NEW WARES

The M68K is the latest product from **Educational Microcomputer Systems** (EMS). Built around Motorola's MC68000 32-bit central processing unit (CPU), the M68K can be used as a single-board computer for experimentation and controller applications or as a base for a powerful computer system.

The on-board memory consists of 20K bytes of fast (100nsec) static RAM and 16K bytes of EPROM space used by the on-board monitor. You can also add 256K bytes of memory with the expansion connectors. Two serial asynchronous ports are provided—one for connection to a CRT terminal and one for a modem or host computer used in download operation mode. Both serial ports operate at 9,600 baud. A 16-bit parallel bidirectional port is also provided. The input section of this port is interrupt driven and can be used for printer input/output (I/O) operation. An on-board watchdog circuit works in conjunction with the parallel port to monitor the CPU activity.

Seven autovector interrupts and three expansion interfaces are provided. All interfaces are completely buffered. Power requirements for the board are 5V at 1.5A and ±12V at 100mA.

Also available from EMS is the MK68KE system enclosure. Its all-aluminum construction can accommodate four M68K boards and provide sufficient power for system operation. The MD512K memory/disk controller card expands the memory capability of the M68K system to 512 bytes of fast (100nsec) static RAM operating without wait states. In addition to its memory capabilities, the MD512K has an on-board universal floppy-disk controller allowing implementation of complex operating systems such as CP/M 68K or FMMROS.

For details on all these products, write to EMS, PO Box 16115, Irvine, CA 92713, (714) 553-0133.

Fast Reply #JH836

Two new products are now available from **Proto PC Inc.** The Cool It fan can increase the life of computers, disk drives, stereos, VCRs and other electronic equipment by blowing cool, filtered air into the heat vent, thus creating a positive-pressure seal to keep out harmful dust and smoke. The fan consists of a long-life, low-noise fan and a replaceable filter. You can install it without tools on any vented equipment. The fan is black and measures 4 by 4 by 1⅝ inches.

The EX2000 is a microprocessor-based test instrument used to align and repair floppy-disk drives with industry-standard SA400 and SA800 interfaces. Features include quality European keys and gold connectors, test points for easy scope hookup, speed check (instantaneous and average) and step rate select, as well as all standard exerciser functions. Optional accessories include cable sets for 5 and 8-inch drives, along with alignment disks and manuals for virtually every floppy-disk drive.

Information on both products is available from Proto PC Inc., 2439 Franklin Ave., St. Paul, MN 55114, (612) 644-4660.

Fast Reply #JH929
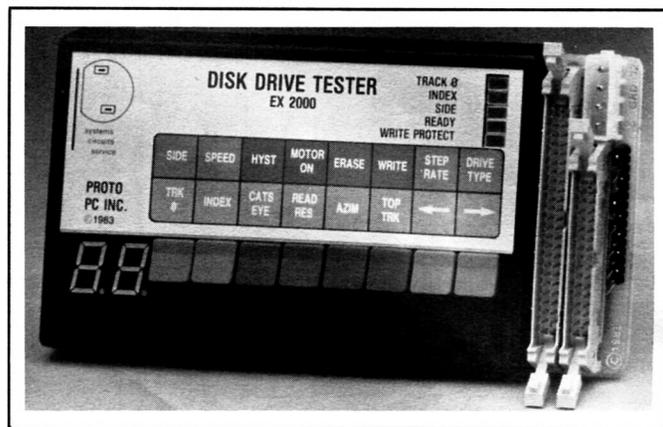
The **Folklife Terminal Club**, an international Commodore computer users group with members in more than 12 countries, has made its software library available to other users of Commodore equipment. The club has just issued a new catalog of free software from its archives, which contain more than 6,000 public-domain programs in education, science, business, games, utilities and more than 25 other categories. The programs are stored on disk and may be used on various configurations of PET, CBM, 64, VIC, 16 and Plus 4 computers.

Separate catalog disks, containing a listing of all available programs, instructions and an associate membership to the club, are available for each Commodore computer. The club charges a copying and mailing fee of $15 per disk.

To find out more about this software, contact the Folklife Terminal Club, Box 555-SB, Co-op City Station, Bronx, NY 10475.

Fast Reply #JH990

Two free *Application Note* guides are now available from **Analog Devices.**

The first describes applications for the functionally dense AD7226, a monolithic CMOS quad DAC (data acquisition and control) system containing four DACs, interface logic and output amplifiers for buffered voltage. Among the applications discussed are programmable offset voltage adjust of operational amplifiers; a digital-to-analog (D/A) converter providing automatic calibration for four op amps; a set-point controller circuit that allows fine adjustment over a wide voltage range; and a self-programmable reference voltage using one DAC.

The other guide deals with the AD667, a complete 12-bit monolithic D/A converter with on-board latches and output amplifier. This guide illustrates the AD667's flexibility when used in data-conversion applications and describes interface techniques using the 68000 and IBM PC. Analog signal-processing guidelines and how to generate custom output ranges are outlined.

To obtain copies of these two publications, write to Analog Devices, Route 1, Industrial Park, PO Box 280, Norwood, MA 02062.

Fast Reply #JH987

The N2960 Error Detection and Correction (EDC) device is a single-chip solution to memory reliability in high-performance computer systems. It is pin and function compatible with the industry-standard AM2960C and is available in a 48-pin, plastic dual in-line package (DIP) or a standard, hermetically sealed, ceramic DIP.

The N2960 boosts memory reliability by correcting all single-bit errors in very-high-speed microprocessor-based systems. It also detects all double-bit and some triple-bit errors. In typical use, memory reliability is improved

60-fold over non-EDC implementations. In operation, the N2960 generates check bits on either an 8 or 16-bit data field according to a modified Hamming code. The device operates on data read from memory.

The high speed of the N2960 (32nsec worst case for data into error detect and 65nsec worst case for data into corrected data out) makes this chip ideal for 8 and 16-bit memory-intensive systems. Because the chip can be cascaded, you can readily accommodate 32 and 64-bit architectures.

The N2960 is made in a proprietary high-performance bipolar process. It operates from a single +5V power supply, is transistor-transistor logic (TTL) compatible and dissipates 300mA (typical). It is rated for operation across the commercial temperature range (0° to 70°C).

Write to **Signetics,** 811 East Arques Ave., PO Box 409, Sunnyvale, CA 94086, (408) 739-7700.

Fast Reply #JH989

■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■

Rapid Systems has introduced an easy-to-use digital oscilloscope peripheral for IBM, Apple and Commodore personal computers. To use it, you simply plug the device into the computer and slip in the supplied disk.

The four-channel scope has a 2MHz sampling rate, 500kHz analog bandwidth and diode protection on all inputs. Its graphics display is color enhanced, using up to 138 by 288 pixels for data display (up to four traces) and four lines of text for initial (default) values of the scope's parameters. A fast, informative, menu-driven operation provides keyboard control of gain parameters for channels A–D, time base values, number of channels and trigger mode. All the post-processing capabilities of the computer are also available to store and retrieve waveforms from disk, analyze and process information, compute and word process.

Digital Devices has expanded its Universal Printer (U-Print) line of computer-printer products to include the Model AP, designed for use with Apple IIc computers. It joins the Model A (for Atari) and Model C (for Commodore), enabling home computer users to use printers manufactured by almost any company with these units.

■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■

Schmidt Electronics Inc. is a good source of sophisticated electronic test instruments. Schmidt offers a $700 Fluke 4½-digit digital bench meter for $400, along with a Hewlett-Packard 32-channel logic analyzer at one-eighth the original cost. The company stocks new computer parts as well.

For information, write to Schmidt Electronics, 388 Main Street, Poughquag, NY 12570, (914) 724-3400.

Fast Reply #JH985

The device includes all the connections to the computer and a program disk. Probes are not included, but may be ordered separately. The peripheral is available from Rapid Systems, 5415 136th Place SE, Bellevue, WA 98006, (206) 641-2141.

Fast Reply #JH948

The new U-Print is available in two models—the AP16 and the AP64. The AP16 has 16K bytes of internal memory for buffering output data, while the AP64 features 64K bytes of internal memory.

All upgraded models in the U-Print series feature a copy button for printing up to 255 copies of a document and a reset button for clearing memory. U-Print has an industry-standard Centronics parallel interface and comes complete with everything needed to hook up a printer, including cables.

For additional details on the U-Print Model AP and other products, contact Digital Devices, 430 Tenth Street, Suite N205, Atlanta, GA 30318, (404) 872-4430.

Fast Reply #JH988

■ ■

Given the right circumstances, the 68010 and 68020 32-bit microprocessors should be capable of matching the throughput of a VAX™ minicomputer. But in practice, they might not live up to expectations, even when surrounded with an expensive boardful of components.

Signetics' new memory-access controllers remedy this situation. They control a hierarchy of memories—cache, main and local—and allow the processors to run without wait states, even when using virtual addresses. They also extend to direct-memory-access (DMA) controllers the ability to use virtual addresses. While doing this, they provide a protection scheme to prevent unauthorized accesses to the memory hierarchy.

The SCC68910 matches the 68010 16/32-bit microprocessor, while the SCC68920 works with the 32-bit 68020. Architecturally, the two versions are the same. Both are made in 2.5μm HCMOS and contain more than 90,000 transistors. The 84-pin 68910 has a 24-bit (16M-byte) addressing range, whereas the 120-pin 68920 spans a 32-bit (4G-byte) range. A third chip, the 68905, is a software development engine that can be used for UNIX support.

For details, contact Signetics, 811 East Arques Ave., PO Box 409, Sunnyvale, CA 94086, (408) 739-7700.

Fast Reply #JH989

AUTHOR FILE

Our article line-up for *Computer Smyth*'s first issue represents a variety of sources and a few happy coincidences that allowed it all to come together.

John Adams is representative of the spirit of self-reliance that is still quite strong in Britain and on the Continent. It is a matter of pride that many amateurs in Britain make all manner of goods for themselves. For example, something just over 2 percent of the beer consumed in Britain is homemade. And lest you suppose that to be a small quantity, Britons consume approximately 38 gallons of the foamy brew per capita per annum.

Thus, when Mr. Adams's SC84 computer (p. 8) appeared in the British magazine *Wireless World,* we were sure it was the sort of project we wanted for *Computer Smyth*.
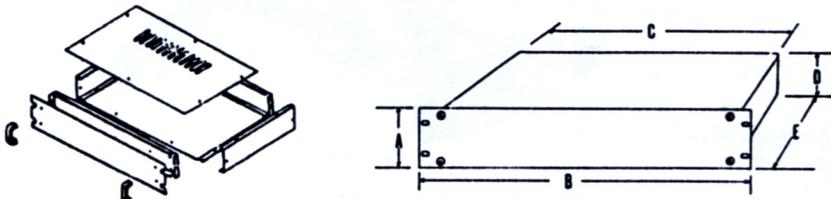
Vern Mastel's charter/plotter (p. 20) came to us as a candidate for our oldest publication (founded in 1970), *Audio Amateur,* but we never seemed to find room for it there. Mr. Mastel is a true craftsman in that he has no hesitation in making the equipment he needs.

Several years ago, I received a short letter full of wrath and anguish from **Derek Neely,** along with a manuscript. It had been rejected by one of the large computer magazines with the comment that no one would want to build a gadget like a wire-wrap tool if he could buy one for "only" $50. Mr. Neely and I thought the editor had missed the point of the article. Building a gadget is a pleasure, and saving money hardly enters into the equation. We could not use the article in our other publications, however, and returned it with regret. When we decided to launch *Computer Smyth,* I remembered Mr. Neely's letter. His article finally finds a home in this issue (p. 30).

Thomas Clarke, who works in marine biology in Miami, Florida, is an enthusiastic do-it-yourselfer. When we announced *Computer Smyth* to a number of authors who had written for our other publications, he came forward almost immediately with his excellent RGB color adapter article, which begins on page 40.

For those who are curious about our name, *Computer Smyth* started out as one word and was spelled traditionally. But we soon found out that five companies use that form, and one, a Baltimore software firm, holds a registered trademark for the moniker. Our imagery probably owes a lot to Longfellow's poem "The Village Blacksmith." The word "smith" (or smyth) has a venerable history going almost as far back as metalworking in Anglo-Saxon, Icelandic and Gothic cultures. While smything in microcomputers is not exactly metalworking, we think it is close enough. □

Computer Smyth is published four times per year in the interest of handcrafted microcomputer hardware construction and enhancement. Circulation and editorial correspondence should be sent to PO Box 176, Peterborough, NH 03458. No responsibility can be assumed for unsolicited manuscripts. All MSS should include a self-addressed envelope with sufficient return postage. The staff will not answer technical queries by telephone. Printed in the U.S.A.

SUBSCRIPTION POLICY: Subscriptions to *Computer Smyth* are available for the whole year only. If you subscribe during the middle of the year, you will receive (upon payment) all issues for that year previously mailed and the remaining when published. All subscriptions begin with issue No. 1 and expire with the last issue of the year's series. Sample issue: $5 in US; $6 in Canada.

RATES: $15 for four issues; $25 for eight issues. Latin America add $2 per year. Canada and all other countries add $4 per year for postage. Air rates on request. Note: all subscribers residing outside the Western Hemisphere are served by air to Amsterdam and by surface from thence.

To subscribe, renew or change address, write to Circulation Department, PO Box 176, Peterborough, NH 03458. Circulation phone for credit card subscriptions 9-4 Eastern time: (603) 924-9464.

COMPUTER SMYTH
THE HARDWARE JOURNAL
Vol. 1 No. 1/May 1985

FEATURES

DEPARTMENTS

OPINION

HOW TO READ COMPUTER SMYTH

Blood bath is the only appropriate term for what is happening to technological magazines as I write this in early April 1985. One firm here in Peterborough, New Hampshire, has killed two computer publications within the past year and is reported to be seeking a buyer for its ham radio publication. Ziff-Davis, before it recently sold a block of its consumer publications to CBS, killed *Microsystems,* which had 25,000 subscribers, and its flagship electronics publication, *Computers & Electronics,* with more than 450,000 circulation.

The reasons for this apparently senseless slaughter lie deep in thickets of tax law and the mindset of business-school-trained managers, who keep their eyes firmly fixed on what they call "the bottom line." Maximizing profit is the popular jargon for their motives.

Publishing managements have a current minimum cutoff size for acceptable bottom lines, and magazine viability is defined purely in those terms. Matters such as reader interest and loyalty do not enter the equation. Indeed, the managers can impose design controls on editorial policy and graphics with a view toward keeping articles short, simple, widely varied in subject and visually appealing. It all makes for shallow, insipid, slick publishing.

What few management people seem to notice is that magazine circulations in general have been getting smaller for 30 years and that we have many more titles now than ever before. The minimum cutoff has, I suspect, also been shrinking every year.

We believe that technological change in publishing capability now offers an unparalleled opportunity to serve readers' very specialized needs. *Computer Smyth* is being birthed amid a rash of computer magazine wakes, but the two phenomena are related. We think of a magazine as a means of connecting the nervous systems of its readers. Human development and change happen when ideas spread and evolve. Printed magazines are a primitive way of implementing the movement and the evolution.

We publish technical, hands-on magazines because we love knowing how things work. We admire and are sometimes awed by how a machine performs. We know a little about the excitement of conceiving a possible project—be it a design from scratch or constructing another's design. We find pleasure in the search for and collection of parts, planning the device, drawing the layouts, building the first ugly prototype and then testing it, and finally building a better-looking version—and possibly even making one for a friend.

We know, too, the inevitable letdown that follows project completion, tempered only by the knowledge that other adventures await us in the next of possibly endless projects. Some of us seem to be born with a curiosity about how things work that almost amounts to a hunger. And in many cases, we feel a nearly irresistible urge to experience the labor, the discipline and the agony of making something for ourselves.

Computer Smyth is based on a desire to serve people who share those feelings about microcomputers as electronic engines. We know that the number of people who enjoy this peculiar appetite is limited, and finding such people is very difficult. But the pleasure of sharing such interests with like-minded folks is, I think, one of humanity's prime satisfactions.

It isn't that we hate money or think lots of advertisers and ads are a corrupting influence. It's just that we are interested in building beautiful, elegant, ingenious machines for ourselves. Our imaginations and hands demand that delight of us, and nothing else will meet the need.

So much for motives. What about content? Well, you have a small sample in your hands, but it is only a taste of what is to come. In future issues, you will be seeing more system articles: Ed Scott will begin a nine-part series in 2/85 dedicated to the 68000. We will have lots of enhancements and extension projects (especially of older designs), peripheral interfaces, and articles on new chips and their capabilities. We will run listings of single-board and kit computers, as well as builders' reports on these items. We have a switching power supply in the works, as well as an EPROM programmer, a modem and much more.

What about software? We will deal with software wherever it is integral to hardware questions. But we believe software interests are served far more than most microcomputer interests by several other periodicals. Unlike marketing managers, we do not believe in trying to cover all subjects and interests.

We hope you will share several items with us.

Your letters are foremost. Tell us what you want, react to what you like and dislike. Please interact with authors. If you wish an answer to your question(s), do include an envelope with your name and address and a stamp on it—if the author lives in the US. If the author lives overseas (as does John Adams, author of the SC84 series, p. 8), please include two International Postal Coupons, available at your local post office, so that authors in other countries can purchase postage.

We will include authors' addresses whenever possible. Please do be considerate and thoughtful in communicating with them. If you get an author's phone number, check the time zones before calling California from the East Coast at 7 a.m. or Boston from Los Angeles at 10 p.m. Authors are a valuable resource, and we make no apologies for the extraordinary measures we will take in their care and feeding. We will forward your letters to authors free of charge, but only if you include a proper return envelope. We will not provide an author's address or phone number to any reader without the author's prior permission.

Speaking of telephones, we cannot and will not answer technical queries by phone. Queries about articles should be directed to authors. If you indicate a need, we will offer an "Ask Computer Smyth" column as a regular Q&A feature.

We will offer some of the basic reference information you need in our "Data File" feature (p. 38). Next issue, we will publish the RS-232/RS-449 and CCITT V24 serial transmission standards, along with modem parameters from Bell 103 through 209. We welcome your suggestions—and your copies of useful data tables.

We hope you will fill a short manuscript bin we have labeled "Smyth Bits." These are circuit ideas, shortcuts, construction tips, clever products and unique uses for them, easier ways to do nasty jobs, tricks and bits of hard-earned experience.

We also hope to develop an informative "In Review" section on the latest computer book releases. If you would like to try your hand at a review, let us know, and we will send along a book for your perusal. Perhaps you already have a book on hand that you think other readers should know about. If so, drop us a line giving a brief description of the book (don't forget the publication date), and we will let you know whether we are interested in running a review.

Take well-lighted black and white photos of your construction projects for our "Smyth Case" section, where you can show off your handiwork. We will pay for "Smyth Case," "In Review" and "Smyth Bits" offerings, of course, which is one good way

to underwrite your subscription or even part of your system cost.

If you are a budding author (and who doesn't dream of it?), drop us a line about your tastiest ideas to make sure we are not about to publish someone else's identical project. Our author instructions are available upon request, along with requirements, rates and terms.

You will find some bind-in cards inside this and future issues. Two of them are "Fast Reply" cards that give you a chance to ask vendors in our "New Wares" section and advertisers for more information. The numbers are also useful in letting us know your interest in a circuit card for a specific project, as in the SC84 series, Vern Mastel's plotter article (p. 20) and Thomas Clarke's RGB color piece (p. 40). In all cases where you respond to a kit project or board proposal, you will be notified whether or not the project is feasible.

Please note the importance of what we call your "magic number." Your address label, which peels off for use on the Fast Reply card, has a number in the upper left corner. This is actually your subscription record number on our circulation database. If you write or call about a subscription problem, your magic number gives us instant access to your file. If you call our subscription desk (9–4 EST, M–F) at (603) 924-9464, we can probably give you an immediate answer to your query about magazine delivery.

All our subscription fulfillment and "bingo card" processing, as well as our text editing, are handled on our venerable three-user, multitasking Ohio Scientific computer. Your Fast Reply requests will be processed weekly for truly fast turnaround. Advertisers might take a bit longer to reply to you.

Our subscription system is somewhat unusual in that all subscriptions begin with the first issue of each calendar year and end with the last issue of that year. Subscribers who sign on during the year receive all the issues previously published for the current year and the remainder as published. This ensures that each reader has complete sets of each year, and it saves a great deal of aggravation and expensive overhead. We believe you will like our system and appreciate its virtues.

We are pleased and excited to launch this, our third, publication. And we are especially eager to get your reactions, suggestions, manuscripts, criticisms and ideas. Some publishers consider a magazine's staff and authors as the source of information and the subscribers as consumers of information and goods. We have come to view subscribers as an integral part of the information interchange network. Your data lines with us are definitely I/O. **E.T.D.**
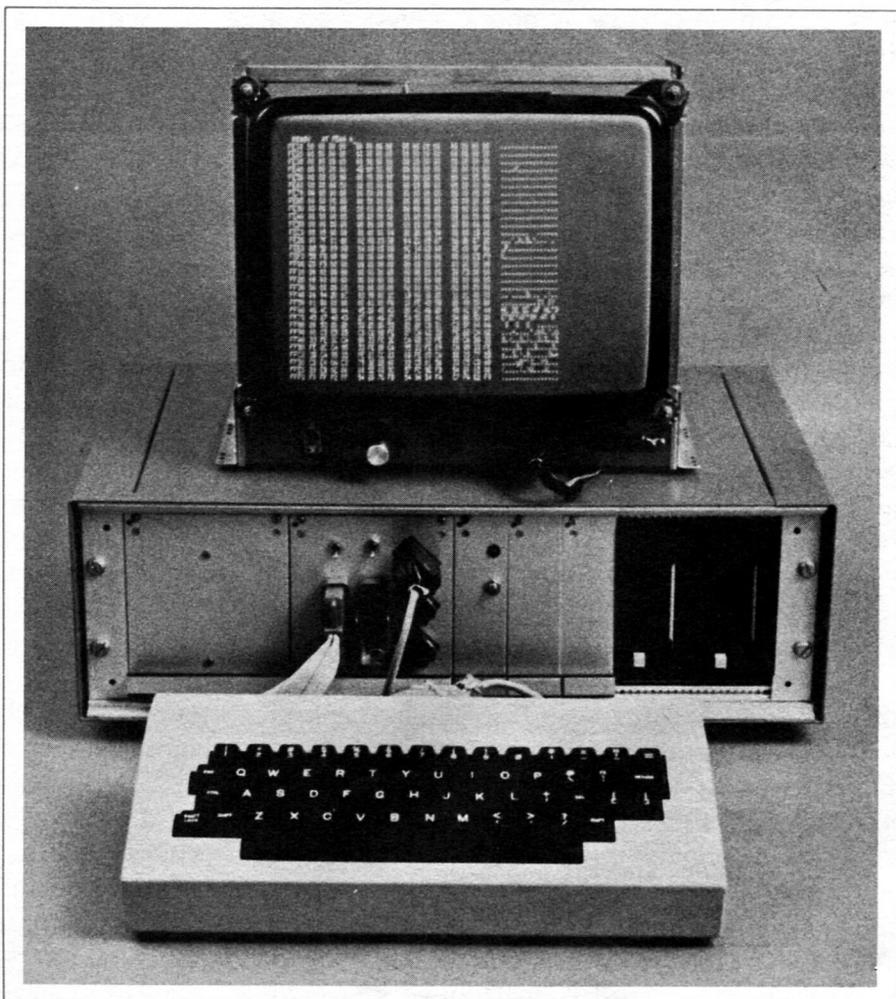
THE SC84 MICROCOMPUTER

Part I

I designed my first computer, the Scientific Computer published by *Wireless World* in 1979, to gain experience with microprocessors. This small system had novel features for its time, including a hardware number-cruncher and up to 5K bytes of random-access memory (RAM). Looking back, the Scientific Computer appears embarrassingly primitive, but judging from correspondence, it served its purpose of giving readers the best possible introduction to microprocessors—hands-on experience.

This new design *(Photo 1)* has a similar objective, but it also permits the use of much readily available software, including word processors, language interpreters and compilers. Re-tained features are the Z80 microprocessor, the resident machine-code operating system extended to provide extra commands, and general accessibility needed for engineering applications. New features are the 64K bytes of user memory, a high-resolution cathode ray tube (CRT) controller and a flexible input/output (I/O) section including interfacing for 3.5, 5.25 or 8-inch single or double-sided, single or double-density disk drives. Up to 32 lines of 96 characters or 192 by 192 picture elements may be displayed, and graphics and characters may be mixed.

My disk operating system, SciDOS (see box at the end of this article), is compatible with most software written for the standard 8-bit operating system, CP/M. I have also designed software to make use of special features of the computer, in particular the visual display unit (VDU). These programs include utilities, disk editors and an extended BASIC interpreter. Much of this software was developed in conjunction with the Scientific

PHOTO 1: *The SC84 microcomputer features a Z80 microprocessor, its own disk operating system (SciDOS), 64K bytes of user memory, a high-resolution CRT controller and a flexible input/output section.*

BY J. H. ADAMS

John Adams heads the microprocessor division of Graseby Dynamics Ltd. Prior to working in industry, he held various educational posts during which he initiated the teaching package "Starting Microelectronics." This article combines his interests in education and engineering. In his spare time, Mr. Adams is a keen classical organist.

Computer, whose disk interface came later, so users of the original computer can run their software on the SC84 with little or no modification.

The SC84 reflects the shift toward microcomputers with most of their programming on disk rather than in read-only memory (ROM). The only ROM in this design is an 8K-byte EPROM (erasable programmable read-only memory), which on switch-on or reset copies the resident operating system into RAM and is then switched out, leaving the system entirely dependent on RAM.

There are two advantages to this approach. First, having everything in RAM means that every aspect of the computer is open to experimentation. Second, while a system with, say, BASIC in ROM will be ready to program in BASIC as soon as it is switched on, that ROM is an encumbrance when you want to use anything else but BASIC. The classic argument against disk-based systems is that a ROM-based system is ready for use as soon as you switch it on, whereas initiating a disk-based system can take as much as 45 seconds. The SC84 initiates in just under one second and leaves virtually all the system RAM available for whatever you want—BASIC, Pascal, machine-code assembly, word processing, and so on.

A major feature of the SC84 is that a disk operating system, SciDOS, has been written especially for it. As well as implementing those commands and functions necessary for CP/M compatibility, this software provides some extra commands and functions that make the system of use to those who see a computer as more than a black box. SciDOS has been kept small by efficient programming; when it is loaded and running, up to 58K bytes of memory are free for user programs.

The SC84 is built on 100 by 160mm (approximately 4 by 6½ inch) Eurocard circuit boards interconnected through a 64-way bus system. The basic configuration consists of a processor card, a character VDU card and an I/O card. Frames for housing Eurocards are available in various sizes and materials, with the interconnecting bus or "backplane" being either a circuit board—again readily available—or a series of card sockets linked using wire-wrapping techniques. Prototypes have been constructed using both methods, and while a circuit board saves time, wire-wrapping a series of sockets together is recom-

mended as being cheaper and giving a little more flexibility should you not want all the connectors wired strictly in parallel, as would be the case in a "daisy-chained" interrupt system.

Bus signals are shown in *Table 1.* Pin designations refer to a standard DIN 41612 64/96 connector—i.e., the type with spacing for three rows of pins but with the middle row missing. Power is provided through the outer two pairs of pins at each end of the connector, which suits circuit board backplanes available from Vero Electronics Ltd. (Unit 5, Industrial Estate, Flanders Road, Head End, Southampton S03 3LG, UK) and other manufacturers. All signals are buffered in and out of the processor board using low-power Schottky transistor-transistor logic (TTL) ICs.

Processor/Memory Board

On this circuit board *(Fig. 1* and *Photo 2)* is the Z80, 64K bytes of RAM, system ROM and a buffered interface to the rest of the computer. The decision to integrate memory with the microprocessor was made because the size of the system memory is largely determined by the processor. Also, without the memory, the processor board would be rather bare, and an extra Eurocard would be needed. Integrating the two on one board doesn't preclude the use of extra memory on other boards—as indeed happens with the VDU memory. The timing diagrams in *Figs. 2* and *3* will be referred to throughout this explanation of the processor board.

There are three types of memory cycle that the Z80 can execute. Fetch-

TABLE 1
BUS CONNECTIONS

Row A	Pin	Row C	Function
GND	1	GND	
+ 5V	2	+ 5	
D0	3		
D1	4		
D2	5		
D3	6	$\overline{INT}$	Z80 maskable interrupt line.*
D4	7	$\overline{NMI}$	Z80 nonmaskable interrupt line.*
D5	8	$\overline{HALT}$	Z80 has executed a HALT instruction.
D6	9	$\overline{MREQ}$	Z80 is performing a memory operation.
D7	10	$\overline{IORQ}$	Z80 is performing an input/output operation.†
A0	11	$\overline{RD}$	Z80 is requesting data from the bus.
A1	12	$\overline{WR}$	Z80 is writing data to the bus.
A2	13	$\overline{BUSAK}$	Z80 has relinquished control of the system.
A3	14	$\overline{WAIT}$	Z80 is being asked to extend the current instruction.*
A4	15	$\overline{BUSRQ}$	Z80 is being asked to relinquish system control.*
A5	16	$\overline{RESET}$	20μsec pulse generated when RESET is operated.
A6	17	$\overline{MI}$	Z80 is fetching an op-code.†
A7	18	$\overline{RFSH}$	Z80 is performing a memory refresh cycle.
A8	19	$\overline{MEMDIS}$	Nonsystem memory is to be used for this operation.*
A9	20	VDUSEL	Character VDU is mapped into memory.
A10	21		
A11	22		
A12	23	CLK	System clock (from processor board).
A13	24		
A14	25		
A15	26		
	27		
	28		
	29		
+ 12	30	− 12	
+ 5	31	+ 5	
GND	32	GND	

Note: Address and data (A and D) lines are active high.
* These lines have a pull-up resistor on the processor board and should be driven by open-collector drivers.
† When $\overline{MI}$ and $\overline{IORQ}$ are both active, the processor is inviting a peripheral device to supply part of an interrupt vector—interrupt acknowledge.
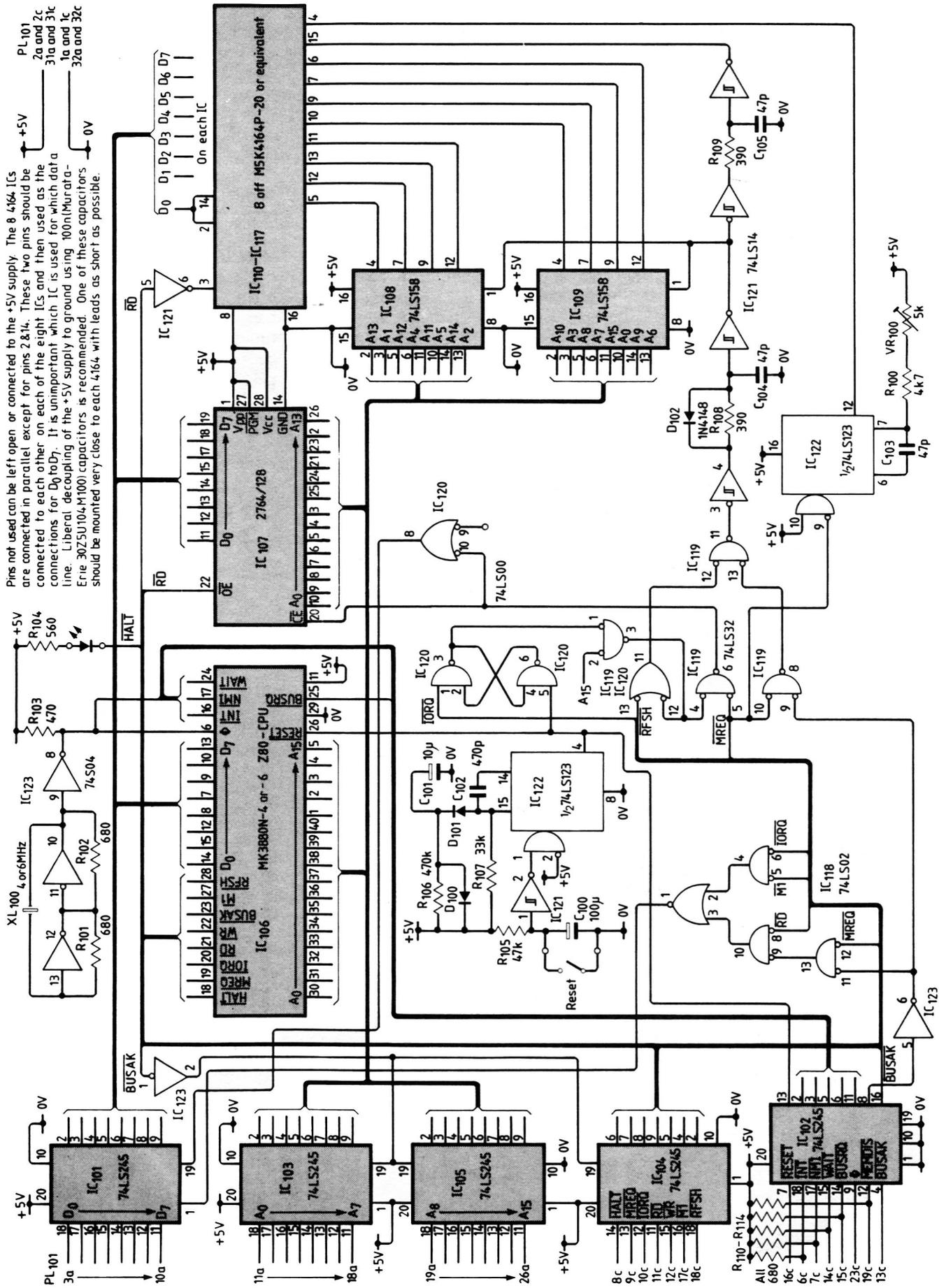
FIGURE 1: The processor is the first of the SC84's three main sections. It has a 64K-byte RAM, operating system EPROM and logic for a dynamic RAM, a bus driver and a reset control. On resetting, part of the ROM content is loaded into high RAM, and the ROM is then switched out, leaving up to 64K bytes for user programs.

ing of an instruction or "op-code" from memory is illustrated in *Fig. 2. Figure 3* is a composite diagram illustrating the writing or reading of data to or from memory. The difference between fetching an op-code and fetching data from memory is that the op-code fetch is shortened and followed by a special memory cycle intended, and used in this case, to refresh dynamic memory.

Three relevant Z80 control signals in accessing memory are $\overline{MREQ}$ indicating that the current cycle is a memory cycle, $\overline{RFSH}$ indicating that memory refresh can now take place, and $\overline{RD}$ indicating that the current cycle will involve data passing into the Z80. There is also a signal called $\overline{M1}$, which becomes active during op-code fetches and interrupt acknowledge periods, and a $\overline{WR}$ signal, which indicates that data is to pass from the Z80 to the system. Neither signal is used in memory access, although $\overline{M1}$ takes part in controlling the buffering of the data bus.

Z80 control signals and virtually all others in this design are active low— i.e., they assert their function by going to the negative or zero state. The normal description of a gate function is based upon positive logic so that, for instance, a 74LS02 is deemed to contain four two-input NOR gates. In this circuit diagram and following ones, gates are shown in their logical context. This can be seen in the 74LS02, which arbitrates the data-bus buffer direction (IC118). Here, three of the four gates have been drawn in their inverse form—i.e., as AND gates with active low inputs rather than as OR gates with an active low output.

Having differently shaped gates in the same IC takes some getting used to, but it helps understanding of the logic. For example, in the case of IC118, direction line $\overline{IN}$ becomes active when $(\overline{M1}$ *and* $\overline{IORQ})$ *or* $\overline{RD}$ *and not* $(\overline{MREQ}$ *and not* $\overline{MEMDIS})$ are active. Translated into English, this means that the data buffer faces toward the Z80 during interrupt acknowledges and during any read other than one on the processor board memory.

Control gating for the bus buffer is fairly complex, as the buffer has to respond to various conditions, summarized in *Table 2*. One reason for such a tight definition of the bus operation arises from the use of mode 2 interrupts. This is the Z80's most complex mode of interrupt organization, where
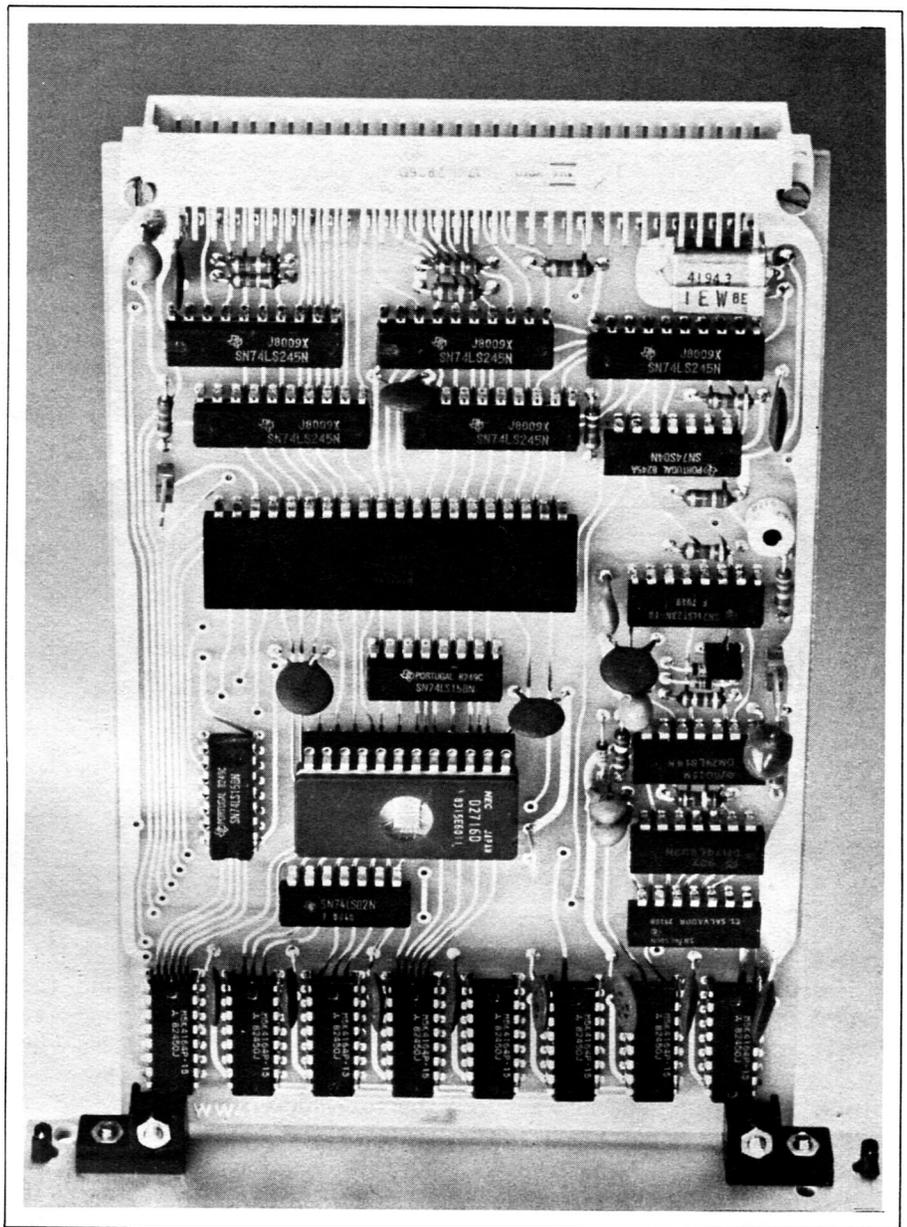
PHOTO 2: Since the size of system memory is largely determined by the processor, the author decided to integrate memory into the processor board. Doing so also eliminated the need for an extra Eurocard.

in response to the Z80 acknowledging an interrupt by taking control lines $\overline{M1}$ and $\overline{IORQ}$ low simultaneously, the interrupting device supplies 8 bits of an address. This address, combined with the contents of the Z80 "I" register, forms a 16-bit pointer to a table of addresses of interrupt-service routines. Each device capable of interrupting is supplied with one or a range of such "interrupt vectors" during the computer's initialization, so upon an interruption, the Z80 is able to pick out and make a call to specific routines for each interrupting vector.

The strength of the system, though, is that by changing the interrupt vector or a particular entry in the table

of addresses, different service routines can be provided for the same interrupt line. This is particularly important, for example, with the disk controller used, which uses one interrupt line to signal both a request for data from the system during disk writing and the offer of a data byte during disk reading. This "interrupt acknowledge" sequence is condition 7 in *Table 2*.

On receipt of an interrupt, the Z80 disables its interrupt sequence, but pauses before acknowledging to allow what may actually be several interrupting devices to decide which has the highest priority. This is done by the daisy-chain technique mentioned earlier. In this way, lower priority
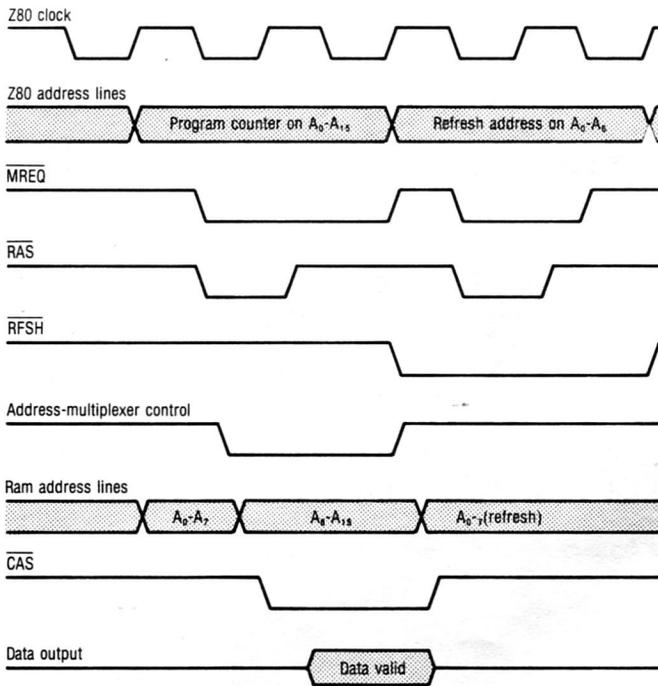
FIGURE 2: Timing for an op-code fetch. The Z80 microprocessor has a special register for use with dynamic RAMs, which provides a refresh address coinciding with a refresh control signal.
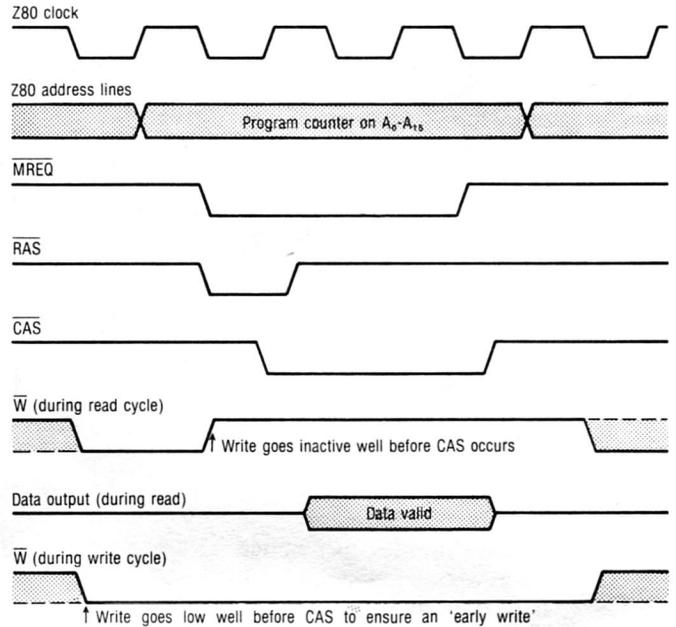

FIGURE 3: Timing for Z80 memory read and write cycles. "Early write" cycles are common in larger systems, but are not found in most 8-bit processors.

devices that might need service are prevented from interrupting more important tasks. Note that condition 4 must be implemented because during an interrupt service, all devices capable of interrupting will want to watch what is being fetched from memory so that they can spot the return-from-interrupt op-code being fetched and automatically reinitialize themselves.

Dynamic Memory
The dynamic memory control is quite novel. For this reason, and for the bad publicity that dynamic memory sometimes gets, it is worth detailing a few features of its operation before describing the external circuits. Modern dynamic memories use a multiplexed addressing technique where the address is split in two, in this case 8-bit, parts. This reduces the number of address pins on the IC from 16 to 10—eight address pins and two "strobes" to latch the address bytes into the memory. A prime consideration here is that this reduces the package size and hence the cost, but it also allows the memory access to be broken into two stages with consequent benefits.

Consider a 64K-bit dynamic memory to be a matrix of memory stores

512 by 128, each row of 128 being connected to a single bus line. Each store is a minute capacitance connected by gates to these lines. When the first part of the address known as the row address is latched into the memory, the highest bit is stored and the other seven are decoded to decide which of the 128 cells in each of the rows should be connected to the bus line for that row. Thus access starts well before the full address is in.

TABLE 2
DATA-BUS DRIVER LOGIC

Condition	Bus-Buffer Drives
1 I/O write	toward bus
2 I/O read	toward Z80
3 System-memory write	toward bus
4 System-memory read	toward bus
5 External-memory write	toward bus
6 External-memory read	toward Z80
7 Interrupt acknowledge	toward Z80

The bus line is, naturally, physically much bigger than the individual cell, which has now been connected to it by activation of the row-address strobe ($\overline{RAS}$), so the potential stored in the cell is all but lost on the bus. At one point on the bus is a sense

amplifier connected back onto the bus lines with positive feedback. While $\overline{RAS}$ is inactive, the sense amplifier is held in balance, so even though it has been all but lost, the potential delivered by the cell is enough to tilt the amplifier one way or the other. Having positive feedback, the amplifier pushes the potential on the line heavily in the direction of the input potential, putting the line—and the cell—back to the level in the cell prior to the access.

There are two implications here. First, there is a minimum length for the active $\overline{RAS}$ pulse in that if it goes off before the bus line is recharged by the sense amplifier, it will disconnect the read cells from their bus lines before they have had a chance to recharge. Second, there is a minimum inactive time for $\overline{RAS}$ as the sense amplifier is brought back into a state of balance. These conditions are paramount, and to meet them, $\overline{RAS}$ is driven by a monostable IC triggered by a signal directly from the Z80 rather than one that has been combined with others and might therefore be subject to glitches caused by timing problems between the various constituent signals. The monostable IC sets the minimum active $\overline{RAS}$ period

and thus by definition the minimum inactive.

Once the leading edge of the $\overline{RAS}$ pulse has latched the first address byte into the memory ICs, the address may be changed to that of the bus row to be fed to the output of the memory. The 8 bits are gated in by the starting edge of the column-address strobe $(\overline{CAS})$ signal and combined with the stored bit from the previous addressing strobe to operate a 1-out-of-512 data multiplexer, which selects and latches the signal from one of the 512 bus lines within the memory. Once this is done, $\overline{RAS}$ may go inactive. Indeed, it is a good thing if it does, because then the sense amplifiers may return to a balanced state as soon as possible, ready for the next access.

CAS also controls the state of the memory-output driver. While it is active, the output is enabled and the selected data bit held there. CAS is a less sensitive signal as far as integrity of the memory is concerned, the main consideration being that it becomes active as soon as possible in the access and stays on until the data is definitely available and the Z80 has it.

Write Cycles
This has been a description of a memory read cycle. A write cycle is similar in that the $\overline{RAS}$ signal connects cells to buses and releases sense amplifiers, and then the $\overline{CAS}$ signal operates the latching multiplexer and activates the output driver. What is different is that the signal on the data-input pin is routed through the multiplexer to the cell. During a conventional write cycle, the data output pin will follow the output of the cell while $\overline{CAS}$ is active. This might seem to preclude the use of dynamic memory in circuits usually associated with static memory, where the same line is used for data input and output, but it is possible to prevent the output of a dynamic memory from coming on when $\overline{CAS}$ goes active by arranging for the write signal to go active before $\overline{CAS}$ does.

These "early-write" cycles are common in large systems, but are not found in most 8-bit microprocessors such as the Z80 where the $\overline{WR}$ signal goes active well into the memory cycle and is too late to be of use. One answer is to use an 8-bit, three-state buffer between the RAM outputs and the data bus, but my solution is to use the inverse of $\overline{RD}$ as a write strobe to the memory. Whenever $\overline{RD}$ goes

high—i.e., at the end of reading memory or I/O—the write strobe goes low, and so the dynamic memory is primed for an "early write." Because $\overline{RAS}$ will be over long before $\overline{RD}$ goes high, there is no chance of a memory-read cycle being transformed into a memory-write cycle. Should it be a read cycle, the write strobe is removed from the memory by $\overline{RD}$ going active low at the beginning of the cycle, well before $\overline{CAS}$ is applied. Except for a slight increase in current consumption during the write-line strobe, the effect is unnoticeable.

The sequence of pulses for the dynamic memory is generated by a series of Schmitt buffers (IC121). $\overline{RAS}$ is generated by the leading edge of memory-request signal $\overline{MREQ}$, which triggers monostable IC122. A potentiometer sets the $\overline{RAS}$ pulse length. For the devices specified in the diagram, $\overline{RAS}$ should last for at least 200nsec and should have a minimum off period of 120nsec. In practice, this adjustment is not too critical with a system running at 4MHz, as a complete $\overline{RAS}$ cycle lasts at least two clock cycles, which corresponds to 500nsec. Set the potentiometer to give the off period required for the dynamic memories used. If measurement is not possible, set the pot to its mid-position for a 4MHz microprocessor or at or near its minimum for a 6MHz version.

The signal at the start of the Schmitt buffers is (MREQ *and not* MEMDIS) *and not* ($\overline{RFSH}$ *or* ROMEN)—i.e., unless $\overline{MEMDIS}$, $\overline{RFSH}$ or $\overline{ROMEN}$ is active, it is $\overline{MREQ}$ delayed by a couple of gates. The starting (falling) edge of $\overline{MREQ}$ becomes a rising edge at the output of the first Schmitt gate. This rising edge is slowed down by the RC combination between the first two buffers so that the falling edge at the second output is somewhat later than that of $\overline{MREQ}$. This signal is used to switch addresses being supplied to RAM through multiplexers IC108-IC109. Further delay is applied to produce $\overline{CAS}$.

To provide a quick end to the memory access so that the multiplexers are definitely reset to the row-address position ready for a refresh cycle, a diode shunts the first time delay, which would follow $\overline{MREQ}$'s trailing (rising) edge. Refresh occurs when $\overline{MREQ}$ cycles while the $\overline{RFSH}$ signal is active. During this period, the Z80 puts out a 7-bit value from a special internal register, which increments after every refresh. $\overline{MREQ}$ triggers the

monostable IC to set off a $\overline{RAS}$ cycle, but the $\overline{RFSH}$ signal inhibits production of address-multiplex or $\overline{CAS}$ signals. From the previous discussion of dynamic memory operation, you can see that the sole result of the $\overline{RFSH}$ cycle, or any memory cycle during which $\overline{MEMDIS}$ or $\overline{ROMEN}$ is active, is to "refresh" $\frac{1}{128}$ of the memory.

A simple inverter ring produces the system clock. The crystal frequency will depend on the microprocessor used—i.e., 4MHz for the Z80A or 6MHz for the Z80B. A Z80A should work with a popular 4.1943MHz crystal. These are relatively cheap, and although the MK3880-4 or Z80A CPU is specified only up to 4MHz, it is likely that they will work at this slightly higher frequency. Each I/O section has its own crystal and oscillator, so the crystal used on the processor board will not affect I/O data rates, with the proviso that the processor clock must not fall below 3.6MHz if 3.5 or 8-inch double-density disk drives are used.

When the reset pin on the Z80 is active, everything, including memory refresh, stops. For this reason, the reset monostable IC generates a short pulse, and no matter how long the reset button is held in, refresh is only briefly interrupted so that no memory corruption occurs. As well as providing a reset signal for the Z80 and all peripheral circuits, the pulse is used to set a bistable IC formed from two gates of IC120. The output of this bistable device gates with A15 to produce ROMEN, a signal that follows A15 while the bistable IC is set and enables ROM whenever A15 is low—i.e., during access at any address from zero to 7FFF16.

On receiving a reset signal, the Z80 starts to fetch and execute instructions from address location zero. This means that following reset, the Z80 executes instructions from EPROM. At the base of the EPROM, it finds instructions to copy a part of the ROM at the top 8K bytes of system memory followed by a jump to that area. This copied software is the machine-code operating system, whose first instruction is an I/O read, which due to the IORQ line going active during its execution, resets the flip-flop and forces $\overline{ROMEN}$ to the inactive high state, disabling the EPROM and freeing the entire 64K-byte RAM. The timing circuit on the reset monostable IC arranges for a much longer time constant to be applied during power-up, providing a reset pulse long enough to

allow start-up of all of the system clocks. EPROM IC107 is shown as a 2764 or 27128, but the board may be modified to take 27256 or 27512 devices.

Input/Output Board

As well as providing basic serial, parallel, keyboard and disk I/O, the I/O board *(Fig. 4)* also provides some system control and special facilities. At its heart is the Mostek STI, the MK3801N-6. This device is one of several types recently introduced that provide a set of peripheral facilities. For those familiar with Z80 peripherals, it combines a CTC, a PIO, an SIO and an interrupt controller. As befits the complexity of most Z80 peripherals, it has 24 internal registers, 16 of which are directly addressable and eight of which are indirectly addressable, and 16 sources of interrupts.

The STI has an 8-bit parallel port, a universal synchronous/asynchronous receiver transmitter (usart) for serial I/O, and four counter/timers, two of which are able to provide delays, count events and measure pulse widths, and two of which are capable of providing only delays. In delay mode, each timer switches the state of an individual output pin at precise intervals so the generators may be used to generate accurate frequency signals up to 500kHz—even four-part music. The two limited-capability timers provide internal timing and/or determine usart bit rates.

The parallel I/O port has three features. It can be used just as an I/O port and as such each line may be configured as an input or output. Alternatively, some pins have special functions. Two are event and pulse-measurement inputs for the timers, and two are "handshake" lines for the usart. Third, each line of the port may be used as a Z80 interrupt line. This is especially useful, as the Z80 interrupt system is excellent but difficult to use with non-Z80 ICs, a good example of this being control of a floppy-disk drive.

There is no Z80 disk controller, and yet interrupts are really useful in a disk interface because of high data-transfer rates. The STI is the answer to this, providing 16 distinct interrupts, each with its own priority. These could be integrated into a larger system, but the STI is so versatile that it is the only Z80 peripheral IC in the basic computer.

If there is a blemish in the STI design, it is that usart receiver and transmitter handshake lines are both outputs, presumably for compatibility with another rather odd Z80 device. This is unfortunate, as logic would dictate that handshaking signals pass in the opposite direction to the data they are controlling, but the STI signals indicate that either the receiver or transmitter in the usart is empty. The former signal correctly warns external devices that the receiver is not ready, but the latter is the wrong way around, the handshake being required from the external device to the STI and not away from it. As a result, these signals are disabled in this design, and their I/O port lines provide handshaking in the conventional manner. It is a pity that this option was not designed into the chip.

Handling Floppy Disks

Floppy-disk-drive interfacing is handled by a Fujitsu MB8877A, which is an improved and yet cheaper version of the common 1793 controller. The Fujitsu device requires only a +5V supply, but for readers with a 1793, +12V is available on the circuit board, so either part may be used. To the Z80, the controller looks like a specialized microcontroller with its own instruction set, including directions to reset the system (i.e., move the head of the selected drive to the outermost track, track zero, as a means of getting the head over a known track), move the head to a particular track on the disk, and read or write one or more sectors or a complete track.

Inside the controller are several parameter registers, which are loaded with the track and sector numbers required before a command is executed and read from or written to during

Input/Output Board Specifications

Serial I/O

Speed	1 to 38,400 baud, separate receiver and transmitter clocks
Format	synchronous 5 to 8-bit, auto-search and sync.
	asynchronous 5 to 8-bit, 1, 1.5 or 2 stop bits
Control	RTS (ready to send) and CTS (clear to send)
System	RS-232C, +12V and −12V levels

Parallel I/O

Input	8-bit port, one low-power Schottky TTL load, Schmitt buffered
Output	8-bit port, TTL compatible, 5 TTL loads

Special I/O
3 MOS I/O lines operating event counters, pulse timers and Z80 interrupts

Disk I/O
Output lines can sink 40mA. Input lines terminated with 220Ω to +5V. Bus lines are active low, but have the following specifications:

Signal	Direction	Function
READY	Input	Implies disk in drive and rotating at correct speed.
RDDATA	Input	Raw data consisting of (nominally) 250nsec pulses.
WPRT	Input	Indicates disk in drive is write protected.
INDEX	Input	Pulses once every disk revolution.
TR00	Input	Indicates that head is over the outermost track.
WG	Output	Enables disk write circuitry.
WD	Output	Data to be written to disk.
LC	Output	Indicates that the write current should be reduced.
HLD	Output	Loads drive head against disk.
DIRC	Output	Sets direction of head stepping. Active means step in.
STEP	Output	Steps head one track in direction set by DIRC.
SEL0	Output	Selects Drive 0.
SEL1	Output	Selects Drive 1.
SIDE	Output	Selects Side 1.

FIGURE 4: Floppy-disk, serial and parallel input/output (I/O) are provided on the I/O board. The heart of the circuit is the 3801, which contains a parallel port, a usart for serial communications, four counter/timers and an interrupt controller.

data transfers between disk and Z80. The controller has two interrupt channels to the Z80 through the STI. One, DRQ, indicates that the controller is ready for data transfer and the other, INTRQ, that the controller has completed a command. In response to the second type, the system can read a status register within the controller to determine whether or not command execution ended satisfactorily or whether an error preempted the command—e.g., the sector could not be found or a write operation was attempted on a protected disk.

The circuit handles both single and double density for all sizes of floppy disk. Switch S201 selects double density when closed, and S202 is shown in the 5.25, 3.25 and 3.5 inch/300 revolutions/minute drive position (the other is for 3.5 inch/600 revolutions/minute and 8 inch).

The MB8877A does not provide all the facilities required for interfacing disk drives to a system. Data separation and regeneration of the data clocking signal are achieved by the SMC9216B (the B version, which is more expensive, is required for double density) and write precompensation by the 74LS195. It is possible to get all these facilities in one IC but at considerably greater expense and complexity.

Data is recorded on disk by converting the stream of data bytes into serial form and recording the occurrence of binary "ones" by reversing the sense of the flux recorded on the disk. The rate at which these flux reversals are made, and hence the amount of data stored, is limited by the caliber of the disk and recording head in the same way that higher frequencies are limited in audio systems. On playback, these transitions are sensed, amplified and returned to digital form.

Different systems have drives running at different speeds. Disks change shape, and data may consist of long strings of binary zeros, leaving long intervals where no transitions come from the disk. Thus additional and more regular information must be written on the disk to keep the playback process in step with the original recording rate. For this reason, extra flux transitions are inserted into the recording. For single-density recording, an extra transition is inserted between every data bit period, making sure that there is a lot of synchronizing information available during play-

back but reducing the amount of data transferred by half. In double-density recording, extra transitions are inserted only between bit periods corresponding to two adjacent zeros in the data bit stream, ensuring that an all-zeros sequence still contains some synchronizing data. By being inserted in a natural gap in the bit stream, however, the transitions retain the speed of the ideal system and do not ask for a recording density—i.e., a frequency response—greater than that needed for single density.

One method gives easier decoding at the expense of storage capacity, while the other optimizes storage at the expense of decoding complexity. Note that the physical requirement of the drive is the same for both methods, so descriptions of some drives as being "suitable for double density"— and the price premium—can be misleading.

SC84 Specifications

Processor
- 4/6MHz Z80 processor.
- Maximum 64K-byte RAM.
- 58K-byte RAM available using SciDOS.

Display
- Up to 32 lines of 96 characters fully programmable. Scrolling window determined by software.
- Graphics mode 0 gives 192 by 96 pixels, mode 1 gives 192 by 192 resolution. Characters and graphics may be displayed simultaneously.

Input/Output
- Up to four single or double-sided 8, 5.25, 3.5 or 3-inch disk drives may be used, either single or double density.
- RS-232 serial I/O data rates range from 1 to 38,400 baud with separate transmit/receive clocks. Synchronous serial I/O format is 5 to 8-bit auto-search and sync or asynchronous 5 to 8-bit with 1, 1.5 or 2 stop bits. RTS and CTR signals control serial data flow.
- Eight-bit parallel data input is buffered by Schmitt ICs. Eight-bit parallel output drives five TTL loads.
- Three MOS I/O lines operate event counters, pulse timers and Z80 interrupts. Four MOS timer lines are available for timing and sound generation.

Analog vs. Digital

Two data input signals are required by the controller. One is raw data from the disk drive, the other a clock signal derived from the data. The relationship between these two is that each half cycle of the clock signal is a window in which a data pulse must lie. There are two approaches to recovering the original clock signal—analog and digital.

The analog technique uses a phase-locked loop with a fast lock-up time. This is an effective technique, but requires adjustment of components for correct working and a fair amount of circuitry, not the least because the recovered frequency differs according to density and disk size.

The digital technique used here requires just one, albeit rather expensive, eight-pin IC, which extracts the clock signal from all permutations of density and disk size without adjustment. It works by dividing an 8MHz signal to the nominal clock rate—125kHz for 5-inch single density up to 500kHz for 3.5 or 8-inch double density—and adding or dropping a divider count to keep incoming data pulses two counts short of the maximum divider count. This roughly phase-locks data pulses to the counter rate—i.e., data pulses definitely fall within a window framed by the state of the most-significant counter bit *(Fig. 5)*. The data pulse is not centralized within the window as it would be ideally, but more than adequately meets controller-input specifications.

As hinted earlier, to get more data on a disk requires better and hence more expensive disks and drive heads. In practice, the head in particular will not be grossly overspecified. Adjacent flux changes interact. As flux changes become closer, the effect of this interference becomes more noticeable,
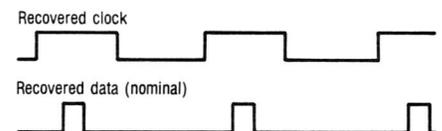
Recovered clock

Recovered data (nominal)

FIGURE 5: The only requirements on disk data pulses are that they should not start within 40nsec of a clock edge and that they must be entirely within one clock half cycle—i.e., they must not be longer than 300nsec for 8-inch double density or 600nsec for 8-inch single density. This gives a wide margin of error in data recovery.
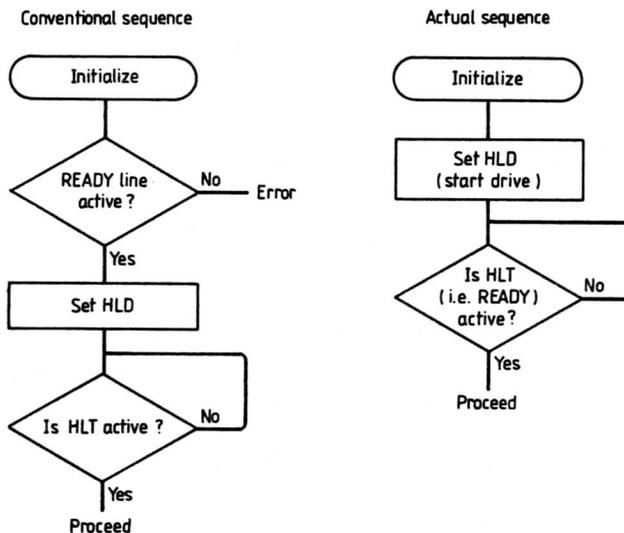
Conventional sequence

Initialize

↓

READY line active? ——No——→ Error

↓ Yes

Set HLD

↓

Is HLT active? ——No——→ (loop back)

↓ Yes

Proceed

Actual sequence

Initialize

↓

Set HLD (start drive)

↓

Is HLT (i.e. READY) active? ——No——→ (loop back)

↓ Yes

Proceed

FIGURE 6: Floppy-disk controller read/write execution sequence.

and transitions appear to be displaced on the disk and hence in time. Fortunately, the sense of the error is predictable, although its magnitude varies from drive type to type, so a correction—write precompensation—can be made before data is written on the disk.

The algorithm sensing whether a pulse should be written late, on time or early is implemented in the controller, and the 74LS195 parallel-loading shift register produces a compensation of +250nsec, zero or −250nsec, which are values shown to suit most drives. Again, the digital solution is preferred, with the write pulse loading a single bit into a shift register being clocked every 250nsec. The bit lines come from the controller "early" and "late" pins and from a gate that derives a "nominal" signal (logically *not early or late*). At the output of the register, a bit appears for one clock period, 250nsec, which is either late, 250nsec later or 250nsec still later, this being an effective method of simulating early, nominal or late write pulses.

Interfacing to the drives is standard in its signals, although you will see that the "ready" line from the drive, generally indicating that there is a disk in the drive and that it is rotating at the required speed, is not taken to the "ready" input of the controller (which is instead wired permanently active) but to the head-loaded test (HLT) input of the controller IC—an input usually driven by a monostable device triggered by the leading edge of the head load (HLD) signal coming from the controller.

Part of the algorithm followed by the controller when executing one of its read or write commands is shown in the flow diagrams *(Fig. 6)*. You can see that if "ready" is used conventionally, extra software and hardware must be provided to start the disk motors (unless they are left continuously running, which will shorten the life of both disk and drive motor) and then wait for the speed to stabilize before attempting to execute a controller command. In this system, the drive motor is turned on by the HLD signal, with drive connections labeled "Head Load" and "Motor On" (or the like) connected together. Ready being inactive does not abort the command; the controller simply starts the drive and waits for ready.

What of the time delay between sensible data coming from the disk and the missing pause normally inserted by the monostable device to give the head time to load? And is it a good idea to accelerate the disk with the head already loaded against it? Some drives such as the Tandon TM100 do not have a separate head-loading mechanism, and those machines that do usually gate ready with the loading signal within drive so the head will not load until the disk is up to speed. Head loading, settling delay and the time taken to get up to speed amount to less than one revolution. As the controller has to have counted five revolutions before it gives up attempting a command, this system optimizes the delay between a command being issued and its completion while using the barest minimum of hardware and software. As an example, the disk operating system loads and the directory is scanned and noted at just over one second when using double density.

Ready or Not...

Some drives do not give a ready signal. If so, leave the ready input to the computer open or wire it to the 5V supply. Also, some drives have optional links on their circuit boards, one

TABLE 3
SIGNAL CONNECTIONS FOR TYPICAL DRIVES

Signal	Sony D32 3.5 inch	Std 34 way for 5.25 inch	Std 50 way for 8 inch
READY	26	6	22
RDDATA	24	30	46
WPRT	22	28	44
TR00	20	26	42
INDEX	18	8	20
SIDE	16	32	14
HLD	14, 1	16, 2	18
WG	12	24	40
WD	10	22	38
LC	—	—	—
STEP	8	20	36
DIRC	6	18	34
SEL1	4	12	28
SEL0	2	10	26
GND	7-25	1-33	1-49

The 5.25-inch pattern is used on BASF, Canon, Shugart and Tandon drives, and the 8-inch pattern is used on DRE 7100 and 7200 types. Many other drives conform to these standards, but connections should be confirmed before the drive is used. Ground connections are joined over the range of odd-numbered pins indicated.

of which offers the choice of head loading being solely controlled by the drive-select line or by a combination of drive select and head load inputs. If so, use the latter option. Advice on using different types of drive will be available through the user group noted in the box at the end of the article.

Nominal allocation of drives is that there are two drives designated A and B by the disk operating system (DOS), hardware selection being by control lines SEL0 and SEL1 respectively. If double-sided drives are used, the reverse side of drive A will be designated C and that of drive B, D. This is nominal, as the selection of each logical drive surface can be altered temporarily (or permanently). Open-collector drivers are used between the interface and drive. It is important that the total length of the cable does not exceed 3 meters (less for the 3.5-inch drives) and preferably should be as short as possible.

Where more than one drive is used, drive-signal connectors are wired in parallel from the computer to the nearest drive, then from this drive to the next. The only exceptions to this are the SEL signals, which are individual to each drive although possibly carried by the same cable. You will find that 5.25 and 8-inch drives contain a pack of resistors usually in a dual in-line package plugged into an IC socket wired to the signal connectors and probably labeled 220/330Ω. These packs must be removed from all but the drive that is physically farthest from the computer.

It is good practice to provide a separate, well-rated power supply for the drives. Disk drives tend to take large amounts of current when the drive motor starts and when the head loads. This can momentarily overload the supply—with devastating results if the computer shares the same power source. Also, the ground lead between the drive and interface, which should be substantial, is happier when it carries only signals.

Table 3 gives connections to widely used disk drives. There are many secondhand drives around at the moment; buying such drives is rather like buying a secondhand car—there are bargains, but there is also rubbish. In particular, I would advise personal inspection and that you watch out for incomplete drives (large areas of circuit board without any components) unless they are a bargain and information on the missing parts is available.

TABLE 4
FORMATTED CAPACITIES
FOR SINGLE-SIDED DRIVES

Disk Size	Tracks	Single Density	Double Density
3.5″	70	140K	350K
3.5″	80	160K	400K
5.25″	35	70K	175K
5.25″	40	80K	200K
5.25″	80	160K	400K
8″	77	250K	616K

Also watch for worn head pads (the pad that pushes the disk onto the head) and, at least in the UK, for drives with 110V and/or 60Hz motors. *Caveat emptor.*

I would recommend that you obtain a drive with a distinct head-loading mechanism (usually a solenoid) rather than one that puts the head to the disk as soon as the door of the drive is closed. As for the choice between two single-sided drives and one double-sided one, there are many advantages to using two drives, such as the ease with which backup copies of disks can be made, reduced head replacement costs and the fact that the computer remains useful when one drive is out of action. Many types of drive—Sony, Canon/BASF, DRE, Shugart and CDC—have been used with the computer, and the names given in the table are not intended as an indication of merit. *Table 4* gives some typical capacities for drives used in single and double-density modes.

Next time, Mr. Adams will describe his visual display unit (VDU), including details on interfacing, memory and control.

Additional Information

Prototypes of the SC84 have been made in wire-wrapped and soldered wiring forms, the most recent version using Vero 03-2989L boards and wiring pen type 79-1732G. Suggested wiring layouts and component placement diagrams for these boards are available from *Computer Smyth*, Dept. SC-84-B, PO Box 176, Peterborough, NH 03458. Make sure you send a self-addressed, stamped, 9-by-12 envelope (postage for 3 oz.) when you request this information. A listing of the SC84's machine-code operating system, MCOS, is also available from *Computer Smyth* (Dept. SC-84-A). Please send a self-addressed, stamped, 9-by-12 envelope (postage for 2 oz.) for this information.

Construction using circuit boards is a much easier matter and will be the assumed method. When using these boards, the ICs should be soldered directly onto the boards, with the exception of EPROMs, which should be fitted in high-quality sockets. Sockets may be used if required, but only high-quality ones. Dynamic RAMs are best soldered in.

The natural fear is that of removing ICs should faults occur. This is quite easy, though, either by using a desoldering tool or snipping all the pins off the IC body and removing them one by one. A system as complicated as this should not be repaired using the swap-and-see technique. Standard pitches have been used for discrete components, details of which appear with each circuit diagram.

If readers express sufficient interest, a set of three Eurocard-format, plated-through hole boards for the SC84 will be available from Old Colony. The estimated price for the set is $72. Enter Fast Reply #860 on the Fast Reply Card if you are interested in purchasing the boards.

Old Colony will also offer software for the SC84. SciDOS with utility software is available for $35. Extended BASIC with graphics facilities costs $20, and BASIC with enhanced file manipulation, I/O control, numeric/constant string handling and 12-digit precision costs $30. For information on this and two ready-programmed EPROMs, enter Fast Reply #JH863 on the Fast Reply card.

An SC84 user group has been organized in the UK. For details about the group, send a self-addressed envelope with two postal coupons to John Hodson, 12 Broughton Rd., Basford, Newcastle-under-Lyme, Staffordshire ST5 0PQ, UK. If anyone is interested in forming an SC84 user group in the US, *Computer Smyth* will be glad to publish a call to action in our Classified section.
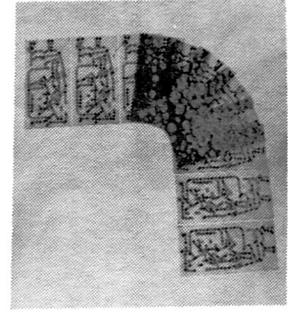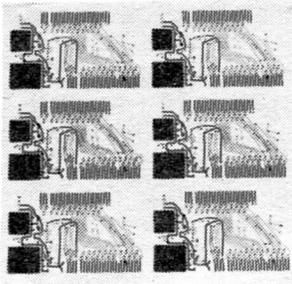
CAUDILL, INC.
Printed Circuit Fabrication
205 East Westwood Avenue
High Point, North Carolina 27262
(919) 884-0229
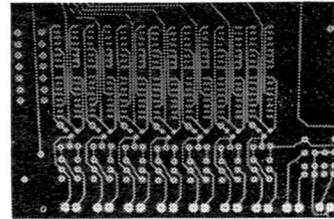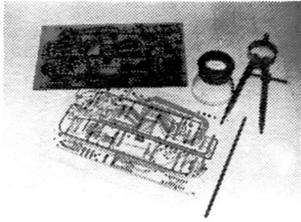
- Specializing in prototypes and small/medium production runs

- We close the gap between the large circuit manufacturers, with their high set-up charges and minimum orders, and the basement circuit shops with their poor quality boards.

- Quality boards, quality service, very reasonable prices

- Single and double-sided boards, plated-through holes

- Photo-reduction

- Computer-aided production, including CNC drilling

- All services done in-house

- Prototype service with turnarounds short as 24 hours

- Competitive quotes, call or write:
  CAUDILL, INC., 205 East Westwood Avenue, High Point, North Carolina 27262   (919) 884-0229
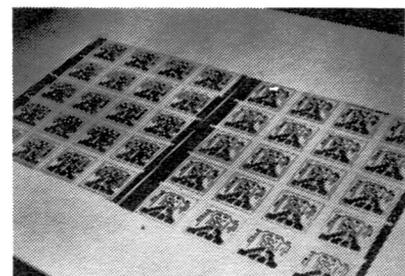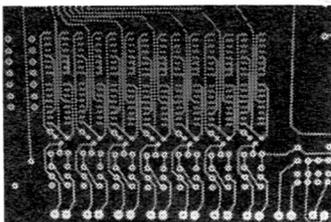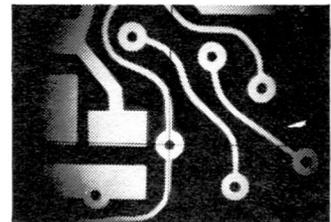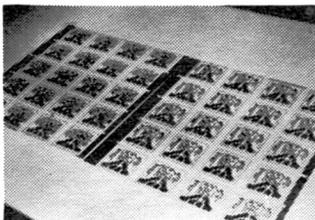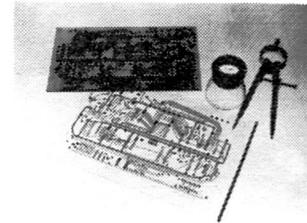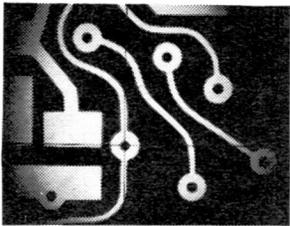
CHART YOUR COURSE

A Plotter/Charter

Anyone who has run frequency-response plots with an oscillator and an AC VTVM knows what a tedious and time-consuming task this is. In the past, whenever I read a test report or review, I looked longingly at the beautiful machine-run curves and plots. After years of frustration, I resolved to build a plotter of my own.

First I determined the design limits for my chart recorder:

■ All the components had to be readily available, off-the-shelf items.

■ All the components had to be affordable, which ruled out luxuries such as digital stepping motors for the drives.

■ Since I intended to use the unit to plot frequency-response curves, a single-speed chart drive would be adequate.

The pen drive would have to be some sort of servo to plot curves accurately.

■ Given the choice between fixed pen/moving paper and fixed paper/moving pen, I chose the latter after much experimentation.

pen as the "pen motor" and the motor that moves the pen assembly the length of the paper as the "carriage motor."

The first section of the servo circuit determines the pen motor's direction of rotation and thus the direction of pen motion. It is composed of IC1, the voltage-summing amplifier; IC2 and IC3, the window comparator; and Q1, Q2, K1 and K2, the relay driver transistors and relays. The voltage-summing amplifier sums the input voltage, the position reference voltage from R14 and the position voltage from R2. The resulting voltage is then fed to the inverted window comparator, which responds to voltages that are above or below the window rather than within its limits. See *Fig. 3* for a diagram of the operation.

This comparator is the "brain" of the servo. It is concerned with whether the input voltage is higher or lower than the position reference voltage, which is the indicator of the actual pen position. If the output of the summing amplifier is positive, IC2 will trip. This turns on Q1, pulls K1
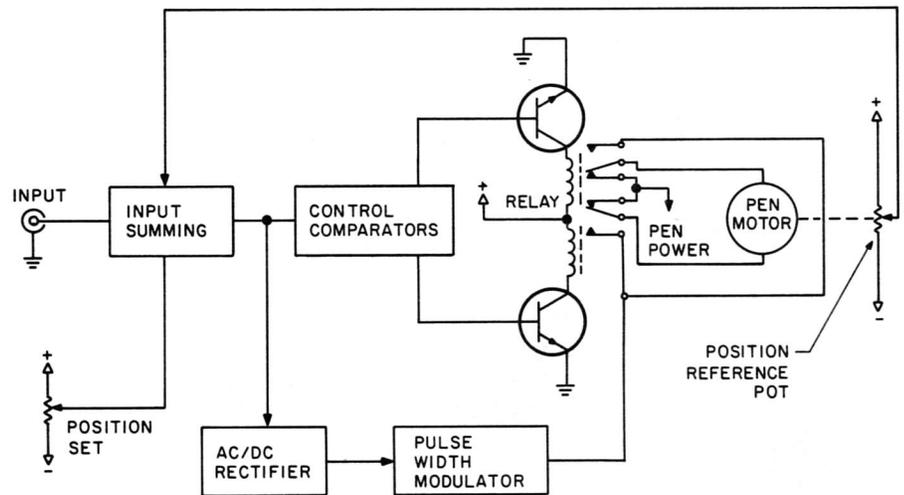
FIGURE 1: Block diagram of the servo circuit.

The Servo Circuit

The servo circuit *(Fig. 1)* is a null-seeking system, which means it will always move the pen to the spot that will produce a null. You could also describe this as a voltage-to-position converter. The complete servo schematic is shown in *Fig. 2.* Although conventional designs apparently use one circuit to determine pen speed and direction, I used two. (I say apparently because I could find very little reference material on the subject.) I refer to the motor that positions the

and applies power to the pen motor. If the output of IC1 is negative, IC3 will trip, turning on Q2, pulling K2 and applying power to the pen motor. In that case, the polarity is reversed, and the motor rotates in the opposite direction.

When the pen has moved to the proper position, the output of the summing amplifier will be very close to 0V. As soon as the voltage fed to the window comparator falls inside the trip points, both comparators will shut off, which turns off both relay

BY VERN L. MASTEL

drivers and cuts off power to the pen motor. Trimmers R9 and R11 set the limits of the window comparator. The size of the window is a function of the application (see my section on calibration below).

The second section of the servo circuit determines how fast the pen will move. This section is a pulse width modulator (PWM). *Figures 4* and *5* illustrate the basic principles of PWM. A triangle wave is fed to one input of the comparator, and the modulating voltage is fed the other input. The output pulse width is a function of the time between crossings of the triangle and modulating voltages. Note, however, that the output pulse amplitude need not have any relation to the modulating signal or reference triangle wave amplitudes. The equal heights of the triangle wave and output pulses of *Fig. 5* are only for illustration. In the chart recorder, the pulses are +15V, while the triangle and modulating voltages are each less than 2V.

Motor Operation

Now the pulses are fed to the pen motor. The motor acts like a low-pass
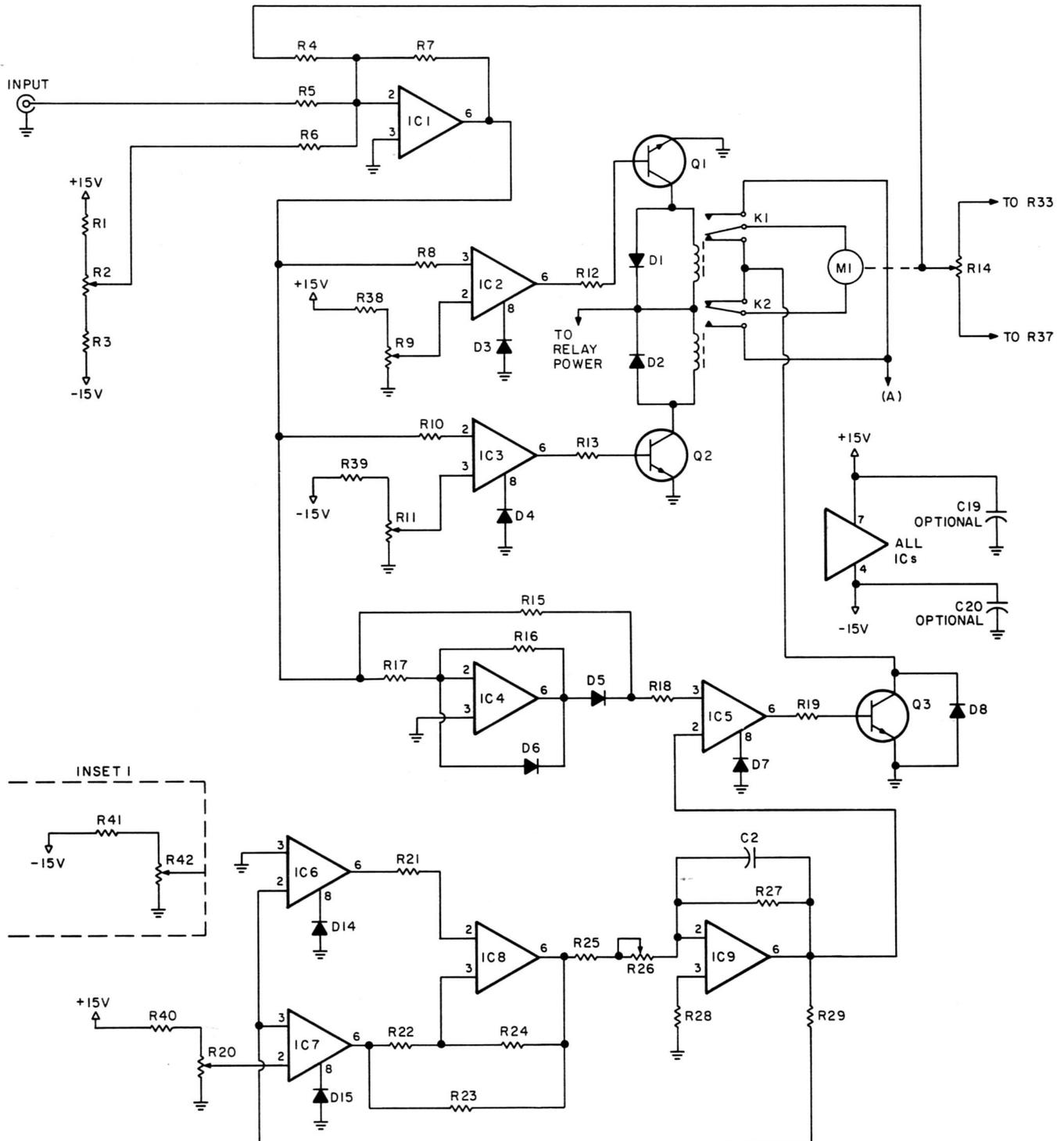
FIGURE 2: *Schematic diagram of the servo circuit.*

filter, averaging the pulses to produce a steady voltage. The longer the pulse, the higher the average voltage and the faster the motor turns. It takes a specific amount of time for a motor to begin to rotate once power is applied. The time is a function of the applied voltage, the number of poles in the motor, the bearing resistance and the magnetic efficiency. You must tailor the frequency of the drive pulses to make maximum use of the motor's characteristics. If the frequency is too high, the motor will behave as though it was not powered at all. If the frequency is too low, the motor will cog severely, causing the pen to jerk. My design allows you to fine-tune the PWM to match the motor you choose.

IC6–IC9 form the triangle wave generator, which is actually a sort of servo circuit that never gets balanced. IC9 is wired as an integrator, which always attempts to track the voltage applied to its input, with the rate of change being a function of the R26 setting. IC6 and IC7 are voltage comparators that look at the output of the
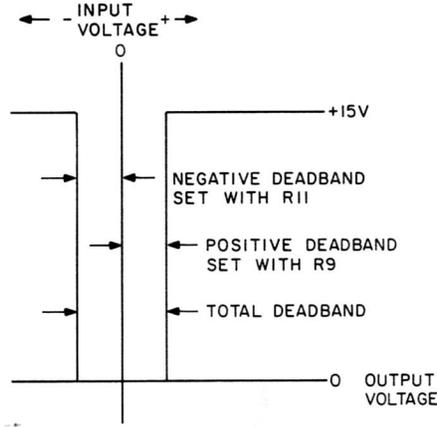
FIGURE 3: Operational diagram of the servo circuit's first stage.

integrator. IC6 is referenced to ground, while IC7 is referenced to a variable positive voltage set with R30. IC8 is a flip-flop whose output is at ±15V at any given moment depending on which comparator (IC6 or IC7) is high. The output of IC8 is the input for the integrator, which attempts to

swing to either ±15V. This is where the loop action takes control.

As the integrator output goes positive, it will reach a point where it is equal to the reference voltage of IC7. At that point, it trips the comparator and changes IC8 from +15V to −15V. The integrator now sees the −15V at its input, reverses direction and begins to discharge toward it. It will never reach this level, however, because when the integrator output reaches 0V, it will trip comparator IC6, changing the output of IC8 back to +15V and repeating the entire cycle. The integrator output is the source of the triangle wave needed for the PWM. The triangle wave circuit need not be used only in the chart recorder. It has an extremely wide operating range and can be used alone to generate triangle waves.

TRIANGLE REFERENCE

MODULATING VOLTAGE

PULSE OUTPUT

FIGURE 4: The sequence of steps in pulse width modulation (PWM). A triangle wave is fed to the input of the comparator, and the modulating voltage is fed to the other input.

PARTS LIST

Capacitors

C1	0.001μF, 25V disk ceramic
C2	1μF, 25V electrolytic
C3, 10	1,000μF, 25V electrolytic
C4, 6, 8, 11, 13, 15	0.1μF, 50V disk ceramic
C5, 7, 9, 12, 14, 16	100μF, 25V electrolytic
C17	1,000μF, 50V electrolytic
C18	100μF, 25V electrolytic
C19, 20	200μF, 25V electrolytic

Resistors*

R1, 3	22k
R2	10k pot
R4–7	100k
R8, 10	10k
R9, 11, 20, 33, 37, 42	10k trimmer
R12, 13	3.3k
R14	10k ten-turn pot (see text)
R15	2.7k
R16, 17, 38–41	27k
R18, 43	220Ω
R19	2.2k
R21	180k
R22	39k
R23	1.2M
R24	150k
R25	4.7k
R26	500k trimmer
R27	15M
R28	470k
R29	4.7k
R30–32	100Ω

R34–36	100Ω
R44	5k trimmer
R45	1k trimmer

*All resistors ½W, 10% unless otherwise noted.

Diodes, Relays, ICs

D1, 2, 8, 11–13	1N4002 silicon rectifier
D3–7, 14, 15	1N914 or 1N4148 silicon diode
D9, 10	SK3102 RCA bridge rectifier
K1, 2	SPDT relay (see text)
K3, 4	4PDT 24V relay
IC1, 4, 8, 9	741 op amp
IC2, 3, 5–7	LM301 op amp
IC10, 12	7815 regulator
IC11	7915 regulator
IC13	LM317 regulator

Motors, Switches, etc.

M1	pen servo motor (see text)
M2	pen carriage motor (see text)
S1	SPST switch (stop)
S2	SPST N.C. push-button switch (stop limit)
S3	SPST N.C. microswitch (reset limit)
S4	N.O. push-button switch (reset)
S5	N.O. push-button switch (run)
S6	N.C. microswitch (run limit)
T1	25.2V ct, 500mA transformer
T2	18V, 500mA transformer
Q1, 2	2N697 NPN transistor
Q3	SK3054 RCA transistor

Misc.—chassis, line cord, hardware, sockets. Refer to text for construction material details.

FIGURE 5: In pulse width modulation, the output pulse width is a function of the time between the crossings of the triangle and the modulating voltages.
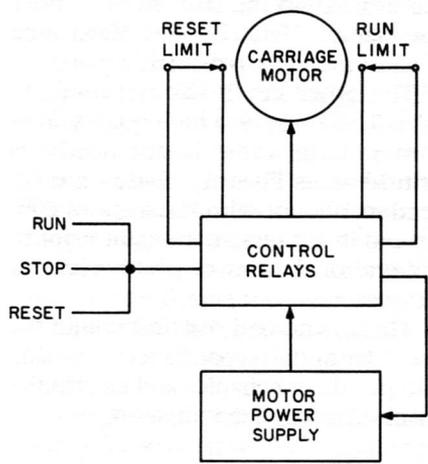
FIGURE 6: *Block diagram of the direction-control circuit.*

The PWM input voltage noted in *Fig. 5* is not the actual input voltage to be plotted. The input summing amp will always produce the difference between the input, the position set and the position reference voltages. Because this voltage can be either positive or negative, IC4's absolute value circuit ensures that the mod-ulating voltage is always positive. Thus, whether the input is above or below 0V, the pen will respond in the right direction and at a speed that tracks the input rate of change.

Pen Carriage

The pen carriage mechanism is quite simple in comparison to the pen servo. Its function is to move the pen the length of the paper and return it to its starting point when the trace is complete. The motor drive circuit is a simple variable-voltage power supply feeding the motor through a direction-control circuit. See *Fig. 6* for a block diagram of the circuit and *Fig. 7* for the actual wiring layout.

The regulator is based on the LM317, a three-terminal type needing only a pot, resistor, capacitor and diode to be complete. The direction control is made up of two 4PDT relays, two microswitches and three push buttons. The relays are wired to be self-latching—once energized they will remain so until the power is removed (sort of the electromechanical equivalent of the silicon-controlled rectifier [SCR]). The micro-switches are the run and reset travel-limit sensors, while the push buttons are the run, stop and reset controls. For the sake of clarity, the schematic of the direction-control circuit shows the basing diagram of the relays rather than the somewhat confusing conventional terminal arrangements.

Operation is straightforward. When you press the run button (assuming the pen is in the starting position), K4 is energized, applying power to the carriage motor. After the pen carriage travels the length of the paper, the limit switch (S6) is tripped, cutting off power to the relay and shutting off the motor. When you press the reset button, K3 is energized, reversing the pen carriage motor and also changing the applied voltage to a higher value. This makes the reset time much shorter than the run time. A manual pen lift is also incorporated to prevent retrace lines from spoiling the traces. I have tried powered pen lift, but it is bulky and consumes extra power.

Construction

I hate to use the term "junk-box construction," but it applies in this case.
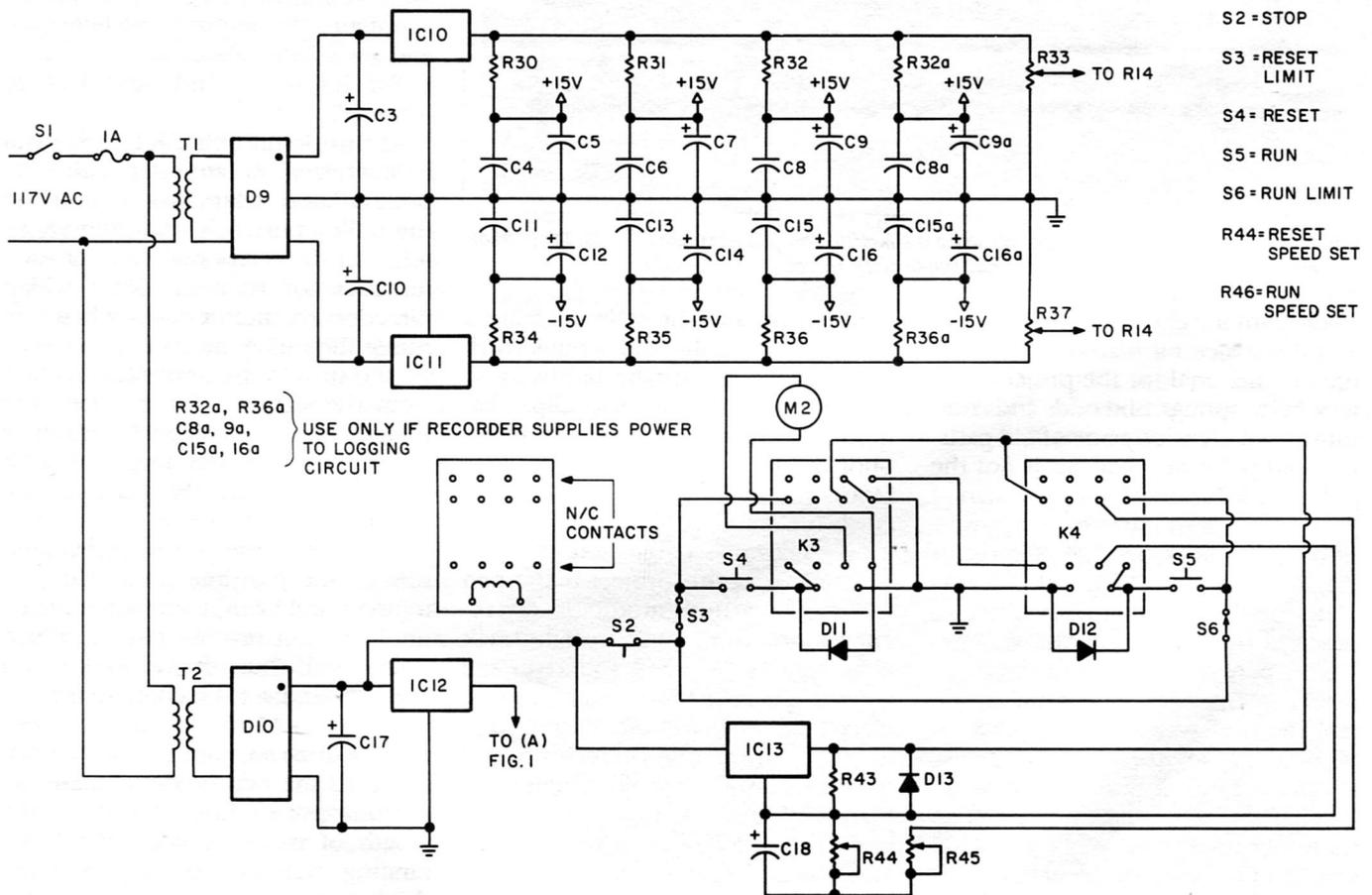
FIGURE 7: *Schematic diagram of the direction-control circuit and power supply.*
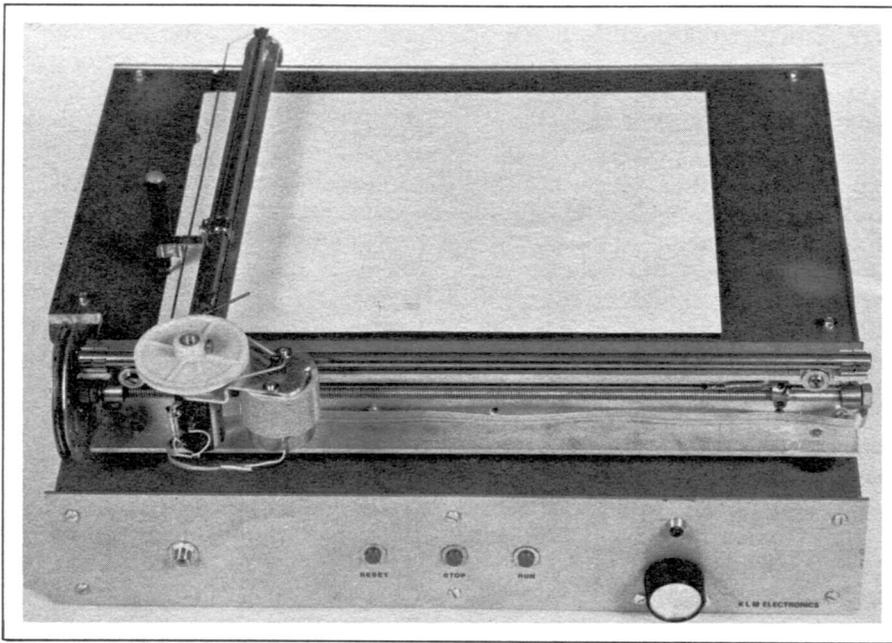
PHOTO 1: *The author's chart recorder is built in two separate sections. The upper one houses the mechanics and the lower one the electronics.*
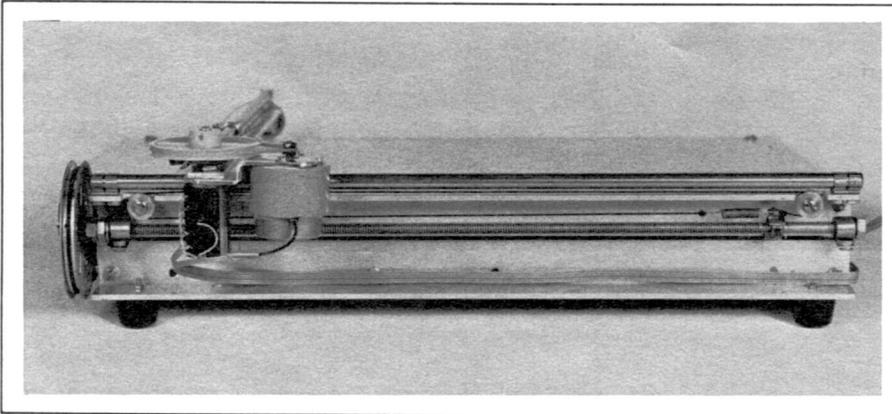
PHOTO 2: *Front view of the pen carriage drive mechanism and pen servo motor, with the position reference pot in the reset position. Overall length is 13 inches.*

Aside from the electronic components and the structural materials, most of the raw material for the project (pulleys, belts, springs, and odds and ends) came from my goody box of old parts. I should point out that this is not the only workable mechanical design. I have tried various approaches, many of which would work fine. Because of this, I will rely on *Photos* 2–7 to explain the design rather than trying to describe the unit in words.

The pen carriage frame is made from a ¾-by-¾-inch aluminum angle and the lead screw from a piece of ¼-inch coarsely threaded rod. (Finely threaded rod allows a longer sweep time.) These materials are available at most hardware stores. Buy several lengths of rod and sort them to get the the straightest one. The guide rods are made of brass and stainless tubing. The brass tubing came from a local

hobby shop and the stainless from a surplus store. Solid rod would work as well, but it must be lightweight, smooth and straight. The clips that hold the rods to the frames are phosphor bronze fuse clips from old fuse blocks and junk equipment. The drive cords are standard dial string from a local electronics emporium.

One key to this project is the pen servo motor. Both motors in my recorder are from junked eight-track tape players, which I found in the service department of my favorite electronics store. These motors have excellent torque, work very well on low voltages and usually come complete with pulleys. The only requirement is that they have a fast-forward lead, which bypasses the internal mechanical governor. If you do not have access to used motors, Jameco (1355 Shoreway Rd., Belmont, CA 94002)

has advertised the same motor under the names Mabuchi and Matsushita (Panasonic) at a reasonable price.

The other key is the pot used for R14. This must be a high-quality, ten-turn pot. Its value is not nearly as critical as its linearity. I used a dual-section 10k pot with the sections connected in parallel. You might want to try one of the newer plastic-element devices.

There is no real reason to build the recorder in two separate sections. You can put the mechanics and electronics in one package if you wish.

Calibration

After you have checked the wiring, it is time to test the unit. Do not install the pen motor drive belt yet. Set all the pots to their midpoints, then turn on the power and check for proper supply voltages. Be on the lookout for hot spots, and don't worry about what the pen motor or the window comparator relays might be doing.

Make the following adjustments:

■ Set R33 for +1.25V and R37 for −1.25V.
■ Set R20 for +1V.
■ Set R26 to its midpoint. A better approach is to connect a frequency counter to the output of the integrator and set R26 to about 20Hz.
■ Set R9 to +50mV and R11 to −50mV.

At this point, either K1 or K2 will be energized. Rotate the position set pot until both relays drop out. Rotate the pulley on R14's shaft and check whether the relays pull, one for each direction of rotation. Note which direction the motor turns when you rotate the pulley on R14. The motor should turn in the opposite direction from the shaft. If, for example, the pulley is rotated clockwise, the motor should turn counterclockwise. If it does not, reverse the leads to the motor.

Now install the pen drive belt and rotate the position pot. The pen motor should run, turning the pulley until the unit reaches null, at which time it will shut off. Go back to R9 and R11 and set the comparator trip points to ±15mV. If you have not already done so, connect the pen dial string to the pen holder. Rotate the position pot to move the holder the length of its guide rod. Watch for binding, chattering or slippage in the drive. I have found it helpful to buff the rod lightly with fine steel wool and lubricate it with a very fine oil.

You must trim the PWM circuit for optimum performance. Grasp the pen motor's shaft/pulley tightly enough so that it will not turn. With your other hand, turn the position pot about ⅛ of a turn. You will feel the motor attempt to turn as it is pulsed by the PWM. Adjust R26 for maximum torque. Notice that as the frequency increases, the torque drops rapidly, and as the frequency decreases, the pulses make the motor want to cog. I found a frequency of 20Hz to be just right.

The pen carriage needs little calibration. All you do is set the run and reset speeds. With my prototype, the maximum time for the run cycle was about 75 seconds I set the speed to give me a sweep of 67 seconds, however, mainly because at 75 seconds the carriage motor was on the verge of stalling. As I noted before, you need a finely threaded drive screw if you want a longer sweep time.

Once the speeds are set, make sure the pen carriage system works properly. The run button should start the sweep, the stop button should interrupt either run or reset, and the limit switches should control the travel of the carriage. Again, be on the lookout for binding, drive slippage and other problems that might interfere with smooth operation.

Additional Considerations

The performance of your chart recorder will be a trade-off between positional accuracy and pen response speed. For example, if you want maximum speed, you must tolerate increased overshoot and ringing in the system. Above a point on R20, the servo can actually be made to oscillate as it tries to null itself. For best positional accuracy, you should use as small a comparator window as possible. I have used as little as ±5mV with no problems. I recommend that you experiment with the operating parameters to find the balance between speed and position that suits your application best. If, like me, you are after frequency-response plots, I recommend the calibration values discussed earlier.

In *Fig. 2,* the schematic of the pen servo, note the addition of Inset #1, an optional circuit I recommend if the primary function of your recorder is plotting curves. This allows the triangle wave to go below 0V and in so doing establishes a minimum pulse width for the drive, which improves
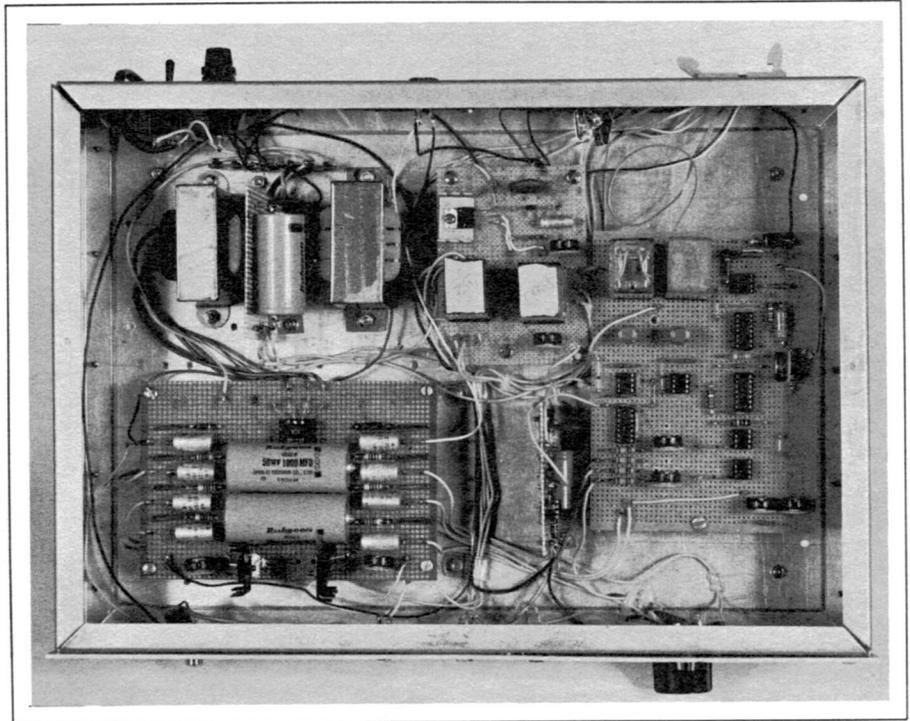
PHOTO 3: Inside view of the electronics package.
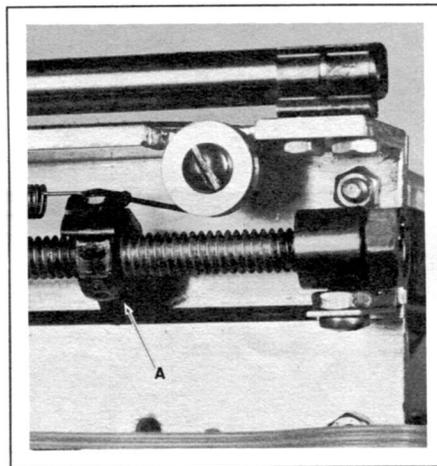
PHOTO 4: Close-up of the end of the drive screw, including the limit switch trip lever (A) and the drive nut connection arrangement. The reference pot is shown in the full reset position.

the pen response at the null point. Keep the voltage low (I use −15mV), otherwise the response at null will be jerky. I do not recommend using this circuit if step-response plotting is your primary use.

The relays I used for K1 and K2 are conventional types that buzz and chatter as the servo is operating. You might consider using reed relays, which are much quieter.

I have included a layout of what I consider to be the most important portion of the chart recorder—the servo circuit *(Figs. 8* and *9).* I did not include the power supplies or pen carriage sections because of the options available to the builder. For example, when I showed the unit to a friend, the first remark he made was to ask

PHOTO 5: Bottom view of the pen carriage, drive motor, wiring and limit switches. A is the run limit, B is the reset limit, and C is the trip lever attached to a nut on the drive screw.

why I had not made a "true" plotter. (In such a plotter, servo circuits would drive the pen and pen carriage.) I had not even considered the possibility. In addition, any changes you might make in the relays, control mechanism or electronics would render an all-in-one board difficult or impossible to handle. Since problems such as distortion, crosstalk and frequency response do not apply to this project, point-to-point wiring and vector-board construction present no problems. Note on the board layout that I allowed room to use either 1741 or 741 ICs. (The 1741 is the 14-pin DIP version of the 741.) My recorder has 1741s.

My chart recorder is interfaced with an MITS SG-1900 function generator (now discontinued) and a slightly modified Paul Bunyan Logger* (*The Audio Amateur,* 3/82, p. 14) to form
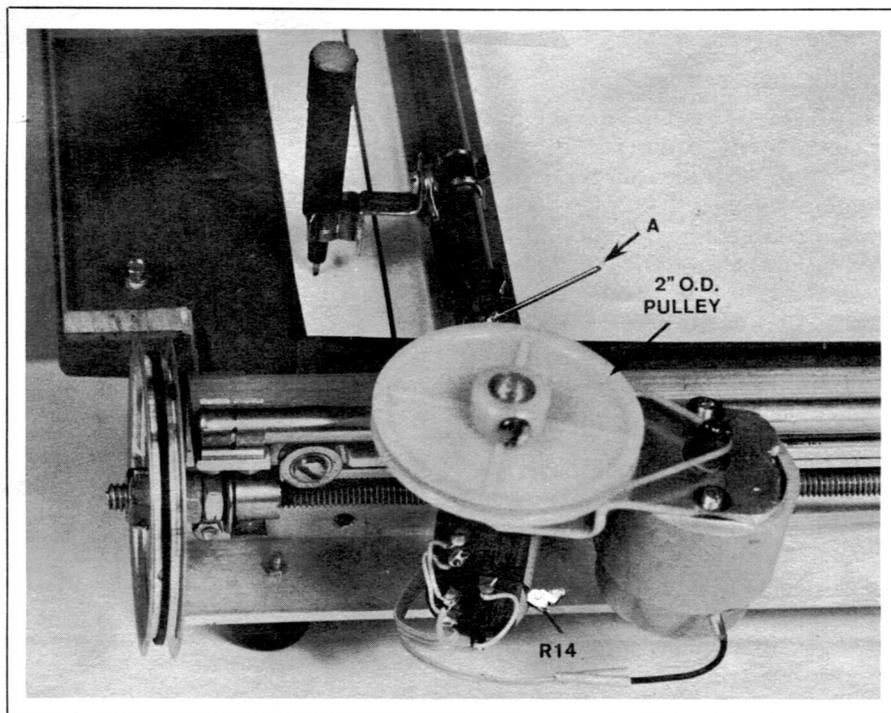
PHOTO 6: Top view of the pen holder, pen lift wire (A) and slide construction. The diameter of the drive pulley is 2 inches, while the Plexiglas writing surface is ¼ inch thick. The pen is a fine-point marker that has been cut off.
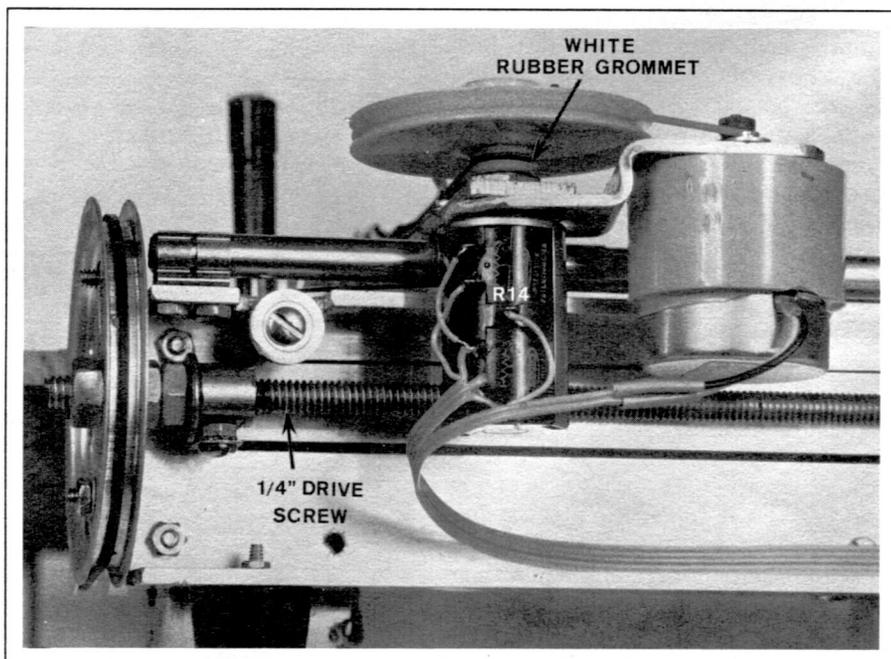
PHOTO 7: Low-angle front view of the pen motor/drive pulley and the dial string for the pen drive. Also shown is a soft, white grommet and a mounting clip for the pen carriage guide rod.
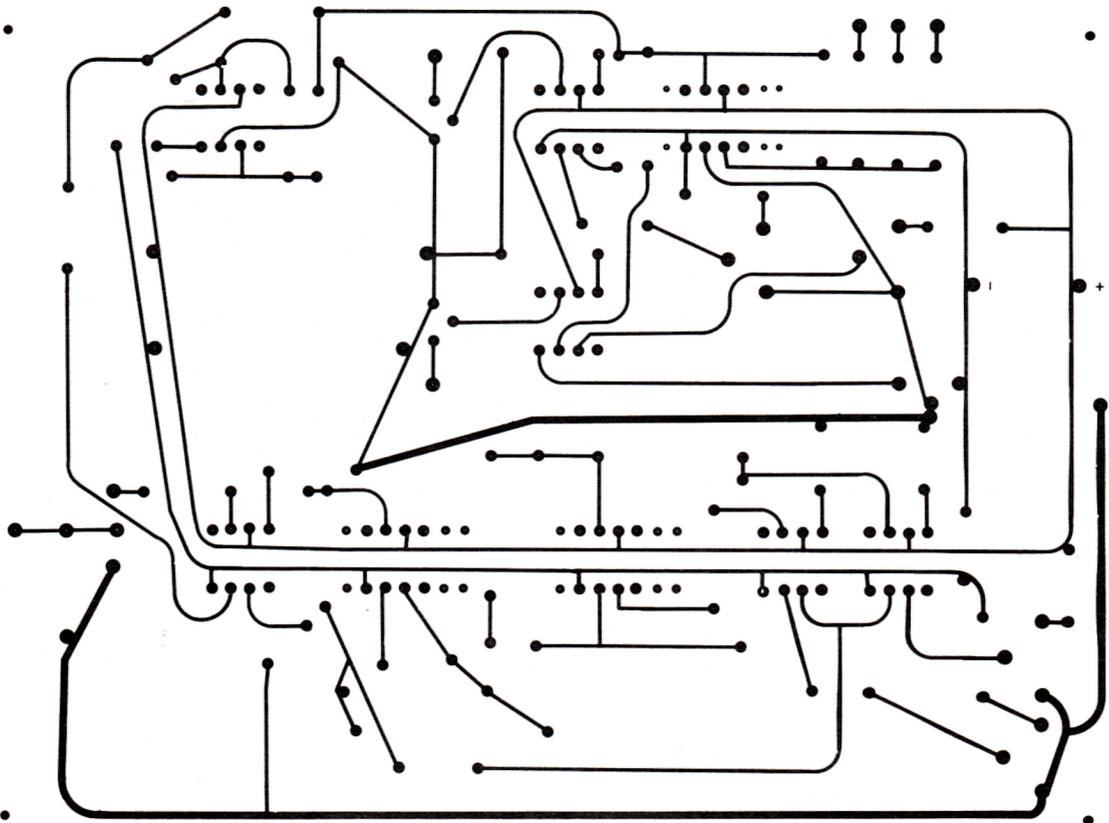
FIGURE 8: *Circuit board pattern for the servo circuit. Enter Fast Reply #859 if you are interested in buying the board (estimated cost, $9.50).*
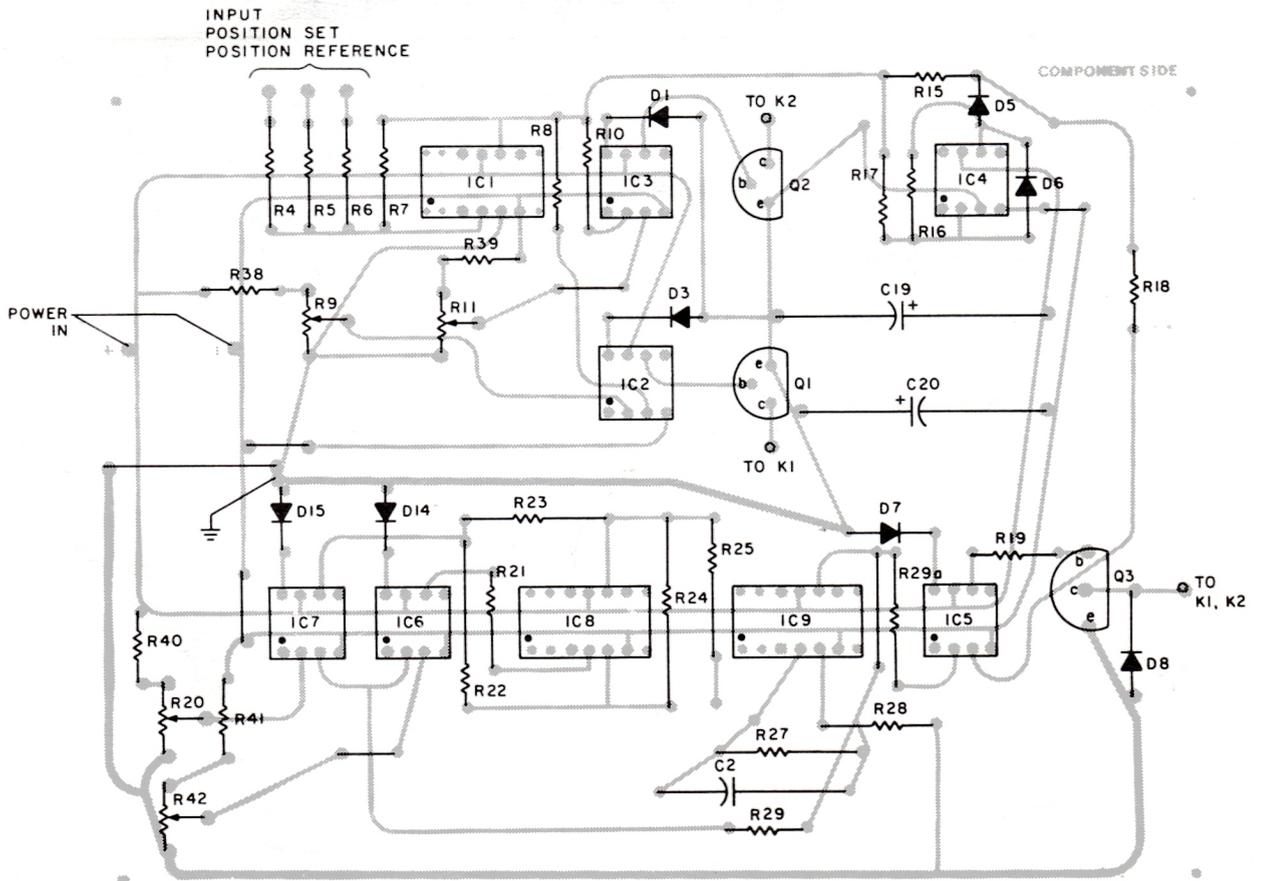
FIGURE 9: *Stuffing guide for the servo circuit. Note that R42 is optional. See text.*

Advertising in *Computer Smyth's* classifieds can give you a big jump on the competition. But before you submit an ad for publication, make sure you understand how our system works best for you.

Ads are filed as received, set in type late in the magazine production cycle, and put on page approximately one month before the magazine is mailed. Delivery of the mailed magazine can take from four days to three weeks.

Personal classified ad copy that is included in one issue is discarded when it goes on the page, and a new file for the next issue is begun. Ads arriving after the issue closes will be run in the next issue.

We strongly suggest that you keep a carbon or photo copy of your ad. We ask your cooperation in following these rules so that we can give you the best possible service.

1. All "For Sale" ads must be personal sale and not for profit. Ads for resale at a profit must be submitted as "Trade" ads at 70¢ per word, prepaid.

2. Ads are limited to one per issue, 50 words or less. A word is any collection of letters or numbers with a space on both sides of it. Words over 50 must be prepaid at 20¢ per word. Longer ads not prepaid will be discarded and not published.

3. Ads cannot be returned. We will make every effort to substitute a revised ad for an earlier submission if both are clearly labeled with the same name and address at the top of the sheets.

4. Copy for ads or corrections to ads will not be taken by telephone. We cannot answer telephone queries about whether or not an ad is in a particular issue.

5. Ad copy should be clearly printed in block capitals or typed. Illegible ads will be discarded.

6. If you include only your name and a telephone number in your ad, your full name, street address, city, state and zip must accompany the copy.

7. Personal ads are a free service to current subscribers. It will help us a lot if you include your subscriber number (upper left corner of your mailing label) with your ad.

8. If you want an acknowledgment of your ad, including in which issue it will appear, please include a stamped, self-addressed post card with your ad copy.
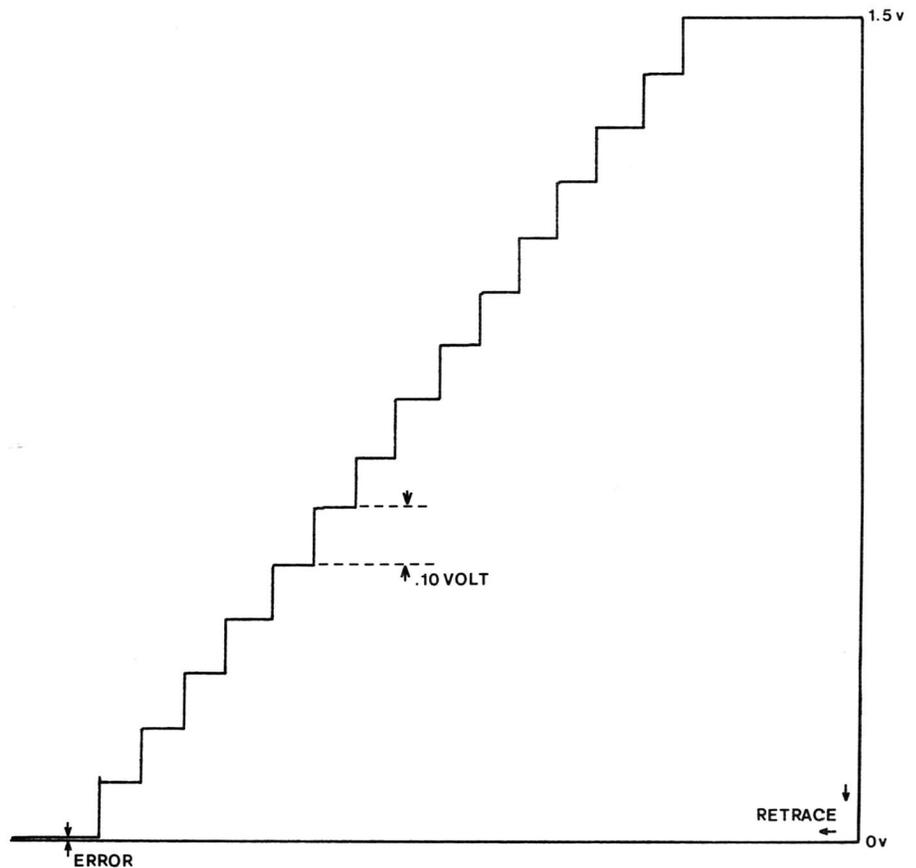
FIGURE 10: *Manually generated stepped voltage trace showing overall linearity and positional error for a complete plot and retrace cycle. Shown at approximately one-half scale.*
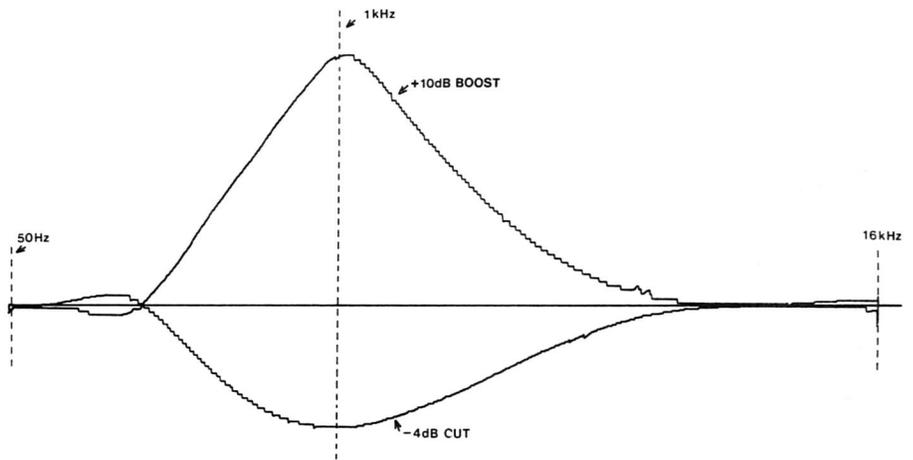
FIGURE 11: *Complete system-frequency plot of a five-band equalizer set alternately for boost and cut. Shown at approximately one-half scale.*

a complete plotting system. The Paul Bunyan was a real improvement over the home-brewed logger I had been using, and I recommend it as a standard working companion. If any of you has an SG-1900, it needs only one modification to make it work with the recorder. Connect a pair of normally closed contacts on the run relay (K4) across the generator's reset button. When you press the run button, the generator will begin its sweep along with the recorder. If you have a Sorcerer's Apprentice* (*The Audio Amateur,* 2/81, p. 21), a similar setup might be possible, although I have not tried it. □

*The Paul Bunyan Logger ($85) and Sorcerer's Apprentice ($145) are available from Old Colony Sound Lab separately or as a pair ($225). For more information, contact Old Colony, PO Box 243, Peterborough, NH 03458.

WHY YET ANOTHER COMPUTER MAGAZINE?

Dear Publisher:

I think the *Audio Amateur* is the best hobby magazine published. You should be very proud of your accomplishments over the past decade. I thank you for your effort!

I wish a similar magazine existed for computers. *Microsystems* and *Doctor Dobbs Journal* are very good for software, but there is no magazine devoted to computer hardware. This is very unfortunate. Currently IBM and Intel seem to have a strangle hold on the hobbyist marketplace. It is not very difficult to build a computer which makes the IBM PC look like a 4-function calculator.

We are in a stagnant holding pattern using hardware concepts which are history. The 8088 and 8086 are not much more than stretched 8-bit processors. (Compare the register names and instructions to the 8085 if you doubt this statement.) There are several very interesting 16-bit alternatives which have not received the attention they deserve—the Motorola M68000, the Zilog Z8000

and the National NS16032. Very soon production quantities of 32-bit processors (Motorola's M68020, Zilog's Z80000 and National's NS32032) will be available. These, along with new VLSI coprocessors and peripheral chips, will make it very easy and reasonably inexpensive to build very advanced and useful computers.

If you ever decide, against the odds of all those "me too" microcomputer magazines, to publish the *Analytical Engine Works Amateur*, please let me know. I want a lifetime subscription. One 64-page issue a year of a computer magazine at the level of the *Audio Amateur* would be a 100% improvement over what is currently available.

I look forward to many years of reading your useful, interesting and very enjoyable magazine. Please keep up the outstanding work!

Sincerely,
Ed Scott
Glendale, CA

ALL WRAPPED UP

A $30 Wire-Wrap Tool

A wire-wrapping tool is one of those luxuries that you don't really need and can't really afford, but that sure would come in handy on occasion. One of those occasions arose a few years back when I had to wire up a couple of kilobytes of 12-bit RAM for my oddball microcomputer. The only reasonable way to wire it was to use a wire-wrap gun, but I did not want to add $87 to the price of the memory. After investigating all the options, I finally decided to spring for a commercial gun, only to find that batteries, charger and tax brought the total to nearly $150. That's when my Scotch genes took command, and the search for a cheaper way began.

When I tried to rent a wire-wrap gun at my friendly neighborhood computer store, the folks there became slightly less friendly. Confronted with this chilly reception, I decided to make my own gun and bought an OK wire-wrap bit instead. By that time, the sales clerks were smiling again. Either they were happy to get my three dollars, or they were choking back a snicker.

Unlike etched circuit boards, wire-wrapped circuits do not have to be perfect on the first attempt. My method of wire wrapping was rather cumbersome, but I quickly fell in love with the ease of circuit assembly using wire-wrap techniques. As might be expected, I came to crave a more portable and docile wrapping tool, and I knew that a good wire-wrapping tool could be made for almost nothing.

Creative Construction

I built the device described here *(Fig. 1)* in two hours. All the parts are inexpensive and readily available, and no precision measuring or machining is required. You can make the device with only a tube cutter, a small round file, a soldering tool and an electric drill, although a drill press and a belt sander save time. One caution concerning construction is in order. I made my first device in about two hours, then I "hurried" on the second one and finished it in three hours. If you take your time and get everything right before assembly, construction is much easier.
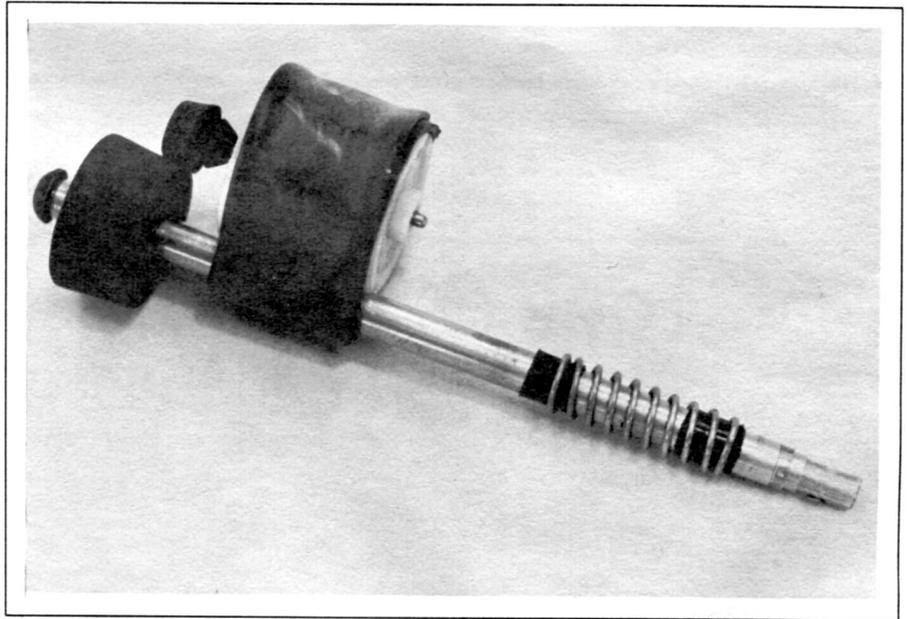
FIGURE 1: All the parts for Mr. Neely's wire-wrap tool are inexpensive and readily available.

I went home and chucked the bit in my electric drill. No luck. The drill was so heavy that there was no feel for the wraps, which were often mashed, broken or overwound. Next I chucked the bit in my Dremel Mototool, using a foot-controlled speed switch to limit the rpm. After some practice, this system consistently produced good wraps, but it was still heavy and touchy to use.

The main body of my wire-wrapping tool is made of ¼-inch outside diameter (OD) brass tubing, while the rotating center shaft is made of the next smaller size (0.218-inch OD) telescoping tubing. These tubes are sold in 12-inch lengths at any hobby shop. The outer tube should be about 4 inches long and the inner rotating tube about 5 inches long (depending on the thickness of your rubber

BY DEREK NEELY

Derek Neely is employed as a research engineer for a large metal fabricating firm. Although educated as a mechanical engineer, he has worked with instrumentation and computer data acquisition and control systems.

wheel, #10). The length is not critical, as extra length can stick out at the bit end. If you use a tube cutter, the tube will have a smaller inside diameter at the cut, and you will have to file it until the inside diameter is back to the original size. A hacksaw or bandsaw does a better job, but you must still deburr the tube. Take care not to crush the tube if you hold it in a vise.

After you have cut and deburred the main tubes, slide the smaller tube into the larger and check for free rotation *(Figs. 2* and *3)*. If it rotates by hand, it is probably all right. It is okay if it is a little stiff, as you will oil it later.

Next run a #10-32 tap into the drive wheel end of the small tube *(Fig. 4)*. If you gently hold the end of the tube with pliers after the tap is part way in, the threads will be cut a little more deeply. These threads will be very shallow, so do not tighten the screw too much.

The Driven Wheel

You have many options for the driven wheel (#10), which should be about 1 inch in diameter and ¼ inch or more thick. The pinch wheel from an old tape recorder works very well if you can find one. Toys and phonographs are other sources. If all else fails, the idler wheel from an 8-track cartridge will work, although it is a little small.

The driven wheel should fit snugly on the rotating shaft. If it is very loose, shim the shaft with a short piece of the ¼-inch OD tubing. If it is too small, drill the wheel hub. Be sure to drill it straight, or the wheel will wobble. You can also build up the shaft with solder or epoxy to get a good press fit. Don't rely on the screw to prevent the driven wheel
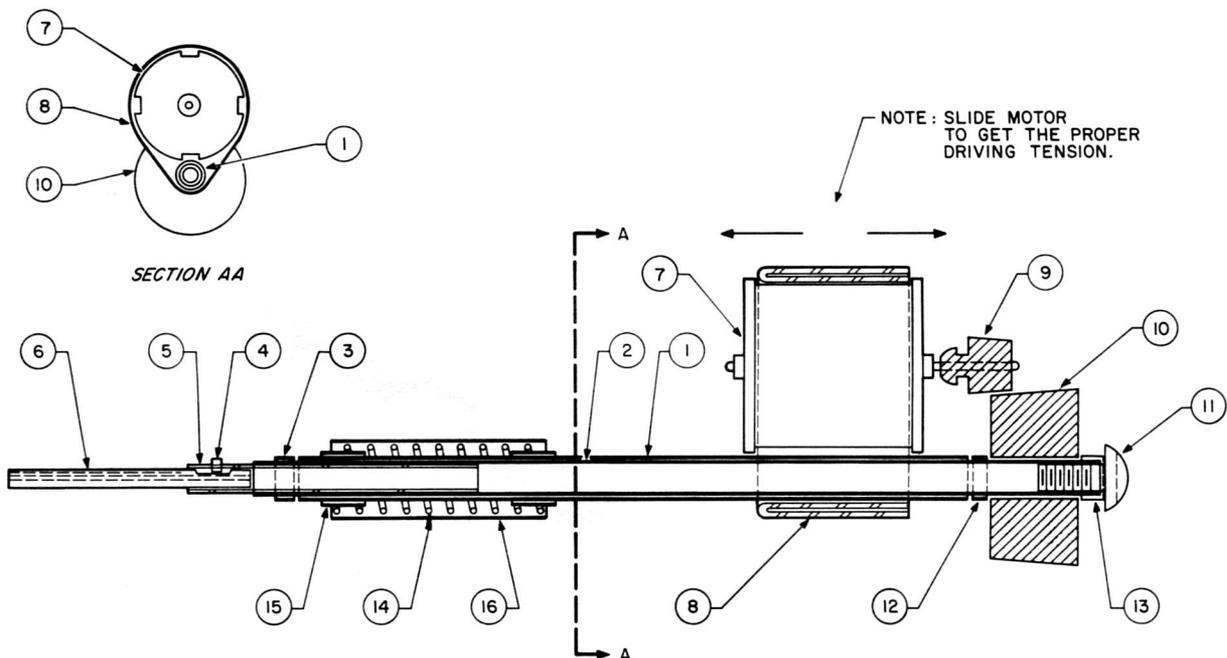
FIGURE 2: Schematic diagram of the wire-wrap tool.
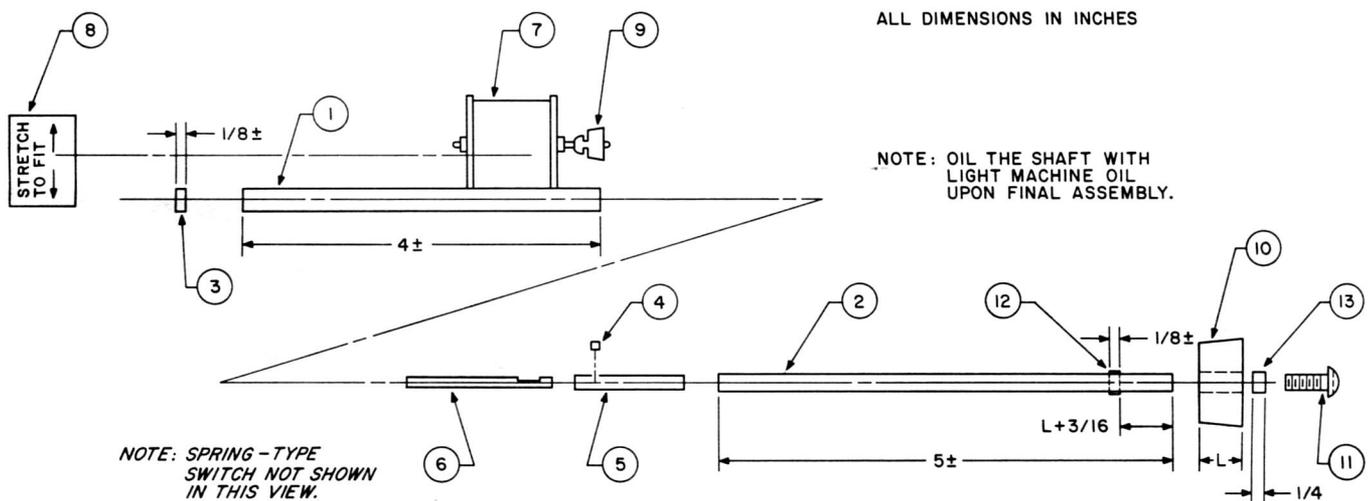
FIGURE 3: Exploded view of the tool's assembly.

B. G. MICRO

P. O. Box 280298 Dallas, Texas 75228
(214) 271-5546 MasterCard VISA AMERICAN EXPRESS Card
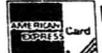
74LS

LS00	.20	LS163	.45
LS01	.20	LS164	.65
LS02	.20	LS165	.90
LS03	.20	LS166	.99
LS04	.20	LS169	1.25
LS05	.20	LS174	.45
LS08	.20	LS175	.40
LS09	.20	LS181	1.50
LS10	.20	LS191	.90
LS11	.20	LS192	.80
LS12	.35	LS193	.80
LS13	.40	LS194	.65
LS14	.40	LS195	.60
LS15	.32	LS196	.70
LS20	.20	LS197	.85
LS21	.25	LS221	.65
LS27	.28	LS240	1.00
LS30	.20	LS241	.80
LS32	.25	LS242	1.00
LS33	.40	LS243	1.00
LS37	.33	LS244	1.00
LS38	.30	LS245	1.00
LS42	.40	LS251	.50
LS51	.24	LS253	.50
LS54	.25	LS257	.50
LS55	.24	LS258	.55
LS73	.35	LS259	2.00
LS74	.30	LS260	.50
LS85	.60	LS266	.40
LS86	.25	LS273	1.00
LS90	.50	LS279	.40
LS93	.55	LS280	1.00
LS107	.37	LS283	.50
LS109	.25	LS290	.85
LS112	.30	LS293	.85
LS122	.45	LS298	.75
LS123	.55	LS299	1.60
LS124	2.75	LS323	2.60
LS125	.40	LS348	.75
LS126	.49	LS364	1.10
LS132	.50	LS366	.45
LS133	.35	LS367	.50
LS138	.45	LS368	.40
LS139	.40	LS373	1.00
LS151	.45	LS374	1.00
LS153	.50	LS375	.50
LS154	1.20	LS377	1.00
LS155	.50	LS378	.85
LS156	.50	LS390	1.00
LS157	.40	LS393	1.00
LS158	.50	LS399	1.25
LS160	.65	LS670	1.50
LS161	.50	25LS2569	3.00
LS162	.65		

TTL

7400	.22	7472	.25	74161	.60
7402	.22	7473	.34	74162	.60
7405	.22	7474	.40	74163	.60
7406	.33	7483	.45	74164	.80
7407	.33	7485	.55	74165	.80
7408	.24	7486	.30	74166	1.00
7410	.19	7490	.35	74173	.75
7413	.33	7493	.33	74174	.85
7420	.22	7496	.40	74175	.80
7425	.25	74107	.28	74181	1.50
7427	.25	74109	.45	74185	1.70
7428	.25	74121	.27	74192	.70
7430	.20	74123	.40	74193	.80
7432	.27	74125	.49	74195	.80
7433	.25	74132	.40	74199	1.00
7440	.19	74148	1.00	74221	1.00
7442	.40	74151	.50	74273	1.75
7448	.65	74153	.50	74365	.60
7451	.20	74154	1.19	74366	.60
7453	.22	74157	.50	74367	.60
7454	.22	74160	.80	74390	1.40

EPROM

2708 1KX8 450 n.s.	2.20
2758 1KX8 +5V 450 n.s	2.00
2716 2KX8 450 n.s.	3.20
2716-1 2KX8 350 n.s.	4.95
2732 4KX8 450 n.s.	4.00
2732A	5.50
2732A-35	4.75
2532 4KX8 450 n.s.	3.00
2764-25	5.00
2764-45	3.75
27128-25	10.00
27128-3	9.00
27128-45	7.50

EPROM SPECIAL

We bought a large quantity of 2708s from a computer manufacturer who redesigned their boards. We removed them from sockets, erased and verified them, and now we offer the savings to you. Complete satisfaction guaranteed.

2708
$1.49 or 10/$12.00

STATIC RAM

2016-2KX8 200 n.s.	8/20.00
2101-1 - 256X4 500 n.s.	.75
21L02-1 350 n.s.	.65
2102AL-4 L.P. 450 n.s.	.49
2111-1 256X4 500 n.s.	2.00
2114L-3 1KX4 300 n.s.	1.50
	8/10.00
2125A-2 1KX1 70 n.s.	2.20
2142-3 1KX4 300 n.s.	1.50
2147 4KX1	3.95
TMS4044 (MCM6641 C-25)	
4KX1 250 n.s.	8/6.00
6116P-4-2KX8	
200 n.s. CMOS	8/20.00

4K STATIC RAMS

LESS THAN 50¢ EACH
MK4104J-4 - 250 N.S. 18 Pin Ceramic Computer Mfg. Surplus. PRIME. Fully Static. Easy to Use. Has Same Pin Out as TMS4044, but slightly different timing. With Specs. (Mostek)
8 for 5.00   32 for 15.95
VERY LOW POWER!

DYNAMIC RAM

2108-4 8KX1	1.50
2118-4 16KX1-5Volt	1.50
4027-4KX1-250 n.s.	.80
4116-16KX1-250 n.s.	8/6.00
4116-16KX1-200 n.s.	8/7.00
4116 16KX1-150 n.s.	8/10.00
4164- +5v 64K 200 n.s.	8/16.00
4164 150 n.s.	8/18.00
TMS4416-16KX4-150 n.s.	3.95
MK4516-15 16KX1-5Volt	1.50
5280N-5 (2107B-4 • TMS4060)	
4KX1	8/3.95
41256 150 n.s.	8/68.00

SPECIAL

AY3-8910
W/60 Page Manual
New Price — $7.00

58321 Clock-Calendar 2.95

8000

Z8002	20.00	8085	4.75
8035	4.50	8086-2	24.95
8039	4.50	8087-3	149.00
8080A	1.25	8088	15.00

8200

8202A	10.00	8255-5	5.00
D8203-1	29.95	8257	6.00
8212	1.50	8259A	3.50
8214	2.00	8259C-5	5.00
8216	1.75	8275	14.95
8228	3.25	8279-5	5.75
8237-5	7.50	8284	3.20
8250B	9.95	8287	5.75
8251	4.20	8288	7.50
8253-5	6.75		

Z80

Z80 2.5 MHZ CPU	1.25
Z80CTC	1.25
Z80DMA-DMA	7.50
Z80PIO	1.49
Z80SIO/O	3.99
Z80A-4MHZ CPU	1.99
Z80A-CTC	1.99
Z80A DART	7.50
Z80A-DMA	9.00
Z80A-PIO	1.99
Z80A SIO/O	5.99
Z80B 6 MHZ CPU	7.95

F.D. CONTROLLERS

1771 Single Density	12.95
1791 Double Density	20.00
1793 Special	12.50
1797	17.50
2793	22.00
2797	20.00

CONTROLLER SET

THREE CHIP SET
1797 or 1793, 2143-03, 1691
by W.D. Compare at up to 86.85.
B.G. SPECIAL
All 3 for only $22.95

UART

TR1602B (COM 2017)	1.75
IM6402-(1863)+5v High speed	
AY5-1013 pin out	2.95
INS 8250B	9.95

6800

6800	2.50	6840	10.00
6802	3.50	6845D	7.50
6803	5.00	6845S	7.50
6809EP	3.99	6850	2.60
6810	2.00	68A09EP	4.99
6820	3.25	68A21	3.00
6821	2.00	68B45	10.00

6500

6502	2.60	6545	5.00
6522	6.95	6551	5.00

SPECIALS

9216	4.95
TM599532	19.95
BR1941L	5.95
LF353	.60
LF356	.60
TL494	2.50
LM555	.30
9401	5.00
DS8835	1.50
MC4024P	2.50
NE592	1.00
MC1350	1.00
LM2917	1.00
LM339	.50

SOCKETS

Low Profile SOLDER TAIL

6 Pin	14/1.00
8 Pin	13/1.00
14 Pin	10/1.00
16 Pin	8/1.00
18 Pin	8/1.00
20 Pin	7/1.00
22 Pin	7/1.00
24 Pin	6/1.00
28 Pin	6/1.00
40 Pin	5/1.00

BUY $10
GET $1.00 - FREE CHOICE

2114 SPECIAL!

COMPUTER MANUFACTURERS EXCESS INVENTORY SALE!
PRIME! 2114-300 n.s.
INCREDIBLE PRICE!
YOU SAVE!
8/$8.00
GUARANTEED

CRYSTALS

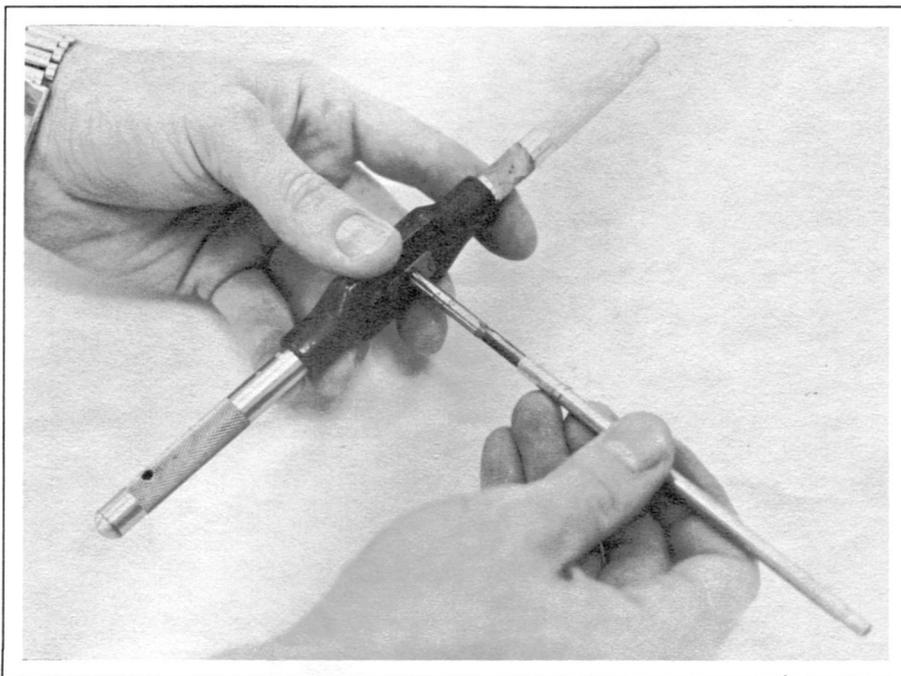|	
32.768 Khz SPECIAL	.65
262.144	.75
300.000	.75
1.5432 Mhz	.75
1.8432	2.49
2.000000	2.49
2.560	1.49
3.000	1.15
3.120	1.20
3.2	1.49
3.4560	1.49
3.579545	.75
4.000	1.75
4.194304	1.50
4.433618	.75
4444.000	1.25
4.9152	2.49
4.916 Bd. Rate	1.25
5.000000	1.50
5.0688	2.50
5.616	1.59
6.000	2.49
6.176	1.49
7.164112	1.00
7.3728	1.49
8.000	1.49
9.000	1.49
9.90000	1.25
10.69425	2.50
10.8864	1.49
10.920	1.49
11.088	1.59
12.000	2.75
13.440	1.00
14.31818	1.00
15.2	1.10
16.00000	1.50
16.5888	1.49
17.430	2.49
18.000	1.49
18.2259	1.00
18.4320	1.49
20.000	1.50
21.87108	1.00
22.092	1.00
32.000	2.49
40.000	2.00
87.3333	1.00
91.000	1.00
104.8	1.00

Fast Reply #JH894

FIGURE 4: Run a #10-32 tap in the drive wheel end of the rotating shaft.

from slipping, though, because you will just be frustrated later when you have to retighten it after every wrap.

Once you have a good fit on the shaft, slide the wheel on almost all the way (Fig. 5). Allow ¹⁄₁₆ inch or so to hang over the end of the shaft. Scribe a mark on the shaft at the other edge of the wheel. Now cut the two collars (#3 and #12) from the leftover ¼-inch OD tubing and deburr them. Slide one collar to the scribe mark and solder it in place. Put the driven wheel and screw in place, and slide the rotating shaft into the outer housing. Slide the other collar over the other end of the rotating shaft until it is up against the outer housing. Allow a few thousandths of an inch for clearance and solder the collar to the rotating shaft. Be careful not to solder the shaft to the housing.

The "chuck" (#5) is made of a piece of ³⁄₁₆-by-⅛-inch ID steel tubing. A short piece of ³⁄₁₆-inch brake-line tubing works well because it has a heavy wall and can be drilled for a set screw to hold the bit. You could also use ³⁄₁₆-inch OD copper tubing and solder the bit in place. I recommend the steel tube and set screw technique because the heat during soldering might affect the bit's hardness.

Cut a section of the steel tubing about 1½ inches long. Make a center punch mark about ¼ inch in from one end and drill a ¹⁄₁₆-inch-diameter starter hole. Change to a ³⁄₃₂-inch drill

bit and redrill the hole. Now run a #4-36 tap in as far as it will go (Fig. 6). If you have a bottom tap, run it through also. You can now insert the chuck into the rotating shaft until slightly more then ⅜ inch is protruding. Solder the chuck in place, again taking care not to damage the collars or solder the rotating shaft to the outer housing.

The Motor & Drive Wheel
At this point, the mechanical work is almost complete. All that remains is to mount the motor (#7) and make a drive wheel (#9). It is best to maintain a ratio of about four to one between the driven and driving wheel diameter. Too small a drive wheel does not have enough contact area to prevent slippage. Too large a wheel will result in a high speed and too little torque. If you use an 8-track
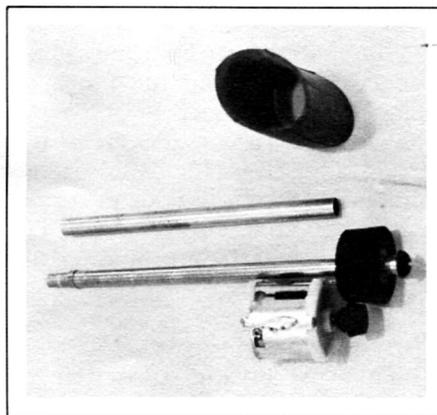
FIGURE 5: Partially assembled tool with the driven wheel on the shaft.

idler wheel, you should use a drive wheel that is as small as possible and will still make contact.

The simplest, cheapest and most readily available item for the drive wheel is a press-in rubber foot pad like those found on the bottom of small electronic equipment. If you do not have one on the bottom of something you are about to throw out, you can buy one, but virtually anything round and rubber will work. It should be about ⅜ inch long and ¼ inch in diameter, but it must be big enough to touch the driven wheel when mounted on the motor.

Note that the motor frame is mounted against the outer housing. You can reduce the diameter of your drive wheel if it is too big. If you are using the specified motor, drill a ¹⁄₁₆-inch hole in the center of the wheel and slide it onto the motor shaft. Now spin the motor. Does the drive wheel wobble? If not, you have used up all this week's luck. If it wobbles, simply slide the drive wheel off the motor and onto the next size larger drill (or a finishing nail). Chuck this assembly into your drill and hold a piece of coarse sandpaper against the wheel until it is concentric with the shaft.

If you wish, you can taper both the drive wheel and the driven wheel using this technique. It is not necessary to taper the wheels, but it looks flashy and allows some adjustment of the friction drive's contact pressure. If you have a belt sander, it is even easier. Just hold the wheel at a bit of an angle to the direction of the belt's motion.

The motor mentioned in the Parts List is available from a number of sources, including Marlin P. Jones, PO Box 12685, Lake Park, FL 33403; Herbach & Rademan, 401 E. Erie Ave., Philadelphia, PA 19134; and BNF Enterprises, 119 Foster St., Box 3357, Peabody, MA 01960. Prices range from $1.50 to $4 each. Be sure to buy at least one spare; it is the only guarantee you get. The motor uses the split metal case for its contacts, so solder a 3-foot section of light-gauge stranded wire to each case section. The plastic end caps have notches every so often (Fig. 2, section AA). They are helpful because they hold the motor axially aligned with the outer housing when it is installed. You might have to make your own notches if you use another motor.
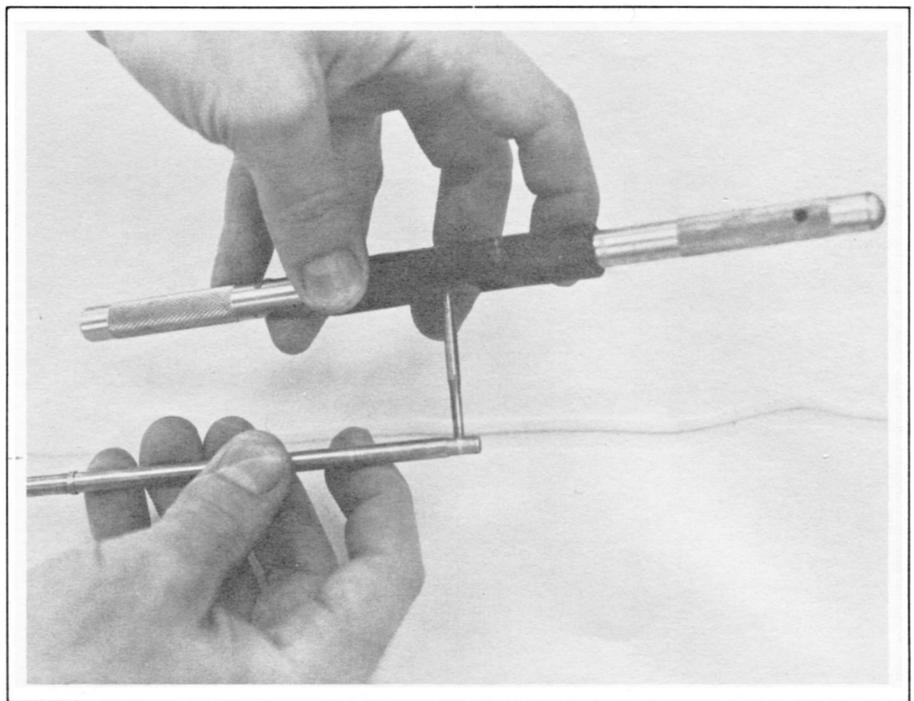
FIGURE 6: Run a #4-36 tap as far as it will go into the set screw bole.
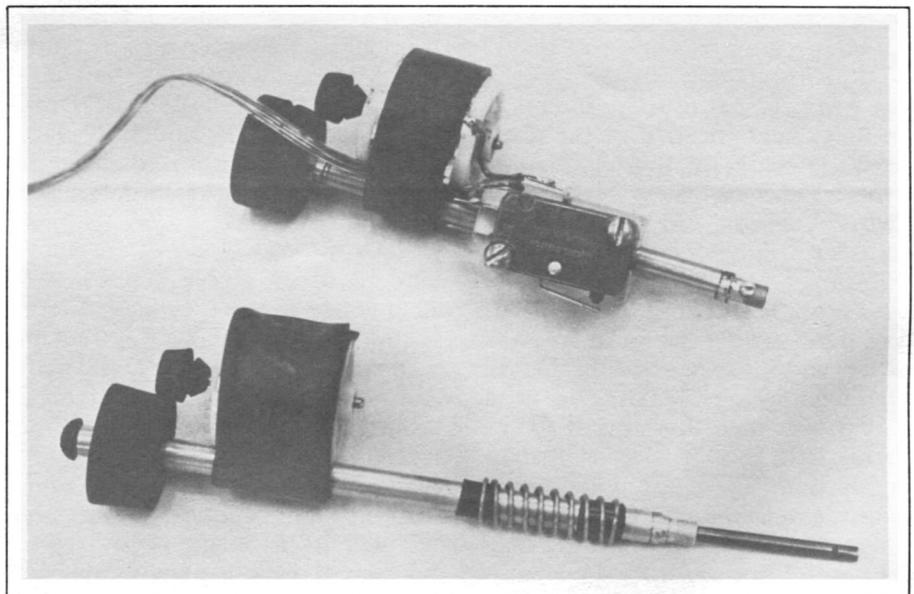

FIGURE 7: Although Mr. Neely used a spring switch (below), you might choose a micro switch (above).

You cannot beat a strong rubber bungee (#8) to hold the motor in place. A doubled section of 27-inch bicycle inner tube works great. It is strong, adjustable, removable, quick and cheap. Swallow your pride and remember, "If it works, use it." You can now install the motor and drive wheel assembly.

The Switch & Supply

You may use any kind of switch you like *(Fig. 7)*. The switch shown consists of a spring with an inside diameter of slightly more than ¼ inch. The spring is one switch contact and is insulated from the outer housing with tape or, better still, heat-shrink tubing. When you are ready to wrap a pin, you deflect the spring with your thumb, causing it to touch the outer housing, which is the other contact. Solder one motor wire to the outer housing for this switch. The other motor wire and the spring are connected to the battery.

The final step is to connect your power supply. You might have been wondering how a 1.5V toy motor would have enough pizzazz to run this

MATERIALS LIST

Part #	Name	Description	Source
1	outer housing	¼-inch OD brass tubing	hobby shop
2	rotating shaft	0.218-inch OD brass tubing (must telescope into #1)	hobby shop
3 & 12	shaft positioning collar	⅛ inch long, cut from excess ¼-inch OD tubing	hobby shop
4	bit clamping screw	#4-36 set screw	hardware store
5	"chuck"	³⁄₁₆-inch OD steel brake-line tubing	auto parts store
6	wire-wrap bit	OK Machine Tool Co. #BT-30	Jameco Electronics
7	motor	1.5V DC toy motor	see text
8	motor mount	2-inch-long section of 27-inch bicycle inner tube or heavy rubber bands	
9	driving wheel	rubber foot or any ¼-inch round, solid rubber part	electronic supply store
10	driven wheel	see text	see text
11	driven wheel clamp screws	#10-32 screws, ½ inch long (±)	hardware store
13	driven wheel clamping collar	¼-inch OD collar	see text
14	switch spring	⁵⁄₁₆-inch ID, light-gauge spring, 1½ inches long (±)	hardware store
15	insulator	heat-shrink tubing, ⁵⁄₁₆ inch ID (±), or tape	electronic supply store
16	switch spring cover	heat-shrink tubing, ½ inch ID (±)	electronic supply store
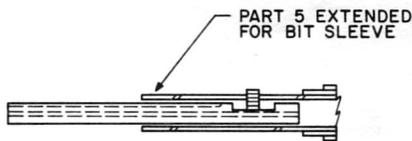
FIGURE 8: You might want to use a bit sleeve to hold the wire while the wrap takes place.
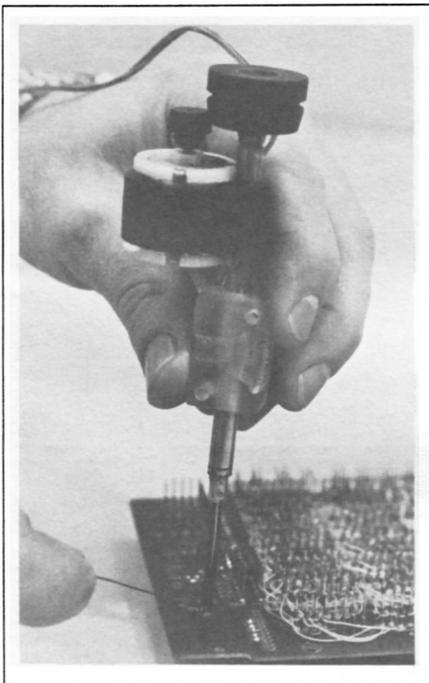
FIGURE 9: Wire-wrapping is a fast means of prototyping that allows you to make changes during the circuit assembly process.

tool. It's simple—you just run it on 9V. A wire wrap takes about one second of motor time and about 30 seconds minimum to strip the wire and locate the proper pin. You can burn the motor out only by demonstrating what a wonderful job it does as a circuit board drill or by trying to figure out the battery life by leaving it on continuously. Under normal use, the motor does not display the slightest temperature rise. The motor draws about 1A maximum at 9V, and any power supply that will provide this will do. A 6V lantern battery will work if it is fresh.

The bit is the standard replacement bit of an OK Machine Tool Company wire-wrap gun. It is available at any computer store or from Jameco Electronics (1355 Shoreway Rd., Belmont, CA 94002) and many other dealers. Some people prefer using a bit sleeve to hold the wire while the wrap takes place (*Fig. 8*). This can be made of a piece of 0.0125 (⅛-inch) ID brass tubing. You can also make piece #5 extend about ¾ inch past the set screw hole to accomplish the same effect.

You are now ready to wire-wrap to your heart's content (*Fig. 9*). If you have not used this method before, you will quickly realize that you have just discovered the fastest means of prototyping known to-day—short of hiring a technician. □

●●●●●●●●●●●●●●●●●●●●●●●●●●●●

AD*I*NDEX

COMPUTER SMYTH'S PRECEDENCE CHART (ASCII)

Dec.	Binary	Octal	Hex	Char.	Alternate Name(s)	Dec.	Binary	Octal	Hex	Char.	Alternate Name(s)
0	0000000	000	00	NUL	NULL, CNTL @	64	1000000	100	40	@	AT SIGN
1	0000001	001	01	SOH	START OF HEADER	65	1000001	101	41	A	UPPER CASE "A"
2	0000010	002	02	STX	START OF TEXT	66	1000010	102	42	B	
3	0000011	003	03	ETX	END OF TEXT	67	1000011	103	43	C	
4	0000100	004	04	EOT	END OF TRANSMISSN	68	1000100	104	44	D	
5	0000101	005	05	ENQ	ENQUIRY	69	1000101	105	45	E	
6	0000110	006	06	ACK	ACKNOWLEDGE	70	1000110	106	46	F	
7	0000111	007	07	BEL	BELL, ALARM	71	1000111	107	47	G	
8	0001000	010	08	BS	BACKSPACE	72	1001000	110	48	H	UPPER CASE "H"
9	0001001	011	09	HT	HORIZ. TAB	73	1001001	111	49	I	
10	0001010	012	0A	LF	LINE FEED, NL	74	1001010	112	4A	J	
11	0001011	013	0B	VT	VERT. TAB, VTAB	75	1001011	113	4B	K	
12	0001100	014	0C	FF	FORM FEED, PAGE	76	1001100	114	4C	L	
13	0001101	015	0D	CR	CARRIAGE RET., EOL	77	1001101	115	4D	M	
14	0001110	016	0E	SO	SHIFT OUT, RED	78	1001110	116	4E	N	
15	0001111	017	0F	SI	SHIFT IN, BLACK	79	1001111	117	4F	O	
16	0010000	020	10	DLE	DATA LINK ESC, DC0	80	1010000	120	50	P	UPPER CASE "P"
17	0010001	021	11	DC1	XON, READER ON	81	1010001	121	51	Q	
18	0010010	022	12	DC2	TAPE, PUNCH ON	82	1010010	122	52	R	
19	0010011	023	13	DC3	XOFF, READER OFF	83	1010011	123	53	S	
20	0010100	024	14	DC4	PUNCH OFF	84	1010100	124	54	T	
21	0010101	025	15	NAK	NEG. ACKNOWLEDGE	85	1010101	125	55	U	
22	0010110	026	16	SYN	SYNCHRONOUS IDLE	86	1010110	126	56	V	
23	0010111	027	17	ETB	END OF TXT BUFFER	87	1010111	127	57	W	
24	0011000	030	18	CAN	CANCEL, CANCL	88	1011000	130	58	X	UPPER CASE "X"
25	0011001	031	19	EM	END OF MEDIUM	89	1011001	131	59	Y	
26	0011010	032	1A	SUB	SUBSTITUTE	90	1011010	132	5A	Z	
27	0011011	033	1B	ESC	ESCAPE, PREFIX	91	1011011	133	5B	[	LEFT BRACKET
28	0011100	034	1C	FS	FILE SEPARATOR	92	1011100	134	5C	\	BACK SLASH
29	0011101	035	1D	GS	GROUP SEPARATOR	93	1011101	135	5D	]	RIGHT BRACKET
30	0011110	036	1E	RS	RECORD SEPARATOR	94	1011110	136	5E	∧	UP ARROW
31	0011111	037	1F	US	UNIT SEPARATOR	95	1011111	137	5F	_	UNDERLINE
32	0100000	040	20	SP	SPACE, BLANK	96	1100000	140	60	`	ACCENT GRAVE
33	0100001	041	21	!	EXCLAMATION POINT	97	1100001	141	61	a	LOWER CASE "A"
34	0100010	042	22	''	QUOTE MARK	98	1100010	142	62	b	
35	0100011	043	23	#	POUND SIGN	99	1100011	143	63	c	
36	0100100	044	24	$	DOLLAR SIGN	100	1100100	144	64	d	
37	0100101	045	25	%	PERCENT SIGN	101	1100101	145	65	e	
38	0100110	046	26	&	AMPERSAND	102	1100110	146	66	f	
39	0100111	047	27	'	APOSTROPHE	103	1100111	147	67	g	
40	0101000	050	28	(	LEFT PARENTHESIS	104	1101000	150	68	h	LOWER CASE "H"
41	0101001	051	29	)	RIGHT PARENTHESIS	105	1101001	151	69	i	
42	0101010	052	2A	*	ASTERISK, STAR	106	1101010	152	6A	j	
43	0101011	053	2B	+	PLUS SIGN	107	1101011	153	6B	k	
44	0101100	054	2C	,	COMMA	108	1101100	154	6C	l	
45	0101101	055	2D	-	DASH, MINUS SIGN	109	1101101	155	6D	m	
46	0101110	056	2E	.	PERIOD, DOT	110	1101110	156	6E	n	
47	0101111	057	2F	/	SLASH	111	1101111	157	6F	o	
48	0110000	060	30	0	NUMBER ZERO	112	1110000	160	70	p	LOWER CASE "P"
49	0110001	061	31	1	NUMBER ONE	113	1110001	161	71	q	
50	0110010	062	32	2	NUMBER TWO	114	1110010	162	72	r	
51	0110011	063	33	3	NUMBER THREE	115	1110011	163	73	s	
52	0110100	064	34	4	NUMBER FOUR	116	1110100	164	74	t	
53	0110101	065	35	5	NUMBER FIVE	117	1110101	165	75	u	
54	0110110	066	36	6	NUMBER SIX	118	1110110	166	76	v	
55	0110111	067	37	7	NUMBER SEVEN	119	1110111	167	77	w	
56	0111000	070	38	8	NUMBER EIGHT	120	1111000	170	78	x	LOWER CASE "X"
57	0111001	071	39	9	NUMBER NINE	121	1111001	171	79	y	
58	0111010	072	3A	:	COLON	122	1111010	172	7A	z	
59	0111011	073	3B	;	SEMICOLON	123	1111011	173	7B	{	LEFT CURLY BRKT
60	0111100	074	3C	<	LESS THAN	124	1111100	174	7C			VERTICAL SLASH
61	0111101	075	3D	=	EQUAL SIGN	125	1111101	175	7D	}	Alt Mode, Rt Curly Bkt
62	0111110	076	3E	>	GREATER THAN	126	1111110	176	7E	~	TILDE
63	0111111	077	3F	?	QUESTION MARK	127	1111111	177	7F	DEL	DELETE, RUBOUT

EASY COLOR CONVERSION

Convert RGB Output to Composite Signals

BY THOMAS L. CLARKE

Thomas L. Clark uses mainframe and minicomputers as part of his job as an acoustic ocean scientist at the National Oceanographic and Atmospheric Administration (NOAA). Professionally, he uses microcomputers primarily for acquiring data for underwater projects. Personally, he uses microcomputers to support his telescope-making and speaker-building hobbies, in educational activities for his two daughters, and for playing ZORK.
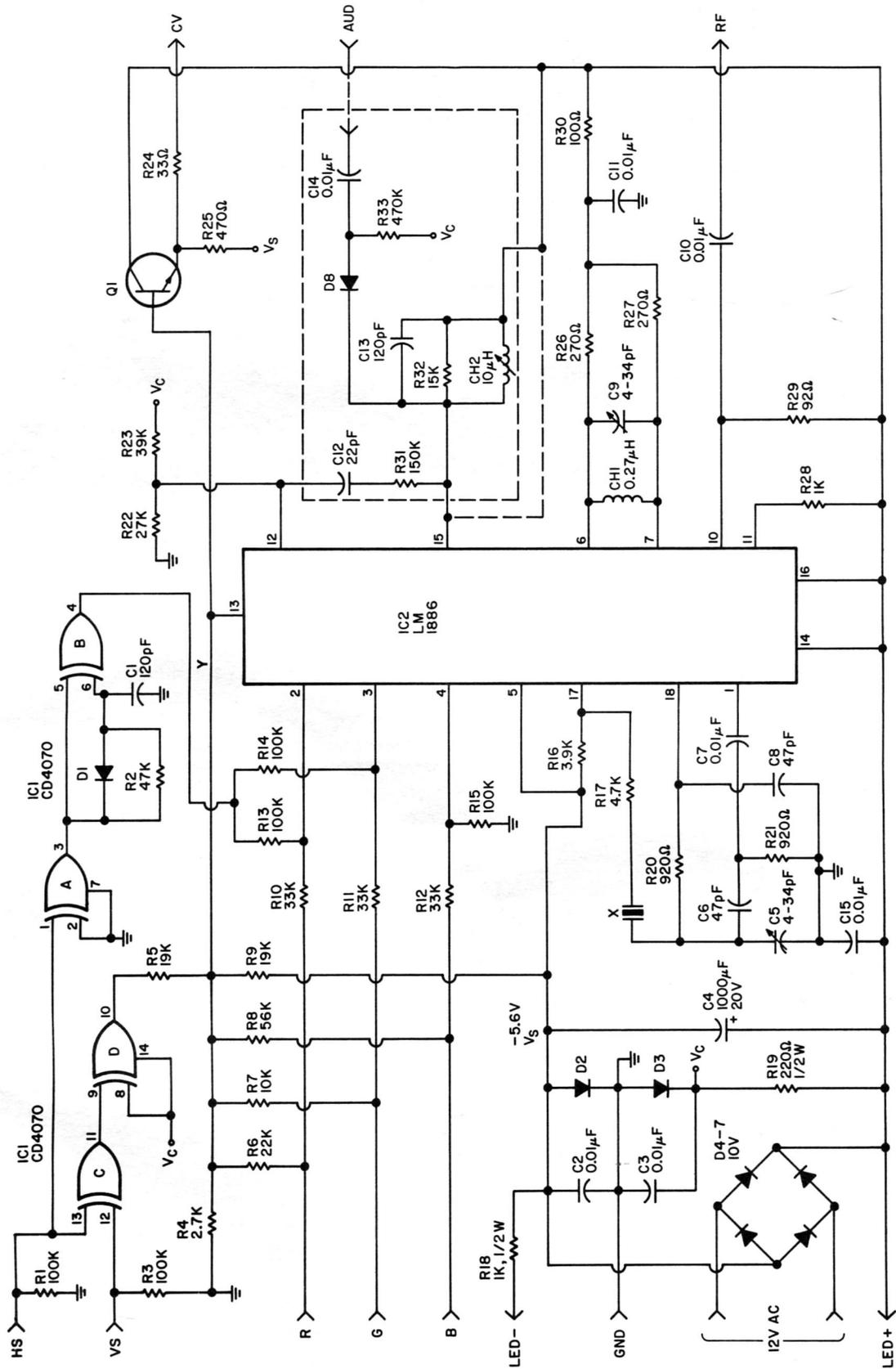
Using color graphics is one of the better ways to make computer output more comprehensible. But getting the right color monitor at the right price can be a problem. That's where my circuit comes in.

Color monitors accept either separate video signals for each of the red, green and blue (RGB) primary colors, or a composite color video signal in which the color information is phase encoded on a 3.58MHz color subcarrier, which is mixed with a luminance (black-and-white) signal. A color TV set can be considered a composite monitor with a radio-frequency (RF) tuner attached.

RGB signals are easier to generate than composite signals because the digital signals from the memory bits corresponding to the three colors are merely routed to the output connector. As a result, many computers (e.g., the Sanyo 550 and some IBM-compatible color graphics cards) have only an RGB output. While this simplifies the computer system box, it requires an RGB color monitor, which is generally more expensive than a composite one. By using an RF modulator, it also precludes the use of a color TV as a monitor.

I have designed an RGB modulator circuit that will convert RGB output to a composite signal and also provide an RF signal suitable for reception by a color TV set *(Fig. 1)*. Although some of the crispness possible with an RGB monitor is lost in the conversion process *(Fig. 2)*, the circuit does allow you to get up and running with moderate-resolution color applications without a large investment. With a moderately full junk box, you can build this interface for less than $20. All new parts cost less than $50, only slightly more than the cable needed to connect the computer to a monitor.

The Circuit

The RGB modulator circuit shown in *Fig. 1* is based on National Semiconductor's LM1886 TV video modulator IC. This chip is designed to convert color signals into standard TV signals on Channel 2, 3 or 4. Because the LM1886 is not normally operated directly from RGB signals, this circuit differs quite a bit from those in National's literature.

Color video signals take several forms. If Y is the luminance, or black-and-white, video signal, and R, G and B are the primary color signals, then the luminance is determined from the color signals by the following formula:

$$Y = 0.3R + 0.6G + 0.1B$$

The Y signal is not simply the average of the R, G and B signals because the TV screen phosphor/human eye combination is not uniformly sensitive to all colors. The relation between Y and RGB shows that any three of Y, R, G and B or any three combinations of these signals are sufficient to reconstruct the complete color image. Published LM1886 applications use Y, $(R - Y)$ and $(B - Y)$ because these signals are commonly supplied by video-game chips and translate more directly into composite video signals.

Figure 1 sums the RGB signals via 22k, 10k and 56k resistors to form the Y signal, which is applied to pin 13 of the LM1886. Sections C and D of the CD4070 combine the vertical sync (VS) and horizontal sync (HS) into a composite sync signal, which is added to Y through one 19k resistor. Another 19k resistor biases Y negative so that black $(R = G = B = 0)$ corresponds to ground and the sync level is $-0.6V$. The sync signals must be active low transistor-transistor logic (TTL) levels. The RGB signals are 0 to 5V, but they may be analog. The 2.7k resistor to ground sets the Y signal level to match the level of the color subcarrier modulator inside the LM1886.

The RGB signals pass through the 33k resistors to the $(R - Y)$, chroma bias and $(B - Y)$ color modulator inputs of the LM1886. Feeding G to the bias input and using undifferenced R and B signals in this way produces differencing in the internal, doubly balanced color modulators. The differencing closely approximates the results of applying the $(R - Y)$, $(B - Y)$ and DC bias signals for which the LM1886 was designed. The 33k resistors, in combination with the 2pF input capacity of the LM1886, filter color signal components above 3.5MHz from the color modulator inputs. Frequencies higher than 3.58MHz would be aliased in the modulation process and would cause strange visual effects. The demodulation circuitry in a composite monitor/TV filters the color signals even more.

Subcarriers

The color subcarrier is provided by a crystal oscillator network attached to pins 17 and 18. Subcarrier frequency

FIGURE 1: This circuit converts RGB output to a composite signal and provides an RF signal suitable for reception by a color TV.

FIGURE 2: *The same graphic image is shown on a Sanyo 555 12-inch green monitor and a 19-inch color TV. What appear as darkly shaded rectangles on the green monitor appear as brightly colored rectangles on the TV.*

is adjusted by the 4 to 34pF variable capacitor. Pin 18 is fed by an RC combination of 920Ω and 47pF, while pin 1 is fed the same signal through a CR combination of the same values. The 0.01μF capacitor merely blocks DC. As a result, the 3.58MHz signals at pins 1 and 18 are 90 degrees out of phase. The phase at pin 1 corresponds to the color red, whereas the phase at pin 18 corresponds to the color blue. Within the LM1886, these two phases, multiplied by the color difference signals, are summed with the Y signal and appear at pin 13.

Absolute phase reference for demodulating the color signals is provided to the monitor/TV by the color burst of the 3.58MHz carrier, which is included in the composite signal following the horizontal sync pulse. The proper phase for the color burst corresponds to the negative of the pin 18 signal, or minus blue. The burst can be inserted by pulling pin 4 negative; the video-game or CRT controller chip usually does this.

To simplify circuitry, I chose the alternative method of pulling pins 2 and 3 positive. Gates A and B of the CD4070 produce a 6μsec pulse following the trailing edge of the horizontal sync pulse. This 5.6V signal pulse pulls pins 2 and 3 high through the 100k resistors. The 100k resistor to ground on pin 4 establishes symmetry. The pulse is generated by the

delay at pin 6 of gate B relative to pin 5 for the positive-going trailing edge of the horizontal sync signal produced by D1, the 47k resistor and the 120pF capacitor. When pins 5 and 6 or gate B are at difference levels, the output is high. This condition is produced for positive signals by the RC delay, but inhibited for negative-going signals by diode conduction.

The remainder of the RGB modulator circuit follows published applications of the LM1886. Pin 12, the Y reference, is biased by dividing the 5.6V logic supply. The tank circuit and supply resistors attached to pins 6 and 7 provide the Channel 2, 3 or 4 carrier, which is internally modulated and
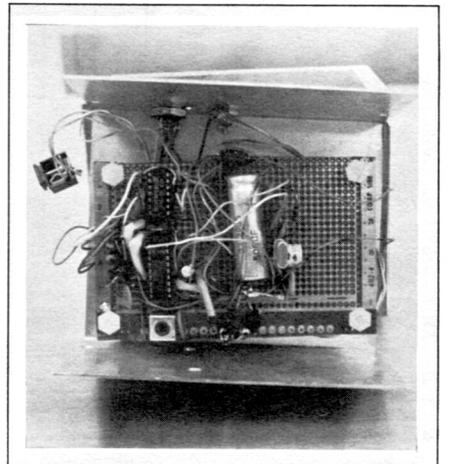

FIGURE 3: *Wiring layout is not critical. The "rat's nest" technique used for the prototype proves this.*
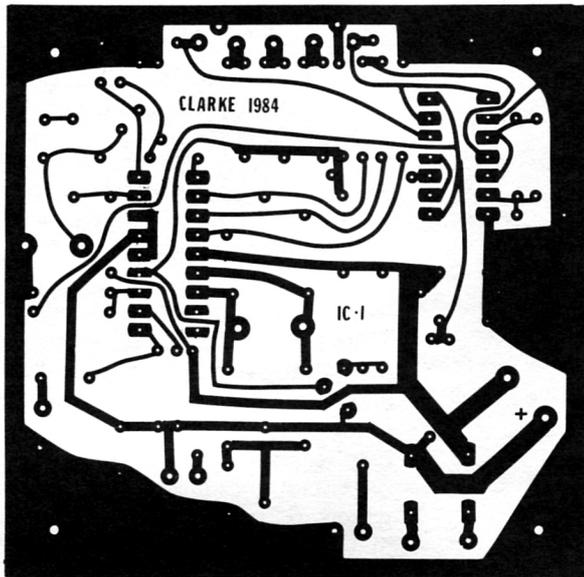
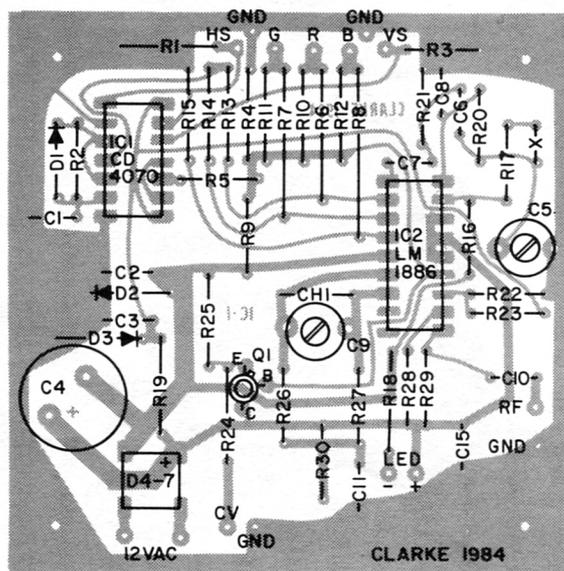FIGURE 4: Board pattern for the RGB modulator circuit.

FIGURE 5: Stuffing guide for the modulator circuit.

buffered and which appears at pin 10. This RF signal has millivolt amplitude and low impedance so that it can be fed directly to a color television set.

Another oscillator-modulator combination is available by attaching a tank to pins 8 and 9 and taking the output from pin 11. Emitter follower Q1 buffers the composite video signal at pin 13. Because this buffered composite signal, CV, has a sync level of −1.3V, I did not use a coupling capacitor. Most monitors include a coupling capacitor and a DC restoration circuit.

The components within the dotted lines in *Fig. 1* represent a sound subcarrier circuit. Tune the tank connected between pin 15 and the 10V supply to 4.5MHz. Tuning D8 frequency-modulates this oscillator and gives full deviation for about a 1V input when biased between the 10V and 5.6V supplies by the 470k resistor. The signal is applied to the Y reference through the 150k resistor and 22pF capacitor. If you require a sound carrier on the CV output, connect pin 15 to pin 13 through a 15k resistor and a 22pF capacitor. If you do not use a sound subcarrier, connect pin 15 directly to the 10V supply. The sound carrier can introduce a moire pattern effect due to beating between the sound and video signals. For best performance, the sound carrier should be omitted.

The RGB modulator circuit requires DC supplies of −5 to −6V, +5 to +6V and +9 to +12V. These voltages might be available from other equipment. If not, the DC supply circuit shown provides these voltages from a floating source of 12V AC such as a plug-in AC adapter transformer. You may also use an LED as a pilot lamp in series with the 1k resistor, as shown.

Layout & Construction
Circuit layout and construction is not critical. I built the prototype on a universal prototyping board with a ''rat's nest'' wiring technique *(Fig. 3)*. Perfboard and any reasonable wiring technique should work. For those who can make etched circuit boards,

Figs. 4 and 5 show the board pattern and stuffing guide for a single-sided layout of the RGB modulator circuit.

TABLE 1
RGB CONNECTOR PIN-OUTS

Signal	D Conn.	DIN Conn.
R	3	1
G	2	7
B	4	8
HS	8	3
VS	7	5
GND	1,5,6	4

It measures only 3 inches square, so you might be able to build it into an odd corner of your existing equipment. It also fits handily into a mini-box enclosure *(Fig. 6)*.

Appropriate connectors should be wired to the input/output (I/O) pads on the board. The RGB output usually uses either a nine-pin D connector or an eight-pin DIN. Pin assignments for these two types of connectors are shown in *Table 1*. RCA phono jacks are nearly universal for RF and CV signals.

Adjustment is simple. After applying power and connecting I/O, tune the RF tank to Channel 2, 3 or 4 (if you are using a TV set) by observing the screen. Then adjust the 3.58MHz oscillator trimmer to produce a stable
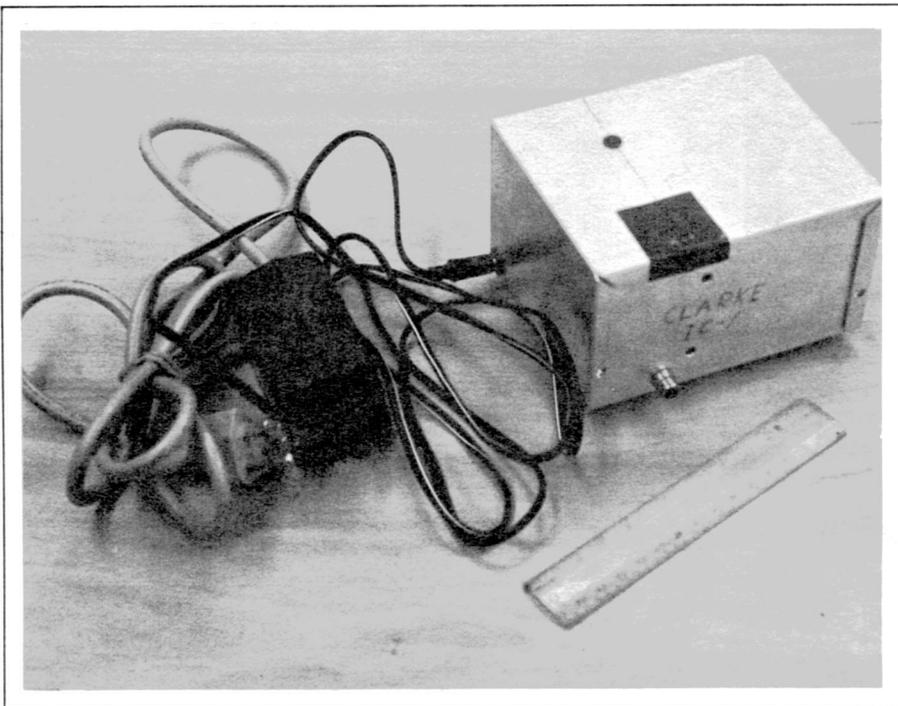
PARTS LIST
OPTIONAL AUDIO MODULATOR

Resistors & Capacitors

R31	150k, ¼ W
R32	15k, ¼ W
R33	470k, ¼ W
C12	22pF ceramic
C13	120pF ceramic
C14	0.01µF ceramic

Misc.

CH2	10µH adjustable coil
D8	1N5447 tuning diode

If you want to experiment, you can vary the 920Ω, 47pF phase-shift networks on pins 1 and 18 to change the exact range of colors represented by the color subcarrier. You can also change the relationship between color and brightness by varying the 22k, 10k and 56k resistors that sum to produce the Y signal. Adjusting these will produce variations from deep, saturated colors to light pastels.

I have not tried to limit the RF bandwidth to the 6MHz stipulated by TV broadcast standards. As a result, on my 19-inch color TV, a line of 80-column text is barely readable. Forty-column text is, however, very easy to read. As I mentioned before, the circuit does filter the color signals, which are probably filtered even more in the TV/monitor, so fine vertical lines tend to lose their color. □

FIGURE 6: You can mount the RGB modulator in a mini-box and use a plug-in transformer to power it. The ruler is 6 inches long.

image with pleasing colors and no rainbow effects. There is some interaction between the 3.58MHz oscillator adjustment and the TV controls. Trial and error will give the right combination.

Old Colony will offer the board for this unit if readers express sufficient interest. Estimated cost is $8. If you would be interested in purchasing the board, enter Fast Reply #KH862 on the Fast Reply card. *Do not send payment.* Old Colony will contact you if they decide to offer the board.

Fast Reply #JH901

IN REVIEW

No one talks much about the care and feeding of personal computers. Everyone seems to act as though you bring it home, plug it in, turn it on and live happily ever after. If a problem develops, a call to your friendly, neighborhood computer store will take care of it—if the warranty is still in effect. If the warranty has expired (usually the day before the problem occurs), your local dealer will be happy to sell you service—at the going (expensive) rate.

A number of my friends have described computers as boring. Although they may not be entirely correct, in terms of hardware, they are not far off the mark. In this interesting book, Henry Beechhold dispels a lot of that hardware mystique, calms a great many fears about what is actually inside those expensive boxes, and offers suggestions about how to solve problems with computer hardware operation.

One reason to buy the book is that it is fun to read, but there are also more practical reasons. The chapter titles give a good indication of the content and style: The Ground Rules, The Tinkerer's Toolbox, The Compleat Junkbox, Peeking and Poking Inside, Block That Diagram, A Few Inside Moves, Power in Short Supply, Do You See What IC?, Cleaning House, Saving Interface, Projects: Making It Better, Projects: Making It New. Beechhold assumes that his readers are ready to approach disassembly, repair and reassembly with attention and care, but he is careful to explain small details so that he will not lose even those who have done nothing more complicated than changing a light bulb or fuse.

The book contains a few minor errors and some helpful hints, and I have a couple of suggestions for additional material that Beechhold might include in future editions.

Several typographical errors appear, including one on page 24 that substitutes 15,000 for 1,500. On page 45, there is some confusion about the relationships among voltage, resistance, current and heat, while page 216 contains mistakes about resistance and capacitance in parallel.

Among the handy hints is a tidbit on page 91 about the nature of computers: "all electronic gadgets—computers among them—are prey to disorders that defy explanation. Perhaps 10 percent, perhaps more, of electronic misbehavior just can't be understood. Who knows why? Yet everything, or nearly everything, somehow gets fixed." That is encouraging news to this reader and hobbyist. Page 116 explains a helpful way of substituting for a possibly defective chip, while the author's suggestion of a possible substitute for an EPROM eraser (p. 245) might be worth the cost of the book, if you are into that kind of thing.

On the other hand, Beechhold might have included some additional information. For instance, on page 114, he might have noted the best and safest way I have heard of to pull static-sensitive chips—i.e., use large binder clips to short across all the pins before pulling. On page 128, when he discusses cleaning contacts, perhaps he should have mentioned Cramolin, a helpful substance for cleaning and preserving contacts.

Those who buy the book receive one free consultation by mail to ask Beechhold's advice on a particular problem. I have not received a response to my seven-month-old request for assistance, but I am willing to believe that the suggestions, *if* and when received, will be practical and helpful.

Beechhold has inspired me to take apart my Chameleon and try to fix a disk drive that, with certain software, gives false indications that the drive door is open. Although more extensive directions about opening that particular type of portable machine would have been handy, his overall approach and practical encouragement were helpful, and I have now been inside my machine a number of times without difficulty, even though I have not yet corrected the problem. For other hobbyists who are also ready to do more than just change fuses around the house, this should be a helpful and encouraging book.□

The biggest problem with *Android Design* is its title. Although it describes the contents of the book, it does not hint at the wealth and diversity of the information therein. Building an android, an R2D2-type robot, is an intricate and complex project involving many different technologies. With all these technologies under one cover, it would be a shame if only the serious android builder were to read this book.

Some of the technologies described are obviously "robotic." For instance, the chapter "Philosophical Considerations" offers some basic guidelines for android programming, including consideration of hazards to people, property or the environment, especially if there has been a failure or two in the android, and giving the android an "instinct for self-preservation." More specific robotic problems are discussed in chapters titled "Obstacles in the Human Environment" and "The Special Problems of Stairways."

Other topics in the book are of more general interest. Chapters on motor drives and batteries offer good overviews as well as solid and practical engineering data in these areas. "Motor Juice Concentrate" explains how to use power VMOS FETs (vertical metal-oxide semiconductor field-effect transistors) for control of large direct currents. Previous technologies used either bipolar transistors, which required lots of power and circuitry to switch them, or mechanical relays, which were susceptible to contact pitting.

The chapter on collision avoidance also provides a wealth of technical information, both practical and theoretical, about object-sensing and range-finding, using multichannel optical (pulsed infrared lasers) and sound reflection.

A robot-specific chapter on hands, which discusses both manipulation and "fingertip" pressure-sensing, is followed by a lengthy discussion (with construction diagrams) of "Ramera," a solid-state miniature televisionlike camera that can provide "vision" to your computer, whether or not it is in a robot.

A section on speech synthesis, complete with IC part numbers, shows how to provide a voice for your computer and make it respond with English words and even sentences. The book also includes a discussion of speech recognition—i.e., giving verbal instructions to the computer—but the bottom line is that the technology is not yet available to make this practical in the field.

Android Design does not pretend to be a complete how-to guide for building your own R2D2. It is a collection of useful high-tech building blocks that are applicable far beyond robotics. The book is well-written, and unlike some other texts I have seen, it contains specific part numbers as well as source names and addresses. This information may seem a bit volatile for a book, but if you ask a manufacturer about an old part, he will usually tell you with glee about the newer, better one. The book also includes a bibliography on speech synthesis and recognition and an excellent index. I would consider this book a good buy, even if you need just one chapter and throw away the rest.□

SMYTH*N*ET

DOCUMENTATION IS A MUST

Editor's Note: This letter responds to a recent editorial in Audio Amateur *4/84 discussing the availability (or unavailability) of product schematics and repair manuals. Because the problem also affects computer owners, we decided to publish Mr. Senger's letter here.*

Thanks for your position on product documentation. This seems to have become a problem only in the past five years, as a peculiar form of personal gain paranoia—perhaps otherwise known as extreme avarice—has swept certain segments of the engineering and manufacturing community. Unfortunately, it has a completely different effect than the one intended—or at least stated.

First, it is no barrier at all to bootleg manufacturers, since the smallest part of such an enterprise would be to hire somebody to make a schematic of a working electronic product or to copy an EPROM. This argument on the part of manufacturers is specious at best.

The real effect is to hinder the activities of the technically competent individual. As such, I resent the effort. But even here, the aim of manufacturers is wide of the mark. The actual copying of a working product is really quite rare because such an activity is quite time consuming. For those relatively few who have more time than money, why not be magnanimous enough to let them be?

It seems to me that the real goal of such a policy is to make it as difficult as possible to *repair* an electronic product and thereby encourage sales of new units. Even here, the plan often goes awry.

Here is a case in point. A few months back, a friend gave me an old Novation DC 102A modem, which apparently had been manufactured in 1972. According to a note I found on it, the unit had not worked since 1977. This seemed to be a fun way to learn how to work on modems. As I did not know much about them, I sent a letter to Novation re-questing a service manual, expecting to pay the usual $10 to $20 fee. When, after about three months, I still had not received a reply, I tried again. This time I received a form letter advising me that this was the second change-of-address notice they had sent. The letter did not say a word about the service manual! My reply to this letter was, I am afraid, rather hot. Finally, I was formally notified that it was not company policy to sell service manuals and, furthermore, that the unit was too old to be repaired, even by them.

This was a new experience for me, but I want Novation and anybody else who is interested to know that I will not be buying any company's products if that company does not provide full documentation and does not publish a service manual. I hope others will do the same. This problem will be solved only when manufacturers realize that withholding technical information only hurts themselves.

Charles Senger
LaJolla, CA 92037

COUNT ME IN

Where have you been these past five years? When will you go monthly? Every third month is hardly enough space to cover the vast range of new hobby and serious electronics possibilities that have arisen since computer chips and other hardware have become available. I have written letter after letter to various magazines, suggesting the need for just this kind of magazine. Isn't it odd that you should get my name from *Ham Radio* rather than one of the computer magazines?

In your promotion, you summed up your philosophy about magazines beautifully: "We believe magazines are hard-copy networks. . . ." In my opinion, the reason sales of home computers have slowed appreciably is that prospective buyers are asking, "What can I do with this beast after I have balanced my check-book?" Your job is to come up with things to make and do that are computer oriented. Your charter/plotter article is a good beginning.

Count me in! I have been seeking a magazine like this for so long that I can almost taste it—both as an avid reader and as a writer who enjoys building from scratch. Hearty wishes for your success!

Waldo T. Boyd
Geyserville, CA 95441

DON'T FORGET THE PC

I am pleased to see that a magazine devoted to computer hardware projects is finally being published. I own a Leading Edge computer, which I chose on the basis of its IBM PC compatibility, price and features. I wanted an IBM compatible because of the tremendous range of available software. I also feel that the PC is the best general-purpose machine on the market today. I hope you will not ignore the PC and compatible computers when planning articles for *Computer Smyth*.

I would like to see several specific projects in your magazine, including the following:
■ multiprocessor boards to mimic other operating systems, such as a Z80 board to run CP/M, a 6502 board to emulate Apple computers and perhaps boards to emulate the TRS-80 and the Commodore 64;
■ graphics cards for use with monochrome and color monitors;
■ input/output cards allowing you to use the computer as a controller or lab measurement system;
■ peripherals.

I was pleased to see that you are planning a project on an X-Y plotter. How about a backup storage tape system, mouse and light-pen input devices, and a graphics tablet? An expansion box/device that would allow you to use S-100 boards would also be of interest.

I hope you do not neglect software entirely. I agree that we do not need another software review magazine, but columns on MS-DOS, assembly language and high-level languages might be worth pursuing.

Bradford Chaucer
Wallingford, CT 06492

Don't keep your ad a secret

Take a peek at this . . . .

CLASSIFIED INFORMATION

Private classified advertising space, up to 50 words in length, is open to Computer Smyth subscribers FREE OF CHARGE for personal, non-commercial sales and for seeking information or assistance. Any words beyond 50 are only 20¢ per word! "For Sale" ads must be for personal sales and not for profit. For resale at a profit, you can place an ad in the "Trade" section of our classifieds for only 70¢ per word. And, if you really want your ad to stand out, how about placing a space ad in our classifieds? Hurry and fill out the form below. Send it along to us with your payment to get your ad in the next issue of Computer Smyth.

Attention: *Computer Smyth* Classified Department, PO Box 176, Peterborough, NH 03458

Private Classified Ads- Add 20¢ per word for every word over 50. _____

Trade Classified Ads- 70¢ per word ($10 minimum per order). Five insertions deduct 10%. _____

Classified Space Ads-
1 in.: $40 per column inch. _____

2 in.: $75 per column inch. _____

3 in. or more $105 per column inch. _____

Prepaid only. Camera ready/film required. Five insertions deduct 10%.

Discount: _____

Total: _____

Payment by: ☐ Check   ☐ Money Order   ☐ Master Card   ☐ VISA

Card No. _____ Expires _____

Signature _____ Date _____

Name _____ Company _____

Street _____

City _____ State _____ Zip _____

PAYMENT MUST ACCOMPANY ORDER