROM's

The EPROM is ultraviolet light erasable. It has a little window on the top that should be covered if you value the programmed contents. Do not expose this to direct sunlight. When programming, the data is stored as a charge on the gate of a FET. Because of this, programming must be accomplished by executing a number of passes to set or reset the charge on each FET in the memory. We must do this to guarantee the installing of reliable information. The number of passes may vary from 200 to 1000 and usually takes place within 1 sec.

Fig. 7a shows a block diagram of a typical 1K x 8 EPROM. Fig. 7b shows a giant-sized EPROM.

are generally faster and easier to handle. Fig. 8 shows a typical bipolar arrangement. If Q is high, the latch hath stored in it logic 1. The diagram beside it shows how the memory sits with respect to a large memory block.

A single memory cell of MOSFET can be constructed using only 8 transistors. This does, however, require a single line for the zero bit and the 1 bit. If T2 is conducting, then a logic 1 is stored. The single cell is illustrated in Fig. 9 and the block of big memory is beside it.

mal capacitor leakage. Because of this, we must refresh the memory. This is accomplished by sending the chip a refresh pulse at least every 1 mS. Some chips can stand as long as 4ms between refresh cycles. Refreshing is the process in which the data is read from the cell, amplified, and then written back into the same cell. Newer chips provide an automatic refresh whenever the $\overline{RAS}$ or $\overline{CAS}$ lines go low. A dynamic RAM cell is shown in Fig. 110. T2 holds the data as a charge on its gate.

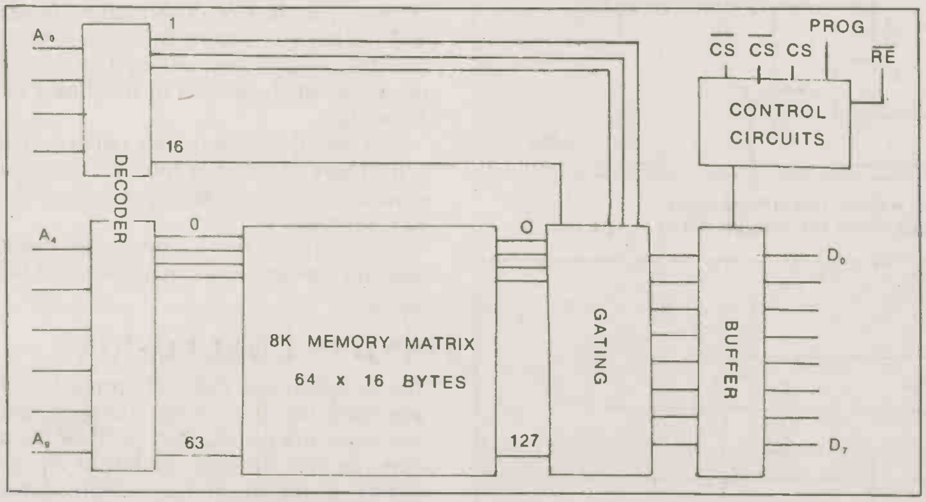



Fig. 7a 1Kx8 EPROM block diagram.

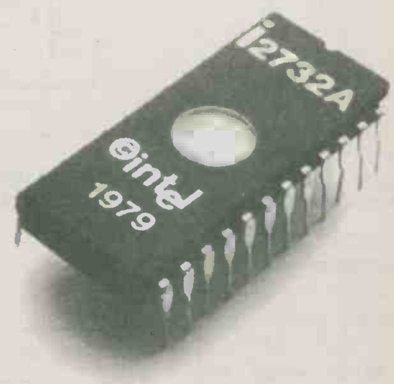



Fig. 7b Large family sized EPROM.

## RAM, DATA, and STATIC CLING

The diagram (Fig. 5) shows that RAM is broken down into MOSFET and BIPOLAR technologies, and this is broken down into static and dynamic types.

The static RAM holds its data in an R-S type flip flop. This flip-flop can be constructed from either bipolar or MOS transistors. The type chosen depends largely on the application of the chip. The FET takes up less space so it can be packed into a high density format; the bipolar

## DYNAMIC RAM

The dynamic RAM is probably one of the most mysterious, yet most versatile RAM. It takes advantage of the fact that there is a tiny capacitor between the gate and the substrate of a FET. The data is stored in the form of an electric charge on this gate. Using this technique, engineers have been able to drop the number of FETs per cell from 8 down to 3. This has allowed very high density RAM to be manufactured and put on the market.

Since the data is stored on an equivalent capacitor, it is subject to nor-

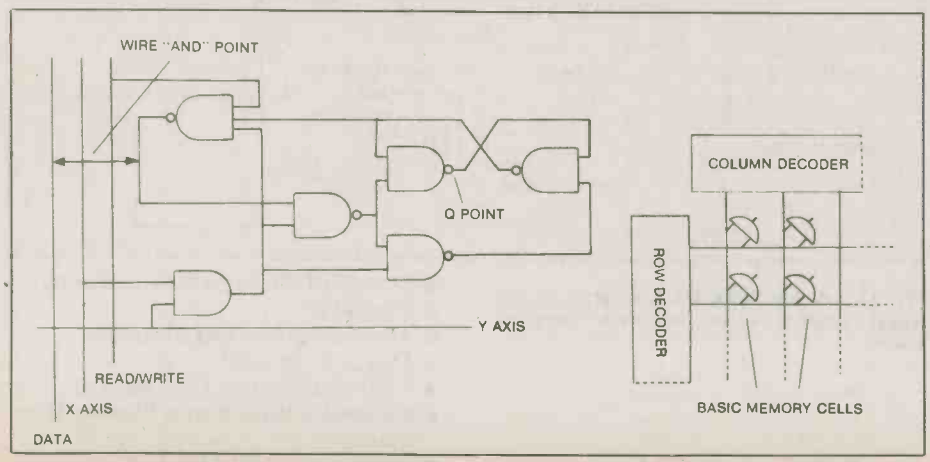



Fig. 8. A single bipolar memory cell built from NAND gates. Each NAND gate may contain 5 transistors. At the right is a block diagram of memory cell organisation.

## A QUARTER MEGABYTE TO GO

Motorola has announced a 256K x 1 bit high speed dynamic RAM. Housed in a 16 pin DIP, the memory cells are accessed by multiplexing the address lines. This allows the use of only 9 of these lines. The decoding is done by the chip itself and controlled by the $\overline{CAS}$. This simplifies the external circuitry and allows for greater flexibility.

The MCM 6256 (catchy name, don't ya think?) also has a "nybble mode" meaning that you, the user, can access 4 bits of data in serial fashion. Now you can store 64K bytes of data in 2 16 pin DIPs. It also features tri-state data output, single voltage power supply requirements and low power dissipation.

With a minimum access time of 100ns in the bit mode and speeds of up to 20ns in the nybble mode, this product will be a serious contender in the silicon market.

The block diagram is shown in Fig. 11.

## TINY BUBBLES . . .

Magnetic bubble memory is coming of age. Known for its ability to store data in a very high density form, it is being used in very harsh environments. Areas which would normally choke the life out of a disk would be prime targets for the bubble memory. It has also found applications in

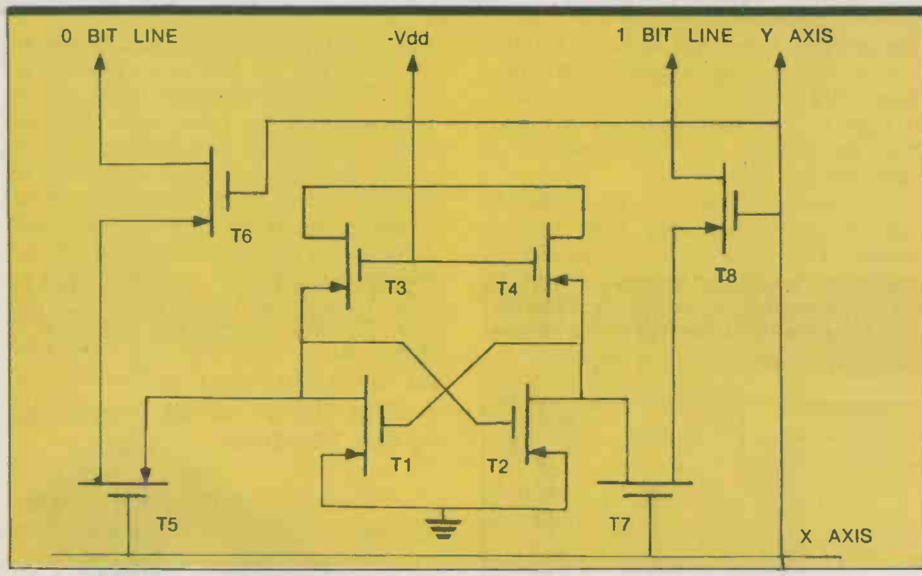
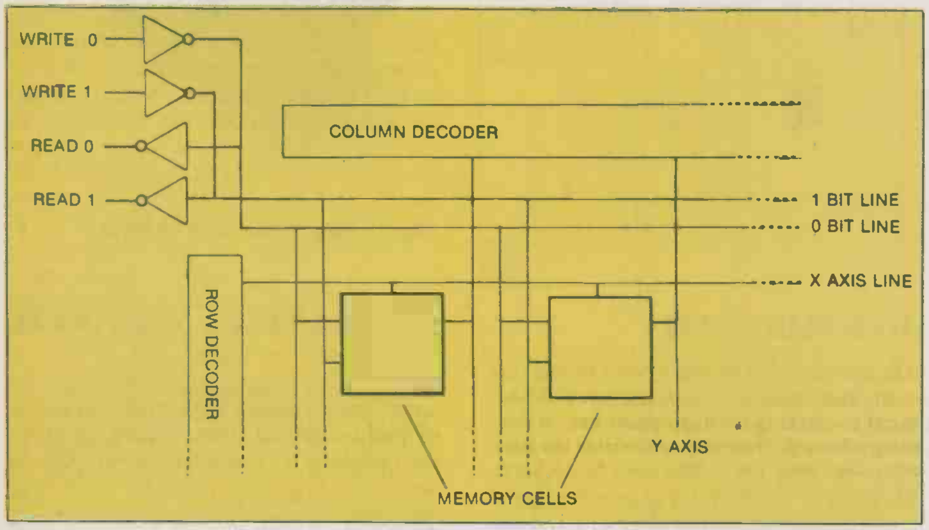



**Fig. 9. Top — basic MOSFET memory cell. This is a static type arrangement.
Bottom — This is the structure of a static RAM chip. Note the separate 0 and 1 logic lines.**




point of sale terminals, military use, fast auxilary storage and electronic disks.

Magnetic bubbles are very tiny cylindrical magnetic areas. The areas can be created or destroyed at will by using the magnetic fields of the X-Y coils. The magnetic domain (area) can be either present or not present at a particular location; thus binary information can be stored.

The bubble is part of a magnetic-resistive element whose resistance changes with respect to magnetization. To retrieve the data, a constant current is forced through the element. The output voltage will fluctuate according to the resistance, and the voltage level of the output will determine the logic level of the binary information.

A bubble memory unit requires two coil drivers (X & Y), a function driver, a sense amp, a controller and of course, the tiny bubbles.

Fig. 12 shows a functional block diagram of an entire magnetic bubble system.

## AND IN CONCLUSION . . .

The computer has definitely come a long way since the days of core memory, but even with storage capacity of 256K on a chip, we are still only scratching on the surface of the tip of the semiconductor iceburg. With refined chip-producing methods, companies like Rockwell International have been able to produce a complete computer-on-a-chip. There is no telling when this explosion will stop, if ever.

If you wish to look further into memory systems, here is a list of books on the topic:

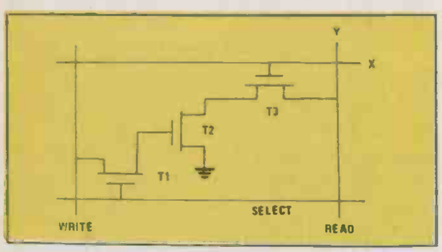



**Fig. 10. Typical dynamic RAM cell capable of storing 1 bit.**

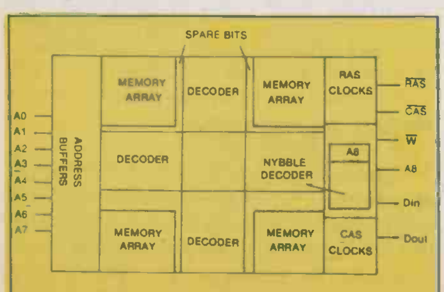



**Fig. 11. A 256K RAM.**

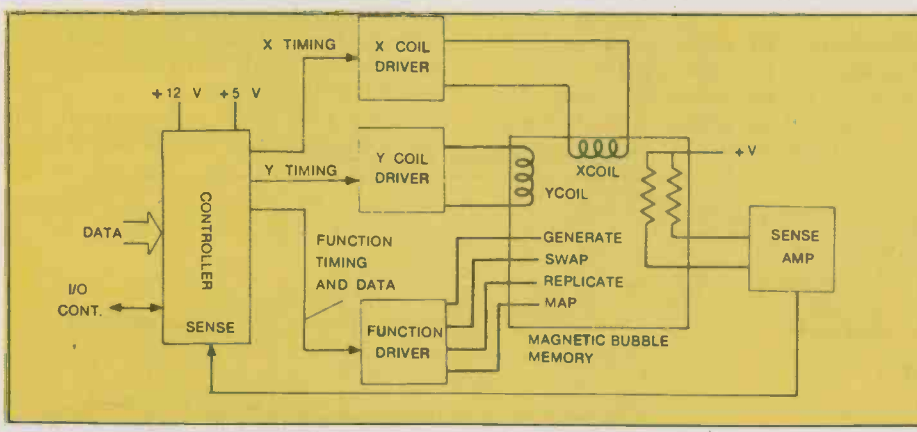
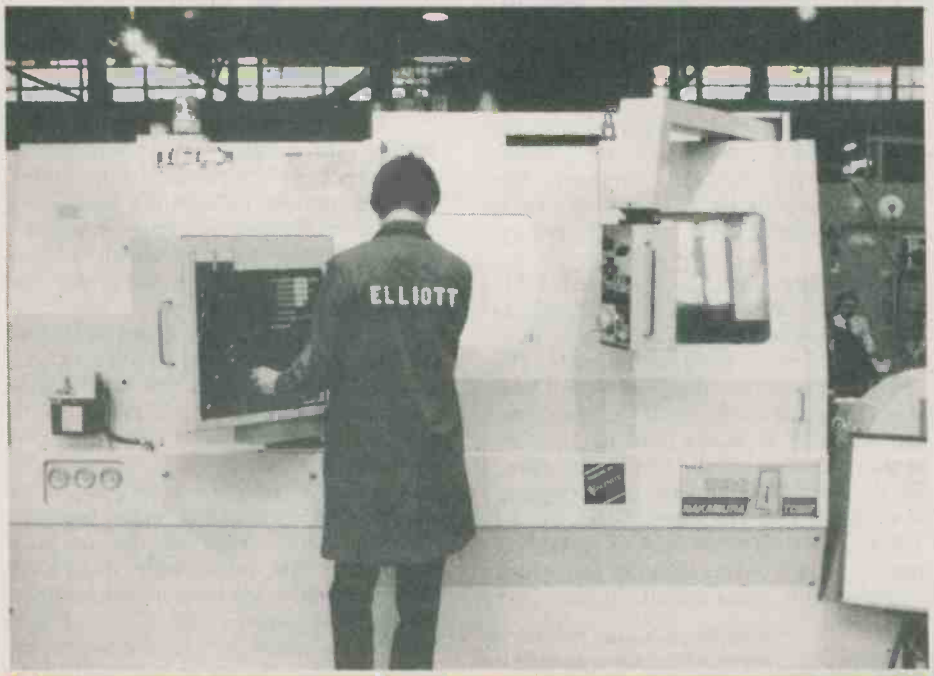



**Fig. 12 - A functional block diagram of national semiconductors magnetic memory system.**

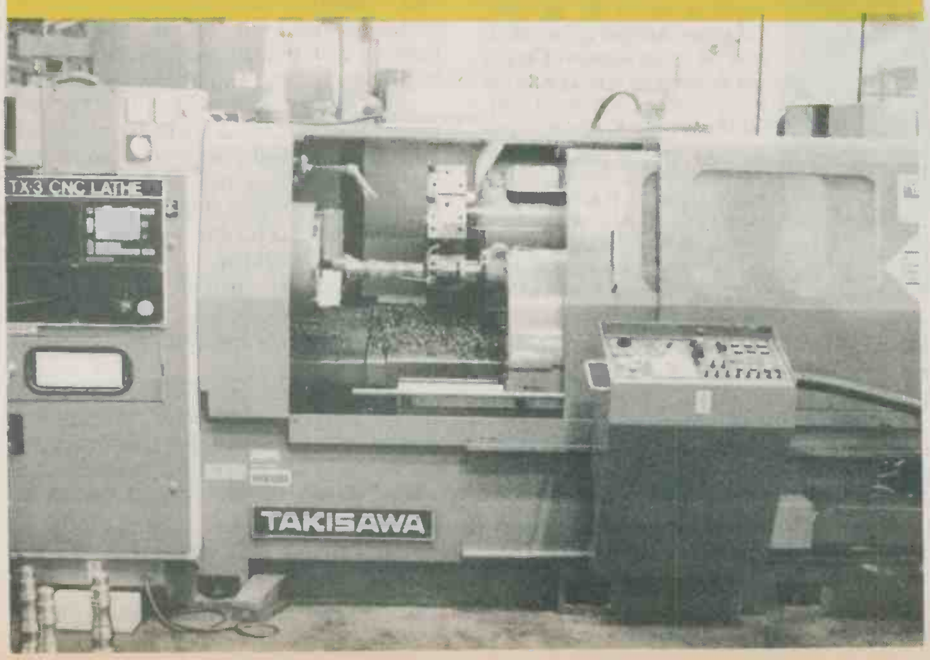
- Simplified Guide to Microcomputers
- Bocchino
- Microcomputers and Memories
- Digital Equipment
- Motorola Memory Data Manual
- National Semiconductor Memory Data Manual
- Computing Now! May 1983 p22 (Memory Systems)

# CAD/CAM

**Computer-aided manufacturing and design is expanding many companies' horizons rapidly, and the machines rarely call in sick. A look at the prevailing technology by Eric McMillan.**




These are two examples of computer-aided machines. The Takisawa TX-3 CNC Lathe is shown with shield open to reveal the drum turret which holds eight different cutting tools. The machine is programmed through the CNC (computer numerically controlled) unit at the far left to select the cutting tools in order from the rotating drum turret for making the appropriate cuts in the material. The control station to the right of the opening allows the operator to override the programming to adjust the spindle speed, feedrate or other functions. The Nakamura TMC-4 Turning Centre is shown being operated by a worker from B. Elliott (Canada) Ltd. which distributes the machine. Note again the CNC unit, with character display screen.




AT THE Wonderful Widget Company of Canada, the lights go on only when a crew arrives to carry out repairs and preventive maintenance. The rest of the time the plant works in darkness because machines do not need light to function.

Production continues twenty-four hours a day, seven days a week. An observer would hear machines turning on and off as they're needed. Apart from the maintenance tour, the only human intrusions are occasional deliveries of raw materials through the chute at the back of the factory and weekly visits by trucks which cart off the finished widgets.

Meanwhile, at the head office in New York, an engineer sits down before a terminal with two blank screens. As he presses keys, the smaller screen responds with printed questions and a list of choices. He makes his selections and the larger screen comes alive with a network of multi-coloured lines. Called up from the company's central computer, this is the blueprint of the new widget he's been designing the past month for production at the Canadian branch plant.

It's almost completed. He consults the menu on the small screen again for the code to display the design from eight perspectives. As the large screen divides into eight windows and begins drawing three-dimensional widgets at varying angles, the engineer folds his arms in satisfaction. Almost done, and right on schedule. He remembers the bad old days when a new model widget spent half a year on the drawing boards. But that was before CAD.

He adds some finishing touches by moving the cursor to the left side view and tapping a special function key as the cursor touches two lines. Another tap and a third line connects the two points. Simultaneously the line appears on each of the seven other perspectives.

But something's wrong. On the widget with the 45 degree forward tilt, he can see that the edge he's just drawn conflicts with a previous line. Mistakes like this used to infuriate him since he'd have to start over with a fresh sheet of paper. But with

CAD he removes the line as easily as it was drawn.

Another part of the widget is too tiny to be seen on this scale. He chooses a perspective and has it fill the entire screen. With the cursor he outlines a small segment which is quickly expanded, revealing lines which were not visible in the overall design.

And so he works away the day, using the graphics terminal not only to draft the blueprint but also to measure parts, to evaluate stress factors and even to project manufacturing costs.

Tomorrow he'll have the design put on paper by a three-colour plotter run by the same computer as his terminal. If the blueprints are approved upstairs, the computer can be transmitting instructions to the Canadian plant by next week. It used to be that a new model could be introduced only after extensive adjustments were made to the machines by employees who interpreted the design specifications. But that was back in the days before CAM. Now everything from the new dies to the machining sequence is worked out by computer.

And since the Wonderful Widget Co. is a leader in CIM, all the processes from ordering materials to handling pieces between machines are fully automated. When the engineer punches the keys to send the design to Canada, the world's latest widget will be as good as made.

**Canadian company Modern Industries Melbourne recently introduced the "Trudo" (how Canadian can you get?) 4+1 Machining Centre, which was developed with assistance from the Federal and Quebec governments and from the University of Sherbrooke. The CNC unit can be seen at the extreme right. The large round drum at top is an auto tool changer which holds 20 tools weighing up to 20 kg each. Tools are changed automatically in six to ten seconds. Cutting can be done on five axes as the piece is turned before the tool. MIM says the Trudo can perform operations that normally would require a number of different types of machines. The company hopes this Canadian-designed and manufactured machine will penetrate the North American market at the rate of 5-10 per cent.**

## CAD and CAM and CIM

CAD, CAM and CIM are the acronyms that has industry buzzing and puzzling over as the North American industrial economy enters the era of high-tech production. The above scenario is slightly futuristic but is becoming a reality probably quicker than you might think.

Of the three, CAM (computer-aided manufacturing) has been around the longest in the form of numerically controlled machine tools. A 1982 survey found that thirty-six percent of the large companies in Canada and forty-five percent of the medium-sized ones are using NC (numerically controlled) machine tools. These are machines which perform according to a program read from punched paper tape by optical or mechanical means. When a small digital computer is mounted on the machine to operate it directly, it becomes a CNC (computer numerically controlled) machine tool.

CAD (computer-aided/assisted/-automated design) is less prevalent than CAM with twenty-three percent of the large companies and ten per cent of the medium-sized companies in Canada reporting the use of computers for engineering design and analysis. But then, the invention of CAD has been more recent.

The first significant uses of CAD were in the automotive and aeronautics industries where computers have been analyzing designs for over a decade. The giant corporations that simulated products on graphics terminals for computer-testing began to realise that the same instruments could create the initial plans. By the later 1970s, Boeing was designing aircraft wings by computer and by the 1980s, most General Motors cars had bodies which were sculpted on video screens before being manufactured in the factories. Today CAD is finding a place in a wide range of businesses, especially with the steel and plastics manufacturers.

Computer-aided drafting can be done on various types of terminals. One system moves a cursor around the screen by means of keys, dials, joy-stick or trackball. Special function keys are depressed to mark points, draw lines, shade areas, and so on. The rest of the keyboard is the usual alpha-numeric sort for entering typed commands.

Other systems allow the designer to draw directly on the screen with a light pen or on an electronic board which transfers the lines to the screen. As with hardware and software in general, different makes of CAD computers offer different capabilities. Some, for example, let the draftsman reproduce a section of the design many times — in drawing a highrise building, he might just sketch a single apartment balcony, indicate where identical balconies belong, and the computer will quickly put them in place and allow him to work out the unique details.

The trend toward user-friendly computers and high-level programming languages is a boon to user's with a drafting background rather than computing experience. Menu-driven systems can take the designer step-by-step through the process with plain English, except for the drafting terms.

Computerised design and manufacturing becomes the catchphrase "CAD/CAM" when the two technologies are linked. Practically all phases of a manufacturer's operations can be connected by computer.

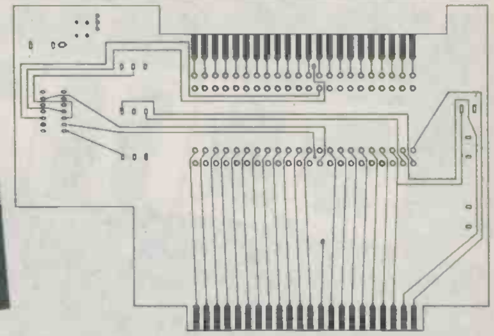
The automation of a company from the 1960s to this decade might take the following route. In the 60s, the company acquires a few numerically controlled machines which are later joined by their computerised mates, the CNCs. From these stand-alone units, the company moves towards relating several controlling computers in a hierarchy to coordinate the machine's activities, while retaining manual methods of forwarding each workpiece from one station to another. The next obvious step is to replace human hands between machines with an automatic materials handling system. At this point it become sensible to let a mainframe computer handle the entire operation. All that remains for employees on the manufacturing side of the business is loading and unloading materials at the beginning and the end of the process.

In the meantime, on the information-processing side, the drafting terminals are joined electronically with other work stations for designing dies and determining machining sequences. This whole area can then be linked to the production side through the mainframe. Distance is no impediment with current technology for transmitting data. The computer can direct operations spread over several cities, even countries.

The connection of all information about design, manufacturing and resources in a single database, accessed by every person and machine involved, is the aim of CIM computer-integrated manufacturing.

## Going With The Flow

Unfortunately, many factories have automated in stages such as those outlined



**Illustrated is the Draft-Aid computerised drafting system designed and sold by Richvale Telecommunications, 10610 Bayview Ave., Richmond Hill, Ontario. It consists of a plotter, an 80-column PET, and a 2-megabyte disk system. The graphics editor allows the user to enter shapes directly to the screen, where they can be manipulated and redrawn until satisfactory; the graphics are then sent to the high-speed plotter. Shown with the photograph is a reduction of a sample plot of a printed circuit made with the Draft-Aid; it was plotted as a test copy with a fibre-tip marker on drafting paper. A technical pen and Mylar would give much sharper traces. For users already equipped with the necessary hardware, the software is to be available separately for about $300.**

above, creating pockets of computerisation which are difficult to integrate due to incompatibility of equipment. Changing over to complete CIM in these cases can be expensive. Consultants recommend that management approach the task with a concept of the total manufacturing process from idea to finished product as one long flow of information rather than as a combination of separate operations.

A typical company might survey the seemingly disparate aspects of its production and find CAD stations, some NCs and CNCs, perhaps robots, varieties of materials handling operations, a research and testing department, some machines grouped together to make related parts, several stock-taking mechanisms, and of course, employees.

By thinking of the whole works as a continuous information flow, the company can reduce it conceptually to a handful of functional areas to be linked in the central computer.

- Computerised graphics involves product design, testing, drafting, tool design and more.
- Storage and retrieval takes the information from the graphics terminals as well as from the other sections to make all the data pertaining to the parts being produced accessible to all concerned.
- Management and control of resources keeps track of the requirements for, and availability of, labour, machines and materials.
- Control of machines is CAM's duty and includes conventional machines as well as robots.
- Materials handling may or may not be a separate function. As automation increases, it become difficult to tell where one machine ends and another begins.

North American industry seems to have recognised that this is the direction it has to go. American companies have already invested $610 million in CAD/CAM and robotics and the figure is expected to quadruple in the next two years, according to a recent survey by Evans Research Corporation of Toronto. The report estimates that Canada alone will have installed half a billion dollars worth of CAD/CAM equipment by 1987.

The trend does face some resistance, however. Fears have been raised in the media about the potential loss of thousands of jobs due to automation. A CIM plant is a plant without workers on the shop floor, the media has warned. A national newspaper has speculated that the microprocessor which runs factory operations is creating a new class of people called "techno-peasants," who cannot understand or compete with the computer.

## CAD/CAM In Education

"It will still be a long time before we have many factories without people in them," says David Coates, Chairman of Engineering Technology at Seneca College in Toronto, which offers courses in CAD/CAM.

Coates said there are two schools of thought as to how CAD/CAM will affect the manpower market. One school projects a demand for "smart jobs" in designing the new equipment, programming the computers and applying the technology, and a lot of "dumb jobs" requiring little formal education. The "dumb jobs" are necessary for setting up CNC machines (a task which requires more flexibility than robots have) and for general machining, since human workers acquire a knowledge of "tricks of the trade" that cannot be taught to computers as yet.

The second school of thought holds that more and more of this expert knowledge is being built into the software, although it is admitted that the point at which the ability of humans is equalled by computerised machines is still in the future.

On the CAD side, some resistance has been exerted by veteran employees. One draftsman told me he knew CAD was the coming thing but he had trouble, after doing the job by hand for years, adjusting to the computer. He maintained he could work faster with pencil and paper, but others have found that designing with CAD is up to seven times as fast as old methods.

Courses such as Seneca's help to ensure that a generation of engineers and designers are going to enter their professions just as comfortable with graphics terminals as previous generations were with slide rules.

Certainly governments see it that way. The CAD/CAM laboratory at Seneca was built with three-quarters of a million dollars from Ottawa. Operational since January, 1981, it includes six training terminals, plus one for faculty and development; a high-speed, electromechanical plotter with two pens; a graphic numerical control terminal for determining tool paths for NC programming; a controlled machining centre; an injection molding machine; and other items, all supported by the college's VAX II/780 computer.

The Nova Scotia government opened a $1-million CAD/CAM centre at the Technical University of Halifax in cooperation with Control Data Canada in April, 1983. Nova Scotia industries are expected to use the facilities.

In Ontario, centres are opening up all over the province. Proclaiming "the computer-driven factory of the future is in sight," the Ontario CAD/CAM centre in Cambridge offers to show manufacturers how to apply the state-of-the-industry computer technology to their businesses. A robotics centre has been established in Peterborough, and in Ottawa, the Ontario Centre for Microelectronics has installed a $1.5-million CAD system to aid companies.

Although experts may disagree on how fast the new technology is replacing the old and whether it is a good thing, most agree that it is taking over.


**by Steve Rimmer**

THIS MONTH we're going to have a look at some of the basics of machine language programming for systems that run CP/M. There are getting to be quite a number of these . . . even if you have a relatively cheap computer, like an Apple clone or a Commodore 64 you can, or shortly will be able to, get a CP/M package to run on it. CP/M is a very good trip . . . it makes life a great deal easier even at the machine language level . . . as this example might illustrate.

If you have ever done any machine language programming before, you will probably have discovered that it is intolerably tedious because you have to write code to look after every scruffy little detail of what you want to do. Even if all you're up for is sticking a character up on the screen, you have to get into writing a whole special routine to handle it. This is a downer, because you spend a lot of time fighting with very trivial programming.

Part of the operating section of CP/M is a large program called the BDOS, for Basic Disk Operating System. For the purpose of this example, it can be thought of as being a large program which contains a number of useful functions . . . actually thirty-seven of them in CP/M 2.2 . . . and a steering section that decides which one is to be executed. Most of the functions, predictably, refer to disk operations, but the earlier ones do screen and keyboard handling, and are quite useful even if you are doing fairly simple programs.

The BDOS is dead easy to use. You load the processor's C register with the number of the function you want. If the function is supposed to take something in, as in the case of printing a character, you put it in the E register. If it's supposed to return something, as in getting a character from the keyboard, it will appear in A after the BDOS is done. Then you do a CALL to location 0005, which will, in turn, leap to the actual location of the BDOS in high memory.

The following is a program which will illustrate the use of the first two BDOS functions, with heavy emphasis on the second, which takes a character in the E register and prints it. It will draw a box around the screen of your computer.

```
BDOS    EQU   005H
BLOCK   EQU   160
SPACE   EQU   32
CLS     EQU   26
;
        ORG   0100H
START:
        MVI   C,2
        MVI   E,CLS
        CALL  BDOS
;
        CALL  BAR      ;draw a bar
        MVI   A,0      ;set counter to 0
LOOP3   PUSH  A        ;save counter
        CALL  FRAME    ;draw one frame line
        POP   A        ;get counter back
        INR   A        ;increment counter
        CPI   21       ;done yet?
        JNZ   LOOP3    ;if not, do another one
;
        CALL  BAR      ;draw another bar
;
        MVI   C,1      ;hit any key to continue
        CALL  BDOS
;
        RET            ;go home
;
; SUBROUTINES
;
BAR:
        MVI   A,0      ;set the counter to 0
LOOP1   MVI   C,2      ;set the call to 2
        MVI   E,BLOCK  ;make BDOS print a block
        PUSH  A        ;save counter
        CALL  BDOS     ;go for it
        POP   A        ;get counter back
        INR   A        ;increment counter
        CPI   80       ;have 80 been printed yet?
        JNZ   LOOP1    ;no, go do another one
        RET            ;otherwise we're done
;
FRAME:
        MVI   C,2      ;print 1 block
        MVI   E,BLOCK  ;
        CALL  BDOS     ;
        MVI   A,0      ;zero counter
LOOP2   MVI   C,2      ;set up to print
        MVI   E,SPACE  ;space character
        PUSH  A        ;save counter
        CALL  BDOS     ;print it
        POP   A        ;get counter back
        INR   A        ;increment counter
        CPI   78       ;done yet?
        JNZ   LOOP2    ;if not, do another one
        MVI   C,2      ;print 1 block
        MVI   E,BLOCK  ;
        CALL  BDOS     ;
        RET            ;we're done
;
        END
```

The inital EQUates set up the constants that are used in the program. The rest of the code is actually pretty simple once you get into it. Printing a character always takes the form MVI C,2, load C with 2, MVI E,CHR, load E with whatever character we want to print and the CALL BDOS to execute the instructions we've just set up.

Note that, if you say PRINT "A" in BASIC, what you are really saying is PRINT "A",CHR$(13),CHR$(10);. BASIC always moves the cursor down to the next line unless told otherwise. BDOS does not . . . if you want to go to a new line after printing something you have to print characters 10, a line feed, and 13, a carriage return.

Finally, this program uses the A register of the processor as a counter. Notice that, just prior to any CALL it is PUSHed, and then, just after RETurning from the CALL it is POPped. This is because both the subroutines and BDOS make use of the A register for themselves, and it would come back mangled. PUSHing it stores its current value away and POPping it brings the value back and puts it in A again. Thus, you can use A for several things by saving the first value prior to sending poor overworked A along to deal with the second. You can PUSH and POP any number of A values providing you remember that, in order to get back what you PUSHed, the values must always be POPped off in reverse order.

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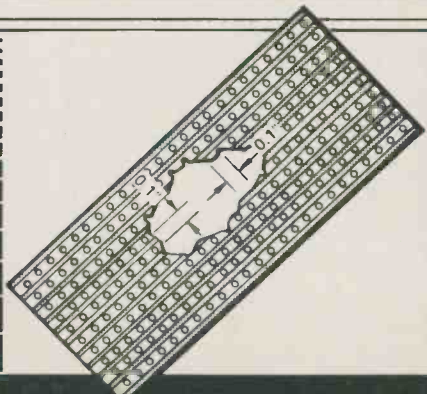


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# Satellite TV Receiver Part 2

**In this second of two parts, the author describes how to turn the signal from your dish antenna into a TV picture. By Ron D. C. Coles.**

THE NEXT stage in the receiver chain is the down converter. This is the piece of electronics which converts the 4 GHz microwave frequencies down to a more manageable 70 MHz intermediate frequency (IF) and also where the individual video channels are separated from the block of 24 which have been amplified and rescued out of the noise by the antenna and LNA. The down converter consists of a voltage tuned oscillator (VTO), a mixer and an IF amplifier (see Fig. 1). The 4 GHz signals are fed into the RF port on the mixer, and the output of the VTO is fed into the local oscillator (LO) port of the mixer. The VTO generates a frequency which is varied between 3, 630 MHz to 4, 130 MHz; this frequency mixes with the incoming RF, which contains the 24 carriers between 3, 700 MHz to 4, 200 MHz. The resultant is a 70 MHz IF which is then amplified to make up for the conversion loss in the mixer. The 70 MHz IF contains the selected video and associated audio subcarrier information which is frequency modulated 18 MHz either side of the 70 MHz.

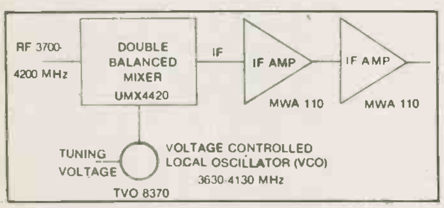



**Fig. 1. Functional diagram of the down converter.**

The process sounds complicated, but it is made very simple by three unique devices. The VCO, the mixer and the modular amplifier, until a few years ago, required extensive circuitry carefully designed with discrete components. It required considerable adjustments and tuning to set it up, was quite bulky and cost in the $1000 range. Now thanks to manufacturers like Avantek Inc., 317 Bowers Avenue, Santa Clara, CA, all the above problems are solved. Avantek manufactures a complete range of microwave VTO's, mixers and modular amplifiers which are housed in 4 pin TO8 and 3 pin TO39 transistor packages.

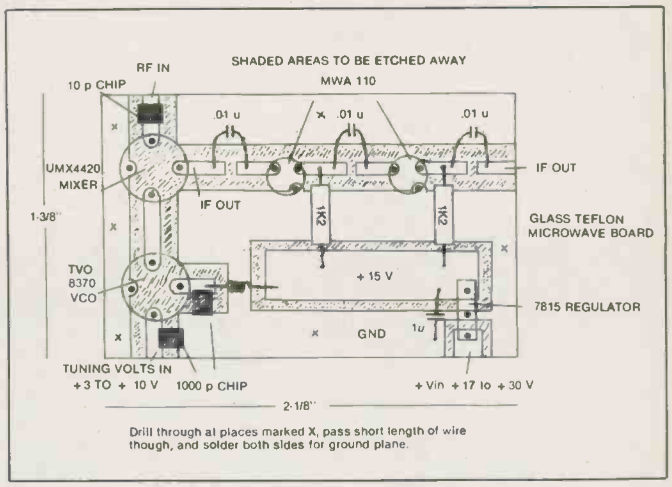



**Fig. 2. Printed circuit layout for the VCO and mixer.**

In the circuit described below I used Avantek's TVO 8370 and UMX 4420, VCO and mixer. The TVO 8370 is powered by + 15Vdc, the output power is + 10dBm (10 milliwatts) and the frequency is adjusted by changing the tuning voltage between approximately + 3 volts and + 10 volts. The matching mixer, UMX 4420, is optimized for the 3.7 — 4.2 GHz TVRO band, and as it is a passive device, requires no power. The MWA 110 type modular amplifier is a complete amplifier with a gain of 12-13dB over a frequency band of 0.1 to 400 MHz with a noise figure of 3.5 dB. The VCO and mixer are designed to mount on a microwave PC board and for the sake of simplicity, the MWA 110's are mounted on the same board, as shown in Fig. 2. The only other components required are the RF input socket, (which should match the LNA output socket, i.e., SMA or type N, depending where you mount your mixer), the IF output socket (BNC or type F), 1 x 3.3uH RF choke, 2 x 1200 ohm resistors, 2 x 1000pf chip capacitors, 1 x 10pf chip capacitor, 3 x .01uf disk ceramics, 1 x 1uF electrolytic and a 7815 15V regulator.

The board can be etched to the microstrip pattern shown. To avoid the trouble of getting a negative printed, I prepared the artwork using black plastic electrical tape cut to the required pattern to be etched and stuck to a piece of clear plastic film. This worked well and I used the same exposure and developing time as I did with the LNA board.

NOTE: The critical dimension of microstrip is the width of the track. For 50 ohm impedance on .03 glass teflon board, the strip should be approx. 2mm wide.

## Board Stuffing

In stuffing the board, again exercise caution against static discharge. The VCO and mixer both come with mounting hardware to ensure that the case are properly grounded to the ground plane on the back of the board, and they should be mounted with this in mind. Take particular care to make sure that the pins do not short to the ground plane. Use a small drill bit to clear the foil around the holes before inserting the pins from the ground plane side. It is important to ensure the MWA 110's are also firmly seated on the ground plane with the case making good contact; a small amount of solder on the tab can ensure good contact. The VCO output pin, and the mixer RF input & LO input pins, are conducting the 4 GHz microwave frequencies; therefore extra care must be taken to ensure that these solder joints to the microstrip track are neat, with a minimum of solder.

With all the components mounted as shown, except the 3.3 uH choke, apply + 17V to + 30V to the regulator input, and − VE. to ground; check that the regulator is providing + 15 volts. Measure the voltage drop across each of the 1200 ohm bias resistors; the voltage drop should be approximately 12 volts, indicating that the devices are drawing about 10mA each. When you are satisfied that the IF amplifiers are drawing the correct current, you are ready to connect the + 15V to the VCO. Remove the power and solder the 3.3 uH choke in place.

You are now ready to mount the mixer and down converter in its housing. The same considerations with respect to having a ground plane above the microstrip that were discussed in the section on the LNA also apply to the mixer, i.e., the box you house the mixer in should preferably be quite shallow with the lid appox. ¼" from the top of the board. Remember the VCO, mixer and amplifiers stick out on the underside of the board; therefore, spacers should be used to provide enough clearance from the bottom of the box to the board. See Fig. 3.

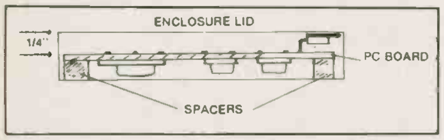



**Fig. 3. Side view of the down converter board.**

As mentioned earlier, the RF input conection should be type N or SMA, and the IF output can be BNC or type F; the latter connectors can also be used to feed the tuning voltage into the VCO. The power should be fed into the housing via a 1500pf feed-through capacitor, and the tuning voltage can be derived using a 1K ohm 10—turn potentiometer connected as shown. See Fig. 4.

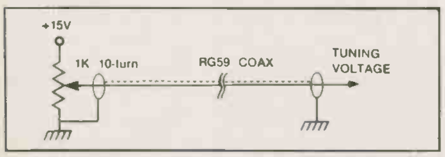



**Fig. 4. The VCO tuning voltage wiring.**

If you do some careful planning, the down converter can also be mounted at the feed assembly of the antenna, in which case you will have created your own LNC (low noise converter). With this arrangement, the cable running from the LNC to your receiver can be RG59U. This works well at 70MHz, and is reasonably inexpensive compared to RG214U which will be required to connect the LNA to a separate down converter mounted behind the disk in a suitable waterproof box. Of course, if your bank balance is overflowing, you can run expensive Andrew's LDF4-50 low loss coax all the way from the LNA to your receiver, and thus you will be able to keep the down converter in the warmth of your living room.

It is interesting to note that in my early attempts to get a signal into the house, I decided in desperation to prove to my son that 4 GHz would not go down a RG11U cable. I connected 150 feet of this 900 MHz cable between my rather unprofessional collection of antenna circuits and the receiver sitting on my TV set. Much to my chagrin and a chorus of "I told you so" from my son, I discovered that 4 GHz did indeed go down RG11U.

I never did get around to measuring the loss, but I'm sure it was quite high. At least it was a testimonial to the sensitivity of the down converter and receiver.

## Testing Your Down Converter

Now, as in the case of the LNA, unless you have access to some pretty sophisticated test gear, you will not be able to check out your down converter in terms of gain, loss and noise in dB, but as you are now looking at a 70MHz signal, you can determine if you have a output. Your common or garden variety TV set tuned to channel 4 (66-72MHz) is a selective receiver and should display something if you are picking up a signal from one of the satellites. The IF from your down converter is frequency modulated, and your TV is looking for an amplitude modulated video, so don't be disappointed if you don't get a picture and audio. You can get excited if you detect something which goes into noise when you move your antenna a few degrees off in azimuth, because that means you are receiving a signal which now requires you to get cracking and finish the complete receiver.

The IF signal coming from your converter is still quite low: let's take a look at our gains and losses so far. The signal entering the LNA was in the region of -91 dBm, the LNA provided 40 dB of gain, giving us -51 dBm at the input to the down converter, and the mixer introduces a loss of around 7 to 8 dB which is compensated for by approximately 20 dB of IF gain at the down converter output. This gives us a level of approximately -39 dBm. Now, allowing for a small loss in the IF cable from the down converter to the receiver, we will need approximatley 40 dB of IF gain. There are several ways of achieving this gain; surplus CATV amplifiers, surplus microwave receivers, using 3 to 4 more MWA 110's, or by building the circuit shown in California Eastern Labs, Santa Clara, CA USA application note AN82302. This is a 55-85 MHz, 75 ohm amplifier using two NE74114 Bipolar Microwave Transistors (Fig. 5).

The application note is quite comprehensive and gives all information necessary to build the 36 dB gain, 2dB noise figure amplifier. The design also includes a matched band pass filter at the input. If necessary an additional NE74114 stage can be added to give about 50 dB of IF gain. If you decide to achieve the required gain by some other method the band pass filter is still necessary in order to select the individual required carrier from its adjacent carriers. Now the next step is to build the FM demodulator to recover the video, and audio subcarrier.

## FM Demodulator

This part of the receiver circuit is where the video and its audio subcarriers are extracted from the IF. The conventional approach, making extensive use of discrete components, has now given way to IC's which have been developed for the television industry. The circuit shown in Fig. 6 makes use of two of these IC's, the MC1357 and the LM733. The MC1357 is a quadrature demodulator originally produced to extract the FM sound from the 4.5 MHz IF in television receivers, but which was found by several experimenters to work satisfactorily up to and beyond 70 MHz. Some equivalent IC's manufactured by other manufacturers do not perform well at 70 MHz and should be avoid-

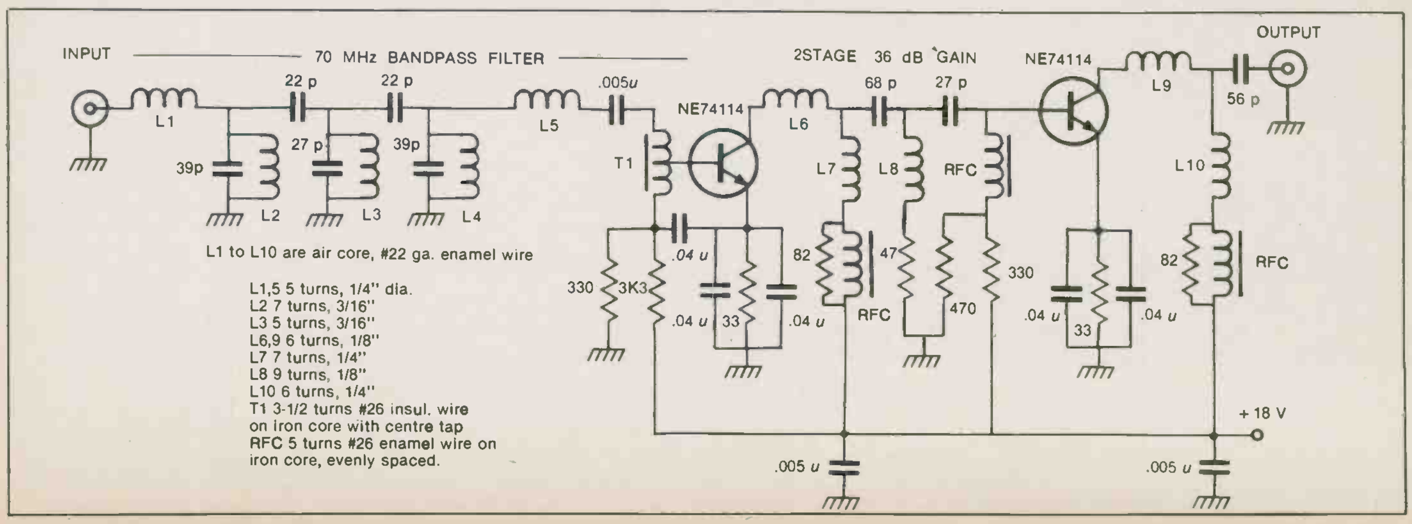



**Fig. 5. A 36 dB gain IF amplifier.**

ed. The LM733 is a two stage differential video amplifier which can provide adjustable voltage gains of up to 50 dB.

The 70 MHz IF is fed into the MC1357 demod chip where the internal discriminator is tuned to the 70 MHz ±15 MHz IF by adjusting trimmer capacitor CTI and inductor T1, which should be mounted as close as possible to pins 10 & 12 on the MC1357 chip for the best picture. The output of the MC1357 is video and associated audio subcarriers; the signals are split at the base input to VT1 and VT2. The video is amplified in VT1 and fed to the standard CCIR 525 line video de-emphasis network. This corrects the pre-emphasis slope which was applied prior to modulation back at the source of the up-link to the satellite. The next stage is the video LP filter to reject the audio subcarriers which are usually sitting at 6.2 and 6.8 MHz. The signal is then fed to the video amplifier chip LM733 which has provision for +VE or −VE output polarity depending on whether you use the upper or lower local oscillator frequency in your mixer. Pin 7 would be used in the normal application where the LO is on the low side, i.e., 3.63 to 4.13 GHz. The video output adjustment is made to achieve 1 V peak to peak at the output of the receiver, or the level necessary to drive your amplitude modulator which feeds the signal into your TV set. This will be discussed later. The video output from the LM733 is now almost ready to view on a video monitor, but requires one final treatment, and that is the clamp.

This part of the circuit is used to remove a 30 Hz oscillation which was applied before the signal was up-linked in order to disperse the energy waveform of the signal being transmitted from the satellite. This is because the 4 GHz band is shared by terrestrial microwave systems, and the 30 Hz oscillation of the whole signal ensures that the transmitted spectral density, even when high energy content static waveforms are present, will not cause interference with terrestrial systems. The removal of the 30 Hz oscillation is done with a high speed switching diode IN914, which is biased with a 6.2 V zener diode and a 2.2 K ohm resistor.

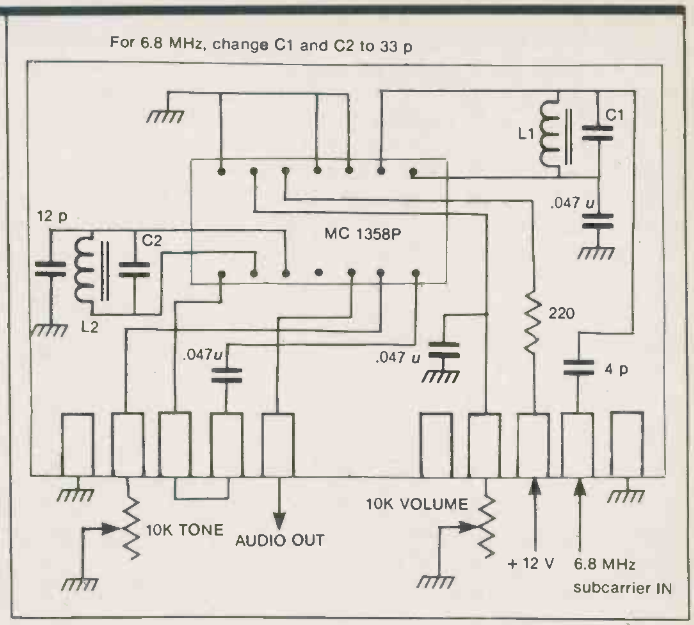



**Fig. 7. RCA XL100 (PM200) sound recovery board.**

## Sound Recovery

You now have raw video and will need to demodulate the audio from the 6.2 or 6.8 MHz subcarrier. I tried using several circuits, one of which worked reasonably well, using the CA3065 or MC1358 chips which are found in TV sound recovery circuits. The outboard circuits used with these chips required minor modification to change the 4.5 MHz TV FM sound carrier to the 6.2 & 6.8 MHz frequency for the satellite subcarrier. The sound recovery module from a RCA XL 100 (PM-200) TV receiver chassis retails for about $14, and with a few component changes as indicated, was made to work satisfactorily. The subcarrier frequency on broadcast receivers is 4.5 MHz, and the frequencies you are primarily interested in recovering are 6.2 and 6.8 MHz, so the input filter C1 & L1 and the tank circuit of the oscillator C2 & L2 have to be changed to accommodate the difference. See Fig. 7.

For 6.8 MHz the values of C1 & C2 should be changed to 33 p. The only problem with this arrangement is that there are minor differences in the sub-carrier frequency from transponder to transponder, and this requires constant retuning of the filter frequency. However, I found the simplest way to recover the audio was by building a simple crystal oscillator running at around 90 MHz and heterodyning the subcarriers up to the FM band at 88-108 MHz in a double balanced mixed I happened to have laying around. This allowed me to feed the signal into the antenna terminals of my FM stero system, and afforded complete tuning of all the subcarriers using the quality front end selectivity of the stereo system.

Fig. 8 shows a simple oscillator circuit which will give a stable crystal controlled output. Using this with an inexpensive double balanced mixer, such as mini circuits "SBL1", will give you an output FM signal which you can receive on a $15 Canadian Tire pocket FM radio, even if your spouse won't let you near the FM stereo.

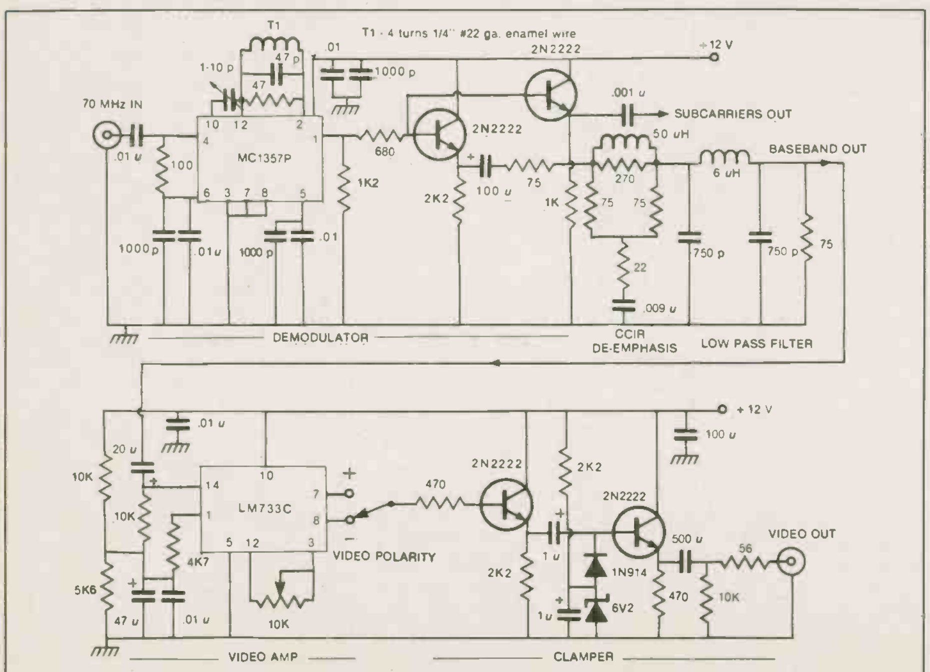



**Fig. 6. The receiver and video conditioning circuit.**

It's worth noting that when I started to look for the circuit for a 90 MHz oscillator, I dusted off some piles of old manuscripts and found a copy of "More Circuits" from ETI; lo and behold, on page 93 I found the circuit shown. (We regret that this title is sold out — Ed.) In fact some of you faithful ETI readers may have already built this oscillator. By using a crystal between 27.5 and 33 MHz the 3rd Harmonic will deliver between 82.5 and 99 MHz; this, when mixed with 6.2 & 6.8 MHz, will deliver your FM subcarrier between 88.7 and 107.8 MHz. Your stereo system does the rest.

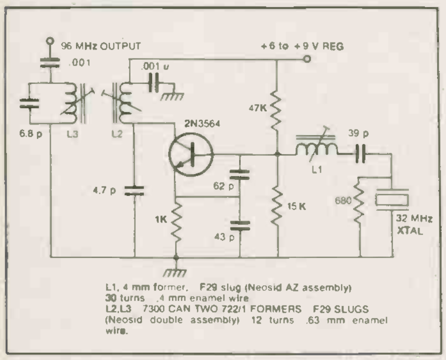



**Fig. 8. 96 MHz crystal oscillator.**

A 32 MHz crystal which fits the requirement is available from Jameco, a U.S. supplier. The capacitor values will be slightly different from the table given in "More Circuits", depending on your choice of transistor. Once you have recovered the audio, the one remaining task is to get the video into your TV set. There are several kits available to do this: one is sold by Radio Shack for around $20, and many other complete modulators are now in use with home computers and VCR's. If, however, your creative genius is still bubbling over, there is a one-chip modulator which requires some outboard circuitry and a suitable shielded box for the RF circuitry. The chip is a MC1374 manufactured by Motorola, and the circuit in Fig. 9 shows the outboard circuitry required to make it work. There are several other TV modulator IC's which can also be used: the LM1889 from National Semiconductor, and the M1373 from Motorola are but a few. Every video game and home computer is likely to host one. There are also several pre-packaged units manufactured from discrete components; one such manufacturer is Astec.

Well, now you are ready to read the whole article again and make that monumental decision whether or not to start your project.

## Look Angles

In order to help you make the decision to start your project, you need to know if you can see the satellites from your back yard. This is particularly important if you

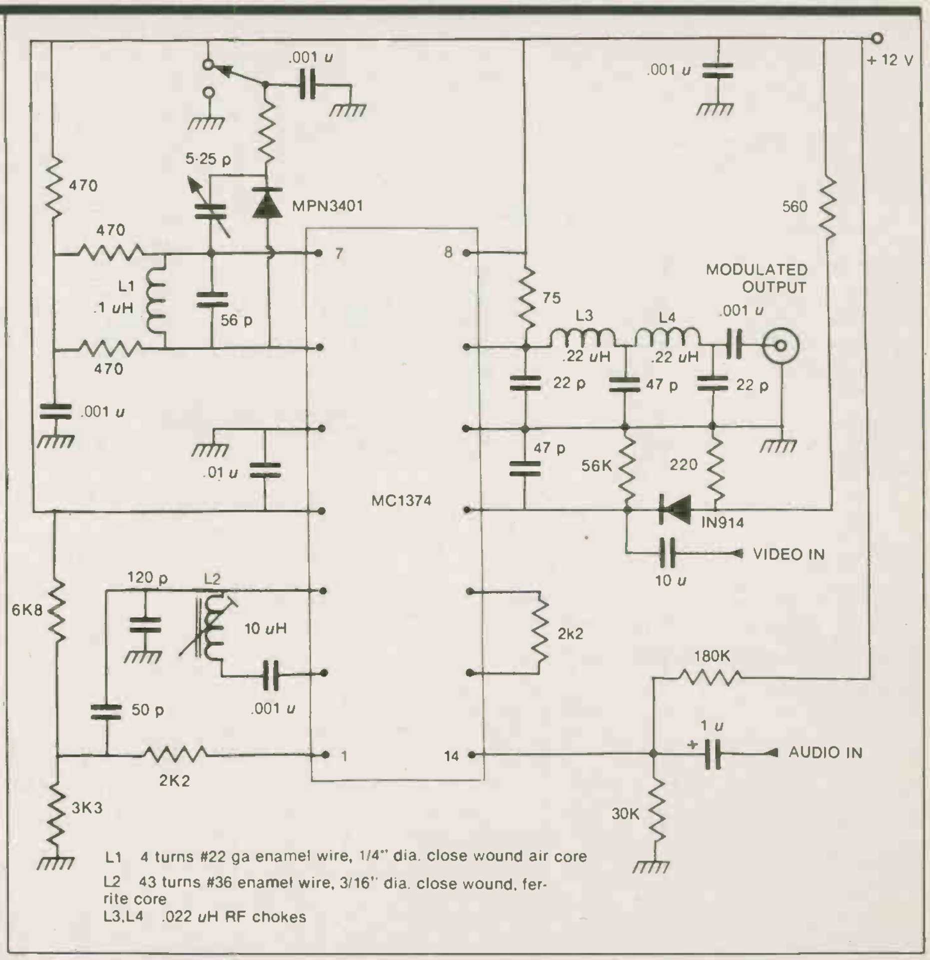



**Fig. 9. A TV modulator using a Motorola MC1374.**

live in the East; as mentioned earlier, some of the satellites are almost on the horizon.

The look angles can be calculated by using the following formula. The latitutde, longitude and magnetic variation for your particular site can be found on the appropriate Energy, Mines, and Resources Survey Map for your area. Don't forget to correct for the magnetic variation for the current year, based on the annual change and the date of the map.

$$E = \tan^{-1}\frac{(\cos G \cos L - (A/(D+R)))}{(1 - \cos^2 G \cos^2 L)}$$

Where:
L = site latitude
G = satellite latitude — site latitude
R = radius of the earth (6370 km)
D = sat. height above equator (35,800 km)
E = antenna elevation

$$H = \tan^{-1}(\tan G/\sin L) + V + 1$$

Where:
H = compass heading
V = magnetic variation, degrees W of N

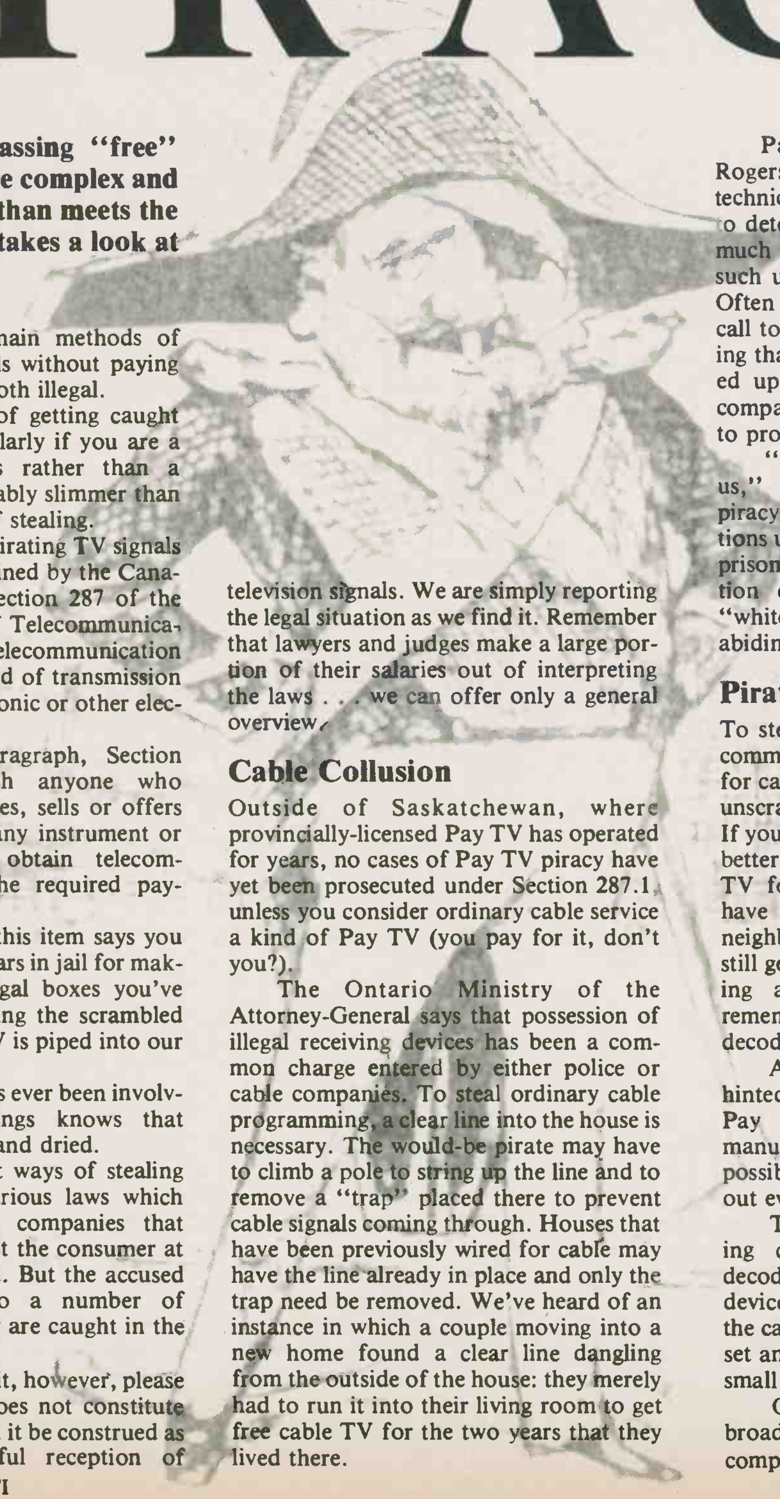
## Parts

Parts availability can be a problem, particularly for the microwave frequency section of your project. I have gone the labourious route of writing to manufacturers and finding that many of them quote prices for carload quantities and have minimum value orders. The final crunch, when you decide to go out on a limb and buy more than you need, is the realization that the Government of Canada wants its pound of flesh and you get zapped for Duty and Taxes. The final irony is that the duty and taxes are calculated on the Canadian value of the U.S. dollar, which today is more than $1.20. The net result is that the cost of the components is in the region of 1.5 times the U.S. dollar figure. I have attempted to acquire many of the obscure parts such as GaAsFets, microwave bipolars, chip capacitors, microwave PC boards and connectors in quantity, and will be pleased to share my booty at reasonable costs. For more information, please send a stamped, self addressed envelope to R.D.C. Coles, RR#2 Tantallon, Halifax County, N.S., B0J 3J0.

**The author would like to acknowledge his debt to various journalists and electronics pioneers for their contributions to the TVRO hobby: Steve Birkill, Robert Cooper, Oliver Swan, Taylor Howard, Bob Coleman, and Norm Gillaspie.**

# Pay T.V.

# PIRACY



**The issues encompassing "free" Pay TV reception are complex and involve much more than meets the eye. Eric McMillan takes a look at the situation.**

THERE ARE TWO main methods of receiving Pay TV signals without paying for them, and they're both illegal.

But your chances of getting caught and prosecuted, particularly if you are a user of illegal devices rather than a manufacturer, are probably slimmer than for many other kinds of stealing.

Bear in mind that pirating TV signals is indeed stealing as defined by the Canadian Criminal Code. Section 287 of the code is titled "Theft of Telecommunication Service" and telecommunication refers to almost any kind of transmission by "radio, visual, electronic or other electromagnetic system."

The following paragraph, Section 287.1 (1), deals with anyone who "manufactures, possesses, sells or offers for sale or distributes any instrument or device" designed to obtain telecommunications without the required payment.

Pared of legalese, this item says you can receive up to two years in jail for making or using those illegal boxes you've heard about for decoding the scrambled signals by which Pay TV is piped into our homes.

But anyone who has ever been involved in court proceedings knows that nothing is quite so cut and dried.

There are different ways of stealing Pay TV. There are various laws which may be used by the companies that transmit Pay TV against the consumer at the illegal receiving end. But the accused also have recourse to a number of defences, provided they are caught in the first place.

Before getting into it, however, please note that this article does not constitute legal advice. Nor should it be construed as promoting the unlawful reception of television signals. We are simply reporting the legal situation as we find it. Remember that lawyers and judges make a large portion of their salaries out of interpreting the laws . . . we can offer only a general overview.

## Cable Collusion

Outside of Saskatchewan, where provincially-licensed Pay TV has operated for years, no cases of Pay TV piracy have yet been prosecuted under Section 287.1, unless you consider ordinary cable service a kind of Pay TV (you pay for it, don't you?).

The Ontario Ministry of the Attorney-General says that possession of illegal receiving devices has been a common charge entered by either police or cable companies. To steal ordinary cable programming, a clear line into the house is necessary. The would-be pirate may have to climb a pole to string up the line and to remove a "trap" placed there to prevent cable signals coming through. Houses that have been previously wired for cable may have the line already in place and only the trap need be removed. We've heard of an instance in which a couple moving into a new home found a clear line dangling from the outside of the house: they merely had to run it into their living room to get free cable TV for the two years that they lived there.

Paul Temple, manager of Pay TV for Rogers Cablesystems, told us it is technically possible for cable companies to detect illegal users from their end but much of the time the companies learn of such use from neighbours or repairmen. Often a family member will place a service call to fix faulty reception without realising that another family member had rigged up cable without going through the company. The companies do not hesitate to prosecute.

"We can't allow people to steal from us," says Temple, who compares TV piracy to shoplifting. Successful prosecutions usually result in fines rather than imprisonment, perhaps reflecting the perception of telecommunication theft as a "white collar" crime that otherwise law-abiding folks indulge in.

## Pirate Pays the Piper

To steal Pay TV signals, using the most common method, you need the clear line for cable reception as well as a decoder to unscramble the signals for Pay channels. If you already have cable, you may have a better chance to get away with taking Pay TV for free. For one thing, you don't have to expose yourself to curious neighbours by climbing a pole. You can still get service calls for cable without giving away your secret, provided you remember to disconnect and hide the decoder before the repairman arrives.

Although cable companies have hinted they can tell who's receiving the Pay signals for free, illicit decoder manufacturers are skeptical. Even if it is possible, they say, the expense of checking out every home would be prohibitive.

The threat that the Pay TV scrambling could be changed to make the decoders obsolete makes sellers of the devices scoff. The trouble and expense to the cable companies would more than offset any advantage gained by disabling the small percentage of illegal boxes.

One Toronto lawyer who deals in broadcasting matters expects the cable companies to attempt to prosecute a few individuals as examples to warn other consumers against Pay TV piracy. He sees a potential problem in proving theft because theft ordinarily involves depriving someone of something, whereas theft of telecommunications does not take anything away from anyone else . . . except the potential fee from the cable company.

The phrasing of the Criminal Code, however, does not make depriving another person of the service a necessary condition. It simply refers to the obtaining of telecommunications without paying the lawful charge as a form of fraud. A good lawyer could argue the point.

Another possible defence for the person caught with an illegal decoder in the house is to argue that it was used for purposes other than de-scrambling Pay signals, but the Saskatchewan case has shown that the prosecution does not have to prove the decoder was being used. The fact that it was hooked up was enough for a conviction.

The Criminal Code specifies that the mere possession of a device whose design renders it "primarily useful" for obtaining signals "under circumstances that give rise to a reasonable inference that the device has been used or is or was intended to be used" to fraudulently obtain such signals is an indictable offence.

Obviously, you are not going to get far with the explanation that you paid a hundred dollars for a decoder, attached it to your television and to the cable . . . but, really, your honour, you never thought of using it. If the decoder was found on your workbench with other electronic parts, you might be able to claim it was just another project that you didn't intend to use. With anything in between these two examples, you take your chances.

As Temple of Rogers Cablesystems notes: "Obviously it's better to go after the manufacturers of these devices. This is pretty easy since he has to go public to sell any."

The law expressly deals with manufacturers, sellers and distributors in addition to possessors of such instruments. The backroom decoder factories have received enough media coverage to allow anyone who's interested to find them in a matter of minutes. Yet, as of press time, no charges have been laid. The Ontario Attorney-General's office says that there is concern but no cases have been brought to its attention by police, although local crown attorneys may be considering action. So far, the cable operators have been too busy promoting Pay TV to press charges.

## Fee Or Free TV?

In addition to the Criminal Code, other bodies of law may be employed against Pay TV piracy. The Radio Act, for example, deals with the standards that electronic equipment must meet and it provides penalties for danger or interference caused by such devices.

The Copyright Act may also come into play. Whenever an audio-video production is sold to or played for the public, the creators receive renumeration. Authors, songwriters, actors and other artists often make their living off of these royalties. If you tape a production off the air and sell it (or even give it away) without permission of the copyright holder, you are violating copyright.

But what if you don't tape it? Theoretically, if you invite your friends over to watch a movie on Pay TV which you receive illegally, a case could be made against you that you are infringing copyright by distributing the presentation without compensating the cable company which compensates the Pay TV company which in turn compensates the producers.

Practically, however, the case is too tenuous and the fines too low to make it advantageous for the companies to prosecute unless you are doing it on a regular basis and charging admission or distributing it to a large number of people, say, through closed circuit TV in a hotel or condominium.

The same would apply to people who use the second, less common method of accessing Pay TV.

## Dishing It Out

Instead of decoding cable signals in the privacy of their livingrooms, some people erect satellite reception dishes or antennae and snatch the Pay signals out of the air before they even get to the cable companies for local distribution.

A great deal of misconception has surrounded the Canadian government's new broadcasting stategy which does away with the requirement to license TVROs (TV Receive-Only earth statons) for individual use.

Many people have understood this to mean that they are free to access any services they desire with a TVRO. They are correct only as far as that goes . . . the government has NOT exempted anyone from having to pay the company which produces the services. Under "Limits to Exemption" the document says, "It should be noted that, despite these exemptions, operators of earth stations may still require permission to receive satellite programming signals from their originators."

That is to say, you can set up a dish but the usual relation between the seller and buyer of TV programming still applies.

Although a number of questions remain to be answered regarding the government's broadcasting strategy, it appears that acquiring Pay TV with a TVRO without paying for the service could still constitute theft of telecommunications under the Criminal Code and the distribution of the service through a community (or housing complex) could infringe upon copyright.

An advantage of going this route for the pirate is that he cannot be charged with possessing (or making, selling, or distributing) an illegal device, as he could with the secret decoder. One disadvantage is that he can't very easily hide a TVRO on his roof or among the zucchini in the backyard. The cable company will know he has one. Some signal distributors in the U.S. have resorted to hiring teenagers to look for such antennae. When confronted with the evidence, a large proportion of pirates have consented to becoming regular Pay subscribers. The rest have become potential targets for court action in which the companies try to prove the dish was picking up Pay TV.

The Pay channels may take another approach that they've been threatening to use in the US. They may scramble the signals bounced off satellites. The local cable distributors would decode it and then send it out to subscribers as they do now (with their own scrambling).

Of course, the response from pirates would be to install devices on their TVROs for unscrambling the satellite signals. It's a cat and mouse game that could go on indefinitely. However, in Canada at least, this would bring the offence more fully under the Criminal Code.

Receiving dishes may be acceptable under the present broadcasting strategy, but no one has yet pronounced a verdict on decoders. Such decoders, like the ones for livingroom use, would be "primarily useful" only for picking up unauthorised signals, as mentioned in the Criminal Code.

The fight goes on between the transmitters and originators of telecommunications and people who don't consider themselves "pirates," "thieves," or "shoplifters" who feel they should be allowed to receive television programming without any costs beyond the price of equipment.

The Criminal Code, the Copyright Act and other statutes were drawn up before Pay TV, video recording, cable programming and satellite transmission began to really change the way we receive images on the tube. With Canadian law based somewhat on the British system of precedents, much will depend on how the first batch of cases regarding Pay TV piracy are decided.

Cases are already underway in Canada, but the verdicts have not been returned.

Fee TV isn't about to see itself transformed into Free TV without a fight.

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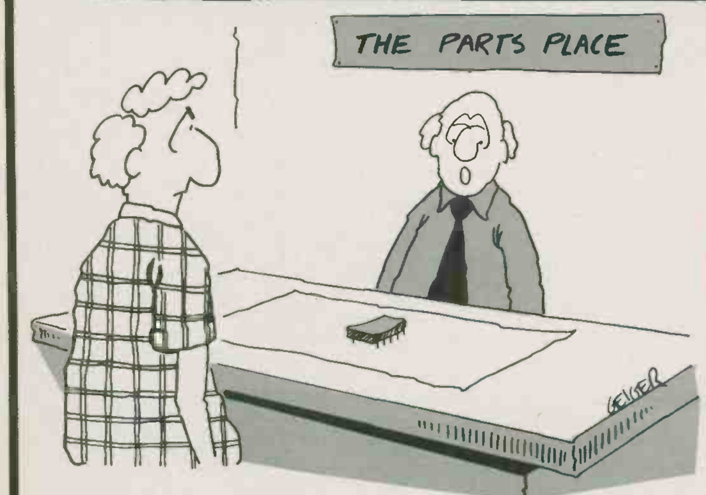
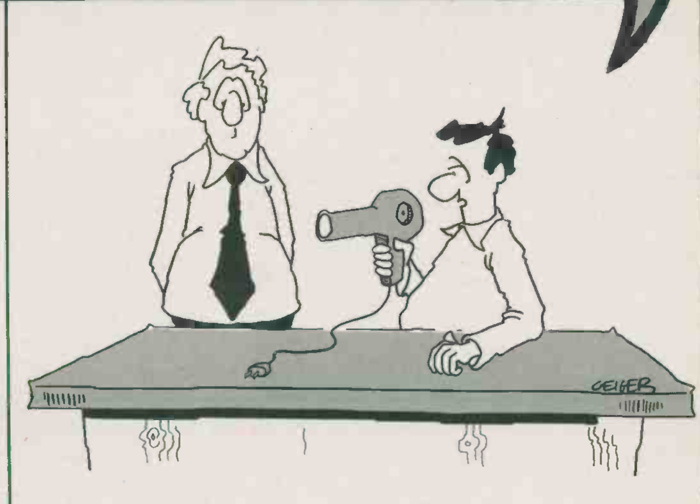
# The Fun of Electronics




"I know it doesn't work, but I can't give you your money back. If you read the data sheet closely, you'll find it's not supposed to work."




"I'm have trouble getting CSA approval for my new microwave hairdryer."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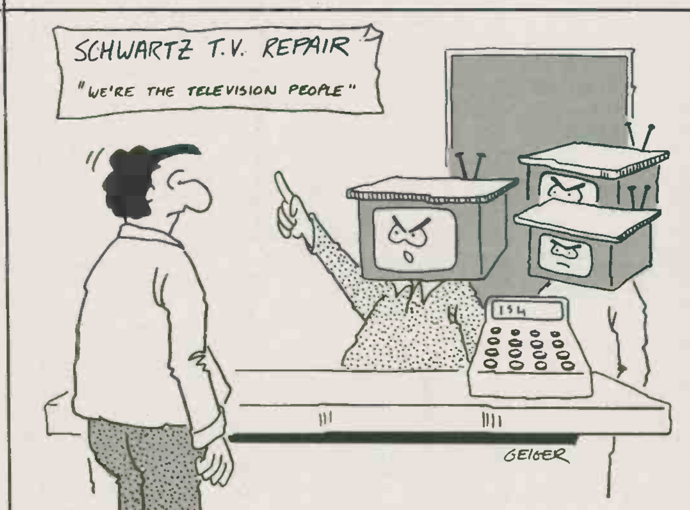
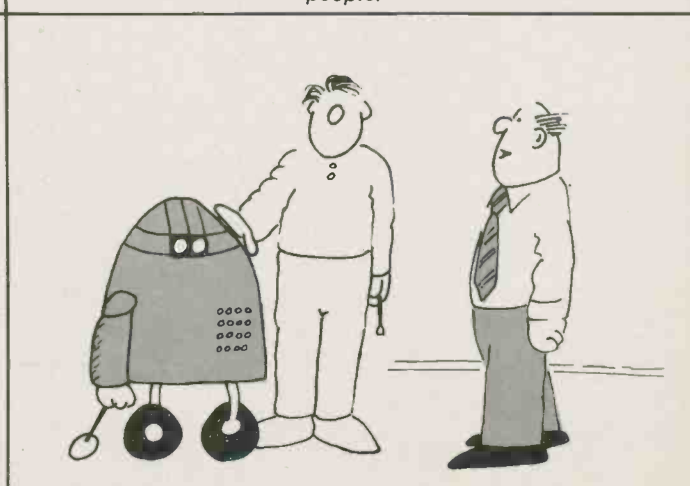



"We want you to take that sign down. **We're** the television people."


"A shift register is one which works nine to five."



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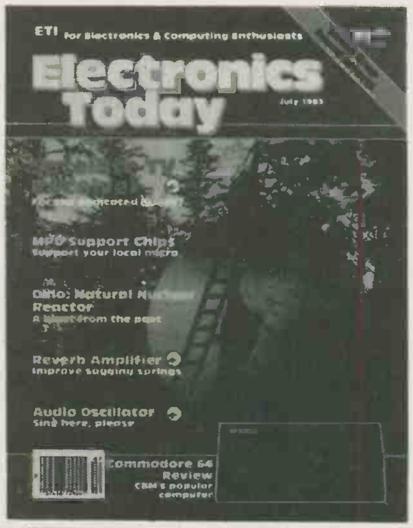


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# Into Digital Part 12

**In the last part of the series, Ian Sinclair provides a brief introduction to microprocessors and how they use the techniques shown so far.**

**Figure 1. Sequence of operations for an 8-bit AND. A similar sequence would be used for any other 8-bit logical operation.**

| |
|---|
| 1. INSTRUCTION: Read a set of data bits |
| 2. DATA (8 bits = 1 byte) IN |
| 3. INSTRUCTION: AND this byte with the next set |
| 4. DATA (second byte) IN |
| 5. INSTRUCTION: STORE — send the result out |
| 6. DATA (byte sent out) OUT |

LET'S LOOK in detail at what has to be done to AND two lots of eight bits. First of all we need to store the first set of eight bits, the first byte of the mouthful, in a register. There has to be an instruction for this, which will open the correct gates within the microprocessor to transfer our first byte into a register (see Fig. 1) For this operation, the register will usually be the main working register of the microprocessor and is called the accumulator. One instruction byte will therefore prepare the path from the eight data pins to the accumulator, and the next byte will be our first set of eight bits which are to be ANDed. Having loaded them in, we now need to tell the microprocessor what it has to do next. The next byte is therefore another instruction which calls on the microprocessor to AND the bits in the accumulator register with the next set of bits which will be fed in, and to store the result in the accumulator. Quite a mouthful that, so we abbreviated it to AND-immediate.

Following that instruction, the microprocessor expects to find the next set of bits we want to AND with the first lot.

The last operation is to deliver the results, so another instruction has to be sent to the microprocessor calling on it to connect the accumulator to the eight pins which we used to enter each byte, and so transfer the resulting byte out again. At the end of this instruction, the byte appears on the eight pins (the data pins) and the process is completed. The total score is three instructions in, two bytes of data (the bytes we wanted to AND) input, and one byte (the result) output: a total of six steps.

Now, for ANDing two bytes of bits together, you might think that six steps of microprocessor action is a pretty poor exchange for just having a couple of AND chips working on two lots of eight bits. You would be quite correct, it is a pretty poor exchange, and if you only ever had to AND two bytes together you'd be a mug to go to all the expense and bother of setting up a microprocessor to do it.

Where the microprocessor starts to score is in applications which need more than just a couple of bytes ANDed together. A lot of machine-control units would need several boards full of ICs just to carry out one of the operations which they do. Because the microprocessor operates on instructions, you can add more tasks just by adding more instructions. In addition, you can change the instructions without having to change the microprocessor. If you have a digitally-controlled machine which turns out one part, and the controller uses separate gates, then to make it turn out a new part means swapping boards around. That's what's called a hardware exercise. If the same machine were microrprocessor-controlled then only the instructions would need to be changed, and that can be a whole lot simpler.

## Once Upon A Time . . .

You'll have started to suspect that this microprocessor caper probably calls for close timing, a bit of the old strict tempo.

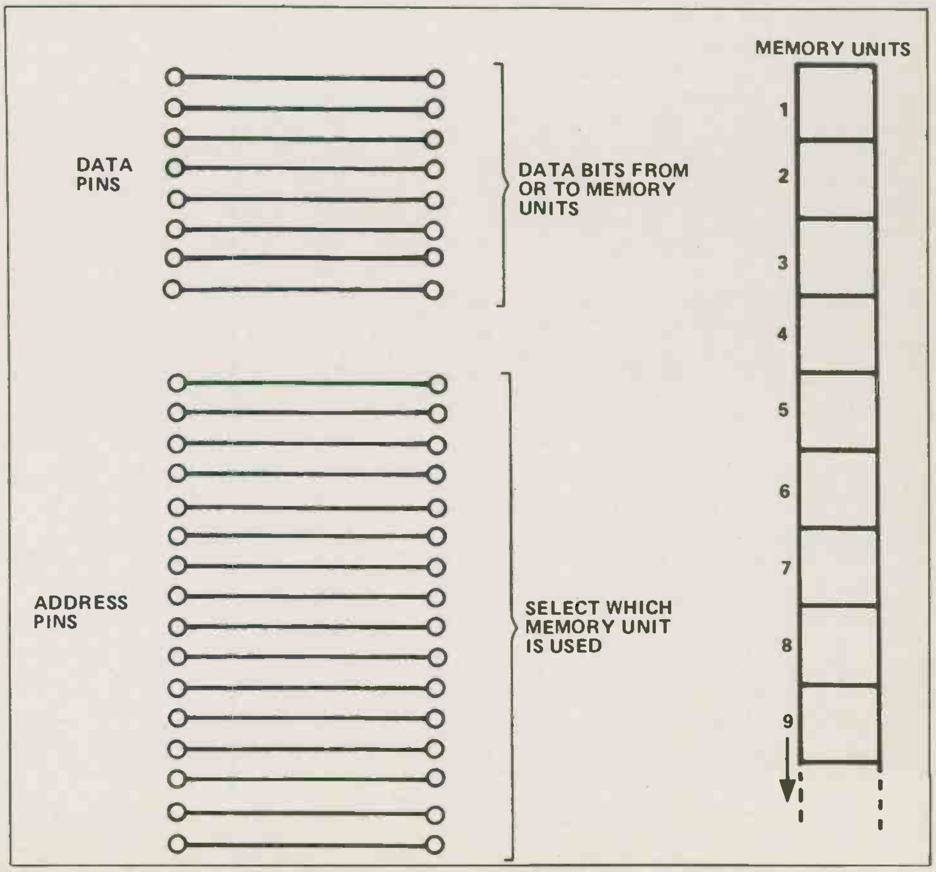


**Figure 2. Using memory to ensure that instructions and data follow each other in the correct sequence. It is impossible to tell without knowing the sequence whether a byte is an instruction or data.**

How right you are! Each stage of microprocessor action is started by a clock pulse, and the clock pulse generator is usually a crystal-controlled oscillator working at 1 MHz or more, so that the instructions are carried out pretty quickly. Now that speed, gratifying though it is, leads to further complications. Remember what the sequence of events was? First of all came the instruction (load) which set up the accumulator to receive the first data byte, then the data, another instruction (AND-immediate), more data, the output instruction and data out. If the clocking rate is as high as a 1 MHz oscillator suggests, how do we make sure that we are feeding the correct byte on the pins at the correct time? Whether we are feeding in an instruction or a piece of data, it's just one byte at a time, and so the sequence just has to be right. How is it all synchronised?

Memory is the answer to the problem. Memory is not something mysterious and new, it's just a word for a set of registers. As far as most microprocessor circuits are concerned, a memory will consist of a set of 8-bit registers, with gates to ensure that only one set of eight bits is connected to the data lines at one given time. The gating system is called addressing, so that when we talk of addressing memory what we mean is passing signals to gates so that one particular register is connected and eight bits can be stored in it or copied from it (see Fig. 2).

In the early days, addressing was rather primitive and a lot of memories used a sequence principle, so that the first byte stored in was the first byte out, and the rest followed in sequence. We still use this idea for cassette-tape storage — you start at the beginning of the tape and you record or replay until you are finished. For a lot of purposes, though, it can be very much more useful if you can pick a byte out of any part of memory without having to go through all the bytes which were placed there earlier. This idea is called 'random access,' and all the IC chip memories that we use nowadays have random access.

It's addressing which makes this random access possible. If you make your gates so that each binary number placed on a set of inputs — the address inputs — will connect a different register on to a set of data lines, then you have the random access you need, because you don't need to go through the binary numbers in sequence. The old memory system which didn't use address lines (one byte was connected in or out at each clock pulse) is never used these days.

## Getting It All Together

Now we can start to see how the microprocessor can carry out its instructions. To start with, all the signals which it's going to need will be stored in memory chips. Taking our example of the ANDing of two bytes, we would need all six bytes stored in memory. The simplest way to do this would be to store them in the same order as they are used, with the 'load first byte' instruction first and the 'store answer' byte last. All we need then is some method of arranging that a byte is connected to the data lines of the microprocessor at each clock pulse, and this is done by 'address lines' from the microprocessor. The address lines come out on pins, usually sixteen of them, which can be connected inside the microprocessor to various counting registers. Their job is to signal to memory which memory byte is wanted.

Sixteen lines allow us to use binary numbers of up to 16 digits, which in familiar terms means a range of 0 to 65,536. Being able to select up to 65,536 different bytes sounds good, and most microprocessor systems need a lot less, but it's worth remembering that large computers need a lot more memory, which is why microprocessor chips with 24 or even 32 address lines are being developed.

For our ANDing, then, we could arrange things so that the first instruction was connected to the data lines of the microprocessor when the address was 1. (You don't want me to write out fifteen 0s and a 1, do you? I'll stick to ordinary scale-of-ten if you don't mind!) This address is obtained by a counting register inside the microprocessor whose name is, appropriately enough, program counter. At each clock pulse, the program counter simply advances by one digit unless we instruct it otherwise. When the 'load a byte' instruction has been digested, therefore, the next clock pulse will advance the program counter to 2, and this has to be the memory address for the first of the two bytes we want to AND. At the count of three, the byte which is stored is the AND-immediate instruction, and address number four brings in the second byte to be ANDed. At step 5 another instruction comes in — an instruction which has quite a different effect, because it commands the microprocessor to send a byte out on the next clock pulse. Clock pulse number 6, then causes a byte to be stored — in this example in memory location number 6.

How do the registers tell the difference between sending a byte from memory to microprocessor (reading) and sending a byte from microprocessor to memory (writing)? Easy, there's a pin which carries a read/write signal. The signal from this pin is normally logic 1, so that the microprocessor reads from whichever part of memory has been activated by the address signals. When the WRITE instruction is received the next clock pulse puts the read/write pin to logic 0, and holds it like that until another clock pulse restores it. That way, a similar pin on each memory chip can be held low to ensure that the gates inside the memory chips are arranged to receive a signal (at the register inputs) rather than send one out (from the register outputs).

Yes, of course there's a lot more to it, but this outline should dispel some of the mystery and explain some of the new words which fly around the microprocessor business. The important point is that once you have swallowed the ideas of digital electronics, microprocessors are just one more byte!

Next month, we begin a new series, Designing Micro Systems, and in the first part, examine the basic architecture of CPU's.

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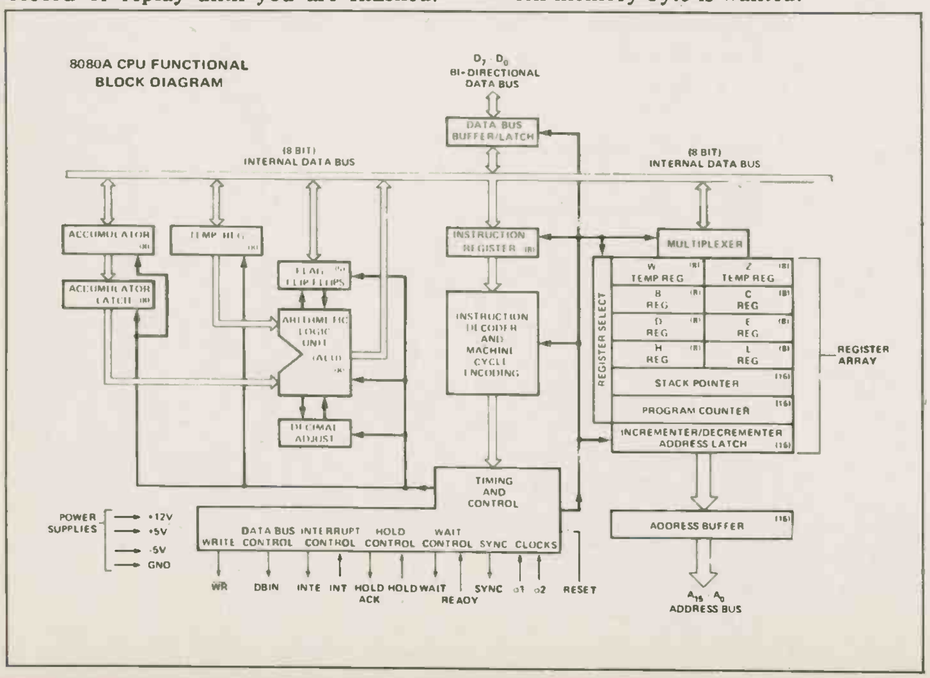


Figure 3. The functional layout of the 8080 Central Processing Unit.

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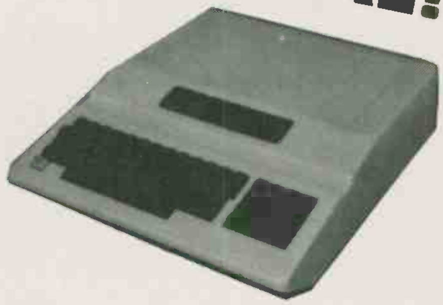

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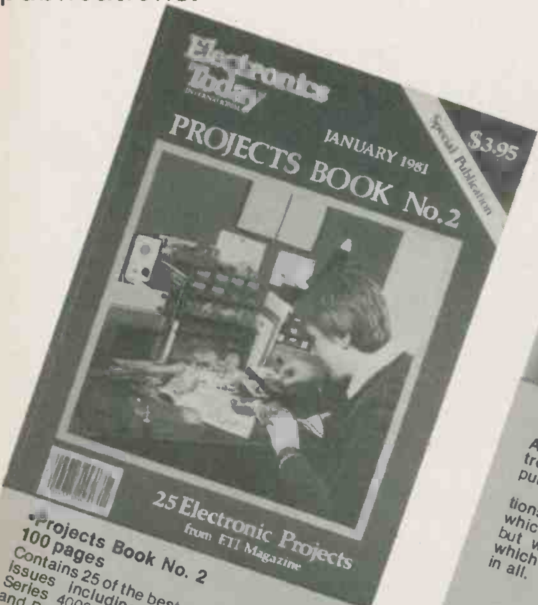


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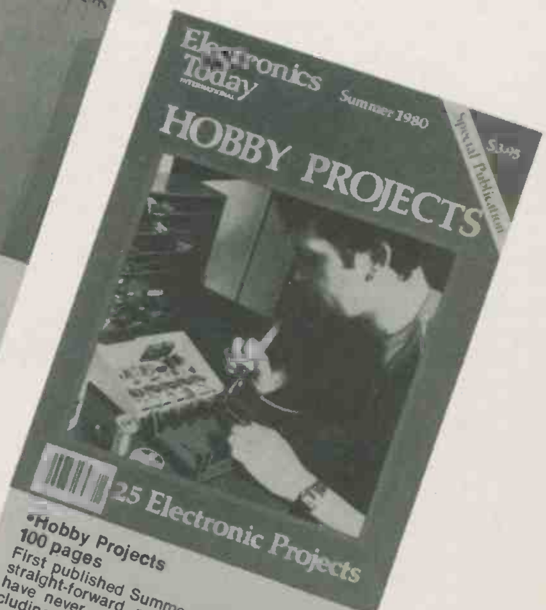


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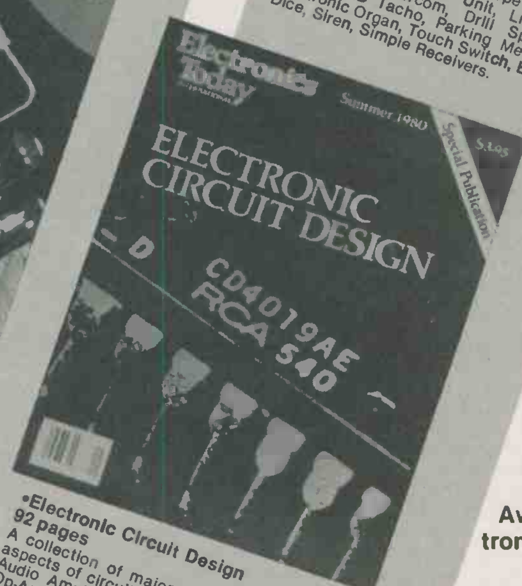


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# TECH TIPS

**Car Radio Latch**
A. Miller

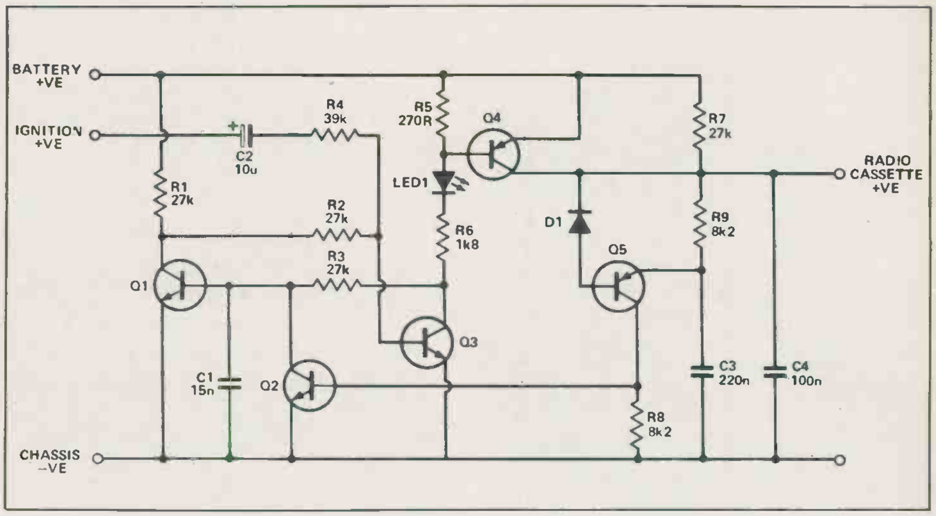
When fitting a car radio or cassette player into a car, one problem is deciding which side of the ignition to connect the supply lead. If it's connected to the ignition side, the keys must be in to use the radio, a potential hazard if children are left listening. On the other hand, if it's connected to the battery side you have to remember to turn off the radio every time you leave the car.

The answer is simple — you connect to both using the circuit shown here. Normally the radio is left switched on and it will go on and off with the ignition. But if the ignition is off, switching the radio off and then on again also turns the radio on.

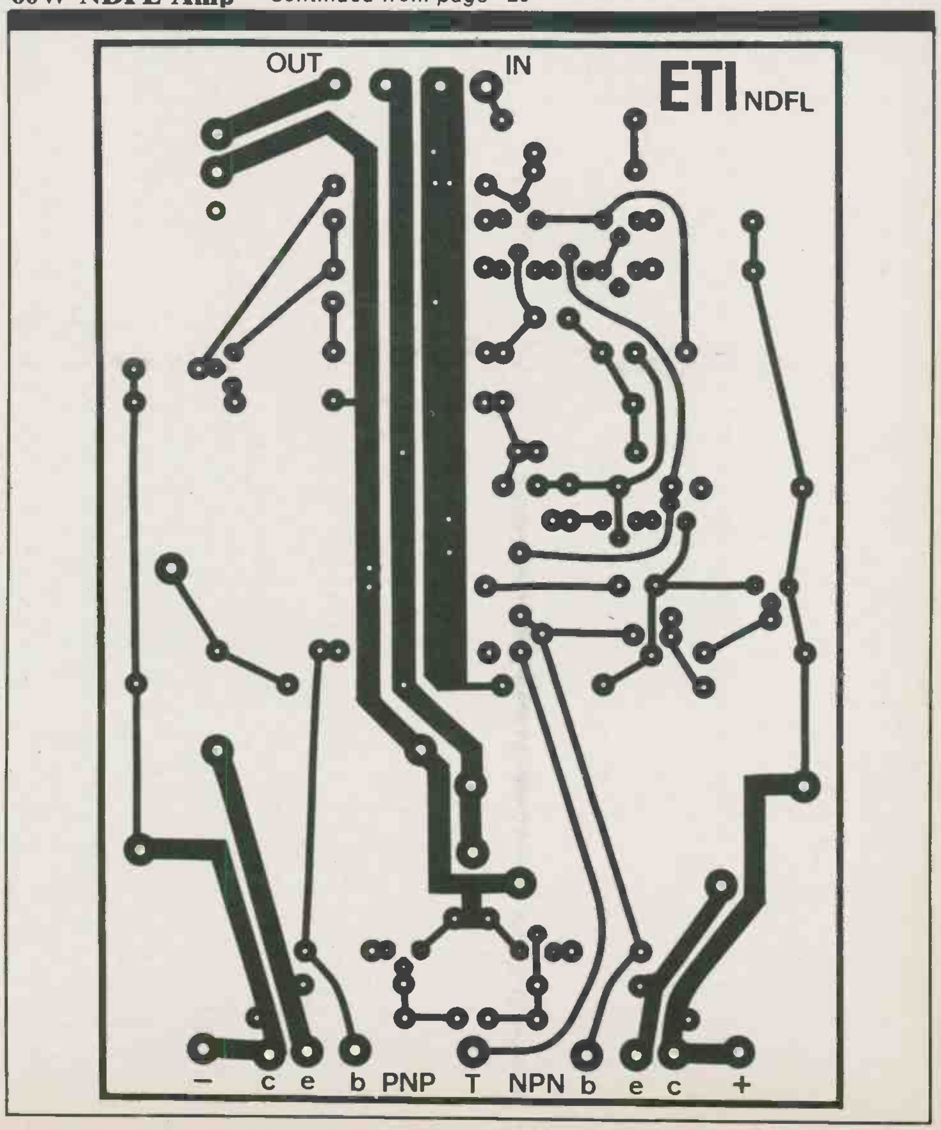
The circuit consists of a latch using Q1 and Q3, which controls a driver stage Q4. The LED indicates the state of the latch and is optional, but it doesn't consume any extra power since without it, the power would only be dissipated in R6. C2 serves to trigger the latch on and off with the ignition, and R4 prevents false triggering during starting. If the radio goes off after starting, R4 should be increased, and if the radio fails to go on and off with the ignition, R4 should be reduced.

When the latch is in the 'off' state, a small current passes through R7 to the radio. While the radio is on, C3 and C4 will remain discharged, but if the radio is off, C3 and C4 charge to the full battery voltage. If the radio is switched on, C4 rapidly discharges through the radio leaving C3 to discharge via Q5 and D1 and produce a current in R8. This turns on Q2, triggering the latch to supply power to the radio. C1 ensures reliable triggering.

Q1,2,3 and 5 are all general-purpose transistors, such as the 2N3904 type, and Q4 is a power Darlington with at least 2 A rated collector current. No heatsink should be necessary for Q4, as it is always either off or in saturation. D1 is a general-purpose diode such as the 1N4148. R4 is the only component with a critical value and may need adjusting as mentioned earlier. All the component values are those used in the prototype and any similar values should work. The quiescent power consumption is either 2 mA or 10 mA depending on the state of the latch, but if the vehicle is to be left standing for longer than two weeks, the unit (or the battery) should be disconnected.




**60W NDFL Amp** *Continued from page 20*



## Scope Bargraph Unit

Graeme Durant

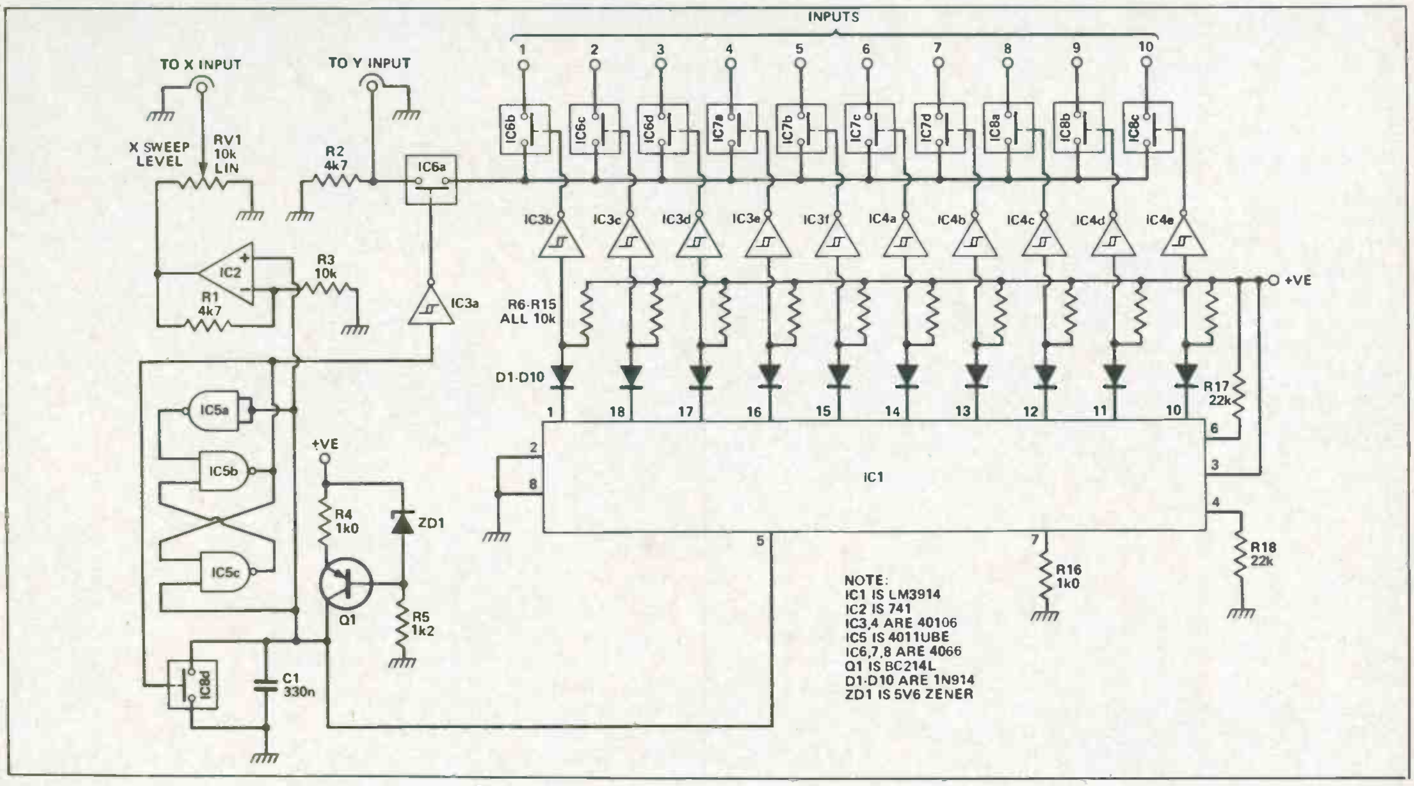
This circuit is designed to be used in conjunction with any ordinary oscilloscope which has an X-deflection input, and allows it to be used as a bargraph display. The screen has 10 useable columns.

The heart of the circuit is IC1, and LM3914 bargraph driver. The input to this, pin 5, is connected to a sawtooth generator running at about 1 kHz, formed around Q1. Q1 is a constant current generator supplying 5 mA and charging a 330nF capacitor to create a linear sweep. As the voltage on this capacitor reaches the upper CMOS threshold, about two-thirds supply, a latch formed by IC5b and c is triggered by IC5a. This rapidly discharges the capacitor through IC8d. When the voltage has dropped to the lower CMOS level, about one-third supply, the latch is reset and the capacitor starts to charge up again. Thus a linear sawtooth waveform is produced.

This is buffered by IC2 and fed out to drive the X amplifier in the scope. However, as this sweep also drives a bargraph IC which has its upper and lower limits set to be similar to the two CMOS switching levels, the 10 outputs go low, one at a time, in sequence. These outputs are used to drive a multiplexing system: a set of 10 analogue switches (IC6b to IC8c). These are driven via inverting Schmitt triggers, diodes and pull-up resistors due to the limited drive capability of IC1 at logic 1.

The multiplexed output is sent to the scope's Y input via another analogue switch, which is normally on, but cut off while the sweep capacitor discharges so as to blank out the 'flyback'. Alternatively, the 'Z modulation' input of the scope could be used if one is available.

In use, the internal sweep generator in the scope is turned off and the circuit is connected. It is recommended that a regulated supply of 15 V is used so as to provide adequate X output drive. The X sweep level is adjusted until a suitable width of display is produced (this being a horizontal line at the present), which should be moved to the bottom of the screen. Now the inputs to the scope may be connected and the Y sensitivity of the scope adjusted to give a good display.



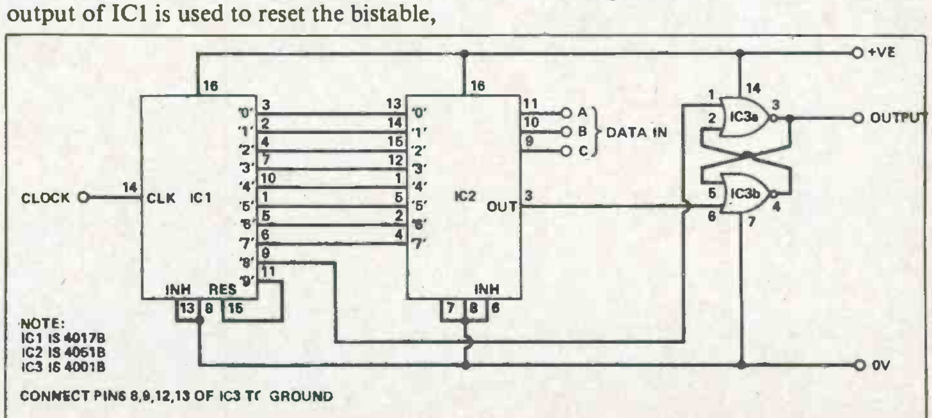

## Low Resolution Pulse Generator

G. Foote

This circuit produces pulses whose width is controlled by a three bit word and which can be used to control motors and similar devices where high resolution isn't needed.

IC1 is a decade counter with outputs '0' to '9' going high in turn. Here it counts from '0' to '8' and is reset by the '9' output which is connected back to the reset pin. Outputs '0' to '7' are connected to IC2, an eight-line-to-one-line multiplexer. The output which is connected to pin 3 by the internal switches of the IC depends on the value of the three-bit word on pins 9, 10, 11.

IC3 is configured as a bistable and is set by the '8' output of IC1. It is reset by one of the other outputs of IC1; the one selected by IC2. The length of the output pulse at pin 3 of IC3a depends on which output of IC1 is used to reset the bistable, the output being selected by the three-bit word input to IC2. Note that the 4051 could be replaced by a 4512 data selector.



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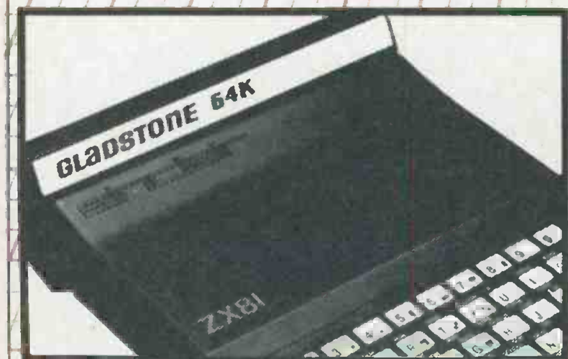


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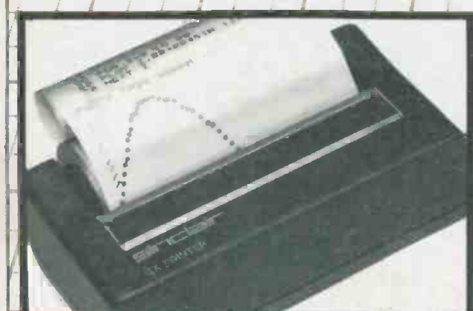

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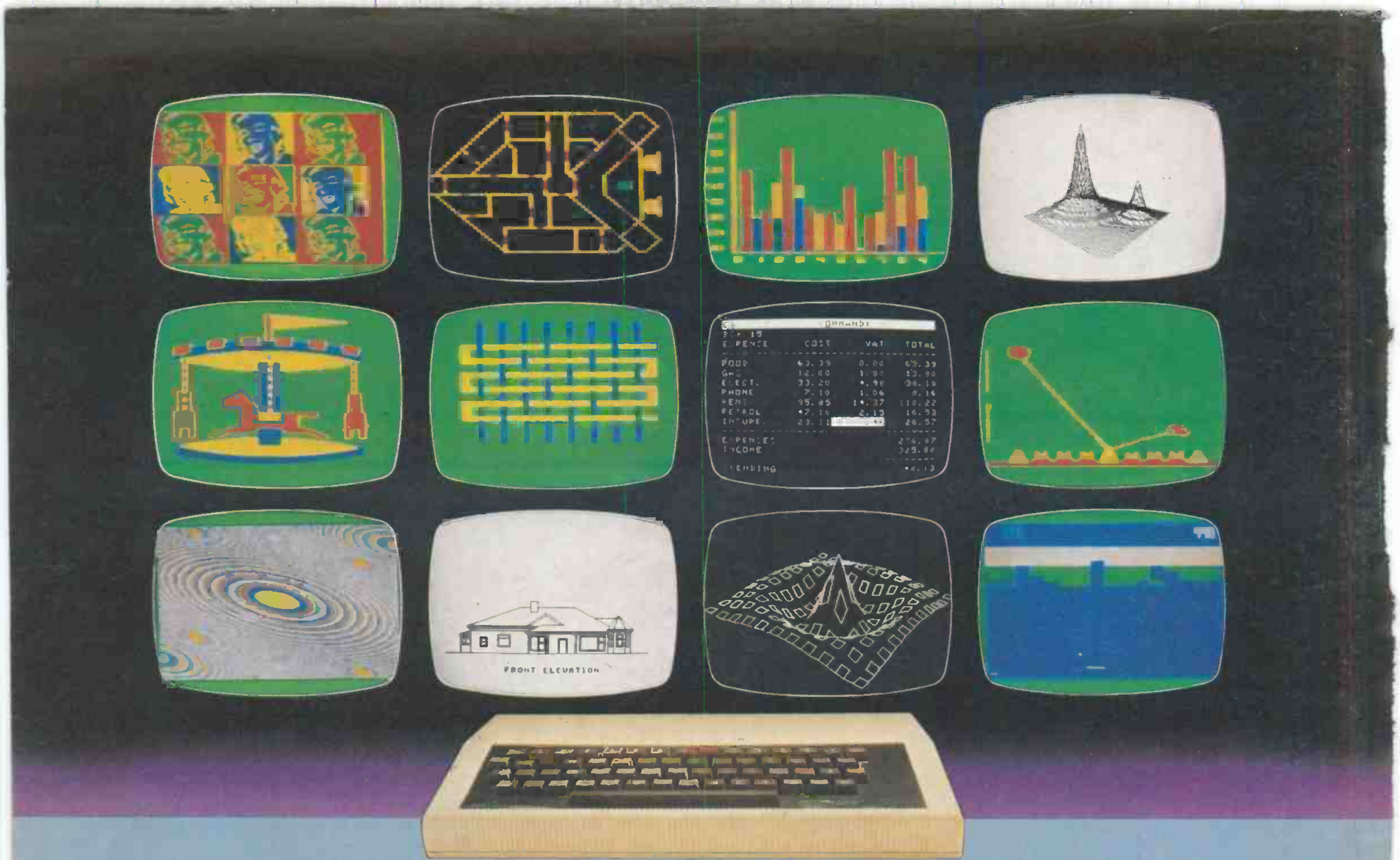


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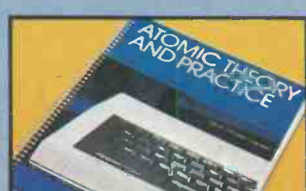


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