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The following microcomputer products are featured on the 1980 Electronic Experimenter's Handbook cover: (left to right) front row, **Apple** disks and cassettes (software), **Apple** Single-Disk Drive and **Apple II** Computer with game paddles; second row, **Heathkit** Line Printer and **Percom** TFD-100 Dual Disk Drive; back row, **Zenith** color TV monitor.

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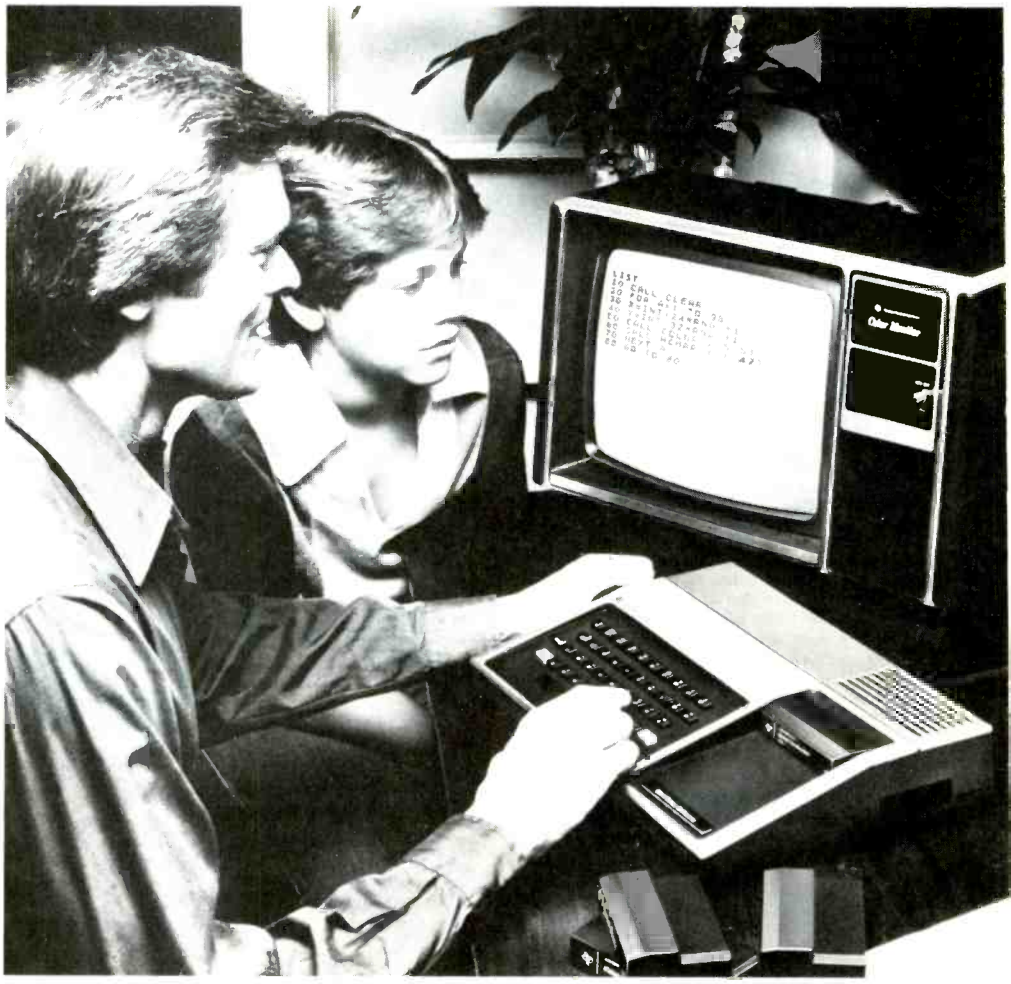


THE choice of computers spread before you in the pages that follow may seem dizzying. But choosing the right one isn't all that hard once you know what you want it for and what requirements your need imposes.

So the logical starting place is the application. Microcomputers are used for a wide variety of purposes: for program development and teaching oneself to program; for business applications such as accounting and inventory; for word processing to develop cleanly typed reports, letters and the like; for small mass mailings; for education in non-computer subjects; to handle home data such as recipes, Christmas card lists and the checkbook; to control home and industrial devices; to play games; and for mathematical computation.

The more such applications you have, the more sense computers (basically all-purpose devices) make. For some single applications, in fact, alternatives to the computer make more sense. If all you want is to play games, for instance, get a programmable video game, and be done with it. The game will probably cost less, and put more interesting, cartoon-like graphics on your TV screen. Similarly, if all you need to do is complex calculation, consider a programmable calculator. Again, the cost will be less—and you'll be able to carry the calculator with you at all times.

But calculators can play only limited games, and TV games have only limited calculating ability, if any (not counting the small but growing number of games that can be converted into full-fledged computers). If you're interested in both these applications at once—or in any of the others so far mentioned—you'll need a full-fledged computer.

But which one? All computers have some similarities: They all have some sort of *input* device to enter programs and data, some sort of *output* device to verify the input data and show what results the computer comes up with when the program runs. They all have *processors*, the chips that do the actual computing; and *memory* to hold programs and data while they're being used. But the types of input, output and processor differ, as do the amount of memory and the number of accessories or *peripherals* which can be used with the system.

Input and Output. The most visible differences between computer systems are usually in their input and output (I/O, for short) facilities. These are channels of communications between the computer and you. Each speaks very different languages, and one measure of I/O sophistication is how cleverly the system can disguise that fact.

In its most primitive (and, today, rarest) form, the system will communicate in *binary*, a numbering system based on twos. A completely binary I/O system would have a row of eight switches to input each 8-bit computer command or data "word" and eight lights per "word" for output.

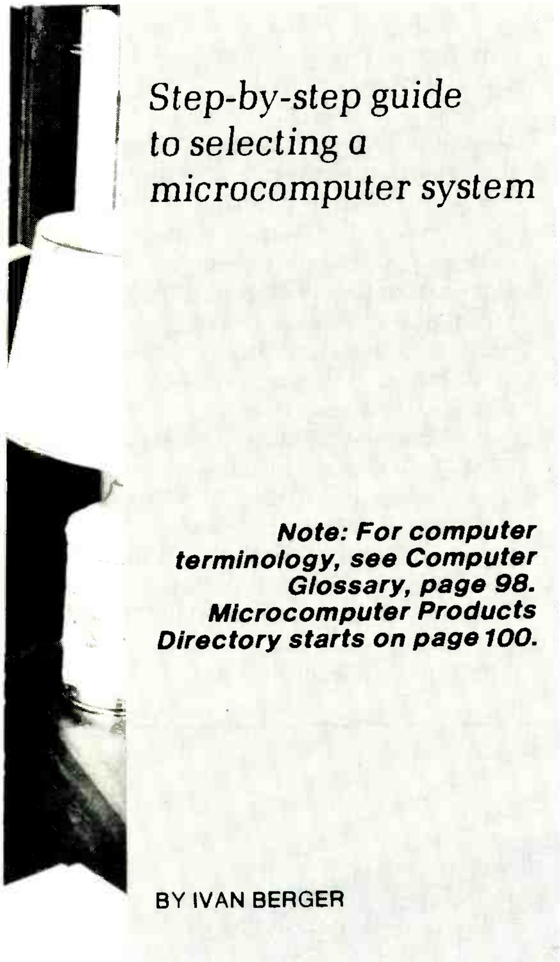
More commonly, the system will translate such binary numbers as "11000000" into an octal (base-8) number such as "300" or a hexidecimal (base-16) number such as "C0". (Since hex numbering requires more digits than our base-10 decimal system, it follows the digits 0-9 with the letters A-F.) Many low-priced, single-board computers have calculator-like keypads and displays for either octal or hex input and output.

But octal and hex are only more sophisticated ways of talking *machine language*, the instructions that computers understand directly. Machine-language programs run very quickly, and don't use much memory. But they're cumbersome to write since you must not only learn at least a hundred or so instructions and how to use them, but must learn them as abstract numbers like "CD" or "305".

Consequently, keypad-and-display computers are only useful as is, for writing very short programs, especially programs designed to interact with other devices rather than with people. Control applications are often a perfect match for these computers. Here, the limitations of keypad programming aren't serious, and the computers are small and cheap enough to be assigned to specific devices, or sometimes even to be built into them.

But most such computers also have

TIPS



Step-by-step guide to selecting a microcomputer system

Note: For computer terminology, see Computer Glossary, page 98. Microcomputer Products Directory starts on page 100.

BY IVAN BERGER

ports for communicating with other I/O devices. Connect one to a *terminal*, which combines a full typewriter-like keyboard with a video display screen or a printer, and you can work with other programming languages which use the entire alphabet and other symbols.

With the keyboard's full set of characters at your command, you can program in assembly or high-level languages. *Assembly* language is just a word-for-word translation of machine language from abstract numbers into more easily memorized abbreviations. In 8080 assembler, for example, the instruction "return if not zero" is "RNZ". In machine language, it would be either "CO" (hex), "300" (octal) or "11000000" (binary). A program called an *assembler* translates the mnemonic abbreviations into machine code, as well as performing such useful tricks as letting you call subroutines (frequently invoked sub-programs) by name, instead of remembering their memory addresses.

But that's still doing things the computer's way, not yours. *High-level languages*, such as BASIC or PASCAL, use standard English words (though sometimes in abbreviated form) to represent whole sequences of computer operations. In BASIC, for example, "PRINT SQR(SIN(Y))" will make the computer tell you what the square root of the sine of Y is. An assembly-language program for that would probably fill up this column.

Just as with assembly language, a special program is needed to translate your BASIC or other high-level language program into the computer's commands. That program can be read into the computer from a tape, or can be permanently built into the computer's memory. If you use BASIC a lot, it is a great convenience to have it instantly on tap whenever you turn the computer on. If you don't, this feature won't make much difference to you.

The typewriter keyboard and video screen are the most common microcomputer I/O devices, but there are variations and alternatives available. Many of these systems let you not only display letters and numbers (*alphanumerics*) on the screen, but "draw" pictures (*graphics*) on the screen as well. The pictures are often rather crude, being composed of clearly noticeable blocks, but they're useful for such applications as games, graphing mathematical functions, and in business for bar-graph and other displays that are easier to understand than tables of numbers. Color makes the games more exciting and the bar-graphs more readable, but raises the cost of the computer, too.

Graphics programs written in BASIC run very slowly; for speed, you'll have to use assembly language programs. Bear that in mind if you plan to write your own graphics. If you want fast graphics at low cost, you'll find a few graphics-capable machines with hex keypad input for machine-language programming.

Even alphanumeric video displays differ. Some computers have built-in video monitor screens. Others are usually sold with a video screen in a separate cabinet. Still others include video output circuits to feed signals to a video monitor screen. To feed it to a regular TV receiver, though, you'll have to convert that signal to a modulated radio-frequency one by passing it either through an *r-f modulator* or through a video-cassette recorder, if you have one. Not all computer/recorder combinations work well, though, nor do all r-f modulators. (The latter cannot be legally sold unless it's in kit form.) Try to check out your combination in the store or on a money-back guarantee. Computers with built-in r-f modulators are beginning to appear, too. This feature makes most sense in home systems, where there's likely to be a TV receiver available, than in a business or industrial system.

There are also differences in how much information you can put on the video screen. Alphanumeric displays are available with 16 lines of 64 characters each, or less, and with 25 lines of 80 characters, or more. Graphics displays also differ in the number of horizontal and vertical elements they can show—the amount of picture detail, in other words. The more information you pack on one screen, the more you take in at one glance. But more detailed displays cost more, and require higher-resolution monitors. As a result, high-density displays often cannot be used with r-f modulators and TV receivers.

Keyboards are more standardized. The basic differences are in keyboard "feel" (more likely to matter to an operator who already knows touch typing than to a hunt-and-peck operator) and in the presence or absence of separate numeric keypads. These keypads are very worthwhile in applications involving large amounts of numerical entries, such as in business accounting or in scientific computation. It's far quicker to punch numbers into a calculator-like nest of keys in a compact bunch than to use a row of number keys spread out across the top of the keyboard.

One major difference between typewriters and computers is that some computers display only upper-case, or capital letters. That's fine for most applications, but not for word processing.

Word processing systems are mostly used for business, where it costs lots of money to turn roughly typed or written drafts into smoothly typed letters and reports. On a typical word-processing system, the operator can enter text, make corrections of all kinds, then command the computer to print out a perfectly typed, finished copy. If it's a form letter, the computer can turn out a separate copy for each name and address on its list. Such systems are being adopted by offices, by free-lance writers and others.

Most small computers communicate with you through video screens. For most applications, this makes perfect sense: video systems are fast, silent, reliable, and don't use up paper.

But there are times when it definitely pays to have a permanent record of the computer's output. Word processing is an obvious example, but so are accounting (including your personal checkbook), alphabetizing of lists, or making written records of your programs that you can send to friends or carry with you while you look for problems and improvements. Properly programmed, a computer could print out your shopping list in the order that the items appear in on your supermarket's shelves.

In the early days of small computers, Teletype® printing terminals were the most common I/O devices. Today, video screens—on terminals or connected directly to the computer—are. But most systems do allow separate printers to be added to the system. If this is important to you, check how easily the printer can be added to any system you're considering, and how much the printer and its connections will cost.

Inside the Computer. It's no accident that we've been talking only about externals so far. For the input-output communication channels between you and the computer have far more to do with its utility than many of the circuits inside do.

The most important of these circuits is probably *memory*. You'll find computers here with as few as 256 "bytes" of memory, each *byte* being an 8-bit computer "word" that can represent a single alphanumeric symbol or a single computer command. You'll also find that many are expandable to as many as 65,536 bytes, variously abbreviated as either "64K" or "65K". (The two figures are equivalent; the "K" stands for "1024", a binary number that's only a little different from the decimal 1000, usually abbreviated "k". The figure of 65,536, representing 64 of those "binary thousands", could be abbreviated as either 64K or, in decimal, 65k; but the capital "K" is used, confusingly, for both, in this one instance.)

Most systems, though, fall into the 2K to 32K range. Memory costs money, so the more you have, the more the system costs. But the more memory you have, the longer the programs you can store, and the more data you can have available for them to work on.

There are two types of memory: RAM and ROM. *RAM* (Random-Access Memory) is used for temporary storage of programs and data and for the results of program runs. The contents of RAM can be changed at will, and many of them change constantly during the running of a program. But those contents also fade out within seconds when the power is turned off.

That's where *ROM* comes in. ROM (Read-Only Memory) doesn't forget—but you can't readily change it, either. Hence, ROM is used to hold vital programs which you'll use all the time, such as those which instruct the computer how to accept input from the keyboard. Some computers have BASIC in ROM, too—on others, you have to load in the BASIC language program from a tape each time you use it.

Most computers have more RAM than ROM. Typically, a system will wind up having about 2K of ROM (about 8K or 10K with BASIC in ROM) and 16K or more of RAM (less, if BASIC is in ROM, since that frees up the RAM space that BASIC would otherwise occupy). They may start with less, but sooner or later, more memory is added.

Some inexpensive systems, usually the single-board, keypad-and-display type, have very limited RAM space on board (perhaps 1K or 2K). Most of these allow other boards to be connected with more RAM. But unless your application is a simple one using machine-language or assembly-language programs (device control, for example), be sure any system you buy can be expanded to include enough memory for all your needs. There's no hard-and-fast rule about how much is enough, except that business systems seem never to have enough memory.

Mass Storage. Programs, other than those in ROM, must be fed into the computer every time you turn the system on or switch from one program to another. Entering them each time from the keyboard or keypad is ridiculously time-consuming, and almost inevitably leads to errors. So it's vital to have some easy, foolproof way to save programs and re-enter them.

The use of punched paper tape has virtually died out, since it's a slow and noisy procedure. Most small computer systems standardize instead on cassette tape, either built in or as an accessory program storage device. Most such systems convert programs and data into tones which can be recorded on ordinary audio cassette recorders, but a few record digital pulses, not audio tones, which requires a special recorder. Cassettes, especially audio cassette systems, are fairly slow (they require several minutes to load BASIC, for example). But they're faster than paper tape, use tape you can buy almost anywhere, and they usually make extra use of a cassette recorder you already own. Cassette programs are not always interchangeable between different computer makes, though a few cassette formats available as accessories for many computers, have achieved fairly wide use.

If you need more reliable loading (cassettes sometimes have to be loaded several times before you get them right), quicker loading, and faster access to a wide variety of programs and data, then it's time to consider *floppy disks*. Floppies are basically magnetic recording tape cut into discs instead of ribbons. They use digital recording and are very fast—BASIC or other long programs typically load in seconds. They also speed up access to programs and data. Getting from the first program on the disk to the last is a matter of moving the head a few inches from the outside to the inside track. In contrast, getting from the first to the last program on a C-60 cassette means moving about 250 *feet* of tape past the head. Disks also load more reliably than cassettes. And, when they don't load properly, reloading takes only a few seconds more.

Unlike cassettes, disks allow much interchangeability between computer systems, especially with systems based on the 8080, 8085 or Z80 processors. Many companies sell 5¼-inch disk programs written for use with these systems. Moreover, Digital Research's CP/M operating system simplifies interchange of programs from different computers using the foregoing processors.

The *processor* is, for the most part, less important than the system you use it in. If you're programming in BASIC or some other language, you'll find as much difference between versions of BASIC running on a common processor as between versions running on altogether different ones. If you program in assembly or machine language, you'll find unlike processors very different to work with, but you'll also find that every processor has its firm adherents, with each processor's advantages being balanced by disadvantages relative to other processors. The best way to choose is to settle for whatever processor is in the system which best suits you, and for which the programs you need are already available.

There are, however, some exceptions. To begin with, there are now several processors (such as the TI 9900 and the LSI-11) which use 16-bit "words" instead of the 8-bit ones used by most microprocessors. This allows them to have larger, more powerful instruction sets (some, for instance, can do multiplication directly, which the 8-bit processors can't), to handle larger numbers, and to run some programs (especially those involving large-number arithmetic) more quickly. But they cost more—and need more memory.

There's also a chip called the Pascal Microengine, which is designed to work specifically with PASCAL, a computer language of growing popularity. So far, there are few application programs available in PASCAL for microcomputers, but you can expect to see more of them in the next few years.

Structure and Expandability. Any computer system worth its salt is designed to allow expansion. Your needs may grow or change; your budget will certainly grow, allowing you to make additions piecemeal.

Computer systems can be expanded in a variety of ways, and a given computer may use several of them. The simplest way to expand a system is to plug more integrated circuits into sockets already provided for them. This is usually done to expand RAM and ROM memory, and only for moderate expansions. Many single-board computers use this method, but so do some larger ones.

A more popular and more versatile route to system expansion is to plug in additional circuit boards. This implies that the computer will have some sort of *bus structure*, which is a group of signal, data, address and power lines into which boards can be plugged in any order. Several bus systems are in use, some are used in just one model of computer, other (such as the S-100) are used in many.

Boards are available for a very wide variety of purposes: to expand memory; to add more I/O circuits for additional terminals, printers and the like; to generate speech or sounds; to accept voice input; to tell the computer what time it is; to allow the user to build circuits of his own; to control other devices; to communicate by phone with other computers and terminals; to test integrated circuits; to add graphics capabilities; to send and receive Morse code; to interface with computers using other buses; to speed math processing; and many more.

Some computers, chiefly very compact ones, require a separate "box" to hold more than a minimum of extra memory, I/O and other circuits. Others combine approaches, with an expansion box built around an S-100 bus.

Peripherals. Much system expansion occurs outside the computer. With the right programs and I/O circuits, a computer (even the kind whose built-in keyboard and video screen make it a terminal unto itself) can support several terminals around an office or house. For a very few machines, there are programs available which allow several terminals to operate at once.

Even a one-terminal system can frequently use an add-on printer, for all the reasons already cited. But the application has a lot to do with which printer should be selected. The main choices are between dot-matrix and character printers; between impact, electrosensitive and thermal printing systems; and between printers offering upper-case (capitals) only and those offering both upper and lower case.

To record computer programs, type mailing labels, do shopping lists and invoices, among other things, an upper-case printer is quite adequate. But for typing letters and manuscripts, both upper- and lower-case are needed. Upper and lower case are also recommended for any long text—pure upper-case text is harder to read. Lower case costs more, but the readability is worth it.

Printers that make fully-formed characters, like a typewriter, also produce more readable, more personal-looking text than those which form letters from a matrix of separate, unconnected dots. Dot-matrix printers tend to be cheaper and faster, though, so you may prefer them for short texts and program dumps. The more dots, the more readable: a 5×7 dot matrix is rather crude to read; a 9×12 matrix almost as easy as formed characters, though it still has a computer-printed look.

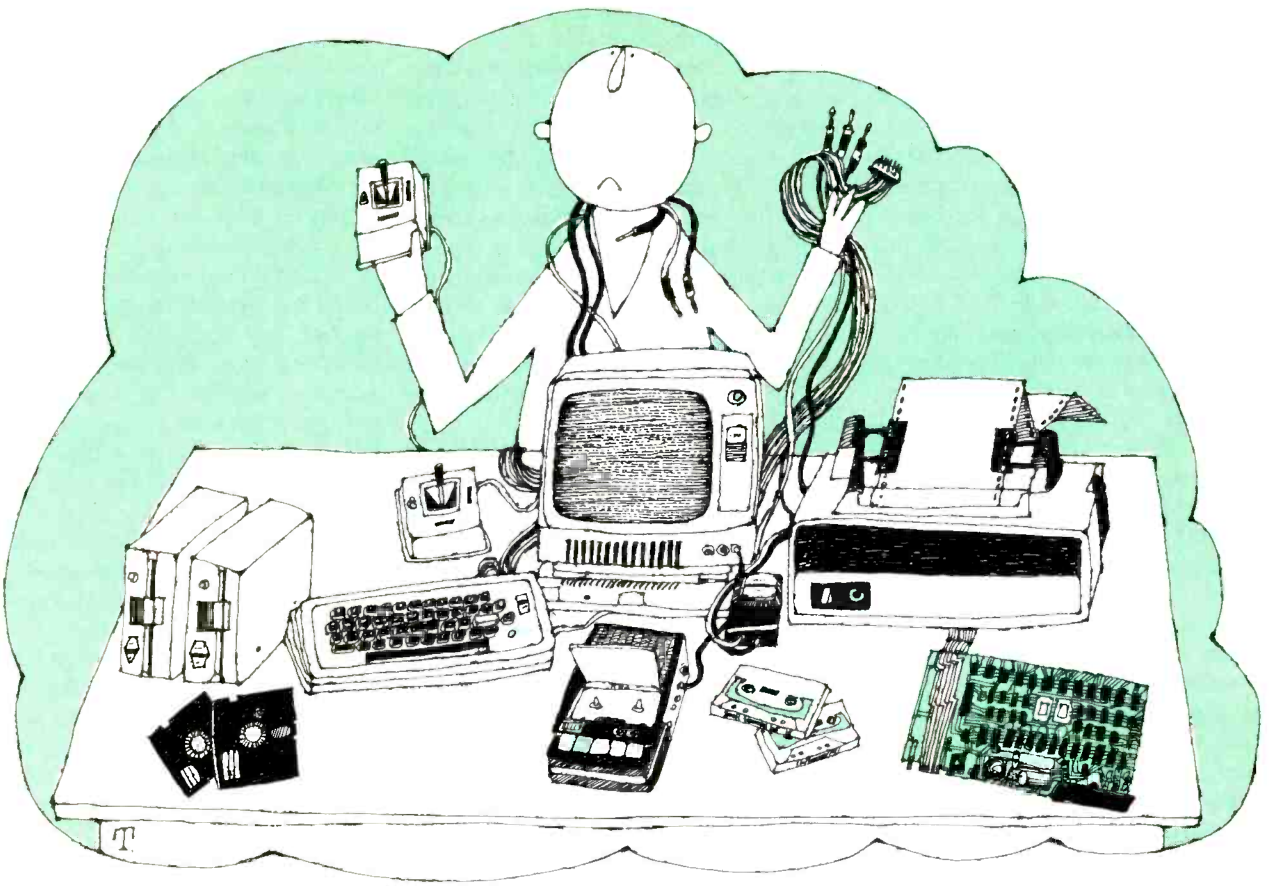
Impact printers work on the same principle as the typewriter, pressing an inked ribbon against the paper. This makes them the noisiest of printers, but allows them to use any ordinary paper (your letterhead, for example) and to produce carbon copies.

Thermal and electrosensitive printers, by contrast, are quiet, require no ribbon replacement, make only one copy at a time, but require special paper that's often available only from computer-supply dealers. That means they cost more in the long run than plain-paper impact printers, though electrosensitive printers are about the least expensive ones to buy. However, electrosensitive paper is silver-colored, not white, which makes it hard to read. Both thermal and electrosensitive printers are only available as dot-matrix types.

Printers can also be used for graphics. At the simplest level, this means mapping your printout as you would when "drawing" pictures with a typewriter. "Daisy-wheel" character printers, such as the Qume and Diablo, can be used to draw even finer pictures, since their printheads can be advanced by 1/10 or 1/12 the width of a normal printed character, but the use of software to do this with microcomputers is not common yet. Many dot-matrix printers can be used to draw dot pictures, too.

Modems are another useful accessory, allowing your computer to communicate with others by telephone. Originate-only modems, the least expensive type, let your computer call up others. Originate/answer types also let others call you up. Some of the latter type also have "auto answer" facilities, so they can answer calls even in your absence.

The Systems Approach. When you buy a computer, you're not just buying a computer. You're starting a *system.* So your choice should be governed by the entire system it belongs to, and how well that system suits your application. Can the system be expanded to keep pace with your future needs? Can you get the peripherals you need—disk drives, modems, printers, device control boards, or whatever? How easily can you add any extra memory you may need, and at what cost? How many companies supply equipment to use with this system? And, most important of all, is software available to make this system do what you want and need it to do? If the answer to all these questions is yes, then you've found the right system. This is an area where the help of a good dealer is well worth seeking. □



GETTING YOUR SYSTEM UP AND RUNNING

BY IVAN BERGER

GETTING a computer system up and running is a process that begins before you buy it: you must make sure that all the pieces you need are included in the system and that they'll all work in harmony. Even when they don't, there's rarely cause for panic. The problem usually is not one of product defects, but of mating those products properly with one another. In a simple system, such difficulties may never arise at all.

For some computers start-up is simply a matter of plugging it in, turning it on, and following instructions in the manual to establish a dialog with it. This is the case with a small, self-contained system that combines a terminal keyboard and video display in one package. For many others, it's almost as simple: the monitor screen and cassette recorder are in separate housings that must be plugged into the computer itself.

But for some others, you'll need to do more, and possibly even buy additional components. Some popular computers, for example, don't include video monitor screens. You'll have to purchase one (your computer dealer will be sure to have some), or have a home TV set modified by a serviceman to include a direct video input, or buy an r-f kit to convert the computer's video output into a TV-channel signal that your television receiver can pick up. Some computers have modulators built in, for use with regular TV sets. And if you have a video cassette recorder, you may be able to use its video input and built-in modulator to put computer images on your TV set's screen—or to record them. This does not work with all computer/VCR combinations, but it does work well with some.

Displaying your computer's output on a standard TV set's screen costs far less than buying a separate monitor. But using a monitor has advantages, too: it leaves the TV screen free for others in the family to use. Moreover, it will likely give you a sharper image because the signal bypasses the modulator and the set's tuning section and, in many cases, because the monitor has higher bandwidth than an ordinary TV set.

Some monitors are just TV sets with the tuners removed (yet with a higher price, alas). Others are specifically designed for higher resolution than TV receivers have. The most commonly cited monitor specification that relates to resolution is bandwidth. A bandwidth of 4.5 MHz is probably the rock-bottom minimum to look for in such a monitor, while anything over 6.6 MHz will be wasted in most home-computer applications. (Computers with high-resolution or high-density graphics output may require more than 6.6 MHz, though; consult your system's manual to be sure.)

Separate Terminal. Many computers come with neither keyboard nor video output. You can communicate with them in either of two ways: by equipping the computer with an input port for a separate keyboard and a video output-board to feed a monitor screen or r-f modulator, or by equipping it with an input/output port through which it can communicate with a terminal.

A terminal is simply a keyboard combined with a video display or printer, with provision to display or print both your keyboard input and the computer's replies. Computers which do not have their own keyboards and screens or video output will either come with the necessary ports or have them available as accessories.

Accessory video and input/output (I/O) boards (as well as accessory boards for memory and other purposes) may either be made for specific computers or be designed to plug into most computers using a given "bus." A bus is a standardized layout of signal lines and connectors that allows circuit boards of many kinds to be added and subtracted at will. The S-100 bus is the most common one among small computers. When adding boards, it is important to check whether the total power drawn by all boards in the system will still be within the power supply's capacity.

Serial and Parallel Input. There are two types of input/output circuit: serial and parallel. Most keyboards require parallel connection, with all eight data bits per data "word" (a character or command) reaching the computer simultaneously, each through its own wire. This is the efficient and inexpensive way, since the computer also processes data in parallel internally.

Most computers use serial connection, with the bits sent one at a time over the same pair of wires. Serial I/O circuits cost more, but are easier to use for long wiring runs. Computer terminals are usually serial devices. Printers are often available in both serial- and parallel-connection models. The extra-cost serial option is for use when the computer and printer must be some distance apart.

Once you've set up whatever devices you need to communicate with your computer, what you "say" depends less on the system hardware than on the software, or programs, which tell it what to do and how to respond to your input.

Most computers on the market today have a high-level language (usually BASIC) in read-only memory (ROM). In some, the computer is ready to talk BASIC with you as soon as you turn it on. In others, you need a key-stroke or two to enter BASIC.

With some computers, though, you have to load BASIC into your main memory from a cassette recorder, floppy disk unit, or paper tape (though paper tape is rare, today). Such computers will usually have a different program in ROM and a monitor program (not to be confused with a TV monitor), which tells the computer how to load new programs from tape or disk and how to interpret your keyboard commands. A very few computers, however, require that you enter a "bootstrap" program into the computer in order to load the monitor from tape or disk. Such computers must have front panels allowing direct input, either in octal or hexadecimal numbers from a keypad, or in binary numbers from a bank of switches (one switch per bit). Even front-panel machines nowadays will usually have ROM monitors, rendering the bootstrap unnecessary. But the front-panel is useful in de-bugging programs and hardware.

Floppies and Cassettes. Loading a program in from tape or disk requires a cassette or floppy-disk system to load them from. Many computers today have one or the other built in. Most, though, require that they be added externally.

Of these, many come with a separate recorder, while others include only an interface for storing data and programs on a standard audio cassette recorder.

Adding floppy-disk systems to your computer (or adding cassette, if your computer lacks it) is usually a matter of inserting a special board into the computer, then connecting the disk or cassette unit to it. (The new, hard disk systems now appearing also require such boards.) As with I/O boards, these may be designed for specific computers or for common busses—but there are also a few which connect to regular I/O ports.

Having a cassette or floppy-disk system does not necessarily mean that you can readily swap programs or data with other floppy- or cassette-equipped hobbyists. There are a wide variety of systems and "standards." Only computers with both the same type of processor (e.g., 6502, 8080/Z80, 6800, 1802) and floppy or cassette systems operating on the same standards can interchange programs in this way.

There are many variations to watch out for. Different cassette systems may record different sets of tones on the tape, may transfer data at different speeds, and may use different combinations of characters for the start and end of each taped record. Record and playback volume settings may be critical when interchanging tapes from systems which are theoretically identical.

With floppy disks, there are even more variations to note. Floppies come in both full (8-inch) and mini (5¼-inch) sizes, and some mini-floppies record more tracks on the disk than others. Some systems use "hard-sectored" disks, with a ring of small holes surrounding the large, central one; others are "soft-sectored," with but a single index hole. Several systems are available in both single- and double-density versions, with single-density unable to read double-density disks.

Despite this wide range of variation, there is far more standardization in floppy systems than in cassettes. Users of S-100 bus systems are fortunate in this respect: the North Star and Micropolis mini-floppy systems, and 8-inch floppy systems using the CP/M operating system have become *de facto* standards, with programs available in these formats from many vendors. The CP/M disk operating system (DOS) is even available for North Star and Micropolis disk setups. Neither, though, can read disks written by the other, or interchange disks with full-size CP/M systems.

There are also several S-100 bus cassette "standards," such as Tarbell, Kansas City (the only one officially adopted as a standard, and one of the least used) and CUTS. But none of them are as popular now as they were before disk systems became common.

Computers of vast popularity, such as the TRS-80, Apple, Pet, KIM-1 and Sorceror become standards unto themselves, of course, with software available for them from many sources. There are even crossbreeds: S-100 bus interfaces are available for all of these computers (though not all S-100 boards can be used with some of them). And several companies have appropriated CP/M for the TRS-80.

Interfacing. Computer boards, peripherals and other extras are not like hi-fi components: You can't just plug them together and automatically expect them to run. Usually, a few adjustments are needed for smooth operation.

Those adjustments may simply involve flicking a few switches, or moving jumper wires from one hole on a board to another. Or they may involve small modifications to programs or hardware. But they always require good documentation—operating and service manuals for your hardware, source listings (or other detailed manuals) for software—so you can figure out just what to do.

It also pays to draw on outside help and advice, when available. A computer club, if there's one near you, will be full of potential helpers. Your dealer or dealers will also help. The more you buy from one dealer, of course, the more helpful he'll be. That's not just because he's made more money from you (though that is a factor). The more of the system that came from him, the more likely he is to be familiar with whatever components aren't working with each other properly.

Problems are easier to deal with when you know what to expect. So here's a list of the major areas likely to need attention when setting up a system:

Memory. Every machine-language program (including monitor programs, interpreters or compilers for BASIC and other languages, assemblers, disk-operating systems, and so on) will be designed to reside and run in a specific block of memory addresses. Make sure when you buy your software that programs which will be in your system's memory at the same time use different blocks of memory. This would include both programs designed to work together (editors and assemblers, for example) and all programs in ROM or PROM.

Be certain, too, that your memory boards are set to the addresses that your programs require, and that no two memory boards are set to the same or overlapping addresses. Changing a memory board's address is usually a matter of moving a jumper wire or resetting some small switches.

Using a fast processor (such as a 4-MHz Z80) with slow memory can cause problems, too. Many memory boards provide for "wait states" to slow down the program long enough for the memory to catch up with the processor.

I/O. Input/output ports have addresses, too. These addresses must also agree with the programs that use them. Setting up your I/O boards' addresses to match your software is as easy as changing a memory board's address. But changing your software's I/O address calls can be easy, too. (Changing a program's memory addresses is often a major undertaking.) So which should you change if the hardware and software disagree?

Where change is called for, the answer may be to split it between software and hardware. Programs in ROM or PROM ("firmware") can't be modified readily, so you'll have to set your port hardware addresses to match those programs. Then modify any software which calls for different port addresses, so it matches the way you've set your hardware up.

Serial settings. Serial I/O may need some further tinkering. First, the baud rate (data transmission speed) of both the port and the peripheral connected to it must be matched. Other options must also be made to agree between the port and the peripheral: Some systems are "full duplex," with the terminal not showing your keyboard input until it's reached the computer and been echoed back; others are "half duplex," printing or displaying the keyboard input as soon as it's entered. Some serial circuits use RS-232 signal levels and connections, while others use 20-mA current-loop levels and connections instead. Parity bits (transmitted as a check against transmission errors) and stop bits (marking transitions between data words) must be set to match as well.

If one component offers no choice in any of these matters, then all other components should be set to match it. Otherwise, the choices can be made fairly arbitrarily, so long as the same choice is made for any two devices which communicate with one another.

Timing requirements. Microcomputer components must work in synchronization with each other. Since they also run at lightning speeds, that makes their timing as difficult as it is critical. The more different sources your boards came from, the more likely such problems are to occur. Getting the timing right can require trial-and-error replacement of capacitors or resistors in timing circuits—strictly a job for the knowledgeable.

Bus variations. Scores of manufacturers made module boards for the S-100 bus for several years before the IEEE defined a standard configuration and standard signal formats for it. As a result, boards from different manufacturers may use the same bus lines for different signals, or one manufacturer's board may require a signal that another manufacturer's board puts out. (This is especially true of Z80 CPU boards, many of which do not generate all the signals which 8080 boards do.) When contacting the manufacturer of any board which seems to be malfunctioning, be sure to list all the other boards in your system so that he can spot troubles which lie in a conflict between boards.

Software. A computer is useless without programs. You'll doubtless buy a monitor program, a high-level language interpreter or compiler (probably BASIC) or both when you get your machine. But you'll quickly find that you need others to perform whatever tasks you purchased your computer for. You can write these programs yourself, key them in from printed books or listings, or buy them on tape or disk.

Writing your own programs is both the most time-consuming and most satisfying of the three. And once you develop the necessary programming skills (often one of the main reasons for buying a computer in the first place), you'll wind up with programs that are custom-designed for your particular needs and ways of thinking.

Keying in a program from a printed listing may do nothing for your ego, but it's faster. You may also find that programs written for other computers may require some modifications to run on yours. There are, for instance, more dialects of BASIC than there are of Chinese, and programs written in one dialect may use commands inscrutable to other dialects. (David Lien's *The BASIC Handbook* is an excellent guide around such problems.)

Entering a program from a tape or disk is fastest and easiest. But to work, the program must be distributed in the disk or tape format your system uses. If written in machine language, it must be configured for your memory and I/O addresses (though you can load it first, then alter it). And if in BASIC or some other high-level language, it must be written for your specific language interpreter or compiler. This can be more critical than it looks. Programs saved on tape from 8K Altair BASIC, for example, may not run properly in 12K Altair BASIC. (The 8K program would work perfectly in 12K, though, if it were entered at the keyboard from a printed listing, not loaded from the tape.)

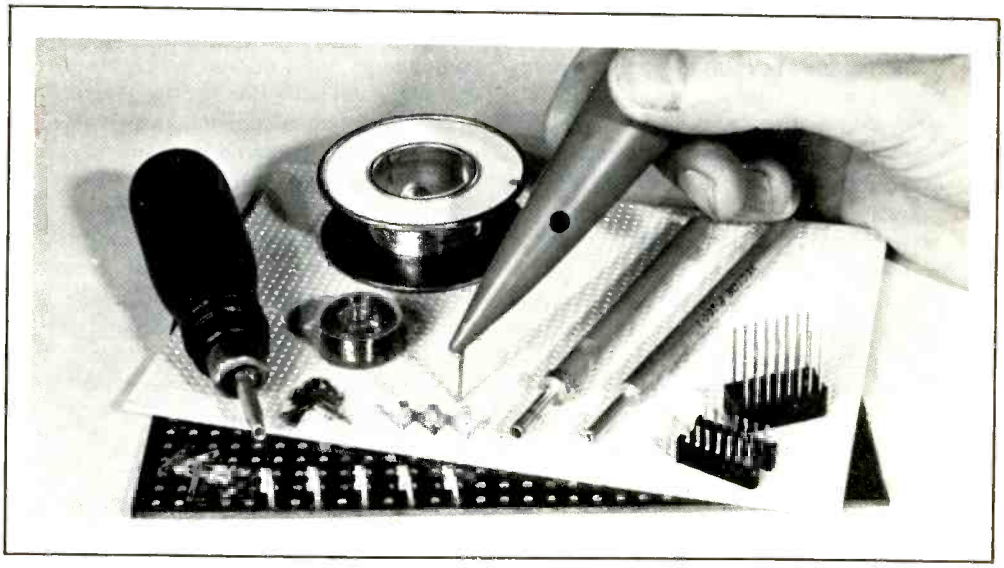
When you buy a program, you should try it in the store, first, to make sure it does everything you want in a way that you find natural and convenient. If possible, try it on a system exactly like yours. Since most dealers sell programs for the systems that they sell, you'll probably be able to try them at your dealer's on a system similar to yours. The main exception to this is the Radio Shack TRS-80. Only Radio Shack stores sell it, and they sell only Radio Shack programs. But the TRS-80's popularity has led many mail-order suppliers to sell programs for it, though they do not naturally have the "walk-in" facilities or local location to permit a demonstration.

In conclusion, don't think that, just because so many finicky details may need attention, a computer system is a chronic invalid. Think of it rather as much like a baby, requiring fussing and attention before it can do anything appreciable on its own. And some computers—like some babies—give you pure pleasure, with no trouble at all. ◇

PERF BOARD WIRING TECHNIQUES FOR EXPERIMENTERS

Rapid circuit assembly and alteration methods using perforated board.

BY ADOLPH MANGIERI



Useful tools include (left to right) pin insertion tool, wiring pencil, manual wire wrapping tool and unwrapping tool.

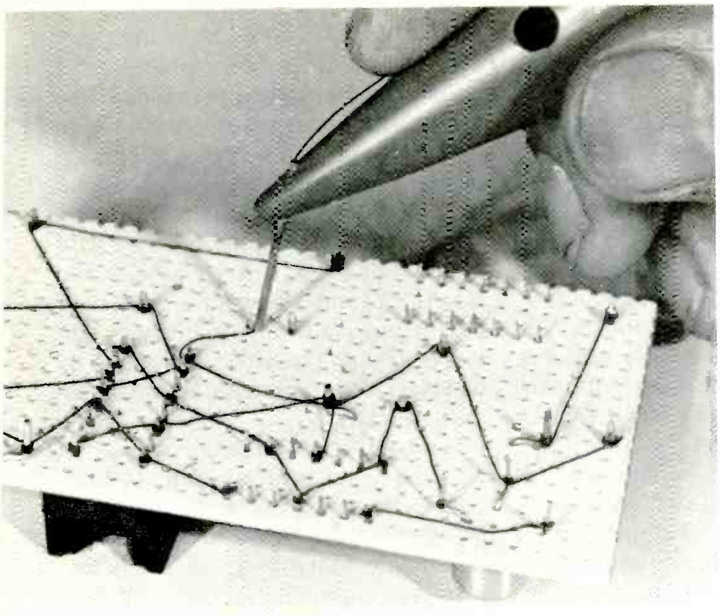
MOST electronic projects are best assembled on either printed circuit or perforated board. Both types have advantages and disadvantages which should be considered before starting a project. The pc board permits compact assemblies but impedes experimentation and circuit alterations. Perf board, on the other hand, permits rapid assembly and easy circuit alterations but tends to take up more room for the same circuit. With few exceptions, any project you can build on a pc board can also be assembled on perf board.

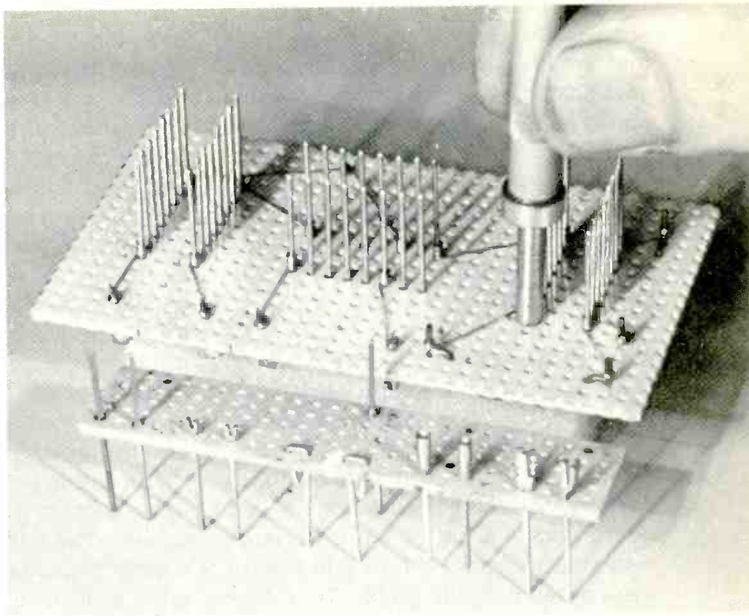
Perf board construction has another important advantage over the pc board. It eliminates the need for using chemicals and drilling holes. This might be an important consideration if you're pressed for time and want to get right to assembly after designing a layout. Needless to say, the perf board technique is a very attractive alternative to project assembly, especially if you do a lot of experimenting.

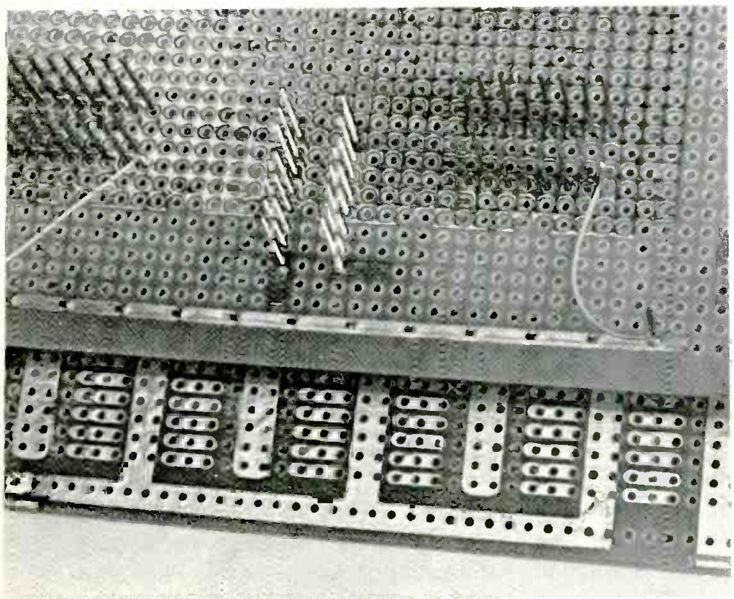
Perf Board Materials. The first step in working with perf boards is to familiarize yourself with the various types of boards, tools, and hardware available. Perf boards are letter-coded according to patterns, sizes, and spacing of holes. Furthermore, you have a choice of XXX phenolic, paper epoxy, and epoxy fiberglass material and unclad (plain) and clad blanks. Add to this list a choice of board thicknesses.

The Table lists the most popular perf board configurations (from two typical sources) according to letter code, the various push-in terminals and insertion tools, and prepunched bus strips to be used with each. It is obvious that you can choose the materials to meet the requirements for your project. For example, use P-pattern board for IC's in dual in-line packages (DIP's) and either P- or G-pattern board for round (TO-5) transistors. A less desirable alternative would be to use F-pattern board and drill extra holes as necessary. For heavy-weight projects, such as power supplies, you can use A-pattern board with extra thickness and the large No. T9.4 push-in terminals. (For general use, 1/16"-thick board is an excellent choice, while 3/32"-thick board is recommended for the majority of the heavier duty jobs.)

Bus strips are flat, prepunched and tinned and made of copper for use as power supply and common buses. They eliminate wiring complexity and







1	2
3	
4	5

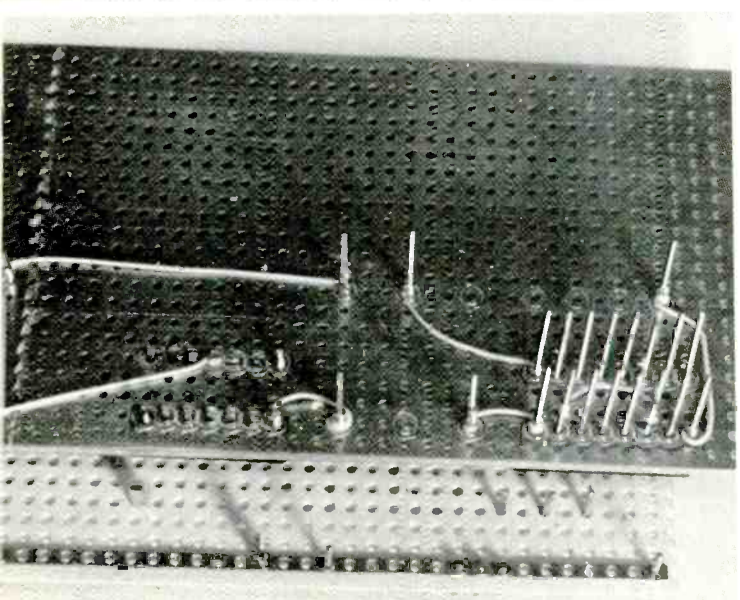
1 *Wiring pencil wraps solder-through insulated wire on leads of resistors, IC's and transistors.*

2 *Wrapping tool used on solderless connections. Terminals in foreground facilitate wire wrapping.*

3 *Ground-plane board at top has terminals for ground connections. Below is interdigitated bus board.*

4 *Clad perf board requires cutting of circle pad for isolation of socket and board terminals.*

5 *Clad ground-plane board requires drilling and line and circle pad cutting. Pad cutter at right.*



reduce the chance of ground loops that create circuit instabilities. Low-cost solder pin insertion tools permit you to install pins safely and speedily.

Accommodating most semiconductor devices (including IC's) and accepting an almost endless variety of board pins, the 1/16" thick P-pattern board will prove to be the most versatile for many projects.

Conventional Wiring Method. As is the case when doing pc work, careful layout planning will be rewarded with neater perf board assemblies and error-free wiring. You can design a parts layout and wiring guide for perf board with the aid of the grid paper available for most board patterns or even ordinary graph paper. To a large extent, your parts layout will follow the schematic diagram for your project. Of course, you'll have to trial-fit the components on the board, making allowance for the pattern and spacing of the holes.

Once you know how a board is to be laid out and wired, you can install push-in terminals, transistor and IC sockets, and power and common buses. If you choose to omit bus strips, use 20-gauge (or heavier) solid bare hookup wire in their place.

When making interconnections, 28-gauge solid wire is suggested for easy handling and manipulation with tools. Wherever possible, use bare wire; but if you must make crossover connections, switch to insulated wire. Use 24- or 26-gauge insulated stranded hookup wire between the board assembly and off-the-board components. When your project includes DIP (dual in-line package) IC's, avoid confusion by labelling pin 1 of each. Better yet, use E-Z-Code self-sticking pin number marking strips.

Fitting wire with longnose pliers can prove to be a trying task, particularly when using P-pattern board and DIP sockets. You can save a great deal of time and avoid much frustration by using a manual tool to wrap the wire on a terminal (such as the Vector No. P160-2A or similar). This tool neatly forms a tight wrap on either socket solder tabs, No. T42.1 flea-clip tails, component lead ends, or directly on DIP IC pins. These aren't true Wire Wraps®, which means that every connection must also be soldered to assure good mechanical and electrical bonds.

After wiring a project, it's always good practice to check for errors before applying power. Look for reversed installation of diodes, electrolytic capacitors, LED's, etc.; IC's and transistors plugged in backwards; and transposed connections to battery clips and holders.

"Pencil Wiring." Recently, a new approach to wiring perf board assemblies has been introduced. Vector's new Model P173 wiring pencil promises to become a very popular tool for perf board work. Applied Manufacturing of Texas has a similar tool for making Solder Wraps®.

The wiring pencil eliminates having to cut wires to size and strip away insulation. The pencil dispenses and wraps 36-gauge solder-through insulated solid wire around any size post or terminal. Much faster than point-to-point wiring, pencil wiring permits you to interconnect a number of terminals with an unbroken length of wire. Once the wire is wrapped around a terminal, you apply heat directly to the joint. The insulation immediately vaporizes to allow you to flow solder into the connection. A very important advantage of pencil wiring is that it permits you to omit all sockets and most solder terminals.

As shown in Fig. 1, the wiring pencil feeds the wire from a bobbin containing 250′ (76.2 m) of wire through the tool's barrel, out one of two holes, and down through a hollow "needle." Wire feed and tension are controlled by finger pressure on the wire where it comes out of the hole in the body of the tool. (The two holes are provided so that either right or left handed people can use the tool.) At the end of a run, you simply twist the pencil, and the point of the needle quickly and neatly clips the wire.

Sockets and solder clips can be omitted during assembly by using the pencil to wire directly to protruding leads and lugs. To use this technique, however, the components must be staked to the board (leads bent to mechanically secure parts in place) as shown in Fig. 1. You can use longnose pliers for staking, but Vector's No. P174 staking tool makes the job easier. Components can also be cemented to the board with a quick-set adhesive, and eyelets make excellent solderable anchors for problem components.

You can avoid having to stake components by isolating circular pads on copper-clad perf board (discussed later under Ground Plane Methods). Solder upright ends of component leads and socket tabs to the circle pads to anchor the parts in place. Use pre-punched bus strips on the top of the board (unclad side) for the power buses. For feedthroughs, use either No. T42-1 flea clips, double-ended No. K31C round-shank pins inserted with a No. P133-A tool, or the single-ended No. T50 round-shank series shorting pin. Using clad perf board, you can dispense with bus strips altogether by isolating strips of copper (also discussed later).

Here are a few useful hints when working with a wiring pencil. Form your wraps slightly away from the board's surface to avoid marring the board with heat during soldering. Use a soldering pencil that has a tip temperature of at least 650° F (343° C) and "wet" the tip with solder before applying heat to a joint or wrap. To prevent wire breakage, dress the wire close to the board and secure lengthy runs with drops of quick-drying cement. Isolated round-shank pins make good pivot points for routing wires around obstacles. Alternatively, you can use a No. P179WS plastic wire spacer for grouping wires in a bundle. In a pinch, you can use 30-gauge bare solid wire, at least for ground returns.

Wire Wrapping. Wrapping wires around terminals, either with or without solder, offers wiring flexibility to permit rapid circuit changes. The standard wrapped connection consists of six to eight turns of wire applied under tension to square, sharp-edged wrap posts. The modified wrap, or anti-vibration wrap for extreme conditions, includes an additional one or two turns of insulated wire at the start of the wrap.

If you plan to use this technique, you'll need an efficient and easy-to-load manual wrapping tool, such as Vector's No. P160-2A. The No. P160-1A is an unwrapping tool for easy removal of wrapped connections. The preferable wire size for wrapping is 28-gauge bare or Kynar insulated (Vector No.'s 2323A-28-3 or 2323A-28-4). Pre-cut and pre-stripped wire (Cambion sells a 30-gauge No. 601-2515 wire kit) will speed assembly but, unless trimmed as you go, will leave you with a maze of slack wires.

You can assemble an entire project using wrapped wire and the appropriate pins as shown in Fig. 2. From left to right, the pins shown include pairs of Vector No.'s. T46-3 double-ended

PERFORATED BOARD CONFIGURATIONS

Board Pattern	Hole Size	Hole Spacing	Push-in Terminal Vector	Push-in Terminal Radio Shack	Insertion Tool (Vector)	Bus Strip (Vector)
A	0.093"	0.265"	T9.4	—	P122B	T58
B	0.062"	0.188"	T28	270-1394	P91A	—
F	0.062"	0.20"	T28	270-1394	P91A	T104
G*	0.062"	0.20x.10"	T28	270-1394	P91A	T104
P	0.042"	0.10"	T42.1	270-1392	P191A	T107

*Alternate rows staggered .10".

wrap posts that should be inserted with tool No. P133-A; T44 Miniwrap posts (No. A13 insertion tool); K32 J pins; R32 socket pins; and the versatile T49 Klipwrap post (No. P156 insertion tool). All this hardware is designed to fit P-pattern perf board.

It's difficult to insert a pin perpendicular to a board's surface unless you have an alignment block, such as Vector's No. MB45-20-062. It consists of 10 pieces of 1/16" P-pattern board glued in a stack. If you wish, you can make a small version from scrap board for use in tight places.

Forming perfect wrapped connections is a simple procedure, but it takes some practice to get the knack of handling the tool for positioning and dressing the wire. Use bare wire wherever possible. As with the wiring pencil, you can wrap a number of posts with an unbroken length of wire by passing the wire down through the handle of the wrapping tool.

Practice loading the wire until you can do it instinctively. The wrapping tool has a central hole that fits over the post. The end of the wire fits into a smaller off-center hole or tunnel near an index mark. If you're using 28-gauge insulated wire, strip away ¾" (about 2 cm) of insulation. Hold the tool about horizontal with its index mark up. Catch the end of the wire in the cross slot of the tool's recessed tip near the index mark and insert into the wire tunnel. If the wire bottoms out before accepting the entire stripped end, it's in the wrap post hole. You'll have to withdraw and try again. Once the wire is properly inserted, anchor it in place by withdrawing half way, bend the wire about 30°, and push home before making the final right-angle bend.

Projects requiring numerous wrapping card sockets are best assembled with a cordless power wrapper, such as Vector's No. P160-4, which accepts the No. P160-2A manual wrapper.

Ground Plane Methods. Having a large area of copper at ground potential, the ground plane affords minimum ground circuit impedance and permits the shortest possible connections to ground. This not only eliminates instability in broadband vhf amplifiers, it also minimizes noise and ringing in digital circuits. To achieve these benefits, keep lead lengths as short as possible and inputs and outputs well separated.

Beginning with P-pattern etched ground-plane board (Vector No. 3677-7), the copper surrounding the board holes is pre-etched, leaving circles of insulation around the holes (Fig. 3). Primarily intended for wire wrapping, this board can also be used with any other wiring method. To ground a wrap post to the ground plane, push a self-fastening No. T112-1 bus link onto the post with a No. P133A insertion tool and solder the tab to the plane.

With all ground-plane wiring methods, it is best to run insulated wire right up to the pin to avoid short circuits. Better yet, wrap a turn of insulated wire on the pin nearest the board. This is easily accomplished with the No. P160-2A wrapping tool by pushing a bit of wire insulation into the recessed tip before bending the wire at a right angle. Alternatively, you can bend the wire on the insulation before loading the wrapping tool. (You can also use this tip to form antivibration-wrapped connections.)

Etched padboards that have generous interdigitized ground and supply buses (Vector No. 3677-6) closely approximate the full-ground type plane. Assign ground to buses passing between socket pads. By jumpering common-ground and supply buses, a further reduction in ground and supply bus impedance can be effected. The padboard lends itself well to any wiring scheme. A manual line cutting chisel (Vector No. P139) permits you to safely cut through a bus or pad to isolate it.

Fully clad (one side only) perf board can be used for ground planes (Fig. 4). For P-pattern board, you'll need a circle pad cutter, such as Vector's No. P138C tool. Cut circle pads at all pin locations where the circuit must be isolated from ground. Grounded points should not be isolated. To avoid rapid cutter wear and tearing out pads, use a low drilling speed. (Hint: With high-speed power tools, like those made by Dremel under the "Moto" brand name, use a solid-state speed control set for about 45 volts ac.) You can avoid drilling too deeply into the board by backing the board with a metal plate to serve as a stop for the cutter bit's pilot pin. If the cut is too shallow and doesn't remove enough copper, place an index card between board and plate.

Accidents are bound to occur. So, if you do tear out a pad, install a No. T102 or T103 eyelet with flange on the clad side of the board. Pads not required for use as anchors or supports are best removed wtih an Xacto knife to reduce the chance of solder bridging or wiring shorts to ground. If you capture a pad within the cutter, remove it with a large needle or awl. Before you start wiring a circuit, check all pads with a magnifying glass and redrill any that have copper bridges to ground.

Use No. T107 bus strips on the unclad (top) side of the board, or section off a strip of copper on the bottom of the board using an electric line cutter. A tungsten carbide router bit (Dremel No. 9909 or Vector No. P141A) chucked into a Dremel Moto tool will make short work of line cutting, as shown in Fig. 5.

You can make a line cutting guide by cementing a 4"L×1½"W×1/16"T (10.2×3.8 cm×1.6 mm) piece of insulation board to a block of ¼" (6.4-mm) thick plywood, overlapping it by ¼" along the long dimension. Cement a sheet of nonskid rubber to the bottom of the plywood. To use the block, place the guide along the line to be cut and hold the cutting tool at about a 45° angle to the board's surface and held firmly against the guide edge. Don't try to cut the line in one pass; make several light passes until all copper is removed along the line. A prepackaged line cutting kit containing a Dremel Model 260 drill, router bit, and several accessories is available from Vector as the No. P141B kit. ◈

THE OSCILLOSCOPE GRAPHIC ARTIST

BY MITCHELL WAITE

Create exciting, computer-generated, three-dimensional drawings on your oscilloscope

A DIM light traces a delicate pattern of geometrical lines on the screen of an oscilloscope. The lines form a rectangle that suddenly tilts back and transforms into a revolving ring of diamonds. You can produce these, plus many more, effects by operating the controls on the Graphic Artist project described here. You can easily make an image rotate in three dimensions, compress and expand, break up into other shapes, or slowly oscillate.

The Graphic Artist is a visual pattern generator that is designed to use the CRT screen of an oscilloscope as a "canvas" and its electron beam as a high-speed "brush." The real-time three-dimensional display on the CRT screen has all the delicate geometric beauty and detail of the computer-generated three-dimensional drawings with which we are all familiar.

The beam in an oscilloscope is forced to follow two complex, harmonically related signals in producing the geometric patterns. Phase-shift networks, working in concert with a simple modulator, in the Graphic Artist add a signal that produces a depth and volume cue for the scope image.

If you're into electronic music, you might try feeding the output signal of the Graphic Artist into a stereo amplifying system to hear the tones associated with the on-screen images. Even more interesting, you can feed harmonics from a music source into the Artist's circuit in place of the oscillator signals. This allows you to view the patterns created by harmonically related musical notes.

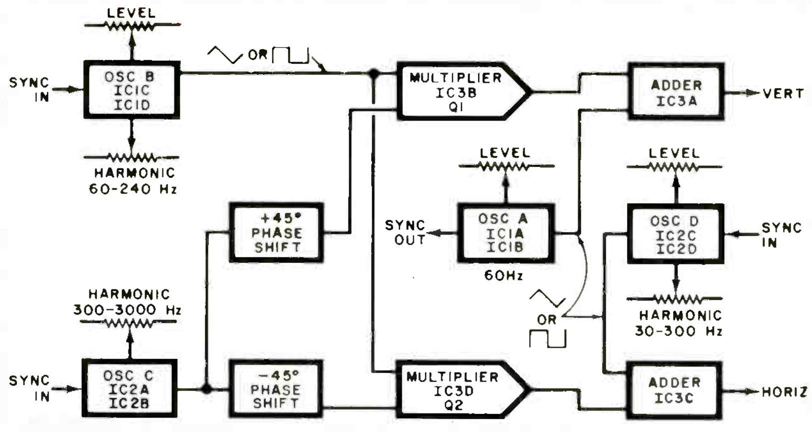
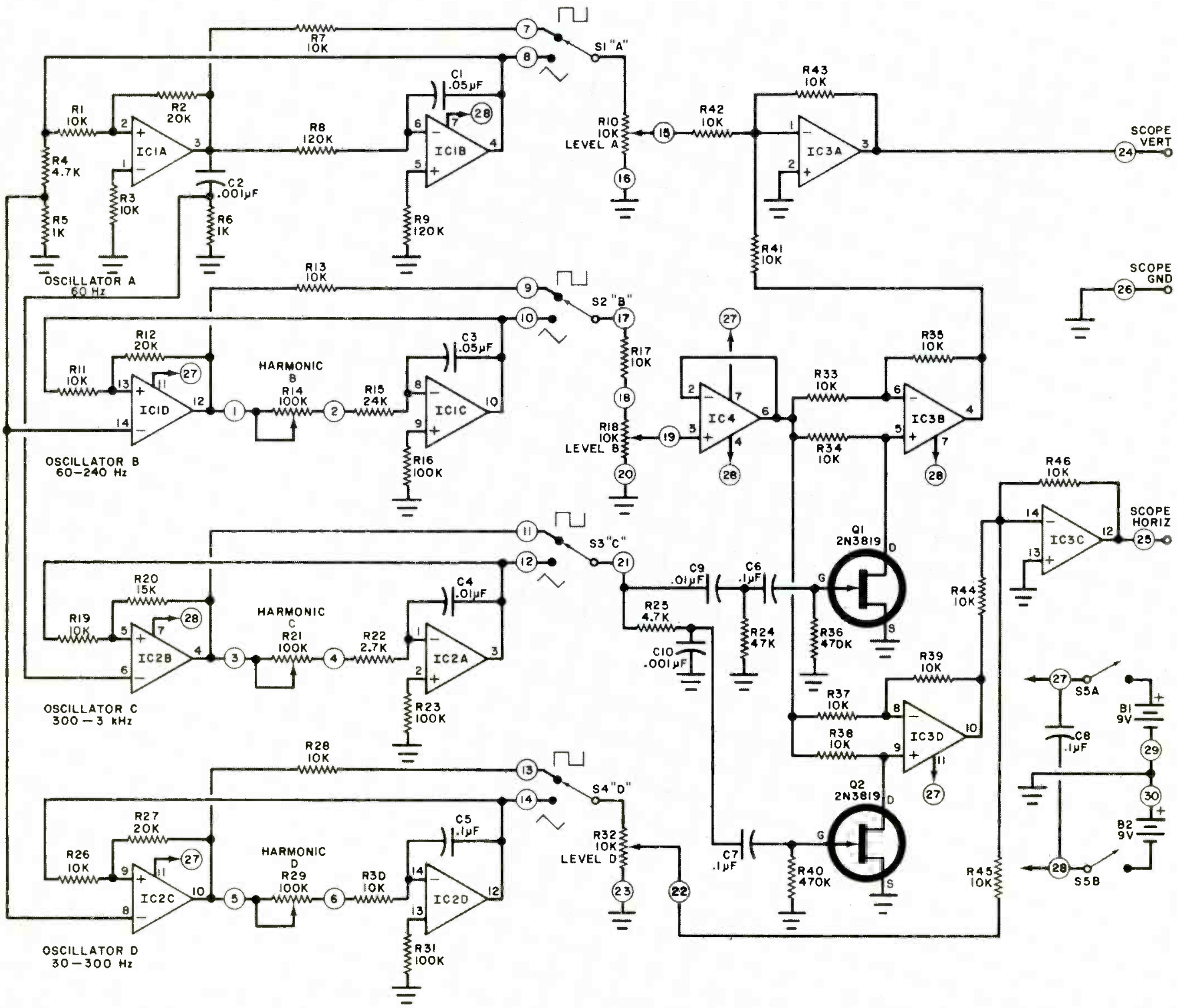


Fig. 1. Block diagram of Graphic Artist.

About the Circuit. As shown in the block diagram in Fig. 1, two almost identical signal channels in the Artist are connected to the vertical and horizontal inputs of an oscilloscope. This hookup results in a CRT trace that is known as a Lissajous figure—a circular-like trace that is proportional to the vertical and horizontal displacement of the scope's electron beam.

Each channel in the Artist consists of two oscillators (A and D) that generate square and triangular waveforms. Added to the signals produced by



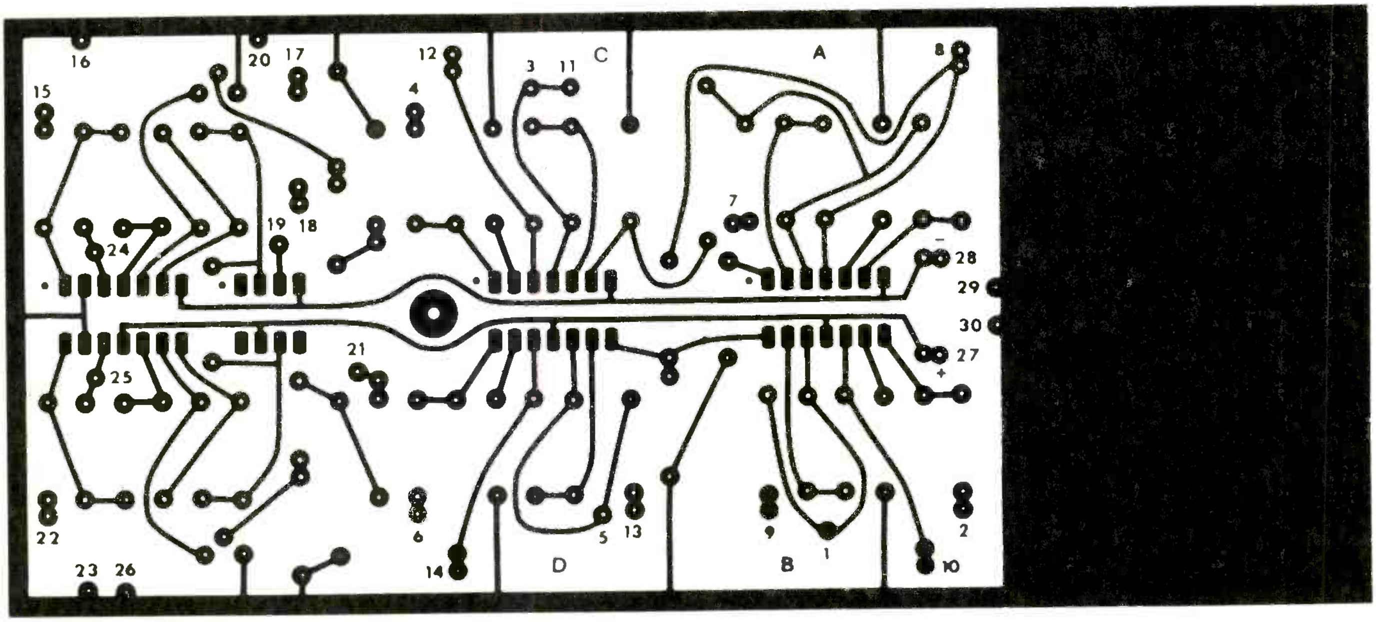
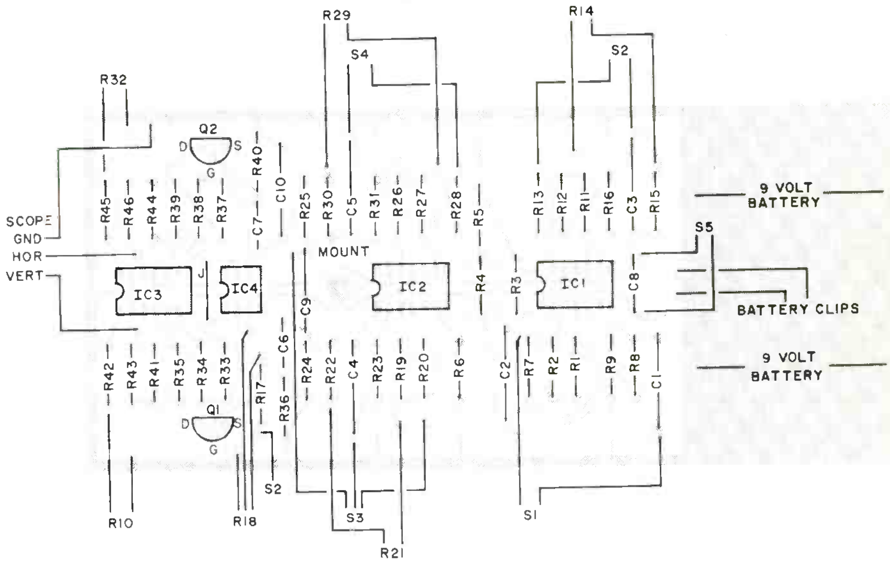


Fig. 3. Etching and drilling (above) and component (right) guides.



PARTS LIST

B1,B2—9-volt battery
C1,C3—0.05-μF Mylar capacitor
C2,C10—0.001-μF Mylar capacitor
C4,C9—0.01-μF Mylar capacitor
C5,C6,C7,C8—0.1-μF 100-volt Mylar capacitor
IC1, IC2,IC3—Quad 741 operational amplifier integrated circuit (Raytheon RC4136DB)
IC4—741 operational amplifier integrated circuit
J1, J2, J3—Five-way binding post
Q1,Q2—2N3819 junction field-effect transistor
The following resistors are ¼-watt 10% tolerance:
R1,R3,R7,R11,R13,R17,R19,R26,R28, R30,R33,R34,R35,R37,R38,R39,R41, R42,R43,R44,R45,R46—10,000 ohms
R2,R12,R27—20,000 ohms
R4,R25—4700 ohms
R5,R6—1000 ohms
R8,R9—120,000 ohms
R15—24,000 ohms
R16,R23,R31—100,000 ohms
R20—15,000 ohms
R22—2700 ohms
R24—47,000 ohms
R36,R40—470,000 ohms
R10,R18,R32—10,000-ohm linear taper potentiometer
R14,R21,R29—100,000-ohm linear-taper potentiometer
S1 thru S4—Spdt slide or toggle switch
S5—Dpdt slide or toggle switch
Misc.—Printed circuit or perforated board; 7½"L × 4¼"W × 2"D (19 × 11 × 5.1 cm) case; knobs (6); battery clips (2); lettering kit; hookup wire; machine hardware; solder; etc.

these oscillators is a common modulated signal derived from oscillators B and C. The overall shape of the Lissajous pattern is set by the signals from oscillators A and D. (For example, a simple rectangle results when triangular waveforms make up these signals.)

The modulation component is comprised of a variable high-frequency carrier from oscillator C and a variable medium-frequency envelope from oscillator B. The carrier is shifted in phase by ±45°. The +45° component is modulated by waveform B in the multiplier and summed with the waveform from oscillator A in an adder. Likewise, the −45° carrier is modulated by waveform B but is summed with the waveform from oscillator D. When the phase-shifted components interact in the scope, they form another Lissajous pattern that is perpendicular to the major rectangle pattern, creating the three-dimensional illusion of volume.

Each oscillator can be switched to generate square waves. Depending on which oscillator is switched to square waves, the pattern will either break up into multiple images or change the character of its surface composition. There are three level controls, which tilt or expand the image and change the relative sizes of the modulating components. The harmonic controls are frequency setting potentiometers that are used to adjust the ratio between the various harmonic signals. The ratios of the signals in turn control the "family" of images you see.

To prevent the patterns from revolving on the screen (this occurs whenever the patterns are derived from uncorrelated oscillators), one of the four oscillators is fixed in frequency. The output from this "master" oscillator is used to synchronize the remaining oscillators, forcing them to run at an exact multiple of the syncing frequency.

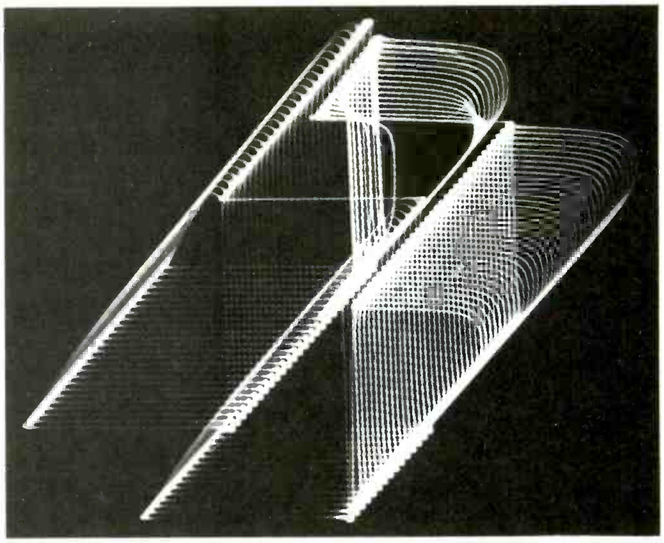
In addition to using the controls on the project, you can also use the vertical- and horizontal-gain controls on the scope to adjust the width and height of the images.

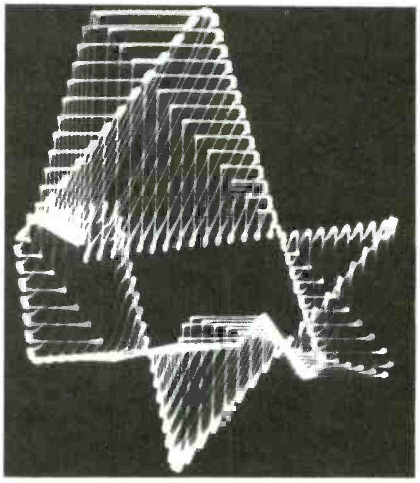
Circuit Details. As shown in Fig. 2, the four oscillators are identical except for their frequency-determining elements. Oscillator A is fixed at approximately 60 Hz by *R8* and *C1*; oscillator B is variable from 60 to 240 Hz; oscillator C is variable from 300 to 3000 Hz; and oscillator D is variable from 30 to 300 Hz. The oscillators are arranged in a classical comparator-integrator configuration.

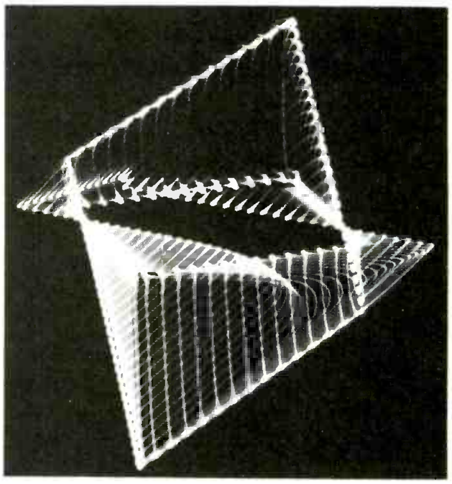
Taking oscillator A as an example, *IC1A* uses *R1* and *R2* to set the trip point at about $\pm V_{cc}/2$. The output of this comparator connects to integrator *IC1B*, which in turn, connects back to *IC1A's* input. When *IC1A's* output is at −9 volts, *IC1B* linearly charges *C1* through *R8*. Hence, the output of *IC1B* is a positive-going ramp. As soon as the ramp reaches $V_{cc}/2$, *IC1A* changes to the positive state and *IC1B* linearly discharges *C1* to initiate a negative-going ramp. When this ramp reaches $-V_{cc}/2$, *IC1A* trips to the negative state and the cycle repeats itself.

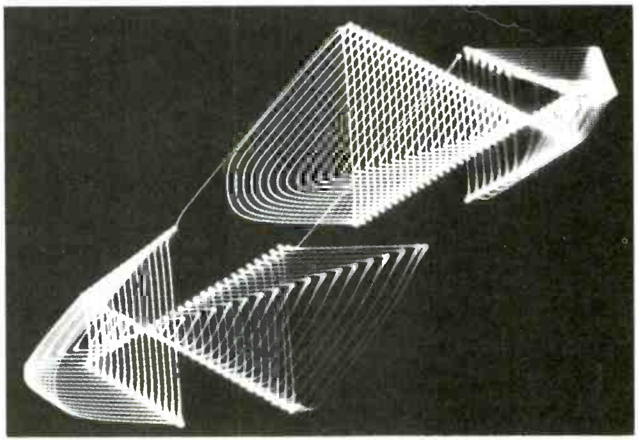
Potentiometers are used to set the frequencies in the three variable-frequency oscillators by varying the charging currents. The outputs from the comparators (*IC1D, IC2B*, and *IC2C*) are symmetrical square waves, while the outputs from the integrators (*IC1C, IC2A*, and *IC2D*) are triangle waves. Resistor *R10* in fixed-frequency oscillator *IC1A/IC1B* sets the amplitude of the two waveforms. Level controls are provided for all but oscillator C. Oscillator C has no level control because only one signal need be variable if both signals go to the inputs of a multiplier to cause the output of the multiplier to vary.

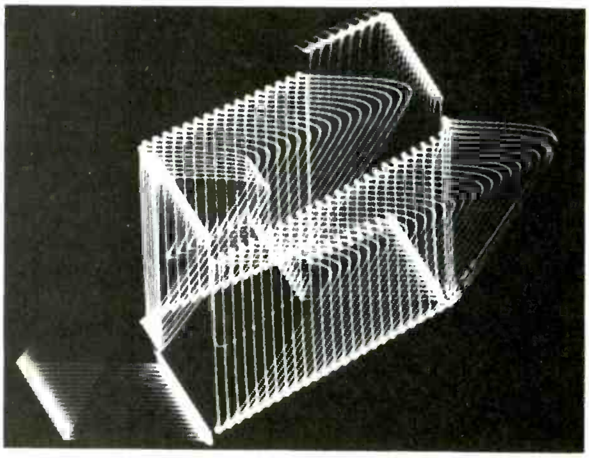
The square-wave output from oscillator A is differentiated by *C2* and *R6* to create a sync pulse. This pulse is fed to the inverting (−) input of *IC2B* to force oscillator C's operating frequency to be an exact multiple of the operating frequency of oscillator A. To sync the remaining oscillators, the triangle-wave output from oscillator A is attenuated by *R4* and *R5* and fed to the inverting inputs of *IC1D* in oscillator B and *IC2C* in oscillator D. The 60-Hz











Photos illustrate only five of the countless varieties of waveform displays possible.

triangle wave forces oscillators B and D into exact sync. Resistor *R7* in oscillator A makes the square and triangle waves in this oscillator equal in amplitude. Switches *S1* through *S4* provide means for selecting the desired waveforms.

Integrated circuit *IC4* is an op amp follower, used here to reduce the source impedance to chopper-type multipliers *IC3B* and *IC3D*. In this type of multiplier, a bipolar transistor or JFET is used to switch the op amp between a noninverting (+) and an inverting (−) unity-gain buffer. Transistor *Q1* serves this purpose in this circuit.

When the signal in oscillator C goes positive, *Q1* conducts and *IC3B* reverts to an inverting amplifier. When oscillator C goes negative, *Q1* starts to cut off, and *IC3B* becomes a noninverting amplifier with unity gain. This switching action results in suppression of the carrier, and the output of *IC3B* is a balanced four-quadrant signal.

The signal from oscillator C is shifted in-phase by +45° in network *C9-R24* and by −45° by network *C10-R25*. So, the waveform to each JFET (*Q1* and *Q2*) is out-of-phase, resulting in a modulated output from the multiplier also being out-of-phase. Networks *C6-R36* and *C7-R40* provide dc restoration for *Q1* and *Q2*.

The output from multiplier *IC3B* is summed with the signal from oscillator A in adder *IC3A*. The output from multiplier *IC3D* is summed with the signal from oscillator D in adder *IC3C*. Finally, the outputs from the two adders are fed to the oscilloscope to form the complex Lissajous patterns.

Power is supplied to the Artist by two standard 9-volt batteries (*B1* and *B2*). Capacitor *C8* aids in reducing instability in the IC op amps.

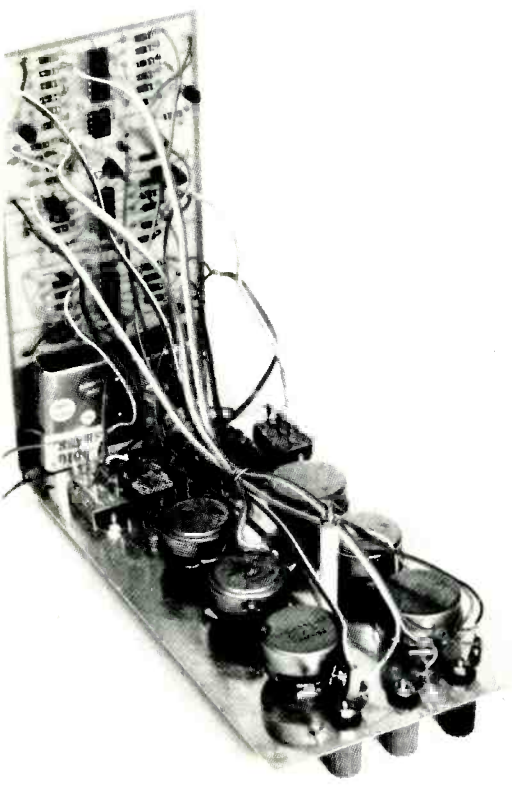


Fig. 4. Construction details.

Construction. The project can be built on either printed circuit or perforated board. The actual-size etching and drilling guide and components-placement diagram are shown in Fig. 3. After preparing or buying a ready-to-use pc board (see Parts List for supplier), mount the components on it as shown in the placement diagram, paying particular attention to the orientations of the IC's and transistors. Place *B1* and *B2* on the blank end of the board, terminals pointing away from the components, and fasten them in place with loops of wire passed between the batteries. Temporarily set aside the board assembly.

Next, machine the front panel for the six potentiometers, five switches, three binding posts, and a No. 6 machine screw. The last hole should line up exactly with the large hole in the pc board assembly. Mount the pots, switches, and binding posts in their respective locations (see Fig. 4). Pass a 6-32 × 2" machine screw (to support the circuit board assembly) through the remaining hole, slip over its threads a length of plastic spacer, and follow with a No. 6 machine nut. The spacer should be just long enough that, when the nut is in place, about ¼" of screw thread is still visible. Label the controls, switches, and binding posts.

Referring back to Fig. 2 and Fig. 3, finish wiring the project.

Operation. The oscilloscope used with the Graphic Artist must have an external horizontal input. Connect test-lead cables from the output binding posts on the Artist to the appropriate inputs on the scope. Set all waveform switches to triangle. Switch on the project and scope.

Set time LEVEL B control fully counterclockwise (off). Because oscillator B connects to both multipliers, making LEVEL B zero eliminates the modulated component on the screen. You should now see a simple rectangular or square Lissajous pattern. Adjust the horizontal- and vertical-gain controls on the scope so that, when LEVEL A and LEVEL D controls are set to midrange, the image just fills most of the screen.

Slowly turn up LEVEL B. This adds the modulated waveform to the existing pattern. Readjust LEVEL A and LEVEL D for a pleasant balance and to keep the image from drifting off-screen. Adjust HARMONIC B to sync the modulated envelope with the image. In essence, this control sets the number of "lobes" riding on the primary Lissajous pattern.

Next, adjust HARMONIC C so that the high-frequency carrier is in sync with the image. You should now have a display similar to those shown in the photos. The next thing we can do is alter the Lissajous "family" by using combinations of the waveform switches. For example, switching WAVEFORM A to the square-wave position and setting WAVEFORM D to the triangle-wave position causes the image to break up into separate shapes. There are 16 combinations for the four waveform switches. Add to this the effects of the six HARMONIC and LEVEL controls, and chances are you will never see the same pattern twice.

After you've familiarized yourself with the operation of the controls (it does take some skill), you might try connecting a pair of stereo headphones to the two output channels. The sounds of the four oscillators mixing and adding produces beat notes that are fascinating in themselves. You can even "play" the sounds by twisting the various controls.

Some very different and interesting effects can be produced by running the Graphic Artist in reverse. Take a signal from an external source, such as an electronic organ, and connect it in place of one of the oscillators. You can do this by disconnecting one waveform switch input and connecting your signal in its place. Choose your notes to be exact even or odd harmonics of oscillator A, which operates at approximately 60 Hz. The images will appear to stop their motion and their actual shape will depend on the particular waveform of the note being played. ◈

A BCB LOOP ANTENNA FOR DX'ING

Increases reception range of inexpensive AM radios by inductive linking.

BY NORMAN FALLON

IF YOU'RE anxious to hear distant stations on the AM Broadcast Band—say, to catch blacked-out home-town sports events—then the Broadcast Band Loop is just what you need! When coupled to a good AM transistor radio with a built-in ferrite bar antenna, it will bring in lots of stations you could never copy before—be they TA's (transatlantics), rare "locals," or clear-channel stations from distant cities. It is easy to build and use, fairly small, and inexpensive—total parts cost is about $20 to $30!

About the Loop. The use of a loop antenna is not new, but its advantages are timeless. It has good directivity, and can be easily rotated. Further, the loop works only with the magnetic portion of the radio wave (which contains both electric and magnetic fields), so it is inherently quieter than higher-gain long-wire outdoor antennas. The loop contains no fragile semiconductors and requires no power supply, unlike the "amplified loops" that some MW DX'ers are now using.

A simple loop antenna is shown in Fig. 1. It's an electrically short loop consisting of turns of wire with a total length much less than a wavelength. Medium waves are fairly long, e.g. 500 m (1640 ft) at 600 kHz! Obviously this loop or an outdoor longwire are the only real options.

The loop is really an inductor. When shunted by variable capacitor C, the combination can be tuned to resonance. Its nominal directional pattern (Fig. 1) is a figure eight, with maximum response in the plane of the loop. Turning the antenna broadside to a station will cause an appreciable drop in signal strength.

Selectivity is another loop characteristic. The antenna favors signals at the resonant frequency at the expense of those nearby. Its response gets progressively narrower as its Q increases (which varies directly with the C/L ratio). For our purposes, we'll want as high a Q as possible.

We have adapted the loop to better serve our purpose by eliminating the direct connection between the Loop and the receiver. Experience indicates that unwanted signal pickup occurs when a transmission line is used to couple signals to the receiver's antenna input jack (if there is one). In this design (Fig. 2), signals are coupled inductively, simply by positioning the built-in ferrite bar close to the loop base. This offers the advantage of being able to adjust the degree of coupling between the coils to suit variations in signal strength. Operating the loop and ferrite bar in tandem will yield a cardioid directional pattern due to interaction between the coils.

Further flexibility is afforded by a switch which shorts out one turn of the Loop when closed. This is often desirable when working the high end of the MW band, since a decreased L requires more C for resonance. The result is a higher Q, and slightly less gain. In most cases, though, the effect on signal strength will not be noticed—but the sharpened tuning will be greatly appreciated. It's easy to see that the *L1* and the ferrite bar in the receiver act as an r-f transformer. The "audio circuit" has been included as an operator convenience. To best work DX, headphones should be used. They are more sensitive than loudspeakers, so it will be easier to hear weak signals. The acoustic isolation from background noise will also come in handy—you'll be able to listen without bothering others around you, and vice versa.

To accomplish this, audio will be coupled from the earphone jack on the receiver to jack *J3* by a short patch cord. Make use of the new crop of high-sensitivity, lightweight (Mylar transducer) stereo headphones, which require only a few milliwatts of drive.

It's also wise to use battery power rather than an ac battery eliminator, as hum problems can arise. Of course, if you don't want to use phones or already have a mono miniature/stereo phone jack adapter, the audio circuit can be ignored.

Physical Construction. The Loop's frame will be assembled first, using doweling, two pieces of hardwood, aluminum tubing and aluminum U-channel. Refer to Fig. 3.

First, take two pieces of ½-inch (1.3-cm) ID seamless aluminum tubing, 34" (86.4 cm) long, and flatten the center 1½" (3.8 cm) in a vise as shown in step 1. (Steps are shown in Fig. 3.) Drill a 7/32-inch (5.6-mm) hole in each tube at the center point. Then drill two 5/32-inch (4-mm) holes 6" (15.2 cm) from the center point on each length of tubing. Next, drill two ⅛-inch (3.2-mm) holes 16.5" and 15" (41.9 and 38.1 cm) from the center point on each length of tubing.

Center-drill ½-inch (1.3 cm) holes ¼ inch (6.4 mm) deep on each of three 2⅝-inch (6.7-cm) lengths of ¾-inch

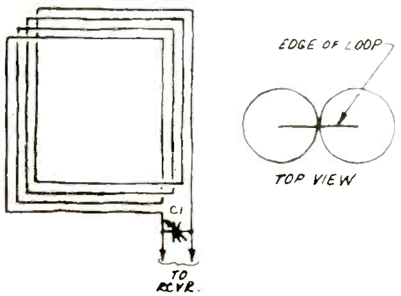


Fig. 1. Loop acts as an LC parallel circuit.

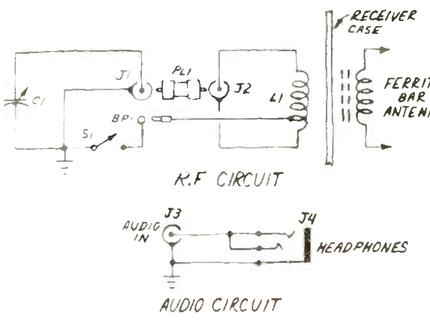


Fig. 2. Schematic shows how loop and radio antenna form r-f transformer.

(1.9-cm) doweling. File six grooves ⅜" (9.5 mm) apart on the dowels, spacing the outer ones ⅜" (9.5 mm) from each end. Take a 12¼-inch (31.1-cm) length of ½-inch (1.3-cm) doweling and drill two ⅛-inch (3.2-mm) holes 1¼" (3.2 cm) and 2¾" (7cm) from one end. Repeat four times. Then, glue the dowels together to form three T-shaped wire supports as shown in Step 2. Save the remaining dowel for later use.

Form a cross by overlapping the two lengths of tubing. Line up the center holes and secure with a ¼-20 × 1 inch bolt, flatwashers, and wing nut. Slide the Tee's into ends B, C, and D of the cross until the holes line up. Secure the Tee's in the tubing with ¼-inch self-tapping sheet metal screws (Step 3). Form four support braces from 9-inch (23.9-cm) lengths of ½" × ½" (1.3 cm × 1.3 cm) aluminum U-channel. Drill two $^{11}/_{64}$-inch (4.4-mm) holes ¼" (6.4 mm) from each end. Then fasten the braces to the cross by lining up holes and using 6-32 × 1 inch machine screws, flatwashers, and nuts. Two lengths of channel should be on opposite sides of the tubing at each juncture.

Now prepare the fourth Tee by center drilling a ½-inch (1.3-cm) hole ¼" (6.4 mm) deep on one long side of a 4" × 1¼" × ¾" (10.2 cm × 3.2 cm × 1.9 cm) block of hardwood (Step 4). Drill a $^{3}/_{16}$-inch (4.8-mm) hole ⅞" (2.2 cm) from one end of the block for the center conductor pin of *J2*, an SO-239 coaxial connector. Then drill a $^{3}/_{16}$-inch (4.8-mm) hole $^{9}/_{16}$" (1.4 cm) away on each side of the center conductor hole for two securing screws. File seven grooves ⅜" (9.5 mm) apart, spacing the HOT END groove $^{5}/_{16}$" (7.9 mm) from the edge of the block. Drill a ⅛-inch (3.2-mm) hole in the center of both the HOT and GROUND END grooves. Then drill a $^{3}/_{16}$-inch (4.8-mm) hole ⅜" (9.5 mm) to the right of the HOT and GROUND END holes on the top (ungrooved) side of the block. Mount solder lugs above each hole, using No. 6 × ½" wood screws.

Referring to Step 5, prepare an SO-239 coaxial jack, cutting two corners with a hacksaw to fit the hardwood block. Solder one end of a 6-inch (15.3-cm) length of hookup wire to the center conductor pin of *J2*, and thread it through the center conductor hole. Then secure *J2* to the wood block using No. 6 × ¼" wood screws, looping one end of a 4-inch (10.2-cm) length of hookup wire under the head of the screw nearest the GROUND END groove. Thread the other end through the hole in this groove and attach to the nearest solder lug (above *J2*). Trim excess. Attach the free end of the center conductor wire to the other solder lug, trimming excess.

Glue the hardwood block to the remaining 12¼-inch (31.1-cm) dowel to form the fourth Tee. Insert the Tee into the remaining corner of the cross (A), lining up the holes. Secure with ¼-inch self-tapping sheet metal screws. Then drill a $^{3}/_{16}$-inch (4.8-mm) hole ⅞" (2.2 cm) above the bottom of the vertical tubing (above corner A). Make the hole slightly more than ⅜" (9.5 mm) deep.

Take one end of a 74-foot (22.6-m) length of 18- or 16-gauge (solid or stranded, bare or insulated—enamel or plastic—almost anything will do!) copper wire, thread it through the HOT END hole and solder it to the HOT END solder lug (trimming excess). Then tightly wind the wire around the cross, using the Tee grooves as guides to make six turns in all. Thread the free end through the GROUND END hole and solder to the lug, trimming excess. Remove the insulation (if any) from the wire near corner A on the fifth turn. Solder one end of a 4-inch (10.2-cm) length of hookup wire to this point. Leave the other end free for the moment.

Control Panel Construction. We'll now assemble the Loop's Control Panel. It should be fashioned from a 4.75" (12.1-cm) square piece of $^{1}/_{16}$-inch (1.6-mm) aluminum plate. Physical layout is flexible, but use Fig. 4 as a guideline. Form a support bracket from aluminum stock, or use a commercial aluminum angle about 2½" × 1½" × 1½" (6.4 cm × 3.8 cm × 3.8 cm). Install the bracket centered along one side of the aluminum panel. Then drill mounting holes for an SO-239 coaxial jack—this should be set back 1" × 1" (2.5 cm × 2.5 cm) from the corner nearest the notched side of the bracket—and for the main tuning capacitor, switch *S1*, binding post *BP1*, and the RCA phono and headphone jacks (if desired).

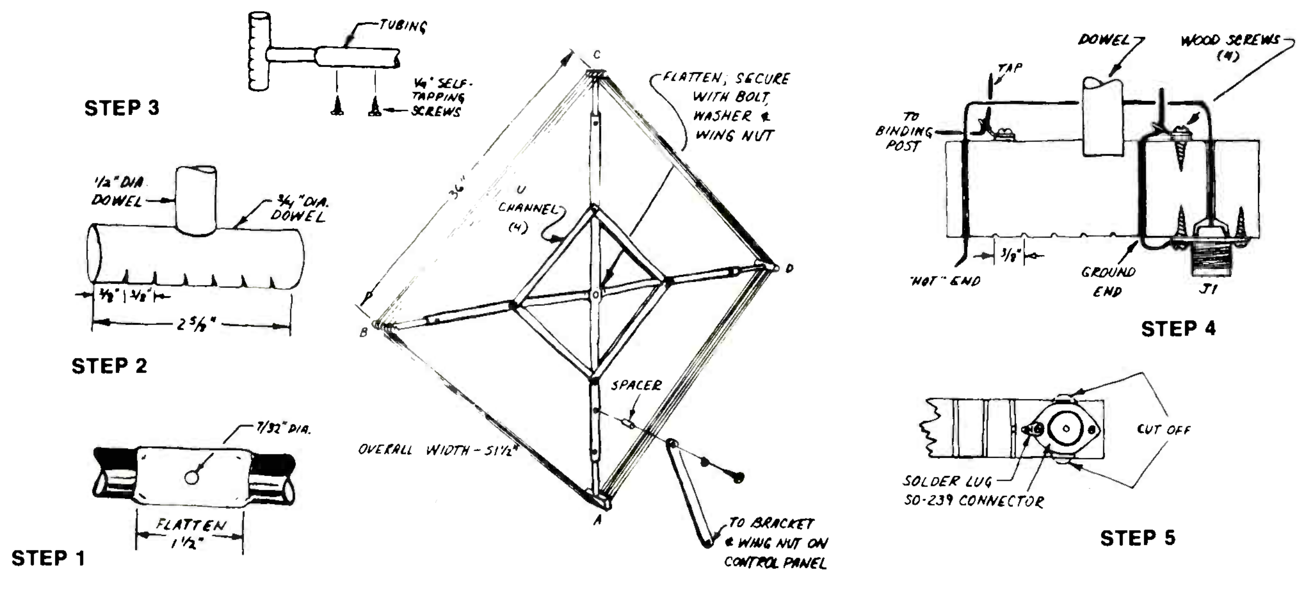


Fig. 3. Above are directions for constructing the frame for the loop. Aluminum tubing, U-channel, and wood dowels are used. Steps 1 to 5 are referred to in the text.

A note about capacitor *C1*—any surplus, multi-gang variable capacitor may be used. Total maximum capacitance should be about 1200 pF. Suitable models are available from most surplus sources with an approximate cost of $3.00. If, however, you have trouble finding a capacitor on the surplus market, buy three 365-pF AM tuning capacitors and gang their shafts together. After installing all components, wire the Control Panel in accordance with the schematic (Fig. 2) using 18-gauge solid hookup wire. Try to keep all leads as short as possible.

The Control Panel should be mounted in a cutout on a rotatable platform—a lazy susan arrangement. The platform should be big enough to accommodate your AM receiver also, since it must be rotated in step with the Loop.

Once the Panel is mounted, drill a 7/32-inch (5.6-mm) hole in the support bracket ⅜" (9.5 mm) down and 1" (2.54 cm) over from the un-notched top corner. Then drill 7/32-inch (5.6-mm) holes along the center line ⅜" (9.5 mm) from each end of an 11¼" × 1" × ⅜" (28.6 cm × 2.5 cm × 9.5 mm) hardwood strip. Attach one end of the strip to the support bracket using a 10-20 × 1" hex head bolt, a hex nut as a spacer between the strip and bracket, and wing nut. Keep the wing nut relatively loose. Now secure the other end of the strip to the Loop frame using a 10-32 × 1½" bolt, washer, and a ¾" (1.9 cm) spacer. Use the 3/16-inch (4.8-mm) hole previously drilled above the bottom of the vertical tubing.

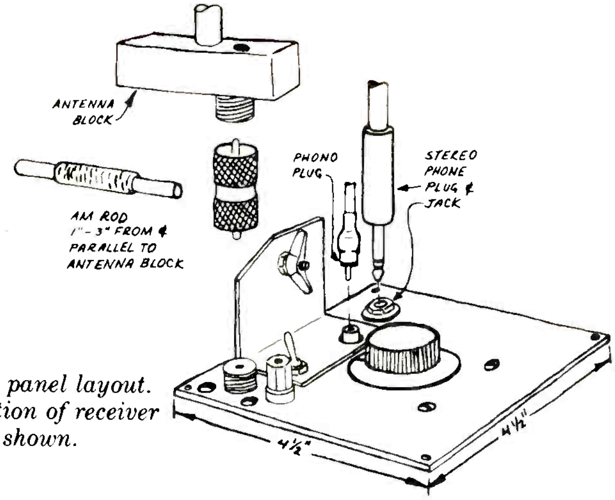


Fig. 4. Control panel layout. Proper orientation of receiver rod antenna is shown.

Attach the Loop frame to the Control Panel using *PL1*, a double male uhf coaxial adapter (Amphenol 83-877), between jacks *J1* and *J2*. Then connect the free end of the hookup wire from the loop to binding post *BP1*. Tighten the hardware holding the hardwood strip. Leave *S1* open, and position your AM receiver below the Loop, orienting its rod antenna as shown in Fig. 4. The two coils should be about 1" to 3" (2.5 cm to 7.6 cm) apart.

Using the Loop. Tune the receiver down to the low end (540 kHz) of the AM Broadcast Band. Turn *C1*'s tuning knob so that the plates are fully meshed. Then, carefully tune in an audible signal using the receiver's tuning capacitor. Slowly unmesh *C1*'s plates (reduce capacitance) until the signal peaks strongly. You have now tuned the Loop to resonance at this frequency.

It's possible that loading effects by the Loop may "pull" the receiver off its dial calibration. If this occurs, just continue to adjust both *C1* and the receiver's tuning capacitor for maximum intelligibility. You'll probably find that the two controls interlock, but with a little practice you'll be quickly zeroing in on the station you're after. Try rotating the loop to get an even stronger signal. Best results will be obtained when the plane of the loop extends in the direction of the desired signal. You can also use this directivity to null out an interfering station on the same frequency—turn the loop broadside to the offending signal.

With *S1* open, the Loop can be tuned just about to 1600 kHz. It also has maximum gain in this position. But there are times when a bit more selectivity is desirable over gain—for example, when two fairly strong stations are a few kHz apart. This is particularly true when trying to work the "splits"—foreign stations operating on odd frequencies not multiples of 10 kHz. In situations like this, close *S1*. This shorts out the bottom turn of the loop, giving a higher Q. It also gives you a bit more "room" on *C1* at the top end of the band.

Other Suggestions. The "pulling" action mentioned earlier can cause you to get "lost" in terms of frequency. To prevent this, prepare a list of strong signals in your area, noting them by call letter and frequency. You can then use them as frequency markers to chart your way across the band. It's also a good idea to get a complete list of North American AM stations—especially if you want to DX the band. Several are available, listing stations by call letters, power output, frequency, and geographical location.

Another system variable is the amount of coupling between the Loop and the rod antenna. This should be varied to suit signal strength, but cannot accurately be predicted without experience with your particular receiver. While it should vary between 1 and 3 inches, experiment for best results.

To make tuning easier, a vernier (0 to 100) tuning knob can be used with *C1*. Once you have properly tuned a station in, record its frequency, direction toward which the Loop is turned, position of *S1*, and the amount of capacitance needed. Keep all this information for future reference. ◈

FRAME BILL OF MATERIALS

2—42 inch lengths of ½" ID thin-wall aluminum tubing
4—14-inch lengths of ½" wood doweling
3—2⅝-inch lengths of ¾" wood doweling
4—12-inch lengths of ½" × ½" aluminum U-channel
1—Block of hardwood 4" × 1¼" × ¾"
1—Strip of hardwood 11¼" × 1" × ⅜"
1—10-32 × 1½" bolt and washer
1—¾-inch spacer to fit above.
1—¼-20 × 1" bolt, washers, and wing nut
4—6-32 × 1" machine screws, flatwashers, and nuts
4—No. 6 × ½" wood screws
8—¼" self-tapping sheet metal screws

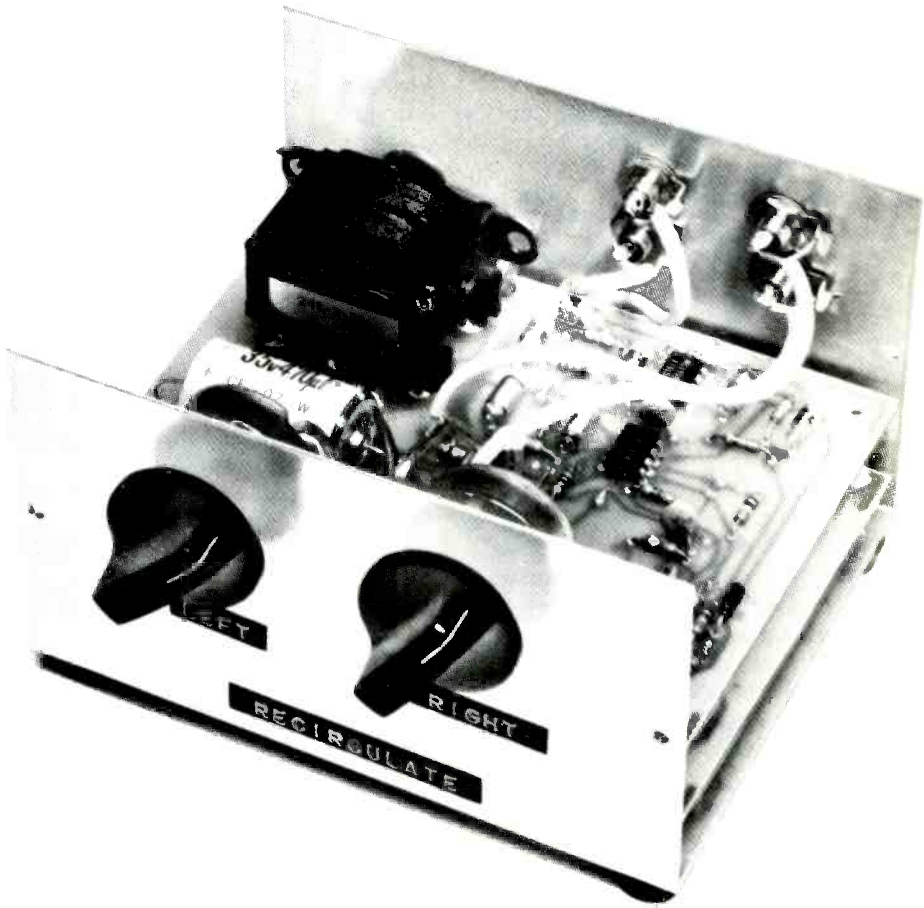
PARTS LIST

BP1—5-way binding post
C1—1200-pF (total) multi-gang variable capacitor
J1,J2—Uhf coaxial jack, SO-239
J3—RCA phono jack
J4—Open-circuit stereo headphone jack
L1—6 turns of 16- or 18-gauge copper wire wound on loop frame
PL1—Double male uhf coaxial adapter (Amphenol 83-877, Lafayette 42 69064 or equivalent)
S1—SPST switch
Misc.—4.75" square 1/16-inch aluminum plate, tuning knob, machine hardware, hookup wire, solder, etc.

BY JOHN H. ROBERTS

THE "BUCKET BRIGADE" AUDIO DELAY LINE

Allows user to simulate larger listening room. Also used by recordists and musicians for special sound effects.



THE SOUND of recorded music being played is a listening experience that changes according to the room you are in. If the room is too "live" or too "dead", the sound appears to be unnatural. When the room has an ultra-modern decor and lots of glass window areas, the effect on the music is "bouncey." With heavy drapes, carpeting, and thickly padded furniture, plus a minimum of hard surfaces, the effect approaches that of an anechoic chamber—with very little sound reflection.

For the latter, you can either throw away your sofa pillows and pull down the drapes, or you can add a time-delay device to your audio system to create a more natural ambience. Since you may not care to redecorate, you can create an echo (audio signal time delay) and reverberation (later reflections) and achieve a livelier sound.

Until recently, the only means of obtaining an audio signal delay has been through the use of very expensive electronic equipment. Now there is a new type of IC—the "bucket brigade"—and you can build your own delay system for as little as $39 in mono and $59 in stereo. Connected between source and preamp or preamp and power amplifier (at the tape monitoring jacks possibly), it provides an adjustable, signal echo that can enhance the sound in most home listening rooms. With minor connection changes, it also can be used as a phasor/flanger, giving you a sound effect for tape recording purposes and electric-guitar playing used by the professionals.

The bucket-brigade IC is a MOS-type shift register that contains two 512-stage registers in a single 14-pin package. When an audio signal is applied to the input of the bucket brigade and a clock generator drives the IC, the signal is stepped along stage by stage until it comes out delayed a discrete interval in time. By adding this delayed signal to the original, reverberation is simulated.

In addition to providing real-time ambience, the bucket-brigade circuit can be used with a tape recorder to provide simulated stereo sound from mono sources, a means for "double voicing," and "phasor/flanging."

Technical Details. If you can delay an audio signal, you can create a number of useful sound effects. The most obvious is simulating echo, though delays provided by the bucket

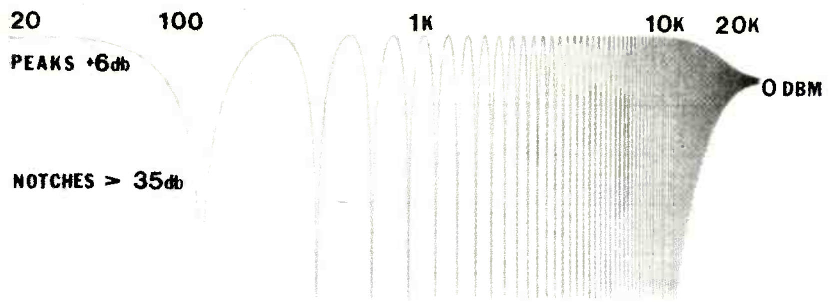


Fig. 1. Frequency between notches on a comb filter is adjusted by varying the clock frequency.

brigade are too short to be discerned as discrete echoes. Recirculating the delayed signal at reduced gain can approximate the natural decay of echoes in a reverberant room. By adding some gain during the recirculation of the delayed signal, you can create an unnatural "door-spring" effect on the music.

Delay an instrument or voice track by 30 or 40 ms and add the delayed signal back to the original signal, and you will make the output sound fuller and give it the effect of more than the original number of voices or instruments. This commonly used technique is known as "double voicing."

Another popular short-delay effect is a strange sound that results from a technique known as "phasing" or "reel flanging." The name is derived from its original implementation where a tape recorder was used to create the time delay and the friction of a well-placed hand on the outside edge of the tape-feed reel varied the delay to produce the acoustic effect. This effect can be created totally by electronic means by delaying the signal 0.5 to 5 ms while adding or subtracting the delayed signal from the original signal.

In the phasor/flanger mode, the frequency and its multiples whose wavelengths are equal to the time delay will be completely cancelled out while all other frequencies are reinforced. The result is a comb filter whose frequency between the notches is adjusted by varying the clock frequency (Fig. 1). In this manner, a tonal quality can be imparted to nontonal sound such as drums, cymbals, and even voices.

The phasor/flanger mode can be used to simulate stereophonic sound from a monophonic source. To do this, the phased output derived by adding the delayed signal goes to one channel, while the output derived by subtracting the delayed signal goes to the other. To the listener, the phasing effect cancels leaving a reasonable pseudo-stereo effect.

The basic block diagrams of the delay-line and phasor/flanger circuits are shown in Fig. 2. The hearts of the circuits, of course, are the bucket-brigade IC's, which can directly process analog signals. The circuits do not require costly analog-to-digital and digital-to-analog converters. When the clock pulse from the flip-flop is applied to the bucket-brigade IC, the dc voltage present at the input is shifted into the register. The discrete bits are transferred stage by stage with successive clock pulses until, after 256 pulses, they reach the end of the line and provide the output.

The output waveform is smoothed by a low-pass filter and duplicates whatever signal was present at the input but delayed in time by 256 times the period of the clock frequency. (Period is equal to the reciprocal of the frequency.) For example, if the clock frequency is 100,000 Hz, the delay would be $256 \times 1/100{,}000 = 2.56$ ms.

Since the audio signal at the input is being sampled at a rate determined by the clock frequency, a theoretical limit of half the clock frequency is the highest audio frequency that can be reliably passed. However, owing to practical limitations, a third of the clock frequency is a more reasonable design goal. Circuits can be cascaded to provide longer time delays at high clock rates, but the increase in noise in the series-connected circuits might outweigh the increase in bandwidth.

In the delay mode, the two shift registers are connected in series, which allows twice the clock frequency to be used. Therefore, twice the bandwidth of a single shift register can be programmed for the same time delay. Even in this double-bandwidth mode, the clock frequency required for a

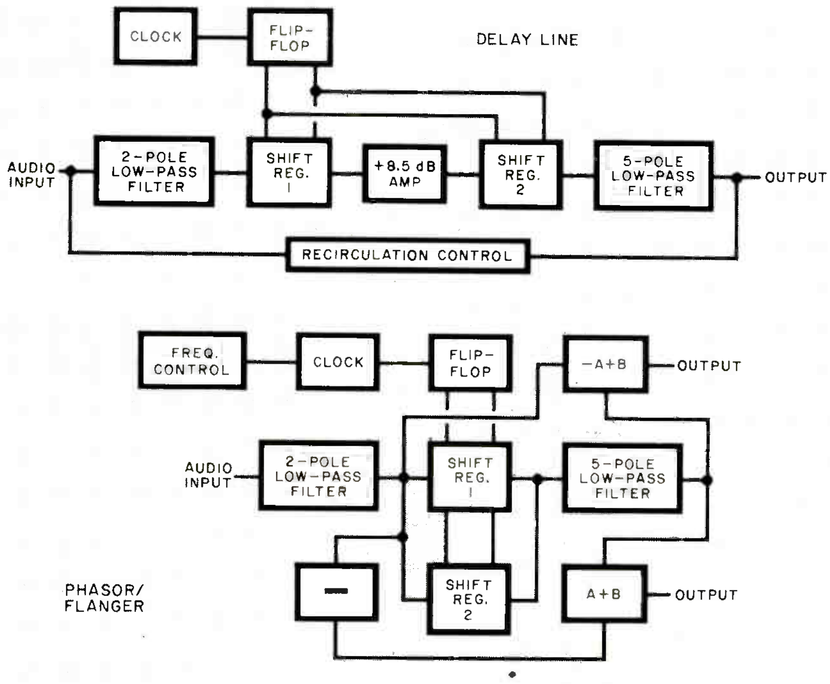


Fig. 2. Basic block diagrams of the delay line and the phasor/flanger circuits.

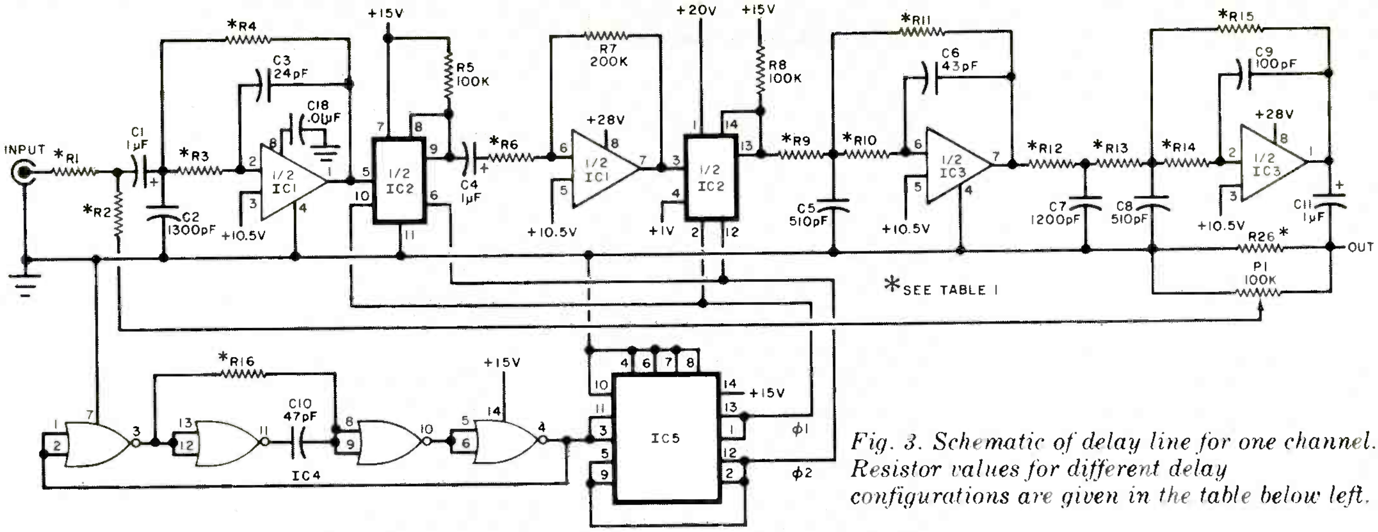


Fig. 3. Schematic of delay line for one channel. Resistor values for different delay configurations are given in the table below left.

TABLE OF FILTER RESITOR VALUES

	A	B	C	D
	(all values in kilohms)			
R1	100	200	300	390
R2	130	270	390	510
R3	36	75	110	150
R4	100	200	300	390
R6	100k	100k	100k	100k
R9	62k	120k	180k	240k
R10	43	82	130	160
R11	120	240	360	470
R12	10	20	30	39
R13	56	110	160	220
R14	33	68	100	130
R15	68	100	200	270
R16	110	240	360	470
R26	200	200	200	200

A = 10 ms or less, −3 dB at 15,000 Hz
B = 20 ms or less, −3 dB at 7500 Hz
C = 30 ms or less, −3 dB at 5000 Hz
D = 40 ms or less, −3 dB at 3800 Hz

PARTS LIST FOR FIG. 3

C1,C4,C11—1-µF, 25-volt electrolytic capacitor
The following are 5% polystyrene capacitors:
C2—1300 pF
C3—24 pF
C5,C8—510 pF
C6—43 pF
C7—1200 pF
C9—100 pF
C10—47 pF
C18—0.01-µF ceramic disc capacitor
IC1,IC3—1458 dual operational amplifier
IC2—MN3001 dual analog shift register (Matsushita)
IC4—4001 CMOS quad NOR gate
IC5—4013 CMOS dual D flip-flop
P1—100,000-ohm potentiometer
R1 through R4,R6,R9 through R16,R26—See Table
R5,R8—100,000-ohm, ¼-watt, 5% resistor
R7—200,000-ohm, ¼-watt, 5% resistor
Note—See Parts List for Fig. 5 for kit information.

40-ms delay limits the bandwidth to a maximum input signal frequency of 3750 Hz, which is adequate for voice but less than adequate for many musical instruments. In most applications where the delayed signal is added to the original signal, the reduction in bandwidth will be masked by the high-frequency signals present in the original. To compensate for normal signal attenuation, an 8.5-dB amplifier is used between the shift registers.

In the phasor/flanger mode, the maximum delay required is about 5 ms, which is short enough that a single shift register can be used without compromising the bandwidth. The second shift register is therefore connected in parallel with the first to improve the S/N ratio. The signals are added in-phase, while the noise adds and subtracts randomly.

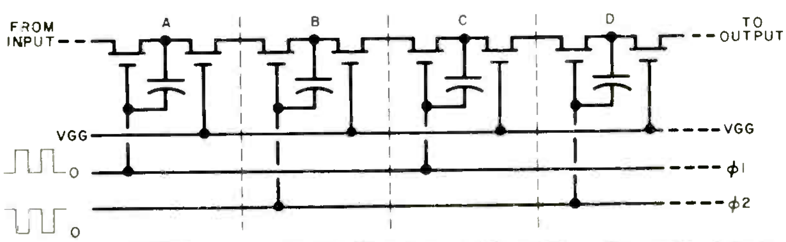
How It Works. The schematic diagrams of the delay-line and phasor/flanger configurations of the circuit

A BUCKET-BRIGADE SHIFT-REGISTER ANALOGY

The name "bucket brigade" conjures up images of a line of men passing along buckets of water to fight a fire. The bucket-brigade analog shift register operates in a similar manner, which is how it got its name. In the case of the shift register, however, the buckets are capacitors integrated right on the PMOS chip. There are more than 1000 such capacitors on each chip (one capacitor and two MOS transistors for each stage). What is being passed along are packets of electrical charge from stage to stage.

It is difficult to pour water both into and out of a bucket at the same time. So, too, it is difficult to simultaneously charge and discharge a capacitor. This problem is overcome in the shift register by utilizing two out-of-phase clocks. While the first clock is high, the "odd" buckets are dumped into the next consecutive "even" bucket. When the second clock is high, the even buckets are dumped into the next consecutive odd buckets. In this manner, individual charges are transferred along the line one stage at a time.

The drawing is a schematic representation of four typical stages of the MN3001 analog shift register. Each MN3001 IC contains two 512-stage shift registers. Note that stages A and C are connected to one clock, while stages B and D are connected to the other clock to provide the odd/even relationship.



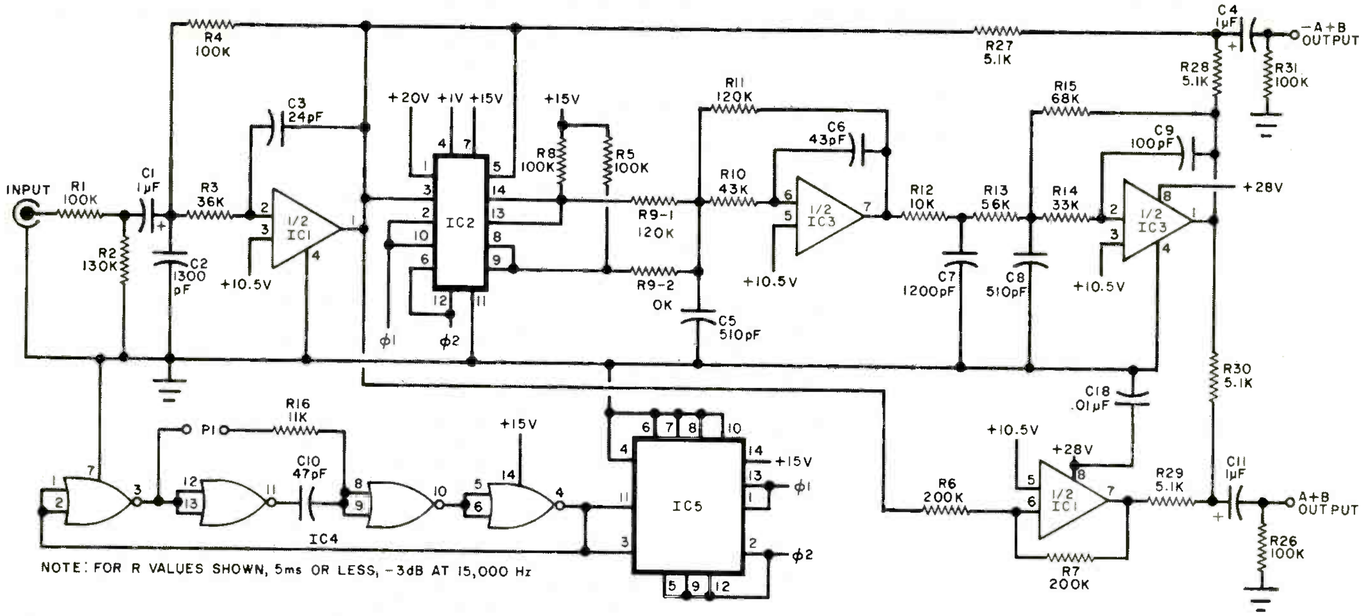


Fig. 4. Schematic of circuit for phasor/flanger.

PARTS LIST FOR FIG. 4

C1 through C11—Same as for Fig. 3
C18—0.01-μF ceramic disc capacitor
IC1 through IC5—Same as for Fig. 3
The following resistors are ¼ watt, 5% tolerance:
R1,R4,R5,R8,R26,R31—100,000 ohms
R2—130,000 ohms
R3—36,000 ohms
R6,R7—200,000 ohms
R9-1,R9-2—120,000 ohms
R10—43,000 ohms
R11—120,000 ohms
R12—10,000 ohms
R13—56,000 ohms
R14—33,000 ohms
R15—68,000 ohms
R16—11,000 ohms
R26—100,000 ohms
R27 through R30—5100 ohms
Note—See Parts List for Fig. 5 for kit information.

are shown in Fig. 3 and Fig. 4, respectively. In both cases, quad NOR gate *IC4* is wired as an astable multivibrator operating at twice the desired clock rate's frequency. The output of *IC4* goes to flip-flop *IC5*, which provides a pair of complementary (180° out of phase with each other) output clock pulses with 50% duty cycles. These pulses then "clock" the shift registers in *IC2*. Frequency determining resistor *R16* is fixed in the delay configuration, while resistance can be added via a pair of connectors to change the clock frequency in the phasor/flanger.

The audio input signal is conditioned by seven poles of low-pass filtering in which *IC3* and half of *IC1* are used. The filters provide a total of 42-dB/octave attenuation above the tuning frequency. For example, if the filter were tuned for 5000 Hz, a 10,000-Hz signal would be attenuated by more than 100:1.

When filters are designed with high-gain operational amplifiers (op amps), it is possible to have their outputs increase before rolling off at the rate of 6 dB/octave per pole. Such filters are termed "under damped." By carefully selecting the proper balance of under-damped and over-damped (RC) filter sections, it is possible to design a filter that is flat in the desired passband so that it is 3 dB down at the tuning frequency and has a roll-off rate of 6 dB times the number of poles. This is what has been done in the delay-line and phasor/flanger circuits.

Quite a bit of mathematical compu-

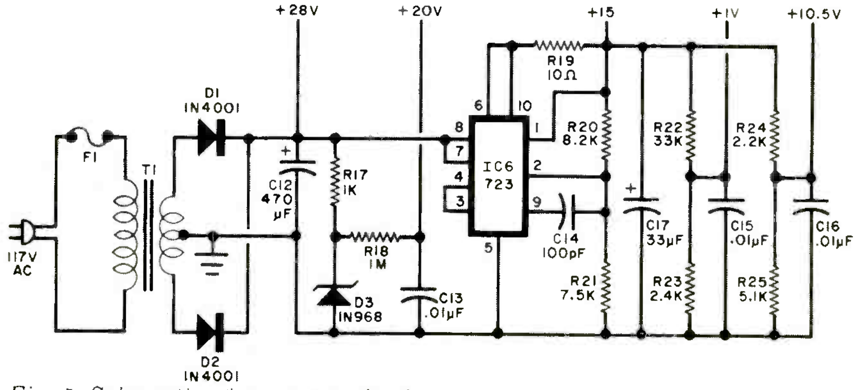


Fig. 5. Schematic of power-supply circuit. Parts List includes kit information for all circuits.

PARTS LIST FOR FIG. 5

C12—470-μF, 35-volt electrolytic capacitor
C13,C15,C16—0.01-μF disc capacitor
C14—100-pF disc capacitor
C17—33-μF, 25-volt electrolytic capacitor
D1,D2—1N4001 rectifier diode
D3—1N968 (20-volt) zener diode
F1—1/10-ampere fuse
IC6—723 precision voltage regulator
The following resistors are ¼ watt, 5% tolerance:
R17—1000 ohms
R18—1 megohm
R19—10 ohms
R20—8200 ohms
R21—7500 ohms
R22—33,000 ohms
R23—2400 ohms
R24—2200 ohms
R25—5100 ohms
T1—Power transformer with two 28-volt secondaries at 50 mA each
Misc.—Chassis; line cord; phono jacks (4); control knobs (2); rubber grommet; spacers; machine hardware, etc.
Note: The following items are available from Phoenix Systems, 375 Springhill Rd., Monroe, CT 06468: Complete kit of parts (delay line or phasor/flanger) No. P-1220-M (mono) for $50.00; complete kit of parts No. P-1220-S (stereo) for $75.00; etched and drilled pc board No. P-1220-B for $6.00; MN3001 analog shift register IC No. P-1220-C for $20.00; transformer No. P-1220-T $5.00. For orders under $10.00, add $1.00 for shipping and handling. Connecticut residents, please add sales tax.

CLAIMED SPECIFICATIONS

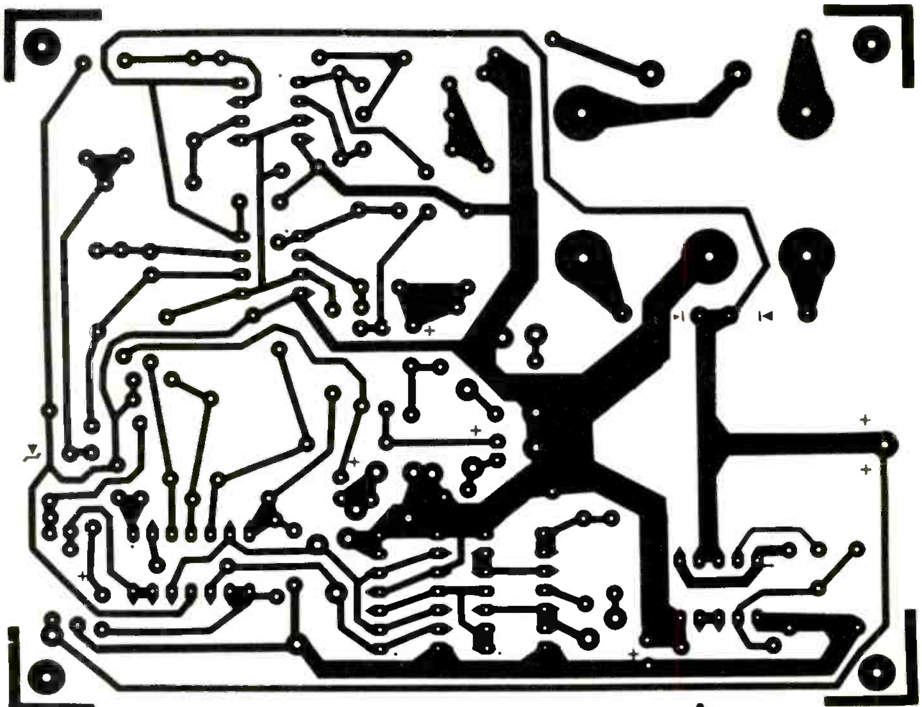
Delay Line:	
Frequency response	15 to 15,000 Hz (+2/−3 dB)
Distortion (THD)	Typically less than 1% (1000 Hz, 1 V rms)
Input impedance	Greater than 100,000 ohms
Clipping level	1.77 V rms (5 V p-p)
Signal-to-noise	Typically 50 dB below 0 dBm
Phasor/Flanger:	
Frequency response	15 to 15,000 Hz (+2/−3 dB)
Distortion (THD)	Typically less than 0.75% (1000 Hz, 1 V rms)
Input impedance	Greater than 100,000 ohms

tation is normally required to determine the values of the filter resistors to use. To simplify matters, you can select the appropriate resistor values from the Table of Filter Resistor Values. Use this Table for selecting resistor values for only the delay-line circuit. (The filter resistor values specified in Fig. 4 and its accompanying Parts List will provide an optimized 5-ms delay, with the output 3 dB down at 15,000 Hz for the phasor/flanger.)

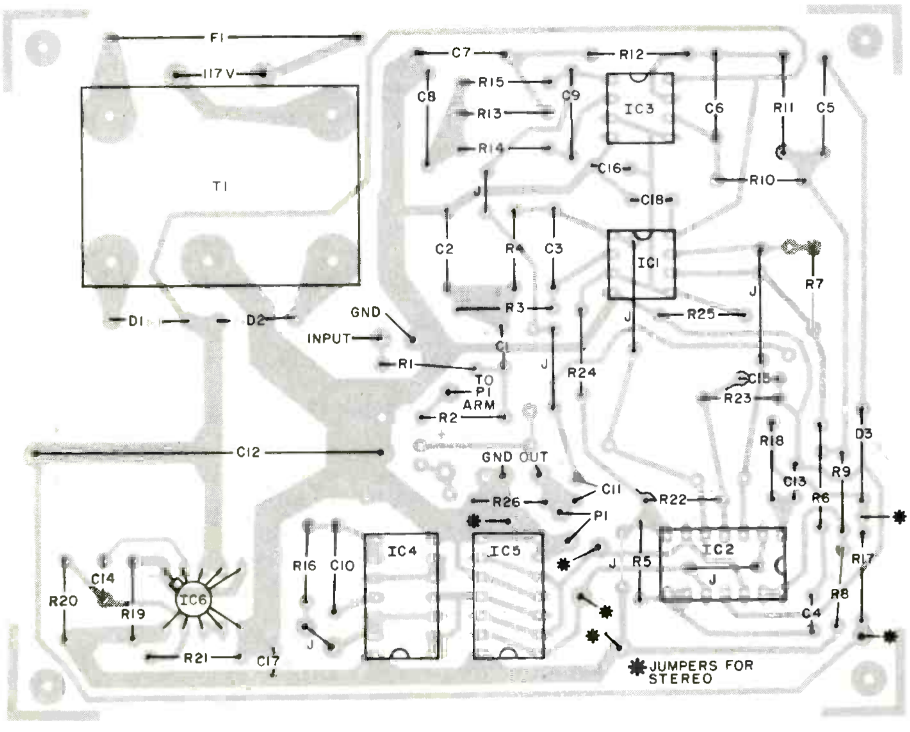
The power supply is shown in Fig. 5. It uses a voltage regulator, *IC6*, to generate the main 15-volt supply output. The shift register requires supplies of both +1 and +20 volts. The +20-volt line is obtained through the use of zener diode *D3*, while the +1-volt line is derived from the voltage divider consisting of *R22* and *R23*. Since the op amps are being operated from a single-ended supply, it is necessary to have the 10.5-volt supply line serve as the reference point in the circuit for these IC's.

Construction. The actual-size etching and drilling guide, the same for both circuit configurations but wired differently as required, is shown in Fig. 6A. The parts-placement guides for the delay-line and phasor/flanger configurations are shown in Figs. 6B and 6C, respectively.

Before installing any components on the board, mount and solder into place the wire jumpers. Then, wire the board as in Fig. 6B or Fig. 6C, depending on the desired mode of operation. Be careful to properly orient all semiconductor devices and electrolytic capacitors. Be sure to handle the MOS devices with care to prevent them from being damaged by static charges. You can mount the IC's directly on the board or use sockets. Use a low-power soldering iron (25 to 35

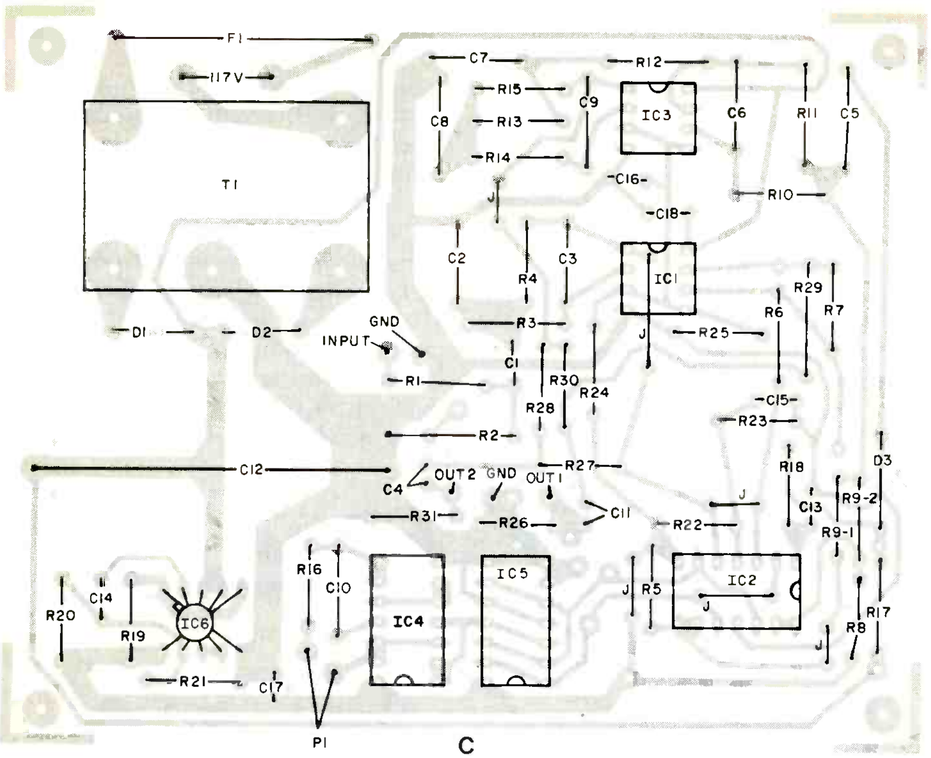


A

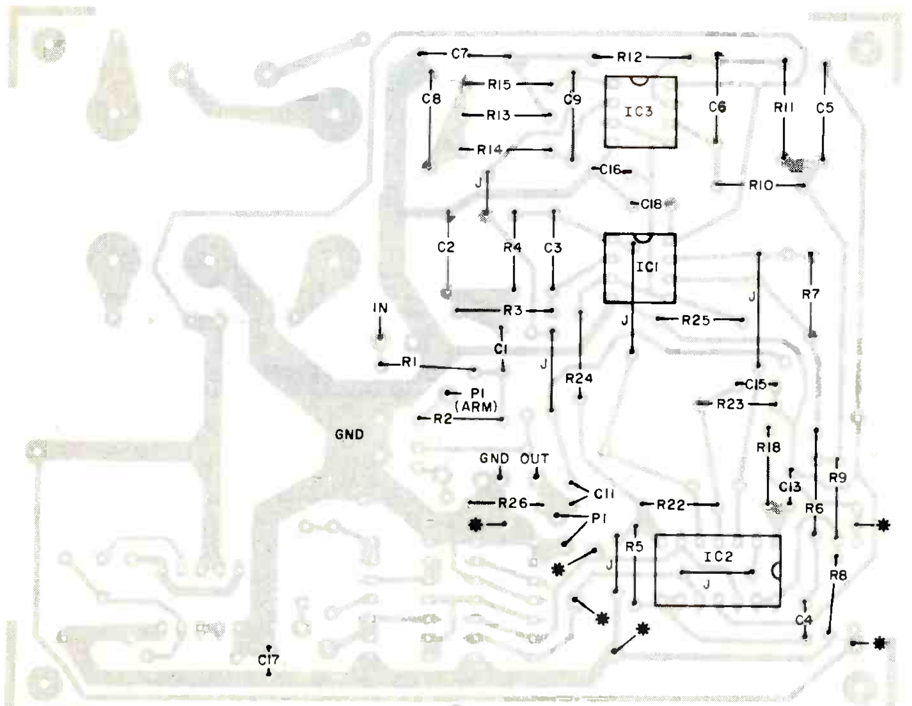


B

Fig. 6. Above (A) is etching and drilling guide for pc board. It can be used for either channel for delay-line circuit, or for the phasor/flanger. At left (B) is component layout for one channel of delay line. It includes the power supply. Component layouts for phasor/flanger and second channel of stereo delay line are on next page.



C



D

Fig. 6. Component layout at top is for phasor/flanger (C). Below (D) is for second channel of stereo system. It uses power supply in first channel.

watts) and fine solder, and watch out for solder bridges between the closely spaced pads on the board.

The wiring guide for the second pc board for a delay line for stereo is shown in Fig. 6D. Note that the power supply section is *not* repeated; you get power and clock pulses from the first board via wire interconnections.

Solder lengths of hookup wire to the pads that are to interconnect with the off-the-board pots and jacks. Then drill holes for the line cord, jacks, pots, and board mounting in a 5″ × 4″ × 3″ (12.7 × 10.1 × 7.6 cm) aluminum chassis box. Locate the line cord and jack holes on a wall directly opposite the wall through which the pot holes have been drilled.

Use machine hardware and spacers to mount the pc board assembly to the floor of the aluminum box. If you are assembling a stereo delay line mount the second board assembly over the first with short spacers and machine hardware after interconnecting the power-supply and clock-drive lines with hookup wire. (Be sure to make the interconnections before fastening the boards together.) Connect and solder the free ends of the hookup wires from the board(s) to the appropriate lugs in the jacks and pots. ◈

HANDS-ON EVALUATION

Both the time-delay and phasor/flanger configurations of this circuit should keep the home recordist occupied for hours, if not days. While the effects are not as apparent as those obtained with professional delay and flanging systems, this system does not cost the $4000 or so demanded for such top-of-the-line professional system.

The flanging effect is heard only while the potentiometer is in motion, at which time the variable comb filter sweeps across the audio bandwidth to create the "flanging" sound. At rest, the comb-filtered sound is noticeable, but it is not as apparent as one would expect from looking at the peaks and dips that occur at regular intervals on the frequency response curve.

Although you might not have occasion to use the flanger as a mono-to-stereo generator, don't overlook this operating mode for the enhancement of a single-output reverberation device. Reverberation is very diffuse by nature, and the flanger outputs, when panned left and right, are a noticeable improvement over a regular mono reverb return. When used in this application, the potentiometer remains at rest.

Use only one output when applying flanging to a recording. For an interesting Doppler effect, try combining the two outputs while rapidly revolving the pot. Better still, replace the standard pot with a free-spinning pot. (Connect the resistance element in series with *R16* and the wiper to either end of the element.)

On the delay line, the recirculation control must be used sparingly. A little goes a long way, and the "door spring" effect can easily get out of control. If you build both circuit configurations, you can experiment by wiring the flanger into the delay line's recirculation path. The slight additional delay in feedback creates even more echoes at the delay line's output. It also helps to keep the door spring from becoming a steady-state squeal.

—*John Woram,*
Woram Audio Associates

BUILD THIS LOW-COST CAPACITANCE METER

Five linear ranges to 10,000 µF

BY THOMAS McGAHEE

WHEN a capacitor is connected to a constant-voltage source through a resistor, the charge on the capacitor increases *exponentially*. If the source supplies a constant current, however, the charge on the capacitor increases *linearly*. This linear charging principle is used here in the design of a capacitance meter which will measure values outside the range of most such meters. By using a constant-current source, the meter determines the time it takes to match the charge on the unknown capacitor to a known reference voltage. The meter has five full-scale ranges of 1, 10, 100, 1000, and 10,000 µF. On the 1-µF scale, values as small as 0.01 µF can be read easily.

How It Works. As shown in Fig. 1, *D1, D2, R6, Q1* and one of the resistors (*R1* through *R5*) selected by *S1A* provide five decades of constant current. With *S2* in the position shown in Fig. 1, this current is shunted to ground via *S2A*. When *S2* is placed in its alternate position, the constant current will be pumped into the unknown capacitor connected across *BP1* and *BP2*, forcing it to charge in a linear fashion.

Op amp *IC1* is connected as a comparator, with its noninverting (+) input connected to *R8*, which determines the reference voltage. When the voltage developed across the unknown capacitor, connected to the inverting input (−) of *IC1*, becomes a few millivolts higher than the preset reference voltage, the comparator output will switch from +12 volts to −12 volts.

The output of the comparator drives a constant-current source consisting of *D3, D4, D5, R10, R11,* and *Q2*. When *S2A* was switched to ground, so was *S2B*. This action shorts across storage capacitor *C1*, therefore the voltage across this capacitor is zero.

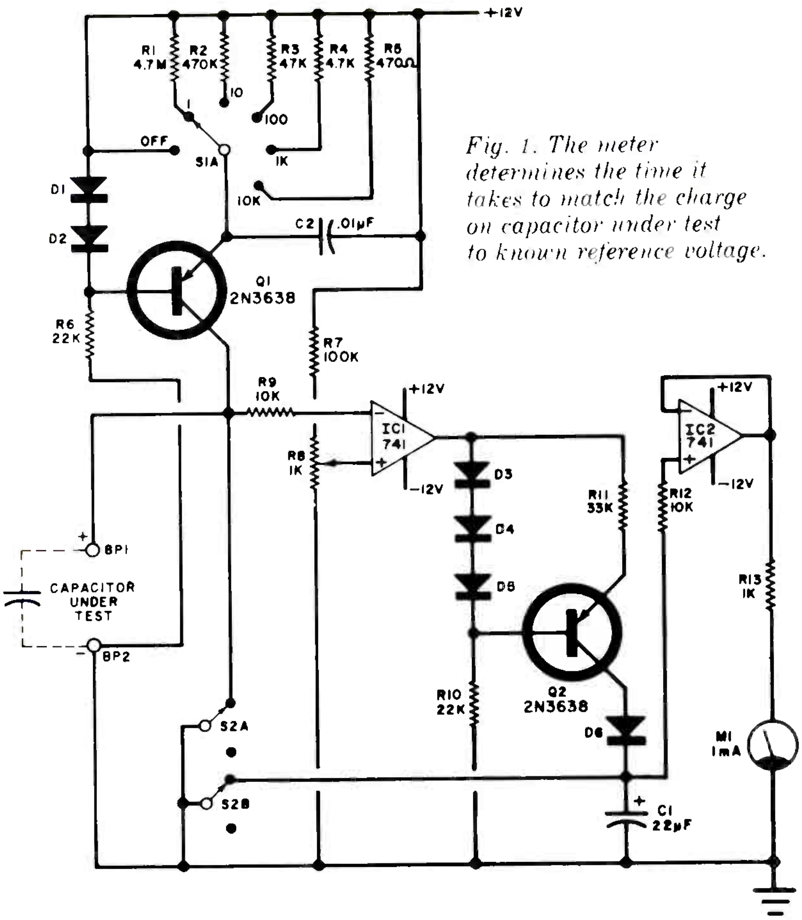


Fig. 1. The meter determines the time it takes to match the charge on capacitor under test to known reference voltage.

PARTS LIST

BP1, BP2—Five-way binding posts (one red, one black)
C1, C4—22-µF, 35-volt electrolytic capacitor
C2—0.01-µF ceramic disc capacitor
C3—220-µF, 35-volt electrolytic capacitor
D1 to D6—1N914 diode
D7, D8—50-volt, 500-mA silicon rectifier
D9, D10—12-volt zener diode
IC1, IC2—741 mini-DIP case
M1—0-1-mA meter (Radio Shack 22-052 or equiv.)
Q1, Q2—2N3638 transistor
R1—4.7-megohm, ½-w 5% resistor
R2—470,000-ohm, ½-w 5% resistor
R3—47,000-ohm, ½-w 5% resistor
R4—4700-ohm, ½-w 5% resistor
R5—470-ohm, ½-w 5% resistor
R6, R10—22,000-ohm, ½-w resistor
R7—100,000-ohm ½-w resistor
R8—1000-ohm, pc-type trimmer potentiometer
R9, R12—10,000-ohm, ½-w resistor
R11—33,000-ohm, ½-w resistor
R13—1000-ohm, ½-w resistor
R14—560-ohm, ½-w resistor
R15—470-ohm, ½-w resistor
S1—Dp 6-pos. rotary switch (Radio Shack 275-1386 or equiv.)
S2—Dpst or dpdt pushbutton or rocker switch
T1—Transformer, secondary 12-V, 300 mA (Radio Shack 273-1385 or equiv.)
Misc.—Suitable enclosure (Radio Shack 270-627 or equiv.), line cord, insulated wire, spacers, rubber feet (4).

When *S2* is opened, the constant current flowing into *C1* causes the voltage across it to rise linearly. When the voltage across the capacitor under test causes the comparator to switch, diode *D6* becomes reverse biased, preventing *C1* from charging any more. Since *C1* only charges until the comparator switches, the voltage generated across it is directly proportional to the capacitance value of the unknown capacitor.

To prevent *C1* from discharging while measuring its voltage, a high-impedance buffer, formed by *IC2*, is used. While this buffer draws very little current, it does draw some, and this results in a very slow downward drift of the meter—but this drift is actually too slow to cause any problems. Resistor *R13* and meter *M1* make up a simple voltmeter readout of approximately 1 volt full scale. If desired, an external voltmeter can be used as long as it has a full-scale range of less than 8 volts. (If you use such an external meter, set *R8* on the 1-µF range, so that a known 1-µF capacitor indicates 1 volt.) Capacitor *C2* is used to prevent oscillation of the *Q1* constant-current source, while *R9* and *R12* protect the op amps in case the power is turned off while the test capacitor and *C1* are charged, otherwise they might discharge via the op amps, causing damage.

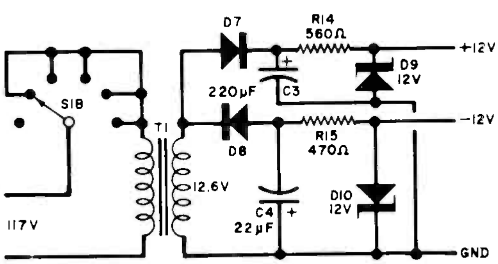


Fig. 2. Power supply delivers sufficient current for meter.

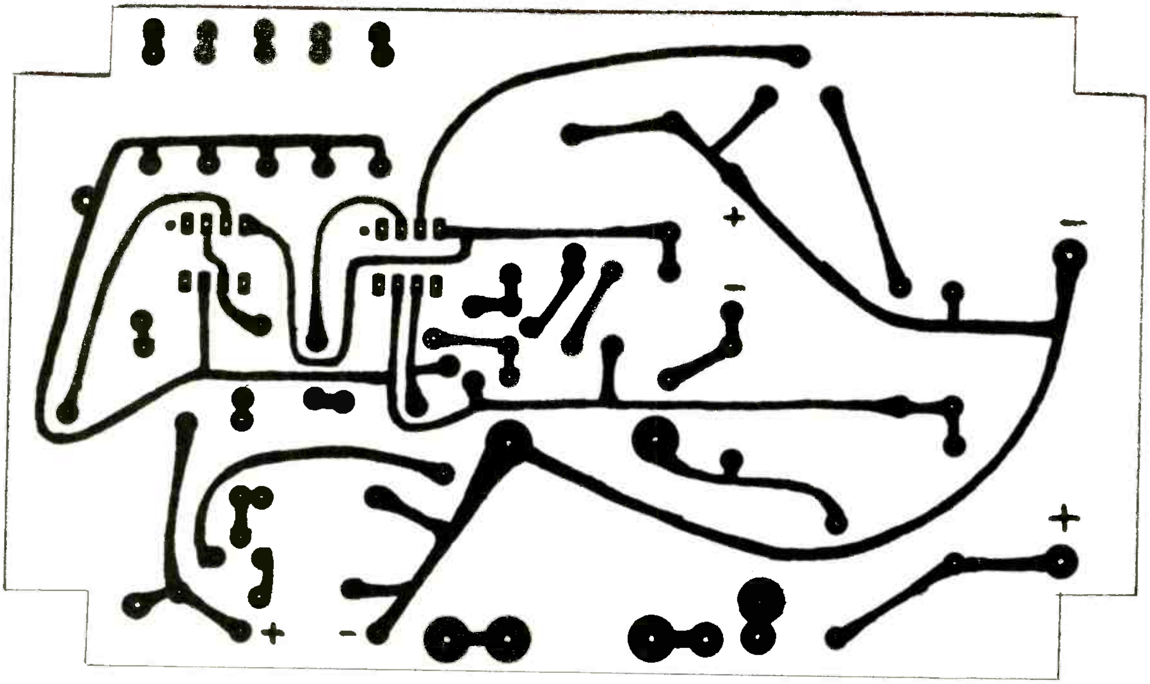
The power supply whose circuit is shown in Fig. 2, can supply sufficient current to power the meter.

Construction. The circuit can be built on the pc board whose foil pattern is shown in Fig. 3, along with the component installation on the nonfoil side of the board. Be sure to observe the polarity of the two electrolytic capacitors and the various diodes. The IC's are identified by a notch code.

The prototype was assembled in a 6¼" by 3¾" by 2" plastic box having a metal cover. The cover was drilled to accept *M1*, range switch *S1*, switch *S2*, and the two binding posts (*BP1*, *BP2*). Note that a red binding post was used for *BP1* as this side is to be connected to the positive lead of the capacitor under test. The line cord exits through a small hole in the side of the plastic box.

Meter *M1* is linearly calibrated to 1 mA full scale. Carefully open up the meter and using press-on type, or other printing medium, mark the scale "MFD" or "µF."

The accuracy of the capacitance meter depends on two factors; the



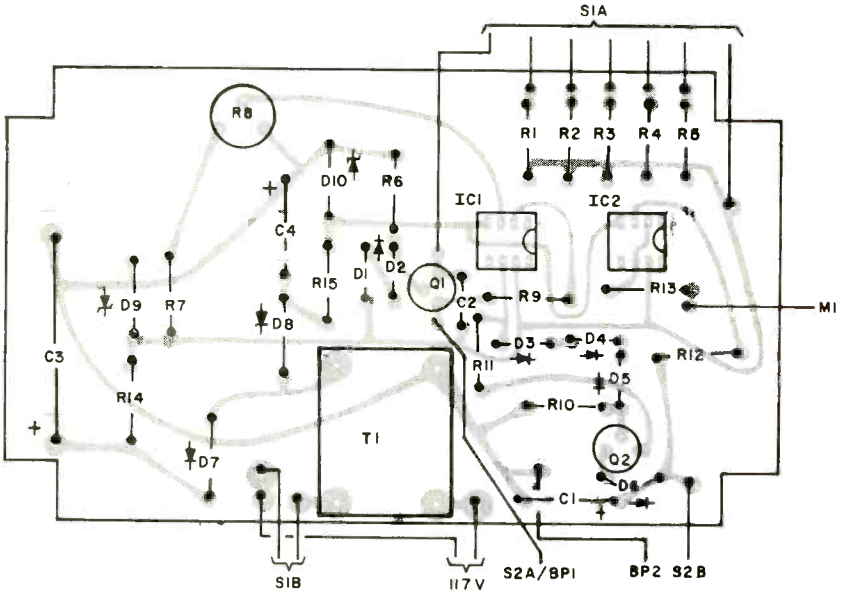


Fig. 3. Actual-size etching and drilling guide is above, component layout at left.

basic accuracy of the meter movement used and the accuracy of resistors *R1* through *R5*. In most cases, the meter accuracy will be 3%, and experience has shown that, with 5% tolerance resistors, the overall accuracy is about 3%. Although this may sound strange, it is due to the fact that most 5% resistors made by the same company tend to be off tolerance by the same percentage, thus reducing the effective percent error between the resistors. Using 10% resistors yields about 6% accuracy.

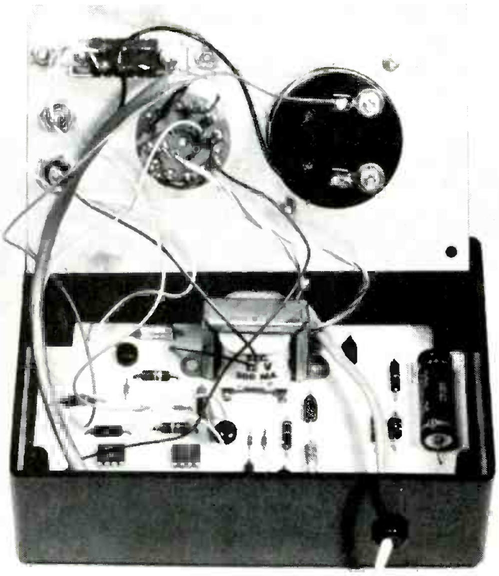
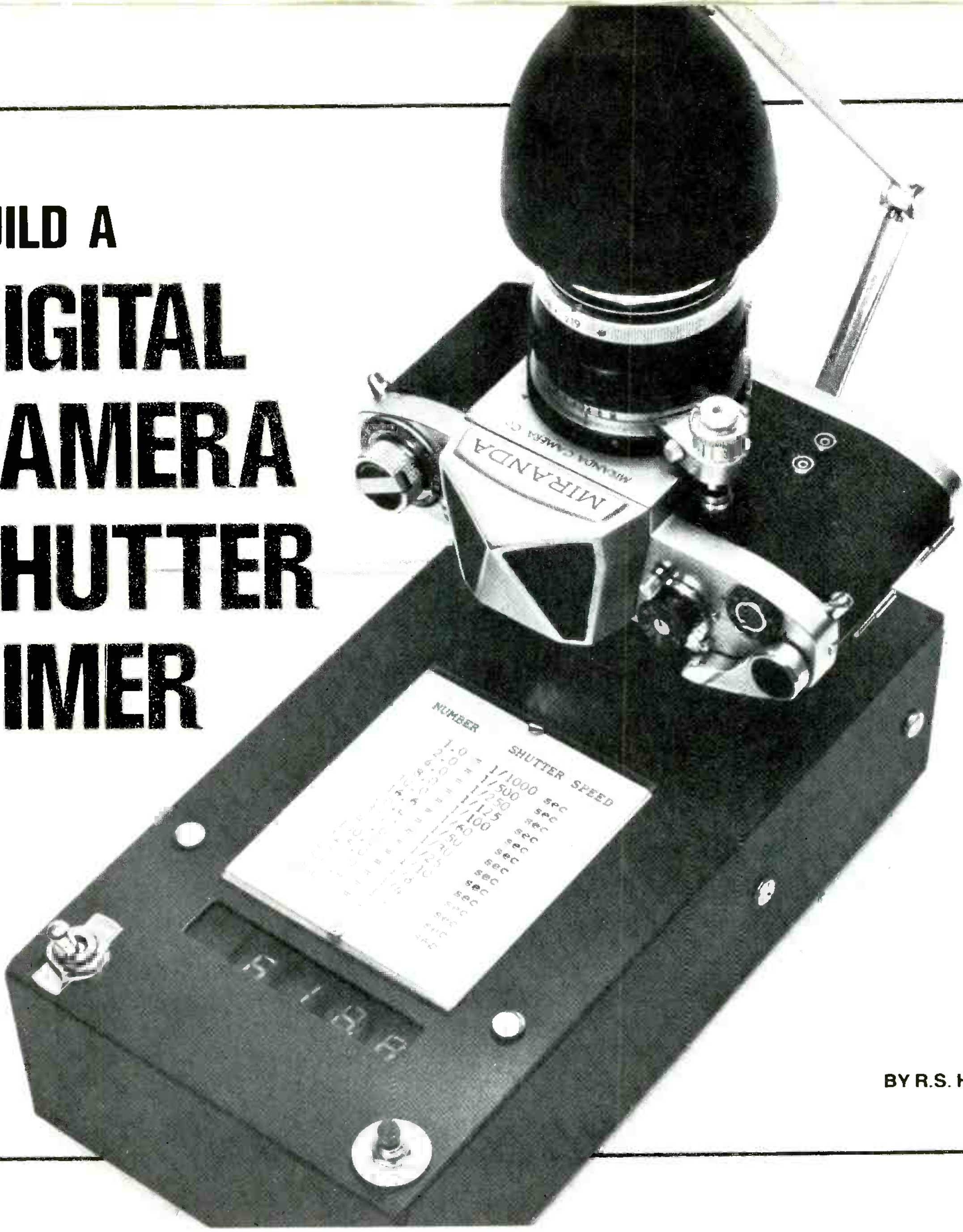


Photo shows how author's prototype was assembled in box.

Calibration. Before applying power to the capacitance meter, use a small screwdriver to set the meter pointer exactly to the zero mark.

Select a capacitor between 0.5 and 1.0 µF at 5% or better. This will be the "calibration standard." Connect this capacitor between *BP1* and *BP2* (positive side to *BP1*). Set range switch *S1* to the "1" position (meter indicates 1-µF full scale). Operate *S2* to remove the ground lead from the two circuits (*Q1* collector and *C1*). The meter should start upscale and stop at some value. Reversing *S2* should cause the meter to drop to zero volts. Flip *S2* again and note the upscale value of the meter. Alternately flip *S2* and adjust *R8* until the meter indicates the exact value of the 5% calibration capacitor. The one calibration will suffice for all the other ranges. ◈

BUILD A DIGITAL CAMERA SHUTTER TIMER



BY R.S. HEDIN

Low cost digital timer provides accurate check of camera shutter speeds from 1/1000th of a second to 1 second.

HAVE YOU ever wondered why a camera whose diaphragm opening and shutter-speed setting are adjusted perfectly according to an exposure meter should regularly produce overexposed or underexposed negatives or prints? Too often, the cause is a shutter speed that deviates too much from the camera's speed markings.

Now you can check your camera's actual shutter speed by building the electronic shutter tester presented here. If the camera displays a gross speed inaccuracy, you'll know that you must compensate for it by modifying the camera's control adjustments (say, an f stop greater or smaller than the exposure meter's indication) or having the camera serviced professionally.

With your own shutter tester, you can test your camera at any time you feel it needs adjustment. The shutter tester described here uses digital circuits and has six decades of display to give a high order of accuracy.

About the Circuit. The sensor/control circuit for the tester is shown in Fig. 1, while the counting circuit is shown in Fig. 2. The two circuits are coupled together via the +V and GND buses and the points marked K going to each other.

When light strikes phototransistor *Q2* and not *LDR1* in Fig. 1, the Darlington circuit made up of *Q2* and ordinary transistor *Q1* triggers on and supplies current to timer *IC6*. This causes the timer IC to generate pulses at a frequency of 10,000 Hz. (Potentiometer *R1* is provided for adjusting the operating frequency of the oscillator to exactly 10,000 Hz.)

If at any time light strikes *LDR1*, the

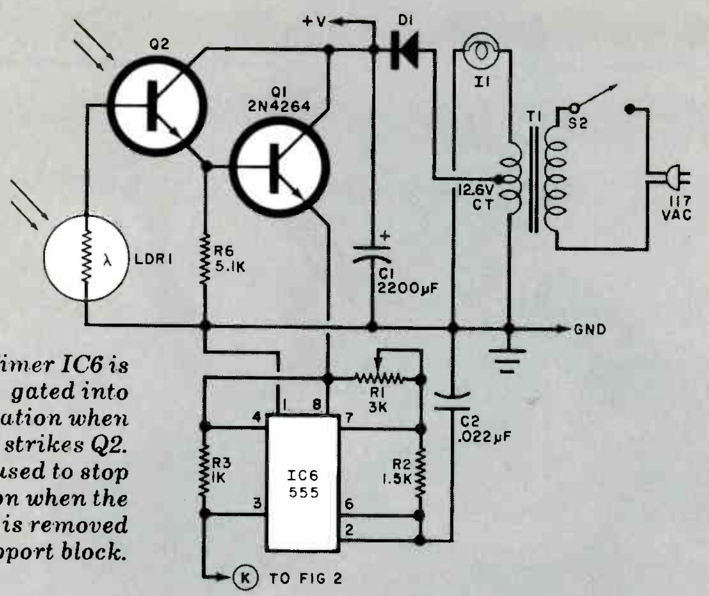


Fig. 1. Timer IC6 is gated into oscillation when light strikes Q2. LDR1 is used to stop operation when the camera is removed from support block.

PARTS LIST

C1—2200-µF, 16-volt electrolytic capacitor
C2—0.022-µF Mylar capacitor
DIS1 through DIS5—½" common-cathode, seven-segment LED display (DL-704 or similar)
D1—100-volt, 1-ampere silicon rectifier diode
I1—12-volt high-intensity lamp with arm and reflector (see text)
IC1 through IC5—4033A CMOS decade counter
IC6—555 timer
LDR1—Light-dependent resistor (Vactec No. VT-214 or Clairex CL-903)
Q1—2N4264 transistor
Q2—FPT-100 phototransistor
R1—3000-ohm trimmer potentiometer
The following resistors ¼ watt, 10% tolerance:
R2—1500 ohms
R3,R4,R5—1000 ohms
R6—5100 ohms
S1—Normally open, momentrary-action spst pushbutton switch
S2—Spst toggle switch
T1—12-volt, 1.2-ampere transformer (see text)
Misc.—Printed circuit or perforated board; 16-pin DIP sockets (5); 14-pin DIP sockets (5); 8-pin DIP socket; chassis with cover (9" × 5" × 2½"); line cord; pine block (3½" × 1¾" × 1¾"); soft vinyl sheet; rubber feet (4); contact cement; machine hardware and spacers; hookup wire; solder; etc.

resistance in the base circuit of *Q2* drops to a low enough value to cause the Darlington circuit to cut off. This, in turn, turns off the timer circuit. Under normal operating conditions, no light will fall on either *Q2* or *LDR1* initially. After pressing reset switch *S1* (Fig. 2), light is allowed to reach only *Q2*. This allows the timer circuit to generate a 10,000-Hz pulse output that is counted by the totalizer circuit shown in Fig. 2. The displays continue to count upward until the light to *Q2* is interrupted or light falls on *LDR1*. At this time, the displays "freeze" to indicate the total number of pulses counted. When the tester is used with a camera, the camera's body covers *LDR1* to exclude all light and the shutter/lens mechanism is positioned directly above *Q2*, in line with a high-intensity light source. Switch *S1* is momentarily depressed to reset the counters to zero. Then, when the shutter is tripped, the system counts the number of pulses generated between the opening and closing of the shutter.

The counting circuit shown in Fig. 2 consists of five decade-counter IC's (*IC1* through *IC5*) and their companion seven-segment displays (*DIS1* through *DIS5*). Note that *DIS2* is the only display whose decimal point is active. This decimal point comes on whenever the tester is powered. Note also that the decade counters are wired to suppress the zeroes to the left of the decimal point. Since the display indicates the number of pulses counted during a discrete interval of time, it does not indicate time. To obtain the time indicated by the number in the display, you must divide that number by 1000. Hence, displays of 1.0, 8.0, 16.6, and 33.3 translate to 0.001, 0.008, 0.0166; and 0.0333 second or, in photography terminology, 1/1000, 1/125, 1/60, and 1/30 second, respectively. (It is a good idea to make up a table of conversions that can be affixed to the completed project, as shown in the lead photo.)

The power supply for the tester is line operated. Dc power for the system is obtained from a conventional rectifier-diode/filter-capacitor (*D1/C1*) setup that is driven from the center tap of transformer *T1*. This circuit assumes that high-intensity lamp *I1* is an integral part of the system. If you prefer, you can use a separate line-powered high-intensity lamp and substitute a 6.3-volt transformer for *T1*.

Construction. The entire circuit, except *T1* and the two switches and *Q2*

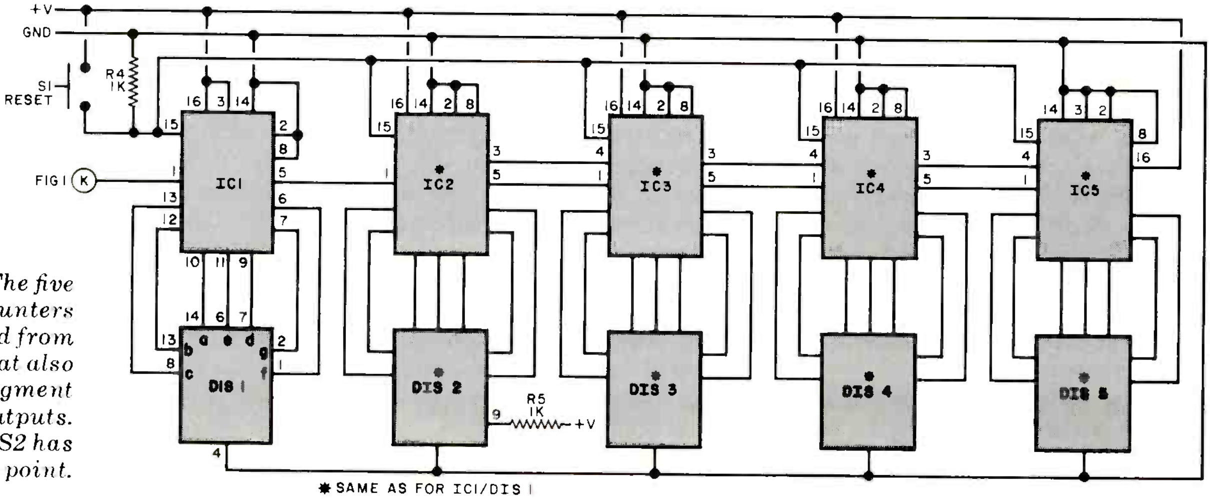


Fig. 2. The five decade counters are formed from IC's that also include 7-segment decoded outputs. Note that DIS2 has the decimal point.

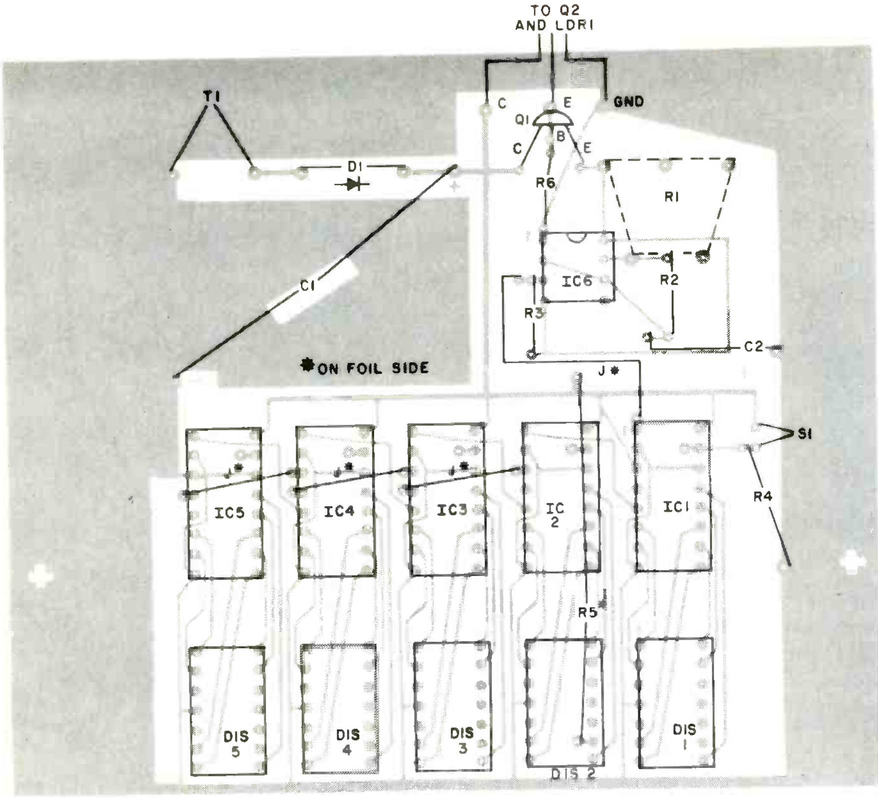
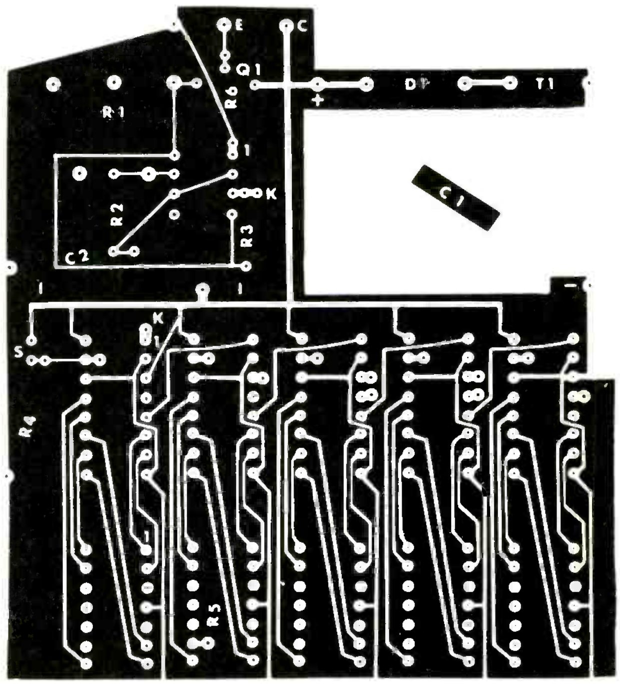


Fig. 3. Foil pattern and component installation. Pin 15 of IC1 through IC5 are connected together by a common jumper on the foil side of the board. Note that R5 and the other jumpers are also located on the foil side.



and *LDR1*, can be assembled on a single printed circuit board, the etching and drilling and component-placement guides for which are shown in Fig. 3. Alternatively, you can assemble the circuit on perforated board, using appropriate solder hardware. In either case, the use of sockets for the IC's and displays is recommended.

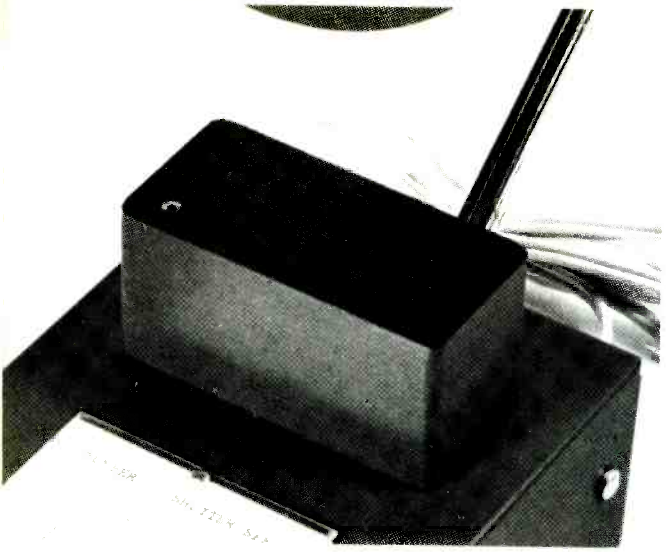
Install the components on the circuit board as shown in the component-placement guide, taking care to properly orient them. Note here that the four jumper wires labelled J and *R5* mount on the *foil* side of the board. To avoid the possibility of short-circuiting the board, be sure to use insulated sleeving on the resistor leads and wire jumpers.

Phototransistor *Q2* and light-dependent resistor *LDR1* mount in a block of pine as shown in Fig. 4. The holes in which these two components mount must be stepped as indicated to permit easy routing of the hookup wires that interconnect them with the rest of the circuit. Note that *LDR1* mounts in the hole at the lower left corner and *Q2* mounts in the hole in the center of the block.

Before you mount *Q2* and *LDR1* in the block of wood, apply a coat or two of flat black paint to all exterior surfaces of the block. Allow the paint to completely dry, and then mount the components in their respective holes, fixing them in place by force fitting. (If the fit is too snug, very carefully ream out the holes; if it is too loose, sparingly apply a drop or two of clear plastic cement to the component edges. Both components mount flush with the top surface of the block. When

CONVERSION TABLE

NUMBER		SHUTTER SPEED	
1.0	=	1/1000	sec
2.0	=	1/500	sec
4.0	=	1/250	sec
8.0	=	1/125	sec
10.0	=	1/100	sec
16.6	=	1/60	sec
20.0	=	1/50	sec
33.3	=	1/30	sec
40.0	=	1/25	sec
100.0	=	1/10	sec
125.0	=	1/8	sec
250.0	=	1/4	sec
500.0	=	1/2	sec
1000.0	=	1.0	sec



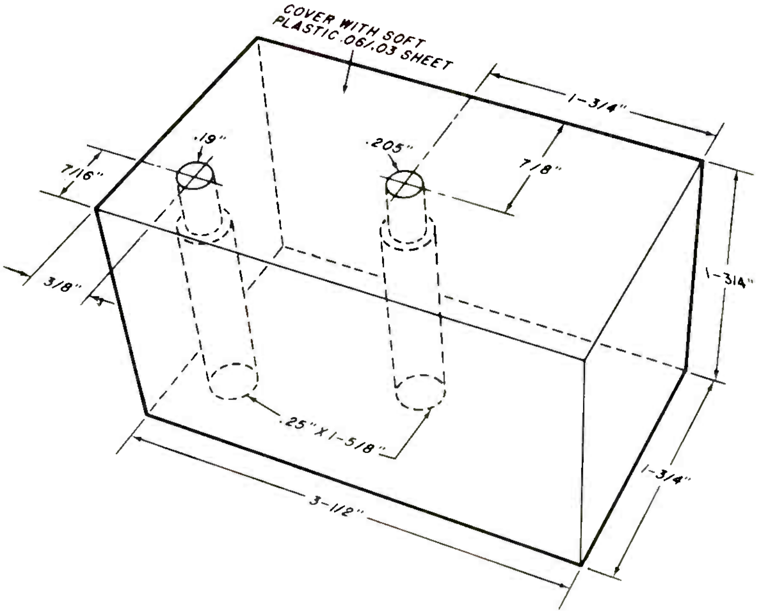


Fig. 4. Details of the camera mounting block. The two photosensitive devices (Q2 and LDR1) are mounted close to the upper surface of the block.

this is done, use contact cement to fasten a thin sheet of soft matte black vinyl to the top of the block after first punching holes in it for *Q2* and *LDR1*.

A 9"D × 5"W × 2½"H (22.9 × 12.7 × 6.4 cm) metal box comfortably accommodates the circuit board assembly, power transformer and its line cord, and switches. The case must be machined to provide a 2⅝" × ½" (6.7 × 1.3 cm) window for the displays; mounting holes for the switches, transformer, and wood block; and access holes for the line cord and leads from *Q2* and *LDR1*. Once the case has been machined, spray two or three coats of matte black paint over all exterior surfaces. When the paint has dried, cement a red filter over the window from the inside. Then mount the wood block with screws, followed by *T1*, *S1*, and *S2*. Next, interconnect the switches, transformer, line cord (passed through the case via a rubber grommet), LDR, and phototransistor. Finally, mount the circuit board assembly in place with machine hardware and spacers, making sure its displays are properly oriented behind the filter.

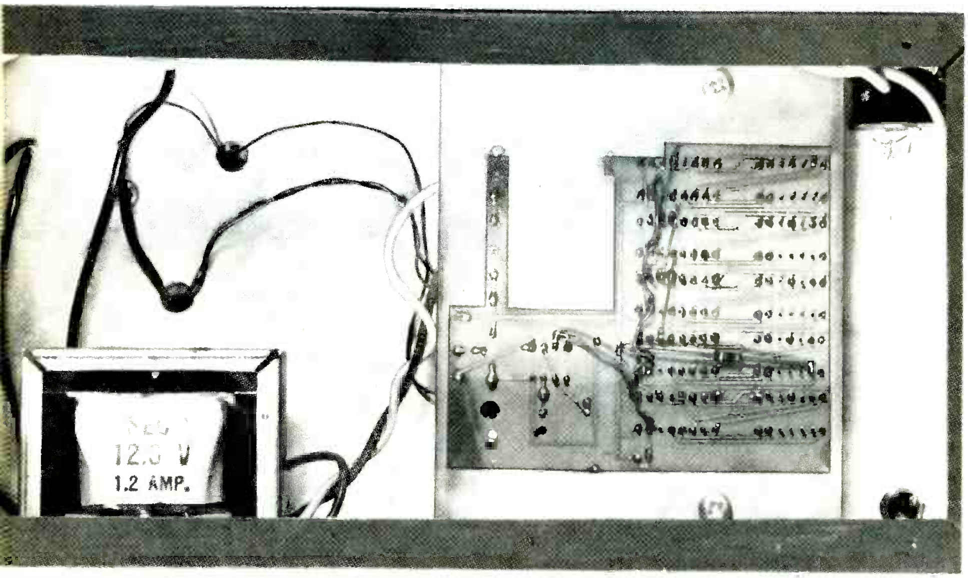
Checkout and Use. Place a piece of black plastic tape over *LDR1*, plug the line cord into a convenient ac outlet, and turn on the tester's power. Now, using an oscilloscope or a frequency counter, adjust potentiometer *R1* for an exact 10,000-Hz output from timer *IC6*. This completes calibration. Remove the tape from *LDR1*.

Open the back of the camera you wish to test and place it on the wood block so that the lens opening is directly over *Q2*. Make sure that the camera body covers *LDR1*. Then set the camera's lens diaphragm for maximum opening, set the shutter speed, and cock the shutter. Depress reset switch *S1* so that all displays read zero. Trip the camera shutter. The displays should rapidly count up and freeze at a number that is the shutter speed in thousandths of a second.

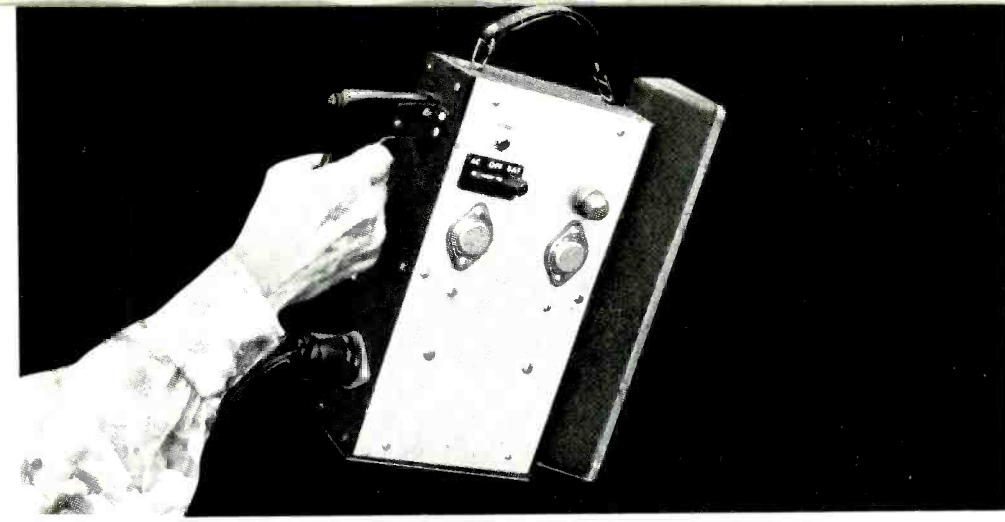
Check each shutter speed at least three times, resetting the display at the start of each test. The shutter can be checked with or without the lens on the camera. With the lens on the camera it is more critical that the lens be placed directly over Q2 as there is a smaller spot of light. In all tests keep the light about 6 inches above the platform.

Do not be disappointed if your shutter speed is not close to its camera setting. Up to 1/500 of a second, the allowable error may be as great as ±25%; at higher settings, the allowable error might increase to ±35%. These figures would depend on the tolerance of the film used, of course.

With the aid of the camera shutter timer described here, you can eliminate some of the uncertainties you have about the accuracy of your camera's mechanism. Additionally, it can tell you why your latest batch of photos did not turn out as they should have. ◇



Underside of timer reveals pc board and transformer mounting.



BUILD A

BLACKLIGHT LANTERN

Battery-powered, long-wave ultraviolet lamp reveals color patterns of many substances. Doubles as camp lantern.

BY W.E. McCORMICK

THERE are many things in nature that, in natural light, look pretty dull. When illuminated by ultraviolet light, however, they take on the appearance of colorful gems. The minerals in rocks, sand, even dirt and some insects fluoresce with beautiful colors under UV light. You can see it all with the aid of the portable black-light lantern described here.

The ultraviolet fluorescent lamp can also be replaced by a 6-watt daylight fluorescent lamp to provide normal light if desired. If you have a source of 117-volt ac, a simple connector change permits the lantern to be used as a light source, while the batteries are being recharged. The lantern uses a 6-volt rechargeable wet-cell; and, since the drain is only about 1.75 amperes, quite a few hours of operation can be obtained from a single charge.

Circuit Operation. As shown in Fig. 1, transistors *Q1* and *Q2* are arranged as a power oscillator. Resistor *R1* determines the turn-on voltage and *R2* determines the frequency of oscillation. With the components specified, the frequency is in the low audio range, but high enough to minimize lamp flicker. Resistors *R1* and *R2* actually form a voltage divider to bias the transistors into conduction before oscillation starts.

The alternating currents in the two halves of the collector winding induce a voltage in the secondary of *T1*. Capacitor *C1* reduces voltage spikes that might damage the transistors. With no load, the voltage is 135 V, which drops to about 110 V (a square wave) with a 6-watt load.

With *S1* in the BATTERY position, the ac voltage lights indicator lamp *I2* and is applied to *I1* through a ballast. Closing switch *S2* completes the lamp filament circuit to heat up the filament. When *S2* is released, the ballast generates an inductive kick to strike an arc in the lamp. This method of lamp starting is used for two reasons: glow-type starters do not work well with the square wave involved here, and such starters may be unreliable at low temperatures.

With *S1* in the AC position, the oscillator is disabled and conventional 117-volt ac can be applied to *J1* through *P2*.

Construction. The transformer used for *T1* must be modified for this application. Begin by removing the metal mounting-binding strap from around

ULTRAVIOLET LIGHT AND FLUORESCENCE

There are hundreds of relatively common substances that are usually quite drab under conventional visible light, but are quite brilliantly colored when illuminated by ultraviolet light. For example, when illuminated with ultraviolet at 3560 Angstroms (as provided by this project), a common, dirty-white mothball becomes a vibrant purple.

Roughly half of the substances that fluoresce strongly enough to be seen by the unaided eye, react to longwave (3560 A) ultraviolet. The remainder react to shortwave (2535 A) ultraviolet, while some react to both wavelengths. Some exhibit a color shift when the wavelength is changed, and others undergo a complete color reversal.

Many substances have a pronounced phosphorescence and continue to glow either the same color or a different one, after the excitation is removed. This can make it possible to differentiate between many materials that have the same fluorescence.

Shortwave ultraviolet lamps can produce sunburn and are dangerous to the eyes. When using an instrument of this type, goggles should be worn at all times. (Window glass or clear acrylic plastic, which are opaque to the wavelength, will suffice.) Longwave lamps provide no sunburn hazard and are optically safe.

Geologists are now using ultraviolet light in oil prospecting. They lay out a grid covering the area under investigation and take core samples at various points from a depth of about six inches. The oil does not have to be near the surface since the hydrocarbons brought up by leaching, capillary action, and evaporation promote the growth of micro-organisms (*bacillus methanicus* and *bacillus ethanicus*) which fluoresce blue under longwave ultraviolet.

This method not only locates oil. It produces an outline of the underground pool on the grid. With a little knowledge of the local shale strata and oil sand, the pool's depth can be determined; and the amount of oil to be expected can be determined from the size of the area that fluoresces. The quality of the oil is indicated by color saturation—high sulfur content shifts the color toward yellow and paraffin content shifts it toward pale blue. Other minerals, in suspension, can also be detected. By color matching, it is possible to tell if the pool is a new strike or leakage from an adjacent field.

Longwave ultraviolet is widely used in criminology to detect forged paintings, altered documents, and the authenticity of antique glass and china.

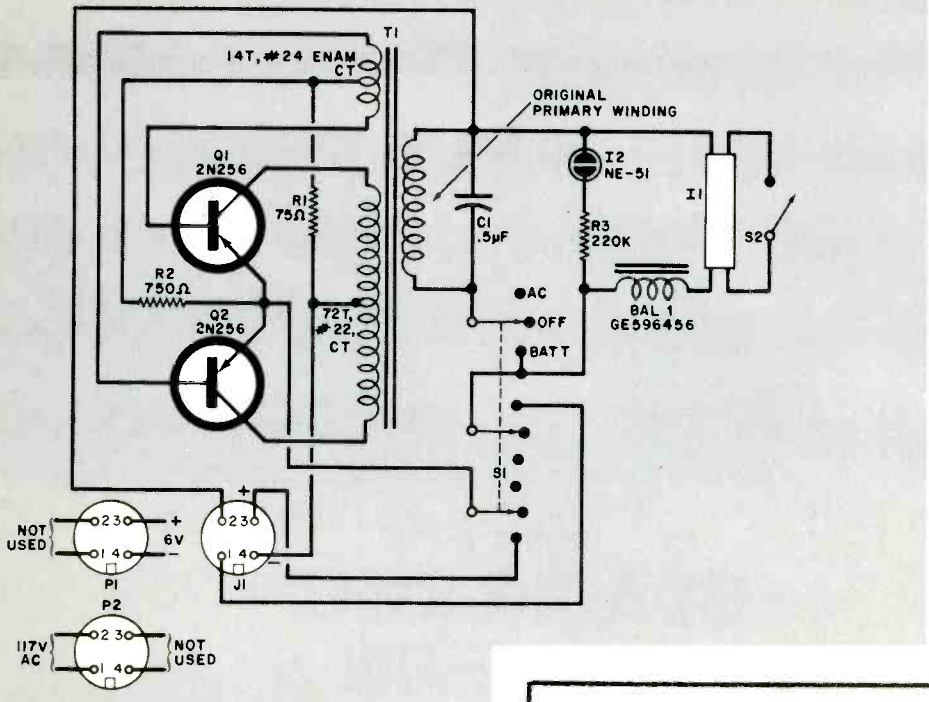


Fig. 1. Two-transistor power oscillator generates approximately 110 volts for ultraviolet lamp.

PARTS LIST

BAL1—Ballast inductor (GE 596456 or similar, available through electrical supply houses)
C1—0.5-µF, 400-volt capacitor
I1—Fluorescent lamp (6 watts); either ultraviolet (GE F6T4/BLB or similar, available from Edmund Scientific, 300 Edscorp Bldg., Barrington, NJ 08007, Cat. No. 60,124, $4.75.) or standard daylight (GE F6T5/CW, available through electrical supply houses)
I2—NE-51 neon lamp
J1—4-pin male plug (H.H. Smith 86CP4 with 12-001-003 adapter plate)
P1,P2—4-pin female connector (Amphenol Series 86-PF4)
Q1,Q2—2N256 power transistor
R1—75-ohm, 10-watt, 10% resistor
R2—750-ohm, ½-watt resistor
S1—4pdt, 3-locking position anti-capacitance switch (Radio Shack 275-600 or similar)
S2—Spst normally open pushbutton switch
T1—117-volt primary; 12.6-volt, 1.2-A secondary filament transformer (Radio Shack 273-1505, modified as per text. Do not substitute.)
Misc.—Plastic case (Bud AC403); metal plate (Bud BPA1590), fluorescent lamp holder (one pair, miniature flush mount, GE 78-X715 or similar); power transistor mounting kit (two, HEP450 or similar); six-foot line cord with plug; three-foot battery cable (#18 stranded); 6-V, 6-A battery (Olson BA-200, $3.49, or PolyPaks, P.O. 942, S. Lynnfield, MA 61940, Cat. No. 92CU1516, $4.95); grommets; decals; mounting hardware; etc.

the core. Then use a thin-bladed knife to loosen the individual laminations and remove them. Be careful not to cut any wires.

Peel the insulating tape from the coil and set it aside for later use. Carefully strip off the secondary (green leads with yellow center tap) and save the wire. Leave the existing primary (black leads) and cover it with a single layer of the insulating tape.

In winding new turns, be sure all winding is made in the same direction. You can wind either way around the core; but once started, everything must be in that direction.

Put the winding (#22 wire) for the collector circuit on first. Color code the start of the winding using a 4" length of spaghetti. Anchor the winding under one of the bobbin flanges by using a small piece of tape. Start wind-

COLOR AND LOCATION OF MINERALS

Minerals	Color under visible light	Color under longwave UV	Where commonly found
Adamite (basic arsenate of zinc)	Pale green	Green	Southwestern U.S. and Mexico
Amber (a hydrocarbon)	Usually yellow, sometimes brown or white	Blue-white	Widely distributed U.S.
Argonite (calcium carbonate)	Indiscernable in mineral mass	Green Orange Brilliant red	New Mexico Sicily Australia
Barite (barium sulphate)	Gray	White, cream or yellow Bright golden Orange	Widely distributed U.S. N. Carolina only
Calcite (calcium carbonate)	White coating in rock seams	Blue Pale yellow Bright Orange in association with red	Widely distributed U.S. N. Jersey, Texas California
Celestite	Colorless crystals Blue crystals	White, blue-white White with green after-glow	Ohio, Midwestern U.S. Ohio only
Cerussite (lead carbonate)	Yellowish gray Dull gray	Yellow	Lead mining regions
Corundum (aluminum oxide)	Red	Deep red	N. Carolina, N. Jersey
Deweylite (magnesium silicate)	Mottled dull green usually in serpentine formation	White	Maryland, Pennsylvania
Diamond	Clear or faintly tinted (any color)	Most commonly blue, but can be almost any color	Africa, Arkansas, U.S.

ing adjacent turns across the bobbin, keeping the turns snugly against each other. At 36 turns, make a 4"-long twisted loop and use a piece of colored spaghetti to insulate and identify it. Bring this out to one side. Wind another 36 turns, fasten it down with tape, and bring out a 4" end identified with colored spaghetti. Place a single layer of tape over the completed winding.

For the base circuit winding, use the #24 wire saved from the original secondary. Use a 4" length of colored spaghetti to identify the start. Wind seven turns, make a center tap as before, and add seven more turns. After all winding is complete, place a layer of tape over the assembly.

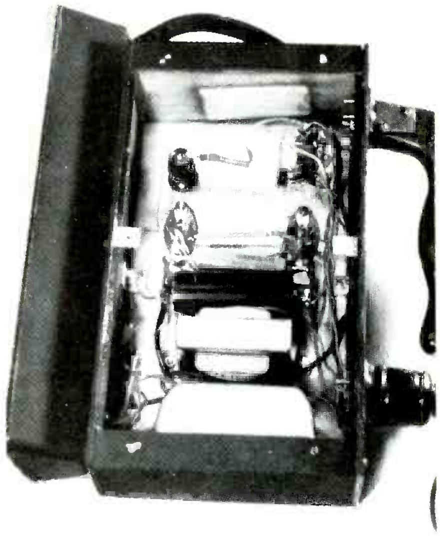
Before trying to reassemble the core (laminations), scrape any excess varnish off them. Otherwise, it may be difficult to fit them back on the bobbin. With laminations reassembled, replace the mounting strap, being careful not to pinch the lead ends.

In the prototype, a 5" by 9½" by 2½" (12.7 x 24.1 x 6.4 cm) plastic box with a metal cover was used. The two transistors are mounted on the outside of the cover using a kit (socket, mica insulator, and insulating hardware) so that the cover provides a heat sink. Be sure the collectors are not making electrical contact with the cover. Switch *S1* and *I2* are mounted on the same cover.

The transformer is mounted in the enclosure, while *S2* and *J1* are on one of the sides. Drill a small hole for the four leads to the fluorescent lamp. The lamp reflector can be made of sheet aluminum with wooden end pieces. The lamp holders are attached to the end pieces. The reflector can then be attached to one long side of the case. A pistol-grip handle can be attached to the case if desired.

The 6-volt battery can be carried in a shoulder holder (cassette case, binocular case, etc.) with a two-lead cable to plug *P1*. A conventional 117-volt lamp cord can be connected to *P2*. ◈

Batteries can be carried in cassette or binocular case with shoulder strap.



Internal layout of prototype.

Diopside (silicate of calcium and magnesium)	Masked by pyroxene mass	White, blue-white	N.Y., N. Jersey
Fluorite (calcium fluoride)	Purple, green or yellow. Occasionally, blue	Blue, dark red	Widely distributed U.S.
Opal (hydrous silica)	Variegated	Green	Western U.S.
Scapolite (complex silicate of calcium, sodium and aluminum)	White, greenish yellow	Brilliant yellow, red	Quebec, Canada
Sodalite (a silicate of sodium containing aluminum and chlorine)	Usually nondescript	Golden brown	N. Hampshire, N. Jersey
Sphalerite (zinc sulphide)	Often indiscernible in mass	Golden orange, blue	N. Jersey, Colorado, Arizona
Tremolite (calcium magnesium silicate)	Colorless crystals or a dull talc	Pink, red, fire-red, orange, gray-green or cream	New York Ontario, Canada only
Willemite (zinc silicate)	Usually indistinguishable, sometimes apple-green, dark brown or red	Yellow-green Blue-white	Arizona, N. Jersey
Wollastonite (calcium metasilicate)	Gray or white	Weak orange or yellow (Blue-white if associated with barite or green with Willemite)	N. Jersey, Arizona
Zircon (zirconium silicate)	Clear, blue Red	Dirty yellow Dirty red	California, N. Carolina

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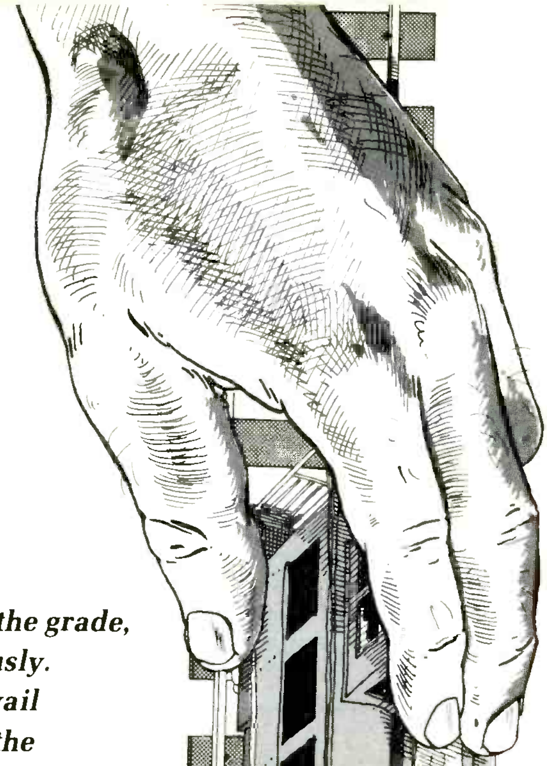
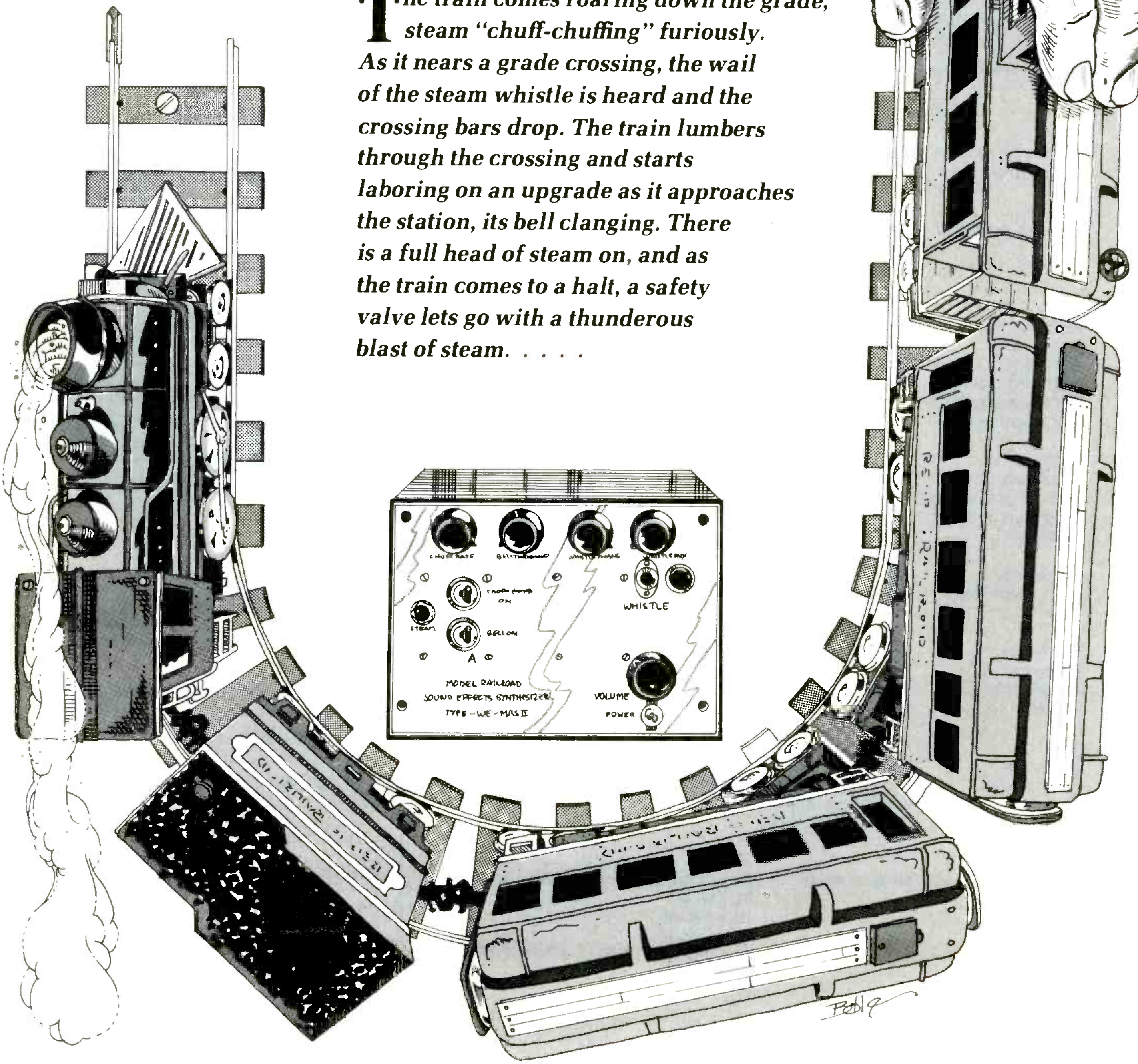
MODEL RAILROAD SOUND SYNTHESIZER

BY HAROLD WRIGHT

ADD CONTROLLABLE "CHUFF-CHUFF", STEAM, WHISTLE, AND BELL SOUNDS TO YOUR MODEL RAILROAD LAYOUT AT LOW COST



The train comes roaring down the grade, steam "chuff-chuffing" furiously. As it nears a grade crossing, the wail of the steam whistle is heard and the crossing bars drop. The train lumbers through the crossing and starts laboring on an upgrade as it approaches the station, its bell clanging. There is a full head of steam on, and as the train comes to a halt, a safety valve lets go with a thunderous blast of steam. . . . .



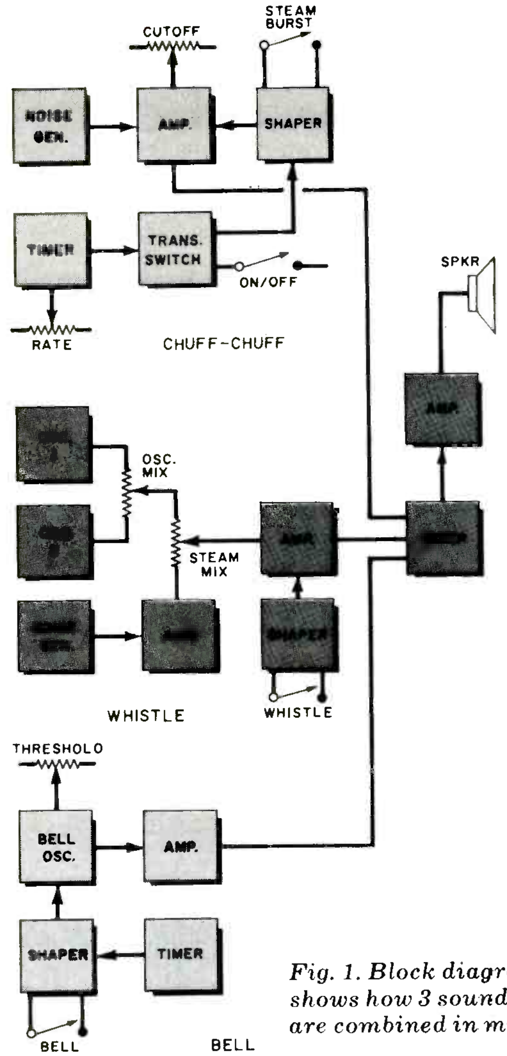


Fig. 1. Block diagram shows how 3 sound effects are combined in mixer.

All of the sound effects described on the preceding page can be obtained in your model train layout if you build this sound synthesizer. Using relatively simple circuits and readily available components, the system can be assembled easily in a few hours. The loudness of the sounds obtained is determined by the audio amplifier that you use in conjunction with the synthesizer.

Since most modern railroad layouts are already equipped with electrically operated switches, signal lights, and speed controls, the addition of the sound synthesizer will have the effect of turning your system from a silent movie into one with sound. The synthesized sounds are quite realistic and are of a wide variety. They can range from those of a distant, rapidly approaching train, with the volume increasing as the train approaches and slows down for the station, to the noise of wheels slipping on an engine trying to start with too large a load.

A block diagram of the complete synthesizer is shown in Fig. 1. It consists of four more-or-less independent circuits: a "chuff-chuff" generator for the steam sound, a whistle generator, a bell circuit, and a three-channel signal mixer.

Chuff-Chuff. As shown in Fig. 2, transistor *Q1* is operated in the avalanche mode and generates a steady white noise (hiss) signal across *R2*. This signal is applied to amplifier *Q3*, which is adjusted to a point just below cutoff by *R10*.

Timer *IC1* produces pulses at a rate

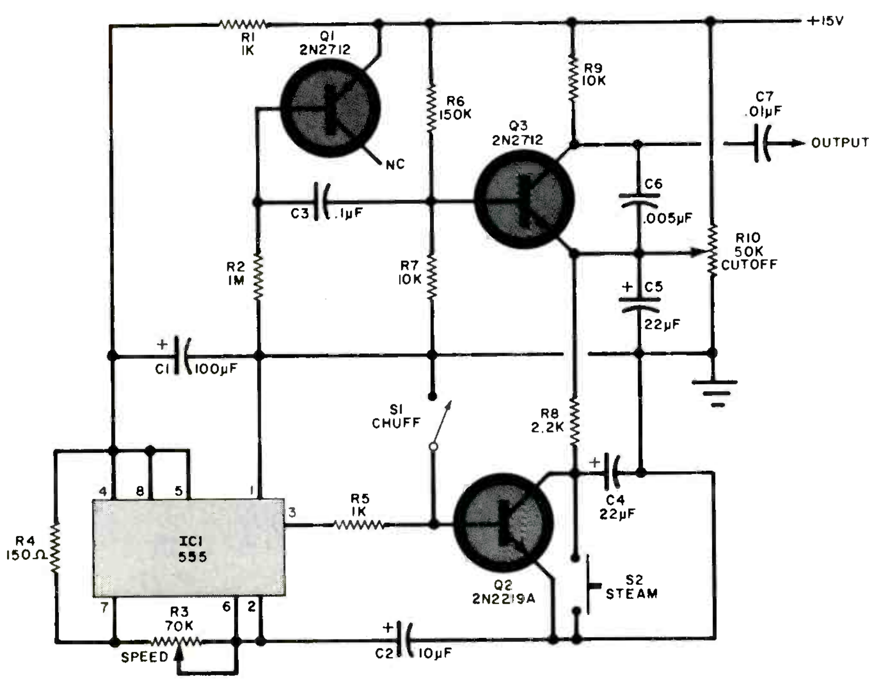


Fig. 2. Steam sound comes from white-noise generator Q1.

PARTS LIST
CHUFF-CHUFF

C1—100-µF, 25-V electrolytic capacitor
C2—10-µF, 25-V electrolytic capacitor
C3—0.1-µF capacitor
C4,C5—22-µF, 25-V electrolytic capacitor
C6—0.005-µF capacitor
C7—0.01-µF capacitor
IC1—555 timer
Q1,Q3—2N2712 transistor
Q2—2N2219 transistor
The following resistors are ½-W carbon composition unless otherwise noted:
R1,R5—1000 ohms
R2—1 megohm
R3—70,000-ohm panel-mount potentiometer
R4—150 ohms
R6—150,000 ohms
R7,R9—10,000 ohms
R8—2200 ohms
R10—50,000-ohm board-mount potentiometer
S1—Spst switch
S2—Spst NO pushbutton switch

determined by *C2* and the setting of *R3*. Thus, *R3* is the chuff-chuff speed control and, with the values shown, can be set to provide sounds from those of a slow starting engine to very fast bursts of steam. Make sure that *R4* is not less than 150 ohms or the speed setting will be unstable.

The pulses from *IC1* are applied to *Q2*, which functions as an electronic switch. When *Q2* conducts, *R8* is shunted across the lower portion of *R10*, thus bringing *Q3* above cutoff. Transistor *Q3* then amplifies for one chuff. Capacitor *C6* rolls off some of the high frequencies to produce a softer steam sound. Capacitors *C4* and *C5* shape the starting and stopping of the individual chuffs. The +15-volt supply is decoupled by *R1/C1* to keep any pulses from getting into the remainder of the circuit.

Whistle. In this circuit, shown in Fig. 3, transistor *Q1* is a fixed tuned twin-T oscillator. The circuit for *Q2* is almost identical except for tuning control *R11*. The second oscillator can be tuned from a zero-beat with the first oscillator to a frequency that simulates the two-tone effect similar to that heard from a diesel engine. Points between can be selected for a variety of sounds, including a steam whistle.

Because the outputs of the two oscillators are fed to potentiometer *R12*, a further range of possible tones exists. The power supply to the oscillators is decoupled by *R13* and *C12*.

Transistor *Q3* is connected as an avalanche-mode white-noise source, whose output (across *R14*) is amplified by *Q4*. The output of *Q4* is fed to potentiometer *R19* along with the output of the two tone oscillators. The final mix of tone and steam is fed to amplifier *Q5*.

When whistle pushbutton *S1* is open, resistors *R22* and *R25* keep the emitter of *Q5* at a higher potential than the base, so that the transistor is cut off. When *S1* is closed, *R24* is grounded, shunting it across *R25*. This causes *C19* to reach a lower charge level since it is now being discharged by *R24*. Thus the start of each whistle is made less abrupt to simulate a real steam whistle. When *S1* is released, the recharging of *C18* removes the terminal thump.

Bell. In the circuit in Fig. 4, transistor *Q1* operates as a twin-T oscillator with potentiometer *R7* set so that the circuit is just below the point of oscillation. If this control is set too low, the bell sound will be dull and have too short a decay time. Transistor *Q2* is an emitter follower isolator between the bell oscillator and the mixer stage. Timer *IC1* generates pulses to produce repetitive ringing with the rate (about one per second) determined by *R15* and *C9*. The value of *R15* can be reduced to increase the ringing rate of the bell.

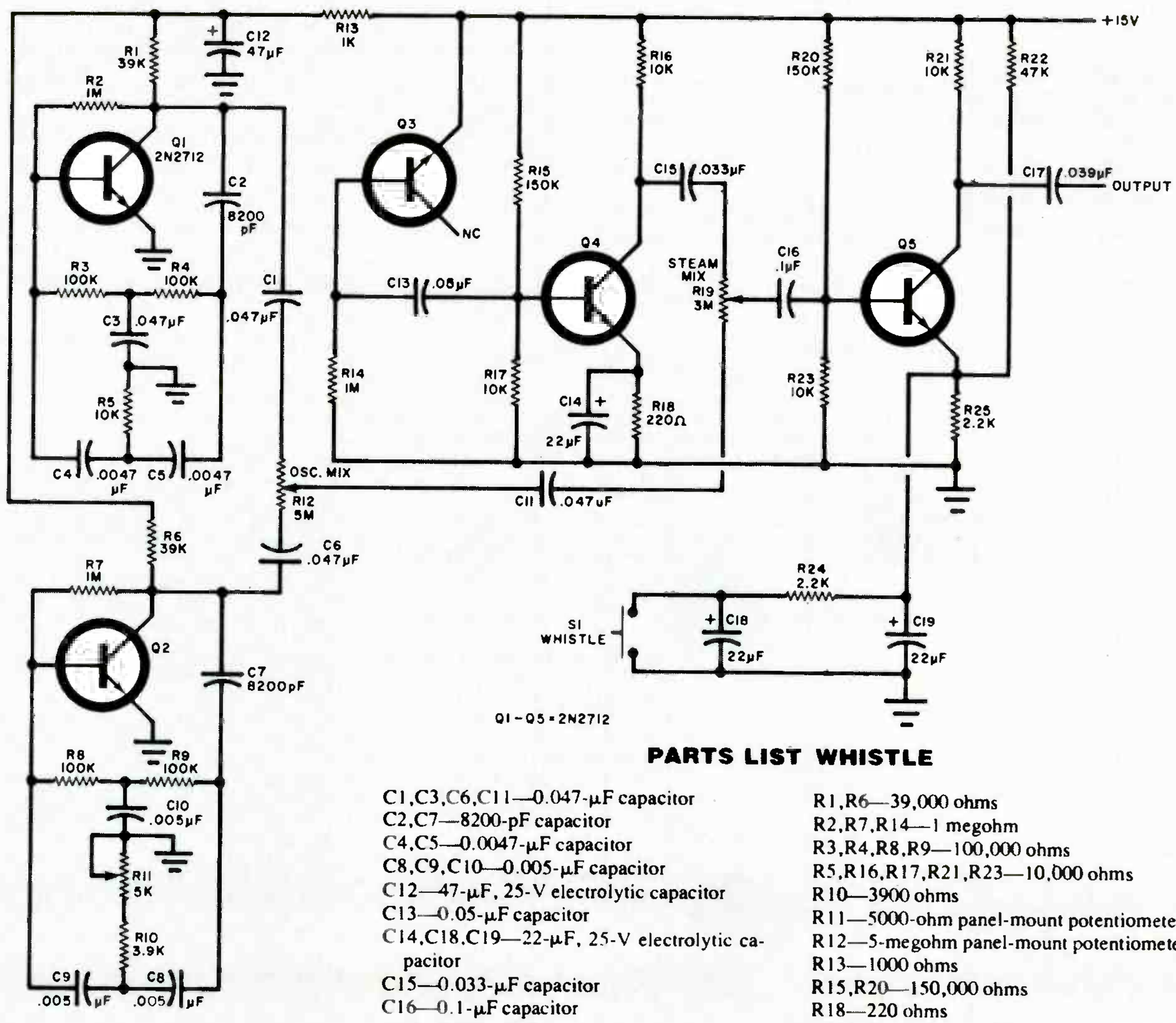
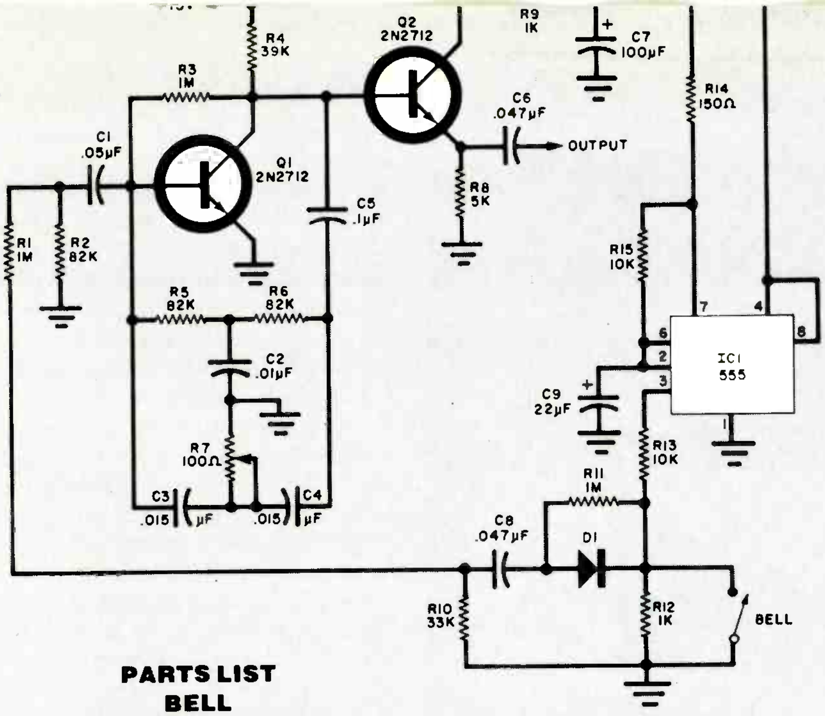


Fig. 3. Oscillator Q1 and Q2 take white noise from Q3 to create steam plus whistle.

PARTS LIST WHISTLE

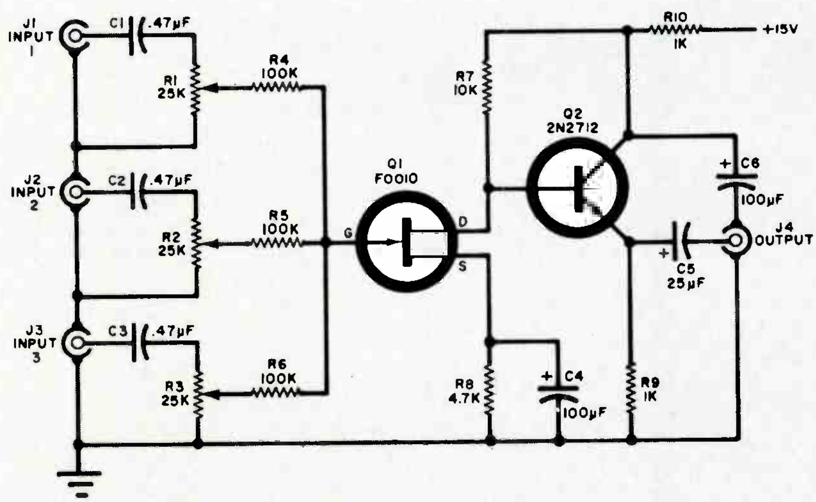
C1,C3,C6,C11—0.047-μF capacitor
C2,C7—8200-pF capacitor
C4,C5—0.0047-μF capacitor
C8,C9,C10—0.005-μF capacitor
C12—47-μF, 25-V electrolytic capacitor
C13—0.05-μF capacitor
C14,C18,C19—22-μF, 25-V electrolytic capacitor
C15—0.033-μF capacitor
C16—0.1-μF capacitor
C17—0.039-μF capacitor
Q1 through Q5—2N2712 transistor
The following resistors are ½-W carbon composition unless otherwise noted:
R1,R6—39,000 ohms
R2,R7,R14—1 megohm
R3,R4,R8,R9—100,000 ohms
R5,R16,R17,R21,R23—10,000 ohms
R10—3900 ohms
R11—5000-ohm panel-mount potentiometer
R12—5-megohm panel-mount potentiometer
R13—1000 ohms
R15,R20—150,000 ohms
R18—220 ohms
R19—3-megohm board-mount potentiometer
R22—47,000 ohms
R24,R25—2200 ohms
S1—Spst NO pushbutton switch



PARTS LIST
BELL

C1—0.05-µF capacitor
C2—0.01-µF capacitor
C3,C4—0.015-µF capacitor
C5—0.1-µF capacitor
C6,C8—0.047-µF capacitor
C7—100-µF, 25-V electrolytic capacitor
C9—22-µF, 25-V electrolytic capacitor
D1—Silicon diode rectifier
IC1—555 timer
Q1,Q2—2N2712 transistor
The following resistors are ½-W carbon composition unless otherwise noted:
R1,R3,R11—1 megohm
R2,R5,R6—82,000 ohms
R4—39,000 ohms
R7—100-ohm panel-mount potentiometer
R8—5000 ohms
R9,R12—1000 ohms
R10—33,000 ohms
R13,R15—10,000 ohms
R14—150 ohms
S1—Spst switch

Fig. 4. Bell circuit uses twin-T oscillator Q1 and switch.



PARTS LIST
MIXER

C1,C2,C3—0.47-µF capacitor
C4,C6—100-µF, 25-V electrolytic capacitor
C5—25-µF, 25-V electrolytic capacitor
J1 through J4—Phono connectors
Q1—HEPF0010 FET
Q2—2N2712 transistor
The following resistors are ½-W carbon composition unless otherwise noted:
R1,R2,R3—25,000-ohm board-mount potentiometer
R4,R5,R6—100,000 ohms
R7—10,000 ohms
R8—4700 ohms
R9,R10—1000 ohms
Misc.—Board, wire, solder, etc. for all four circuits.

Fig. 5. Sound effects are combined in Q1 and drive amplifier through Q2.

The output of *IC1* (pin 3) is applied to the voltage divider made up of *R13* and *R12* to reduce the signal level. The pulses are then rectified by *D1* and differentiated by *C8* and *R10* to produce sharp spikes that trigger the twin-T oscillator, *Q1*.

Mixer. The outputs of the three sound-effect circuits are combined in the circuit shown in Fig. 5. Each input is coupled to its own level potentiometer (*R1*, *R2*, or *R3*) and they are combined at the gate of FET *Q1*. The output of *Q1* is coupled to the external audio amplifier through emitter follower *Q2* and capacitor *C6*.

Construction. The easiest approach to construction of the synthesizer is to build each circuit on its own small board. You can use perforated board and point-to-point wiring or make a small pc board. The arrangement is not critical. Each board can be built and tested using a 15-volt supply and an earphone (or a small amplifier/speaker combination). Be sure that transients generated by the timer IC's are not coupled into any of the circuits. If necessary, more +15-volt line decoupling is recommended. Sockets can be used for the transistors and IC's.

In the prototype, short lengths of shielded audio cable were used to couple the output of the three sound-effect circuits to the mixer inputs. Another length of shielded audio cable connected the mixer output to the audio system being used.

The boards can be installed in any type of chassis, with all controls on the front panel, clearly identified.

Use. Connect the mixer output to a good-quality audio amplifier and speaker combination. In the bell circuit, set the threshold potentiometer (*R7*) for the best sound when bell switch *S1* is operated. There should be no clicks or pops. Do not try to control circuits by turning the power on and off.

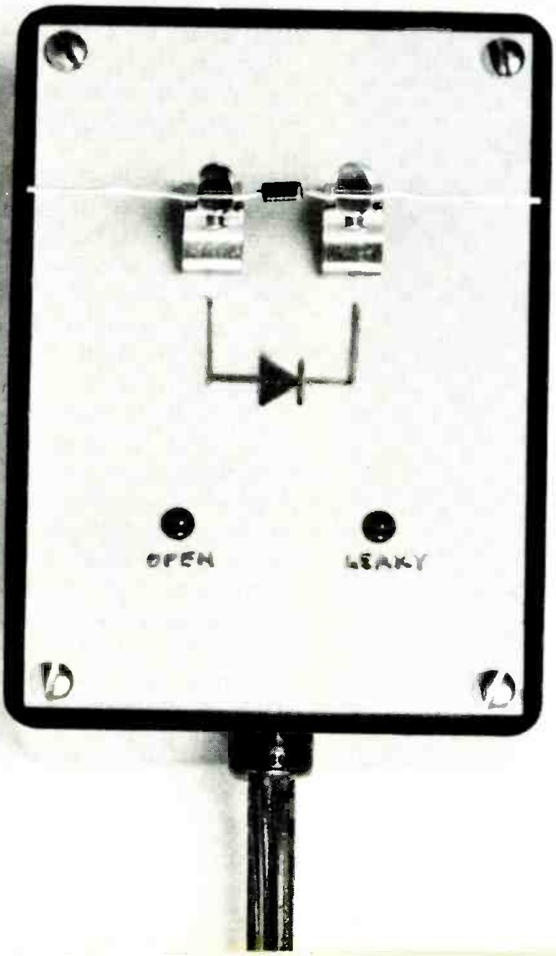
The chuff-chuff has three front-panel controls with *R3* being the rate control, *S2* providing steam bursts, and *S1* for on-off. It is best to group these three controls together so that they can be operated with the fingers of one hand. The whistle circuit has one switch (*S1*); the three internal potentiometers in this circuit should be preset.

If your train system is already equipped with electronic speed controls, you might consider ganging the chuff-rate potentiometer with the train speed control potentiometer for smoother operation of the complete system. ◇

Automatic Diode Checker

Makes a complete check in 1/60th of a second.

BY R. M. STITT



MOST EXPERIMENTERS think that using an ohmmeter is the best way to test a semiconductor diode. However, some ohmmeters supply too much current to the device, causing an "open" where one does not really exist. Other meters indicate values of forward and reverse resistance, which hopefully give an indication of the diode's condition.

In the Automatic Diode Checker described here, the diode is tested in the forward-bias condition for excessive voltage drop and then in the reverse condition for excessive leakage current. Each test is made during one half of the power-line frequency, and the results are displayed simultaneously on two LED's labeled OPEN and LEAKY. The LED marked OPEN is illuminated when there is excessive voltage drop. The other is lit when there is excessive reverse leakage. If the diode fails both tests, both LED's are on. With no diode in the clips, the OPEN indicator is on.

When a good diode is inserted in the test clips (correctly oriented), both LED's should be off. There will be no damage to either the diode being tested or the diode tester if the diode is inserted the wrong way; but both LED's will glow.

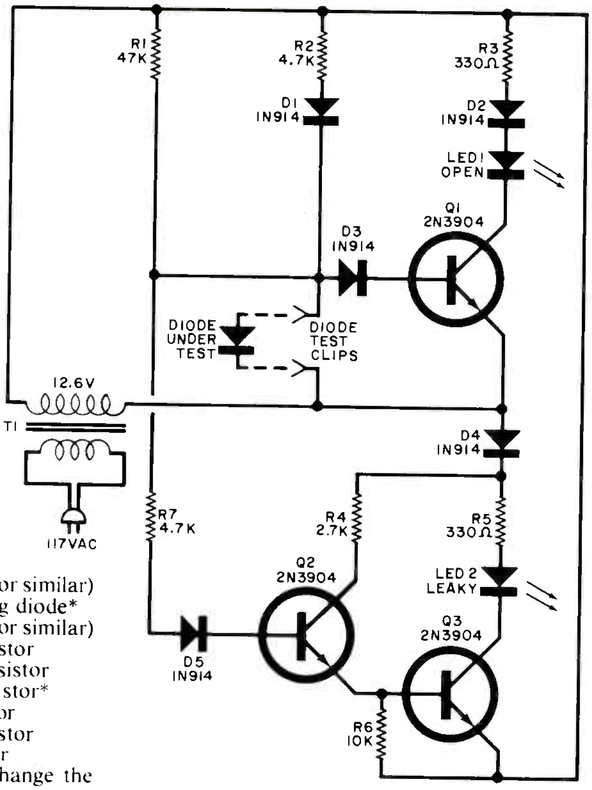
The peak reverse voltage is less than 18 volts and the peak forward current is less than 4 mA. With the values shown in Fig. 1, OPEN indicates a forward voltage drop in excess of 1.3 volts at 3 mA; and LEAKY indicates a reverse leakage current of about 0.05 mA at 16 volts.

How It Works. On one half cycle of the ac supply, the OPEN circuit is active (*D1, D2, D3, R2, R3, Q1* and *LED1*). In this half cycle the upper ac line is positive. (*D4* and *D5* are reverse-biased to isolate the other part of the circuit.) Current, limited by *R2*, flows through *D1* and the diode being tested. The voltage across the test diode is applied through *D3* to the base of *Q1*. If this voltage exceeds 1.3 V, *Q1* turns on and sinks current through *LED1*, indicating high forward drop.

When the ac supply reverses, the lower part of Fig. 1 is active, with *D1* and *D2* reverse-biased to shut out the OPEN part of the circuit. Any reverse leakage current through the test diode flows through *R1*, creating a potential across it. This voltage is applied to the base of *Q2* through *R7* and *D5*. When this voltage exceeds about 2 volts, *Q2* is energized, turning on *Q3* and *LED2*.

Since the circuit uses a conven-

Fig. 1. The "open" circuit operates when upper ac line is positive. "Leaky" circuit operates when this line is negative. Both circuits test diode at line frequency.



PARTS LIST

D1 to D5—Silicon diode (1N914 or similar)
LED1,LED2—Red light emitting diode*
Q1,Q2,Q3—Transistor (2N3904 or similar)
R1—47,000-ohm, ¼-W, 5% resistor
R2,R7—4700-ohm, ¼-W, 5% resistor
R3,R5—330-ohm, ¼-W, 5% resistor*
R4—2700-ohm, ¼-W, 5% resistor
R6—10,000-ohm, ¼-W, 5% resistor
T1—12.6-V, 100-mA transformer
*R3 and R5 can be varied to change the brightness of the LED's.
Misc.—Diode test clips, plastic case (Harry Davis #220 or similar), line cord, grommet, mounting hardware, etc.

tional 12-volt transformer, no dc supply is required and all switching is performed automatically at 60 Hz.

Construction. Although circuit layout is not critical and any type of construction can be used, a unique approach was used in the author's prototype as shown in the photographs. The pc board foil pattern shown in Fig. 2 can be used to make a board which has the components mounted on one side with the other side serving as the cover for the plastic case. The component holes are drilled only half-way into the board. The only holes drilled all the way through the board are those for mounting the LED's and the diode test clips. The other components are mounted by bending and cutting their leads so that they just fit on their pads. Solder must be applied quickly and properly to insure a good mechanical hold.

Transformer *T1* can be attached to the bottom of the plastic case, with plastic foam insulation between the transformer and the components on the board. Use a grommet on the hole for the line cord in the side of the case.

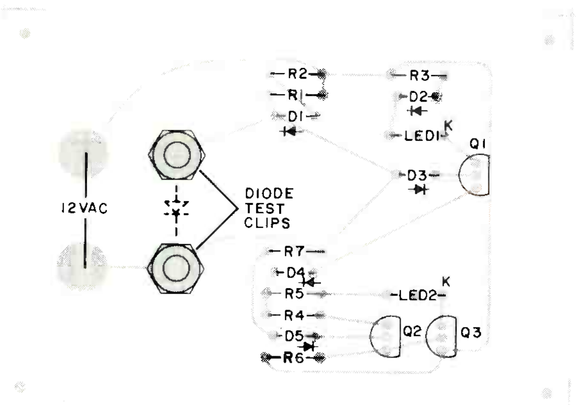


Fig. 2. Pc board can be used as case cover with component mounting as shown at left.

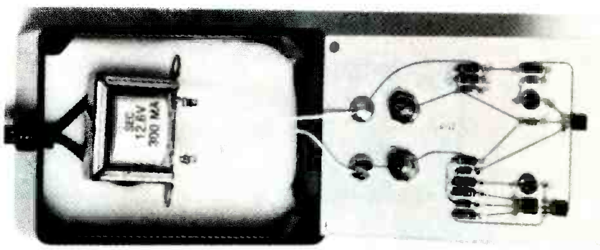
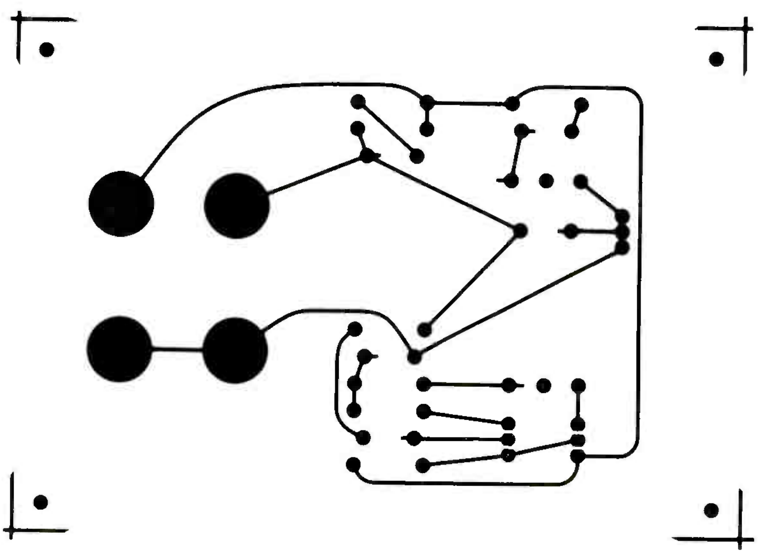
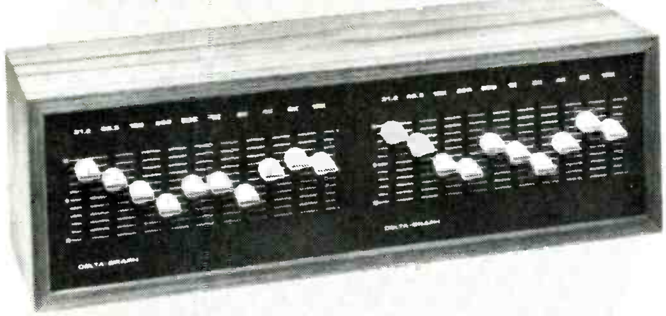


Photo shows how components are mounted on pc board with the transformer in the bottom of the case with foam insulation.



Identify the LED's on the front of the pc board, and draw a diode symbol between the two test clips with the anode side going to the junction of *D1* and *R1*.

Checkout. Check the pc board for correct installation of components, and then apply power to the tester. The OPEN indicator should come on. Connect a diode that you know is good between the test clips. Note that both LED's are off. Remove the diode and connect a 100,000-ohm resistor between the test clips. Note that both LED's are on. Remove the resistor and connect two or three good diodes in series across the test clips. Only the OPEN LED should turn on. ◈



BUILD THE "DELTA-GRAPH" OCTAVE-BAND EQUALIZER

$175 stereo kit features modular design, artificial inductors, and 10-octave control.

BY BRYAN T. MORRISON

THE Delta-Graph ten-octave-band equalizer described here can solve a number of sound problems for home and professional audio systems. In the home, it can be used to compensate for poor listening-room acoustics and the differences in the responses of phono cartridges, amplifiers, and speaker systems. For serious tape recordists or for professional applications, it can be used to emphasize or de-emphasize one or more instruments during a mix-down session and to modify the input signals to create special sound effects.

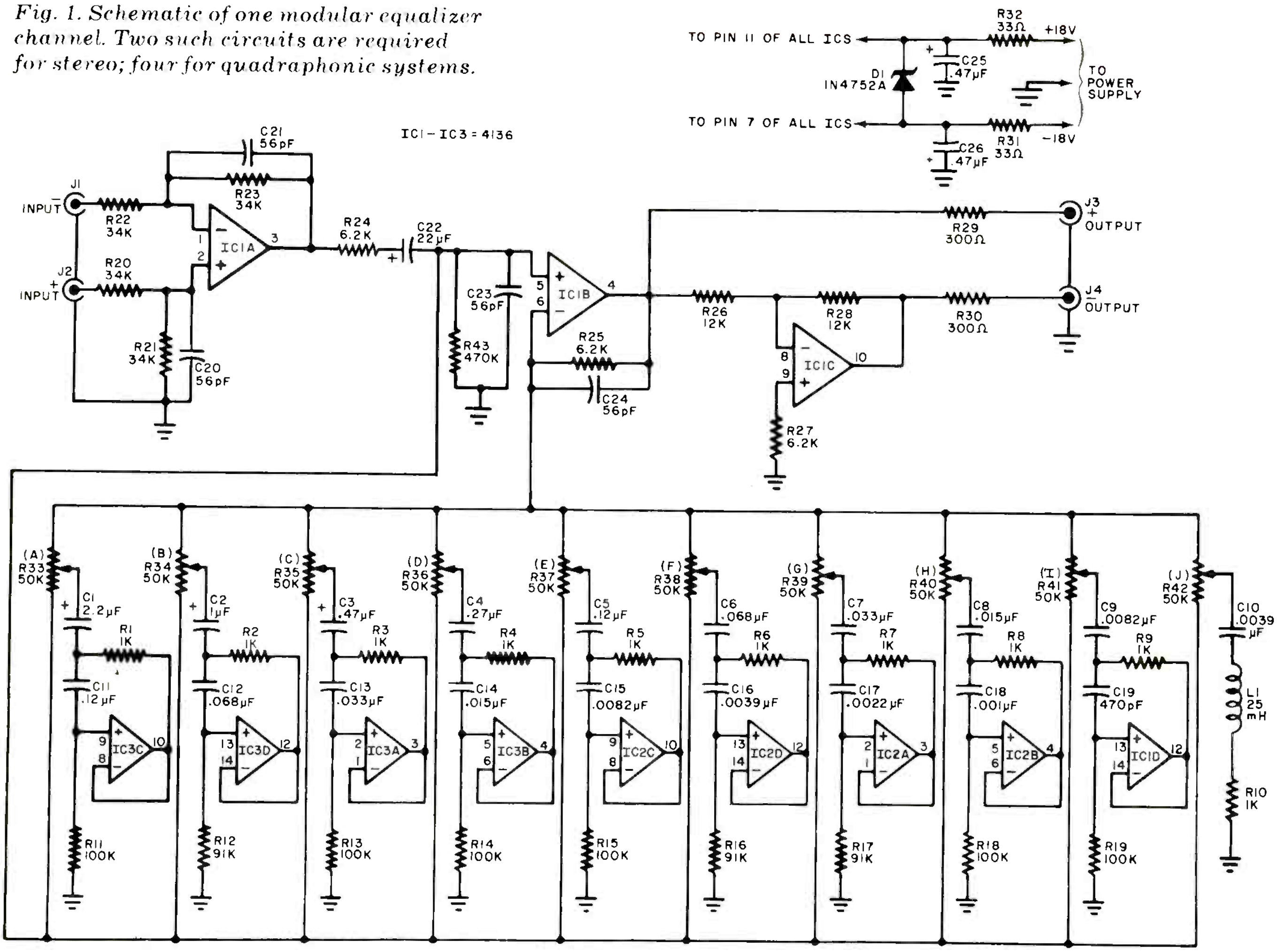
Among the equalizer's features are low cost, modular design, the use of op amp gain stages and artificial inductors, flexible interfacing with a variety of audio devices, and very-low noise figures. (See Specifications box.) Universal input/output circuitry with high-level drive capability provides balanced low-impedance inputs as well as standard single-ended outputs for maximum flexibility. The equalizer's ten slide potentiometers, one for each musical octave, are arranged in a horizontal line to provide a graphic display of the adjustments made to the sound system. The controls provide a boost/cut range of 15 dB in each direction for a total of 30 dB of control in each octave. The equalizer can be built for a monophonic, a stereophonic, or a four-channel system with costs starting at $80 (less power supply) for a one-channel kit.

About the Circuit. Many active equalizers offer a limited number of control "bands" (usually five), which means that each control must cover two or more octaves. Although this is better than no control at all, this approach does not permit separate adjustments of all octaves in the audio range. A better approach is to divide the audio band into ten octaves, as is done in the Delta-Graph. Now, each octave can be individually adjusted with high precision.

The control circuits usually found in active equalizers employ expensive and bulky physical inductors to achieve discrete-band control. The Delta-Graph, however, uses special "gyrator" circuits that electronically simulate inductors to keep down cost and size and to obtain precise, predictable band control. By using gyrators in all but the highest-octave band, the equalizer is highly immune to electromagnetic fields, has accurately predictable saturation levels, and can simulate a wide range of inductances without changes in size or appreciable price variations.

The schematic diagram of the basic monophonic equalizer module is shown in Fig. 1. Note that the first nine bands use the gyrator circuits, while the tenth uses a miniature inductor. (Hum pickup and saturation are not important factors in the highest frequency band.)

Fig. 1. Schematic of one modular equalizer channel. Two such circuits are required for stereo; four for quadraphonic systems.



EQUALIZER MODULE PARTS LIST (per channel)

The following are 50-volt, 20% tantalum capacitors:
C1—2.2 µF
C1—1 µf
C3,C25,C26—0.47 µF
The following are 50-volt, 10% Mylar capacitors:
C4—0.27 µF
C5,C11—0.12 µF
C6,C12—0.068 µF
C7,C13—0.033 µF
C8,C14—0.015 µF
C9,C15—0.0082 µF
C10,C16—0.0039 µF
C17—0.0022 µF
C18—0.001 µF
The following are 50-volt, 20% disc capacitors:
C19—470 pF
C20,C21,C23,C24—56 pF
C22—22-µF, 16-volt upright aluminum electrolytic capacitor
D1—33-volt, 1-watt zener diode (1N4752A or equivalent)
IC1,IC2,IC3—4136PC quad operational amplifier IC
J1 through J4—Phono jack (optional)
L1—25-mH toroidal inductor
The following are ¼- or ½-watt, 10% resistors
R1 through R10—1000 ohms
R11,R13,R14,R15,R18,R19—100,000 ohms
R12,R16,R17—91,000 ohms
R20 through R23—34,000 ohms
R24,R25,R27—6200 ohms
R26,R28—12,000 ohms
R29,R30—300 ohms
R31,R32—33 ohms
R43—470,000 ohms
R33 through R42—50,000-ohm W-taper slide-type potentiometer with silicone damping and center detent ($3.00 each)
Misc.—Suitable enclosure; printed circuit board; eight-contact barrier block (Kulka Electric No. 670A-3100-8 or similar, $1.50); knobs for slide pots; 1/16" thick aluminum stock for rear panel, pot brace, and power supply bracket; plastic standoffs (4); shielded audio cable; hookup wire; machine hardware; solder; etc.

Note: The following items are available from Delta-Graph Electronics Co., Box 741, Pasco, WA 99301: Complete mono kit of equalizer module parts, including pc board, tested IC's, finished case, rear panel, but less power supply, No. EQ10M, for $80.00; Stereo version of No. EQ10M, No. EQ10SP, including power supply, for $175.00; Power supply kit for up to four equalizer modules, No. PS-4, for $25.00; Walnut veneer cabinet that accommodates two equalizer modules and power supply, No. EQ10WC, for $30.00; 25-mH toriodal inductor, No. EQL1, for $3.00. Washington residents, please add 5.4% sales tax. Postage and handling costs are $3.00 within the U.S., $12.00 outside the U.S.

Additional active stages in the circuit provide the balanced inputs and outputs that are so often used in professional recording and PA applications. Resistors *R20* through *R23* make up a precision-balanced input stage for true differential, high common-mode rejection in balanced-line systems. When an unbalanced input is desired, as in home audio systems, the module's inverting (−) input can be grounded and the signal applied to the noninverting (+) input.

Capacitors *C21, C24, C25,* and *C26* stabilize operation of the op amps. Capacitors *C20, C22,* and *C23* provide a gentle frequency-response rolloff in the range beyond the top end of the audio spectrum to limit noise and r-f interference. Resistor

R43 ground references the IC1B equalizing op amp at its + input.

The output of the equalizer is fixed at 600 ohms balanced or 300 ohms single-ended by R29 and R30, which also provide short-circuit protection. Even though the 4136 op amps have built-in overload protection, this is an added safety factor. (The op amps were also chosen for their high slew rates and superior noise ratings.) The output stage will effortlessly supply enough voltage and current to drive a dozen typical power amplifiers into clipping, even if the amplifiers are connected in parallel with each other. Furthermore, it will drive the amplifiers without an increase in THD or IM and without any loss in the bass register.

Resistors R26, R27, and R28 and IC1C form an output that is shifted 180° from the + input. In single-ended applications, an output can be taken from one point while the other point is left open. Both outputs can be used in applications requiring "bridge" driven amplifiers.

Zener diode D1 protects the op amps from overvoltages and power supply transients and permits operation from high-voltage supplies, with the addition of external current-limiting resistors. Internal current-limiting resistors R31 and R32 are optimized for operation with the power supply shown in Fig. 2, while providing extra power supply noise and ripple isolation.

The Fig. 2 power supply is designed to deliver ±18 volts at up to 200 mA. Since the nominal current demand of each equalizer module is 50 mA, the supply will accommodate up to four modules for quadraphonic system equalization.

Construction. The equalizer modules and power supply are best assembled on printed circuit boards, the actual-size etching and drilling guides and components-placement diagrams for which are shown in Fig. 3. Use a low-wattage soldering iron and fine solder.

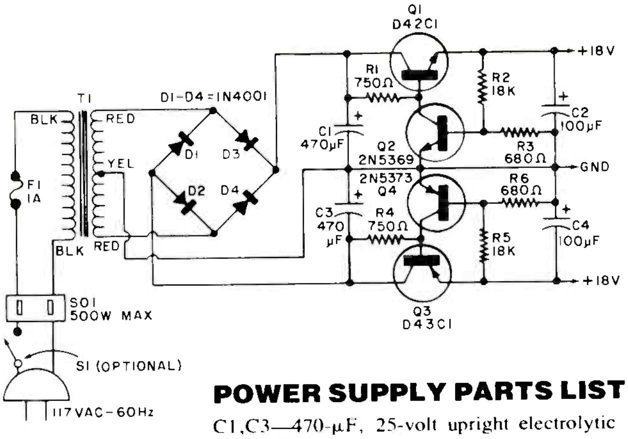
Start by assembling the equalizer module. First install the resistors and capacitors, followed by the diode and toroidal coil (clip off unused leads), then the IC's, and, finally, the slide potentiometers. Be sure to orient all components properly.

The pots should be mechanically tied together to prevent them from shifting, as the sliders are operated, with an 8¾" (22.2-cm) length of ⅜" × 1/16" (9.53 × 1.6-mm) aluminum. Drill ⅛" (3.16-mm) holes ¾" (19 mm) apart, starting ⅜ (9.5 mm) from one end of the strip.

Strip both ends of a 1½" (3.8-cm) length of hookup wire; solder to one end a No. 6 solder lug; and solder the other end to the "ground pot support" pad on the pc board. Place the aluminum strip over the top sections of the slide pots and align the holes in the strip with the threaded holes in the pots. Place a No. 4 washer over a 4-40 × ¼" machine screw, and drive this screw down in the hole of the second pot. Secure the strip to the other nine pots with 4-40 × ¼" screws.

Cut a piece of 1/16" aluminum plate to 8" ×4¾" (20.3 × 12.1 cm) and drill 3/16" (4.8-mm) holes along one of the short ends, locating and spacing them to exactly line up with the input/output and power pads on the pc board. Mount the barrier block so that its solder terminals pass through the holes and do not touch the metal plate. Then drill the holes for the spacers that will be used between the board and rear plate. Use ½" (12.4-mm) spacers and self-tapping 6-32 × ¼" machine screws to fasten the spacers in place. Solder the lugs of the barrier block to the pads on the pc board.

Assemble the power supply board, carefully following the guide for it shown in Fig. 3. Be sure you properly orient the electrolytic capacitors, rectifier diodes, and transistors. Fasten



POWER SUPPLY PARTS LIST

C1,C3—470-µF, 25-volt upright electrolytic capacitor
C2,C4—100-µF, 25-volt upright electrolytic capacitor
D1 through D4—1N4001 rectifier diode
F1—1-ampere fuse
Q1—D42C1 npn silicon transistor (General Electric)
Q2—2N5369 npn silicon transistor
Q3—D43C1 pnp silicon transistor (General Electric)
Q4—2N5373 pnp silicon transistor
R1,R4—750-ohm, ½-watt resistor
R2,R5—18,000-ohm, ½-watt resistor
R3,R6—680-ohm, ½-watt resistor
S1—Spst switch (optional)
SO1—Chassis-mounting ac receptacle
T1—28-volt center-tapped, 200-mA transformer
Misc.—Mounting panel; barrier block (Kulka Electric No. 600Y-3); machine hardware; hookup wire; solder; etc.

Fig. 2. Power supply accommodates up to four equalizer modules.

CLAIMED SPECIFICATIONS

Frequency response: 20 to 20,000 Hz ±0.5 dB.

Dynamic range: Output noise greater than 105 dB below maximum output from 20 to 20,000 Hz.

S/N ratio: Better than 90 dB referenced to 2-volt rms rated output from 20 to 20,000 Hz.

Band centers: 31.25, 62.5, 125, 250, 500, 1000, 2000, 4000, 8000, 16,000, Hz nominal.

Adjustment range: ±15 dB maximum (30-dB total range).

THD: Less than 0.1% at rated output from 20 to 20,000 Hz.

IM distortion: Less than 0.01% at rated output 60/7000 Hz mixed 4:1; typically less than 0.003%.

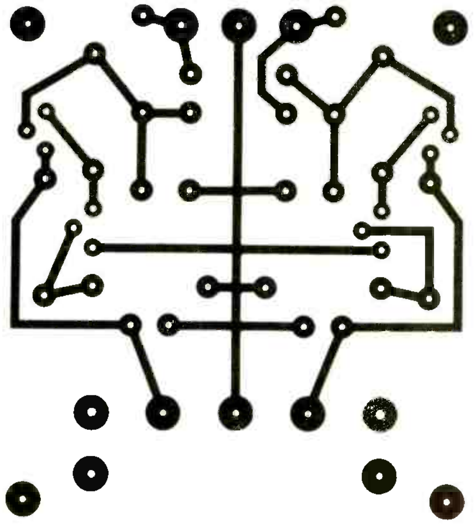
Rated output: 2.0 volts rms into 10,000 ohms.

Clipping output: 10.0 volts rms into 10,000 ohms single ended, 20.0 volts rms into 10,000 ohms balanced.

Input impedance: 68,000 ohms single ended; externally set with terminating resistor for balanced inputs between 600 and 100,000 ohms.

Output impedance: 300 ohms single ended, 600 ohms balanced.

Note: *All controls at 0 dB.*



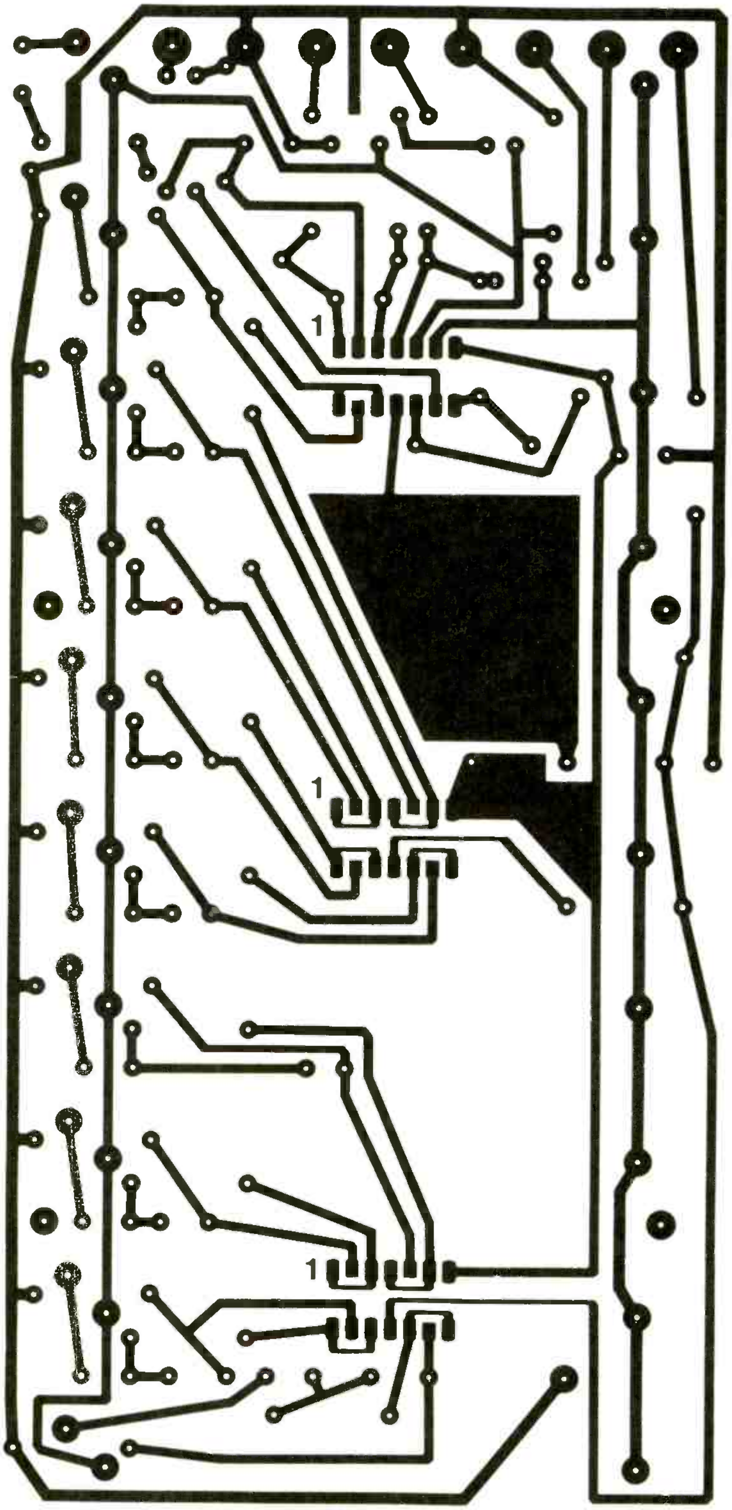
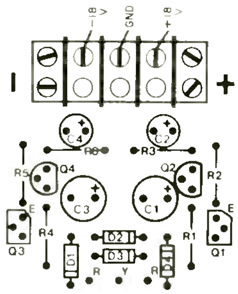
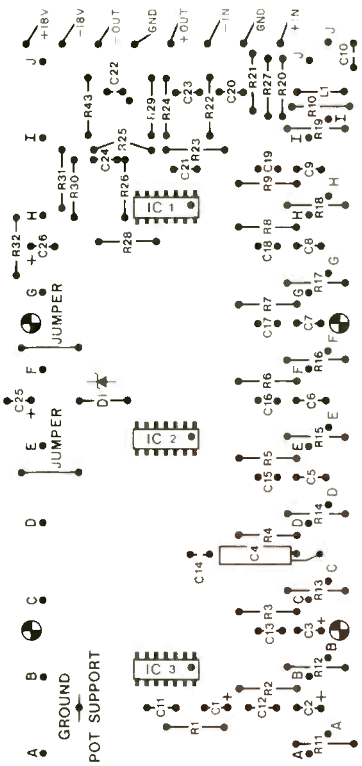


Fig. 3. Actual-size etching and drilling guides (above and right) and component placement diagrams (below) for equalizer module and power supply.





down the small barrier block with No. 6 machine hardware. Note that the transformer, fuse and holder, and accessory ac receptacle mount off the board. Again, you will need a 1/16" thick aluminum backplate. Cut the plate to 6½" × 2¾" (16.5 × 7 cm) and bend the plate along the short dimension 1¼" (3.2 cm) in from the edge at a right angle. Machine the short upright section of the bracket for the line cord strain relief, accessory ac receptacle, and fuse holder. Then drill the mounting holes for the transformer and power supply board. Mount the receptacle, fuse holder, and transformer in their respective locations. Referring to Fig. 2, wire the primary circuit of *T1* as shown, connecting the ends of the line cord directly across the receptacle if you are not using a power switch. If you plan to use *S1*, modify the circuit as shown and plan to mount the switch on the front panel of the case in which you house the equalizer. Snap a plastic strain relief over the line cord and secure it in its hole in the bracket.

Set the power supply board near the secondary side of the transformer and connect and solder the latter's leads to the appropriate pads on the board. Then use ¼" spacers to mount the board to the bracket.

With the equalizer module(s) and power supply subsection fully wired, you can set them side by side and temporarily interconnect them, following the diagram shown in Fig. 4 to check out their operation. (Note that the diagram illustrates the wiring scheme for a home stereo system. If you plan to build only a monophonic version, simply disregard everything to the left of the Channel A barrier block. Alternatively, if you are planning to build a quadraphonic equalizer, Channels C and D are added exactly in the same manner as Channel B is shown connected to Channel A.)

During tests (and in actual operation), the equalizer can be installed between the preamplifier and power amplifier in your sound system. Use shielded audio cable when making the signal-line hookups between the equalizer and your sound system. It can also be connected into the system via the tape monitor circuits, which will allow the equalizer to be switched in and out of the system with the TAPE MONITOR switch of your receiver or preamplifier.

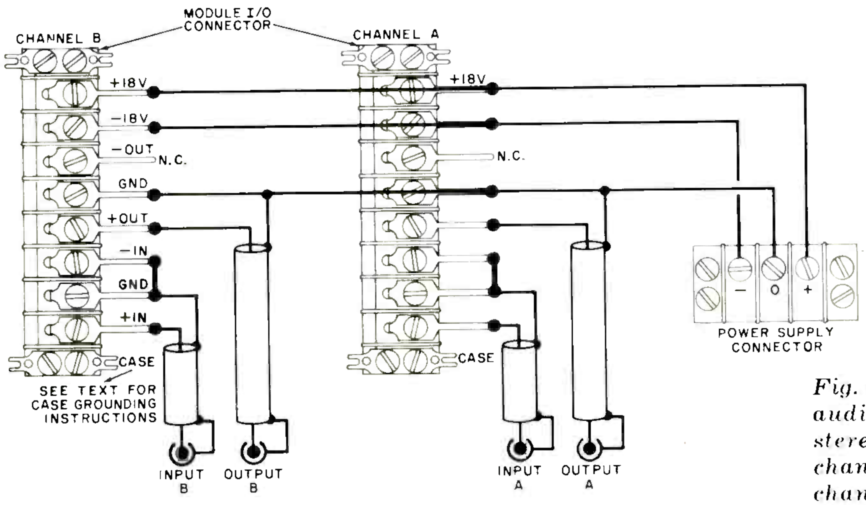
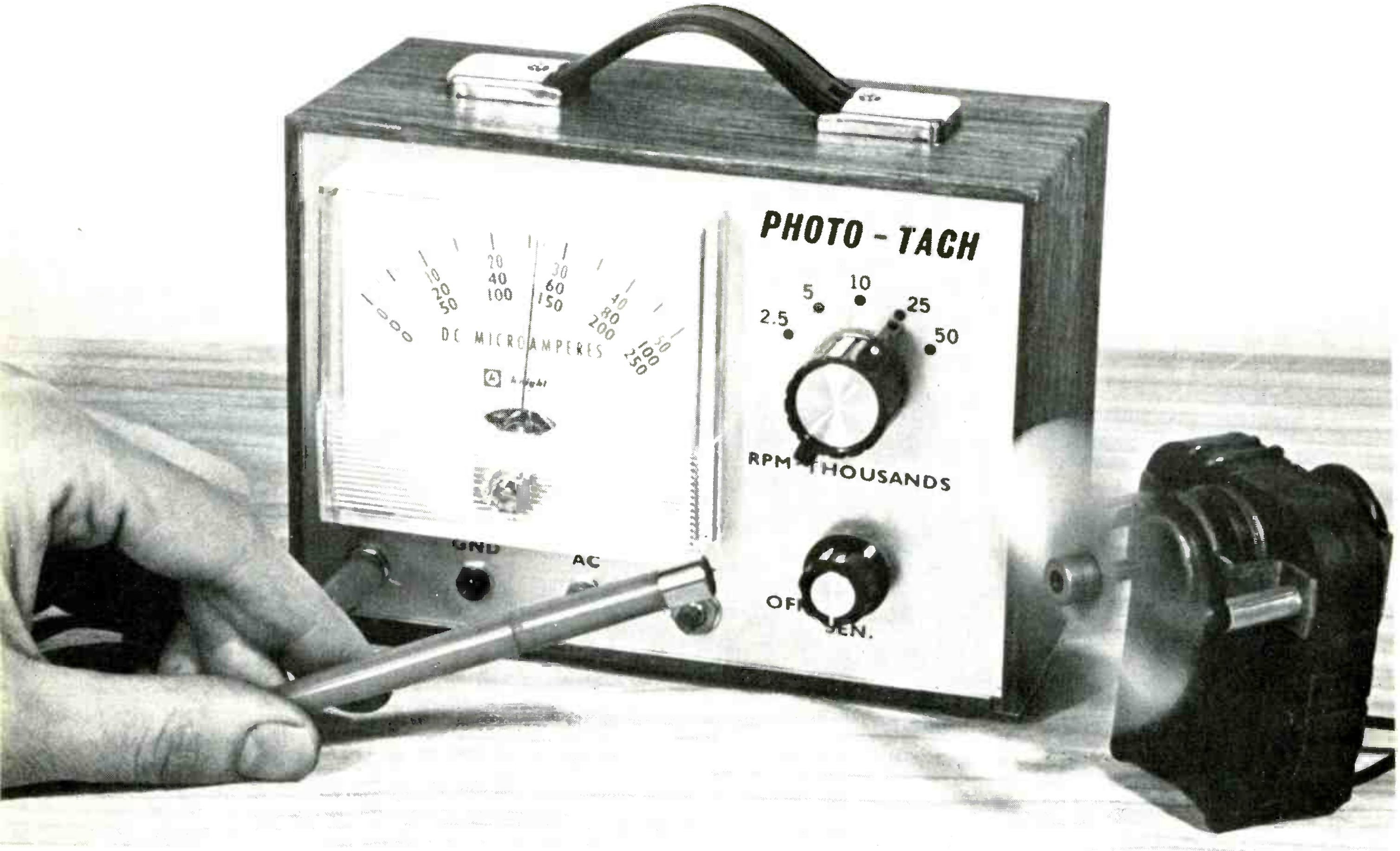


Fig. 4. Wiring scheme for home audio system is shown here with stereo setup. For mono, eliminate channel B; for 4-channel add channels C and D in same manner as shown for channel B to channel A.

Final Assembly. Once you are satisfied that your equalizer is operating properly, disconnect it from your sound system. Then mount the module(s) and power supply in a suitable enclosure. (Do not forget to mount the power switch, if you chose to use one, in a convenient location on the front panel of the enclosure.)

As the circuit is designed, the equalizer's audio and chassis (case) grounds are separate and brought out to terminals on the rear panel via the barrier block. If you use a nonconducting enclosure (such as a wood cabinet, plastic box, etc.), simply tie each module's case ground to its input ground. When you mount the modules in a metal enclosure and the module cases are physically grounded to the enclosure, it is wise to leave the case ground terminals floating so that the audio ground path is connected to the enclosure at only one point in the entire system. This will prevent ground loops.

In Conclusion. As you use the equalizer in your sound system, you will discover that there is a certain amount of interaction among the controls. This is a normal condition. You will also find that, to obtain the best possible equalized sound from your system, you will have to do considerable experimenting with the settings of the various slide controls. However, once you get your system properly equalized, you need never again touch the controls—unless you change speakers, amplifier, or cartridge, or you move your system to a different area. ◊



Measure RPM of Rotating Elements with

THE IC PHOTO TACHOMETER

Battery-operated device gives accurate readings up to 50,000 rpm without physical contact.

BY ADOLPH A. MANGIERI

IF you service the numerous motor-driven appliances and tools found in the home, shop, or factory, consider building this photo tachometer. By recording normal rotational speeds for comparison with later measurements, you can easily detect the effect of worn gear trains or motor brushes and gauge improvement of performance after repairs. With no mechanical coupling required, the Photo-Tach measures the rpm of any type of rotating element, including miniature high-speed, low-power motors. You can also use the Photo-Tach as an analog frequency meter, useful for checking inverters and auxiliary ac generators.

Operated in either the incident or reflected light mode, the Photo-Tach includes five ranges up to 50,000 rpm. A plug-in light probe, using a high-speed photo-transistor, facilitates speed measurements. Using low-cost, high-performance IC's, the battery-operated tachometer features high accuracy and stability. See schematics in Fig. 1.

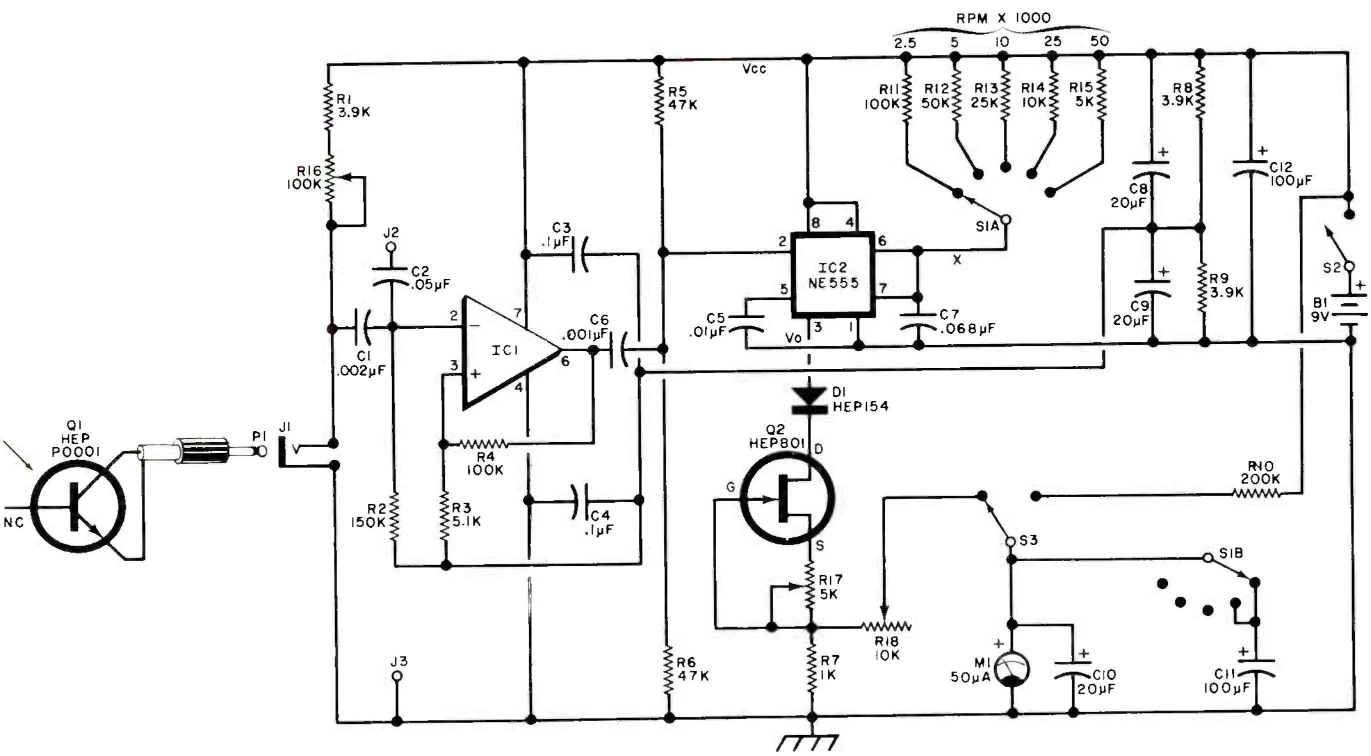
How It Works. Light pulses striking photo-transistor *Q1* produce voltage pulses at the input of operational amplifier *IC1*, connected as a Schmitt trigger which produces a sharply squared output pulse for each input pulse. Resistors *R3* and *R4* provide positive feedback and also determine the input voltage hysteresis or deadband. This prevents the tach from responding to noise components of the main signal and rejects the small 120-Hz modulation of 60-Hz incandescent light sources. Input high-pass filter, *C1-R2*, favors response to fast-changing light signals.

Output pulses from *IC1* are differentiated by *C6-R6* forming voltage spikes which are applied to the trigger input terminal (2) of timer *IC2*, connected as a monostable. When a negative-going trigger pulse drives pin 2 below one-third V_{CC}, the timer delivers a precise output pulse V_O at pin 3. Output pulse duration, independent of supply voltage, depends on timing capacitor *C7* and a timing resistor selected by range switch *S1*. Output pulses V_O pass through diode *D1* and energize FET constant-current source *Q2-R17*, producing constant-amplitude pulses across *R7*. Diode *D1* blocks the small residual voltage when V_O is low. Constant-duration pulses of constant amplitude are averaged by meter *M1* which responds linearly to the repetition rate of input light pulses.

Potentiometer *R16* adjusts the input sensitivity while capacitor *C11* dampens meter pointer vibration at low (2500) rpm. With a pulse duty cycle of near one-third at full scale, meter overrange is within safe limits.

Construction. Assemble the Photo-Tach in a 3" × 4½" × 6½" metal case. In the prototype, perf board construction was used but you can make a printed circuit board using the foil pattern shown in Fig. 2. Use sockets for *IC1, IC2*, and *Q2*, and use short, heavy buses on the circuit board as common tie points to avoid ground loops. Install bypass capacitors *C3* and *C4* close to their *IC1* pins. Wire *R16* so that its resistance is zero with the control set counterclockwise. Voltage-range multiplier resistor *R10* is, preferably, 1% tolerance.

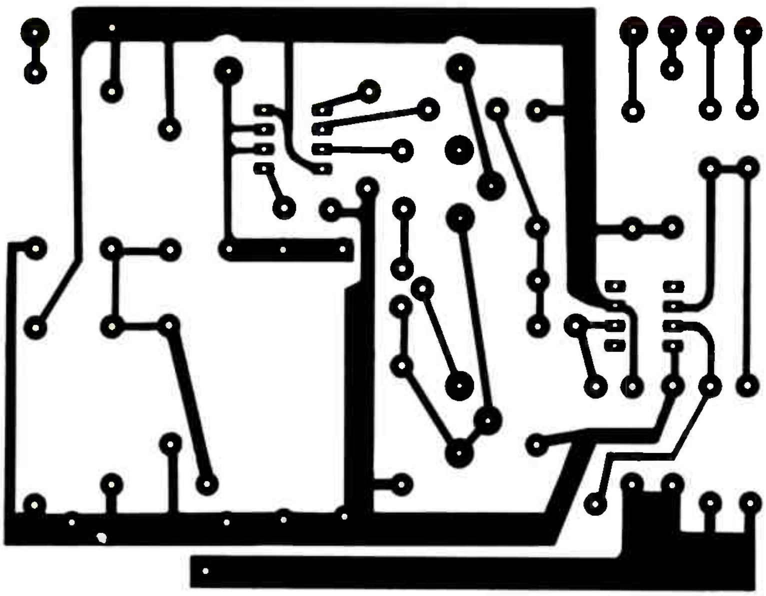
Connect the supply minus to case (ground). Tape over any unused pins



PARTS LIST

B1—9-volt battery (Burgess 2U6 or equiv.)
C1—0.002-μF 10% ceramic disc capacitor
C2—0.05-μF ceramic disc capacitor
C3,C4—0.1-μF ceramic disc capacitor
C5—0.01-μF ceramic disc capacitor
C6—0.001-μF 10% ceramic disc capacitor
C7—0.068-μF 10% Mylar capacitor
C8,C9,C10—20-μF 15-V electrolytic capacitor
C11,C12—100-μF, 15-V electrolytic capacitor
D1—Silicon diode (HEP 154 or equiv.)
IC1—Operational amplifier (HEP C6052P or 741C)
IC2—555 timer IC
J1—Miniature phone jack
J2,J3—Phone tip jack (one red, one black)
M1—0-50-microampere dc meter
P1—Miniature phone plug
Q1—Photo transistor (HEP P0001, HEP 312, or equiv.)
Q2—N-channel JFET (HEP 801 or equiv.)
R1,R8,R9—3900-ohm, ½-watt 5% resistor
R2—150,000-ohm, ½-watt 10% resistor
R3—5100-ohm, ½-watt 10% resistor
R4—100,000-ohm, ½-watt 10% resistor
R5,R6—47,000-ohm, ½-watt 5% resistor
R7—1000-ohm, ½-watt 5% resistor
R10—200,000-ohm, ½-watt 1% resistor
R11—100,000-ohm resistor
R12—50,000-ohm resistor
R13—25,000-ohm resistor
R14—10,000-ohm resistor
R15—5000-ohm resistor
(R11–R15: 5% or better)
R16—100,000-ohm audio taper potentiometer, with spst switch S2 (Radio Shack 271-1727 or equiv.)
R17—5000-ohm trimmer (Radio Shack 271-217)
R18—10,000-ohm trimmer (Radio Shack 271-218)
S1—Dp, 5-pos. shorting switch (Centralab PA-1002 or equiv.)
S2—Spst switch (on R16)
S3—Sp, 2-circuit momentary pushbutton switch
Misc.:—Transistor socket; DIP sockets (2); metal case 4½" × 6½" × 3" (Vector W30-66-46B or equiv.); P-pattern perforated board; knobs (2); battery clip; miniature shielded cable; flea clips (Vector T42-1 or equiv.) hardware; etc.

Fig. 1. The light pulses at Q1 are squared up in IC1 and turn on precision monostable IC2. Constant-current output pulses through Q2 are averaged by the meter as rpm. Five ranges permit testing up to 50,000 rpm.



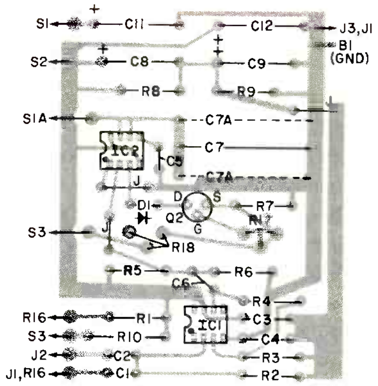


Fig. 2. Though the prototype of the tachometer was assembled on perforated board, it is convenient to use a printed circuit board. C7A is two 0.033 capacitors if this is preferred to one 0.068.

of the IC sockets and carefully observe correct installation of the IC's. Remove the meter dial card and mark the additional scales using dry transfers (see photograph). Otherwise, mark rpm range switch *S1* with multipliers of the 0-50 scale. Do not connect a meter protector across *M1*.

Mount the meter, range switch *S1*, sensitivity control *R16*, battery test switch *S3*, probe input jack *J1*, ac input connector *J2*, and the ground connector *J3* on the front panel as shown in the photographs.

For photo-transistor *Q1*, use either a glass lens (HEP P0001) or plastic lens (HEP 312). Clip off or insulate the unused base lead of the P0001 transistor. Connect the outer braid of a three- to four-foot length of miniature shielded cable to the emitter of *Q1* and center conductor to collector. Make sure the braid is connected to the grounding side of the P1-J1 combination. Install *Q1* within an opaque plastic tube, such as the barrel of a ballpoint pen. Position the lens about one-quarter inch from the tip of the probe. Install battery *B1* on the back plate of the cabinet.

Calibration and Checkout. Set *R17* and *R18* to mid-position and *S1* to 2500 rpm, then connect a dc voltmeter across *R7*. This test voltmeter input resistance should be at least 50,000 ohms on the selected voltage range. Disconnect wire "X" from the rotor of switch *S1A*. Operate sensitivity control *R16* to close *S2*. If *M1* is not pegged upscale, short *R6* momentarily, causing V_o to go high. Adjust *R17* until the voltmeter indicates one volt. Remove the voltmeter, open *S2*, and reconnect wire "X" to *S1A*.

Breadboard the calibration circuit shown in Fig. 3, which supplies a 120-Hz signal (equivalent to 7200 rpm) and connect to jacks *J2* and *J3*. Set *S1* to 10,000 rpm, close *S2* and adjust *R18* until *M1* indicates 7200 rpm. With accurate range resistors, all ranges are simultaneously calibrated to high accuracy. You can use a signal generator to calibrate, check, or trim rpm ranges provided frequencies can be set to high accuracy, as with a frequency counter. Multiply frequency by sixty to obtain equivalent rpm.

Next, check rejection of the small 120-Hz modulation of incandescent light sources. Insert the probe in *J1* and aim the probe at a 50- or 75-watt lamp at distances of two inches to three feet while varying *R16* (sensitivity control) over its range. If *M1* does not remain at zero under all conditions, increase input hysteresis by increasing *R3* to 8200 or 12,000 ohms. If further remedy is required (not likely), reduce *R2* to 100,000 or 82,000 ohms and/or reduce *C1* to 0.001 μF.

Connect a 1500-ohm potentiometer (set for minimum resistance) in series with the plus lead of *B1*. Connect the calibrating signal to *J2* and *J3*. Increase the potentiometer resistance until *M1* drops to 7100 rpm or about 1% lower. Depress pushbutton switch *S3* and observe battery end-point voltage on *M1*, read as 0-10 volts dc. End-point voltage should be near 6.6 volts or less. If the voltage is above 7 volts, use a 12-volt battery for *B1* (made up of eight AA cells connected in series). The additional supply voltage accommodates a FET (*Q2*) having a pinch-off voltage above 3 volts.

Applications. In the incident-light mode of operation, the rotating element whose rpm is to be checked chops or gates the light traveling directly from a light source to the probe. This provides a noise-free, large-signal input to the tach. A reflectorized handy light with a 50- to 100-watt lamp proved a most convenient light source but you can use a desk lamp, drop cord, or a flashlight.

Position the light source about two feet behind the blades of an operating electric fan. Hold the probe near the front of the fan, aimed at the lamp. Advance *R16* until *M1* shows a steady and maximum indication. Observe that

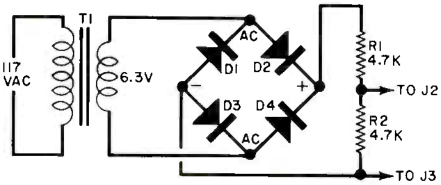
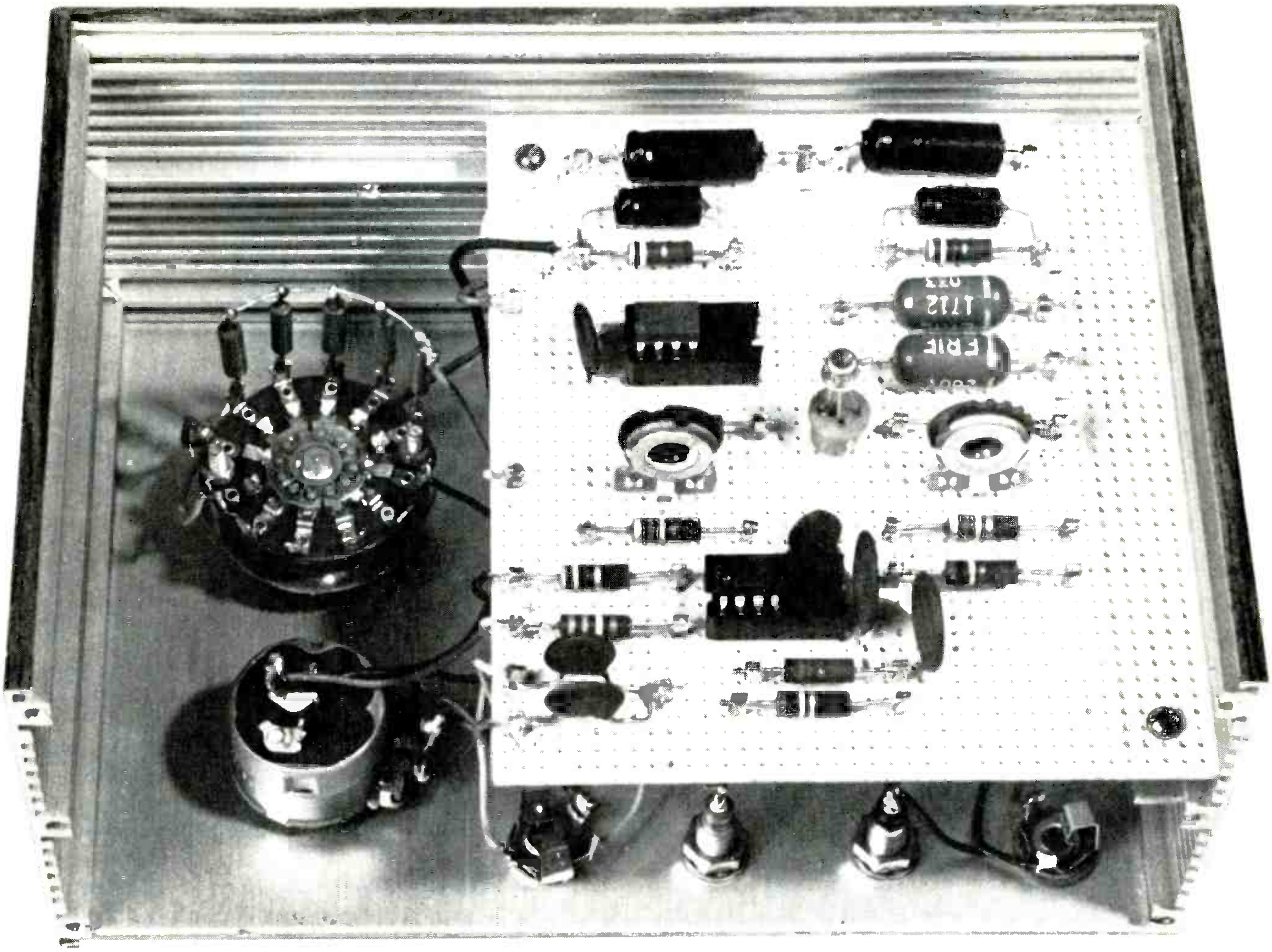


Fig. 3. Calibration circuit delivers a 120-Hz signal equivalent to 7200 rpm. Multiply frequency by 60 to obtain the equivalent speed.



Photograph of prototype, assembled using a perforated board, shows how parts were assembled in chassis. The arrangement of the front panel is shown in the title photo.

R16 can be varied over much of its range while *M1* remains steady. For a fan with four blades, divide indicated rpm by four, etc.

To check the speed of a drill, construct a light chopper using a three-inch diameter cardboard disc. Cut out a ¾" × ¼" light gate at the edge and chuck the disc in the drill using a machine screw. To check motors having various shaft sizes, attach a light chopper disc to a suitable wheel, shaft collar, or knob. The spokes of a large pulley can serve as a light chopper.

In the reflected-light mode, the sensor views light reflected from contrasting surfaces. If surface reflectivity is excessively uneven due to rust spots, discolorations, or other irregularities, a reflected-light pulse may contain excessive noise. This will be recognized as a very high and erratic indication on the meter. Involving two directions of light travel, the reflected-light mode may require rigging of probe or light source, or both, to maintain steady indications.

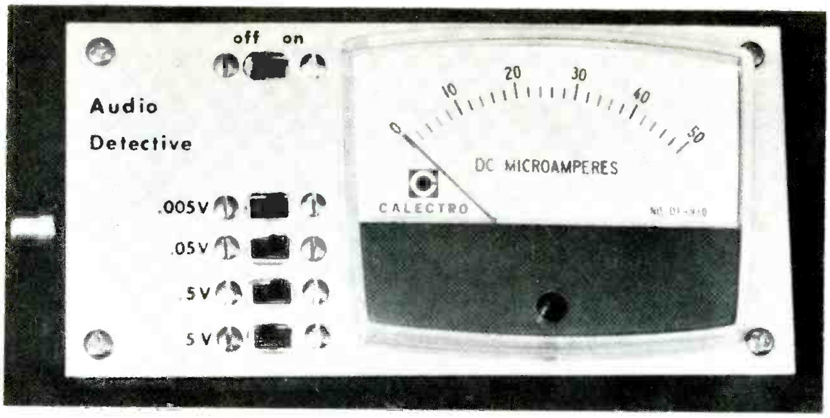
To check the speed of a motor having a half-inch shaft or larger, wrap a strip of electrician's tape (cloth friction type, not glossy surface vinyl) around the shaft. Place the band on a shaft flat if possible. Place a strip of white surgical adhesive tape lengthwise across the band. Or, paint a white strip using fast-dry flat paint. Rig the probe horizontally about one inch from the shaft facing the band.

For the flatted shaft with white strip on the flat, hold the light source directly above the shaft at a distance of about 8 to 12 inches. For the round shaft, hold the lamp about 6 inches above the end of the probe handle. Advance *R16* and verify that the meter indication remains steady over some portion of pot rotation, proving adequate light input. For motors having smaller shafts, attach a reflective disc to a suitable wheel or knob. Paint half of the disc flat black and the balance flat white. Fan speed can be checked by this method provided the fan blades are clean and uniform in appearance. By sighting the running fan from several angles, you can pick a suitable direction to aim the probe. Particularly with very small fans, a slightly twisted blade can result in a missed light pulse.

Meter-pointer vibration becomes apparent below 400 rpm. In this case, include a second light gate or reflective surface and divide indicated rpm by two, etc. Position additional light gates or reflective surfaces in an approximately symmetrical pattern.

Keep tabs on the normal running speeds of appliances and tools for later comparisons. Use speed measurements to isolate problems between motor and drive train and observe effect of repairs. Speed measurements on major heavy-duty appliances such as washers and dryers can forewarn you of progressive wear which may lead to motor overload and possible fire hazards.

The techometer can be used as a low-range frequency meter to check frequencies from about 10 to 800 Hz. Inject one or two volts ac into jacks *J2* and *J3* and divide indicated rpm by 60. Also, by connecting *J2* and *J3* to a scope, you can observe input to the tach as you vary lighting and sensitivity settings. ◇



BUILD THE AUDIO DETECTIVE

Here's a sensitive troubleshooting meter for phono cartridges, microphones, and PA systems

BY RALPH TENNY

THE Audio Detective is a sensitive ac voltmeter which will prove to be especially useful in troubleshooting an audio system. On its lowest range (5 mV), it can be used to test microphones and many phono cartridges. It will also measure potentials up to 5 volts (50 volts, if a simple modification is made). The response of the meter is flat within 5% from 15 Hz to 20 kHz.

The instrument is battery-powered (1 mA current drain) and is conveniently small for portable use. A phono plug is used for the input and input resistance is 100,000 ohms.

Circuit Operation. The circuit made up of transistor *Q1*, *R19*, *C7*, and *D8* is a regulated power supply which provides 14 volts for *IC1* (Fig. 1). Due to the presence of *C7*, the supply turns on slowly to prevent capacitor charging currents on *C2*, *C3*, and *C4* from damaging the meter. Diode *D7* protects the circuit from an accidental reversal of battery polarity.

The network consisting of *R1*, *R2*, and *R3* sets the quiescent operating level of 7 volts at the output of *IC1A*. The dc interstage coupling through *R4*, *R7*, and *R10* maintains this voltage at the outputs of the three following stages. The high input impedance at the noninverting (+) input of *IC1A* prevents loading of the input attenuator. Diodes *D5* and *D6*, in conjunction with *R18*, are used to protect *IC1* from excessively high input voltages, which might damage it.

Sections B and C of *IC1* amplify the audio signal from section A with stage gains determined by the ratios of *R5* to *R6* and *R8* to *R9*. Capacitors *C2* and *C3* couple the ac currents to the common bus so that the ac output of each stage swings about the 7-volt dc operating level.

Section D of *IC1* is a precision rectifier and meter driver. The parallel combination of *R11* and *R13* establishes the gain of the stage. Varying the value of *R13* calibrates the meter so that the meter current is 50 microamperes (full scale) when 5 mV is applied to the (+) input of *IC1A*. Resistor *R12* and the combination of *C5* and *C6* shunt *R11* at the higher audio frequencies to adjust the frequency response near 20 kHz.

Construction. Circuit layout is not critical so perforated board and mounting clips or a printed circuit board can be used. It is advisable to use a socket for *IC1* to avoid possible heat damage during soldering.

Because of the low signal levels required by the measuring circuit, a single common bus is used. Tie all the circuit ground points to this bus and connect the bus to the case at only one point—preferably at the ground lug of *J1*. If *J1* is mounted on a metal panel, make no other connections to the metal portion.

Whatever the layout and case, the checkout of the circuit will be easier if one section is wired and tested before going to the next. Start with section D of the IC and the meter circuit. Since charging currents in *C2*, *C3*, and *C4* will cause current surges in the meter, the operating voltage must be applied slowly to avoid any possibility of meter damage. The test circuit shown in Fig. 2A is used to do this. The dc operating power can be a battery or power supply between 12 and 15 volts dc. Be sure the potentiometer is at the zero position before turning on the power. The signal generator should be capable of delivering a low-distortion, 1-kHz sine wave which can be set to zero output.

When wiring this first section, connect *R10* temporarily to point A of the test circuit. Turn on the power and slowly adjust the test circuit potentiometer to bring the voltage to between 12 and 15. As the voltage is increased, the meter action will be erratic and move upscale. When the power is fully on, the meter should settle back to zero.

Turn up the audio generator connected to the test circuit. As the generator output is increased, the meter will reach full scale when the generator is delivering 0.3 volt rms. Once this section is working properly, reduce the test circuit voltage and audio generator output to zero and remove the connection to *R10*.

Now wire up the rest of the circuit (sections A, B, and C of *IC1*). Perform the above test again and note that the inputs to sections A and B are 5 mV rms for a full-scale meter indication.

Assemble the power supply portion, using 150,000 ohms for *R19*. The time constant for *R19* and *C7* determines

PARTS LIST

B1,B2—9-volt battery
C1—0.1-µF, 50-V ceramic capacitor
C2,C3—100-µF, 25-V electrolytic capacitor
C4—22-µF, 25-V electrolytic capacitor
C5—100-pF capacitor
C6—47-pF capacitor (see text)
C7—45-µF, 25-V electrolytic capacitor
C8—225-µF, 25-V electrolytic capacitor
D1 to D7—1N4148 diode
D8—15-V zener diode (HEP Z0225)
IC1—Integrated circuit (National LM324)
J1—Standard phono jack (RCA)
M1—0.50-µA meter (Calectro D1-910 or similar)
Q1—2N5449 or TIS98 transistor
Following resistors are ¼-W:
R1,R2—47,000 ohms
R3—1.2 megohms
R4,R7,R10—1000 ohms
R5,R8,R18—10,000 ohms
R6,R9—1500 ohms
R11,R12—5600 ohms
R13,R19—(see text)
R14—91,000 ohms (see text)
R15—9100 ohms (see text)
R16—910 ohms (see text)
R17—100 ohms (see text)
S1 to S5—Spdt switch
Misc.—Suitable chassis (Calectro H4-722), battery holder, mounting hardware, etc.

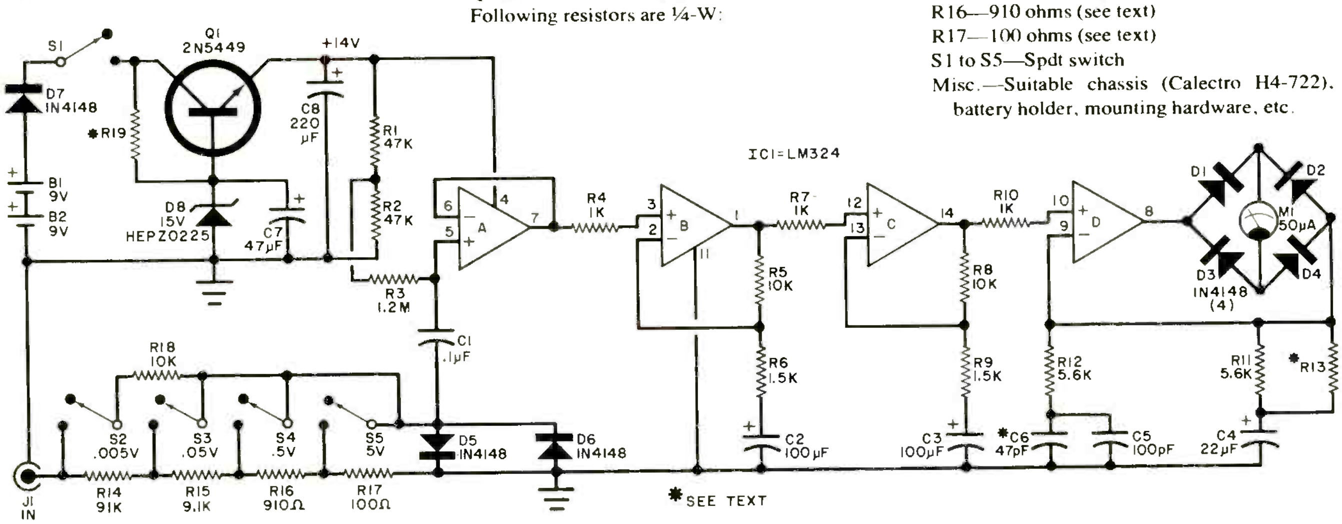


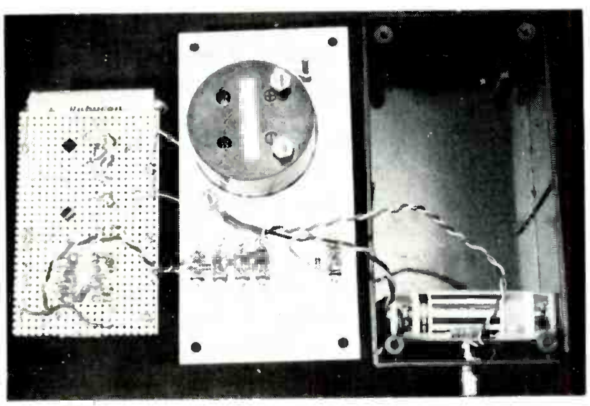
Fig. 1. The first three op amps in IC1 form a sensitive ac amplifier and the fourth drives the meter.

how fast the operating power comes up. Select the value of *R19* so that the circuit comes into full operation without violently "pegging" the meter. On the prototype, the meter settled back to zero about seven seconds after power was turned on.

Complete the assembly, wiring up the input attenuator. The resistors used in the attenuator can be conventional 5% types or they can be selected with a resistance bridge to be as close to the stated values as possible. The more accurate the resistor value, the more accurate the meter readings.

Turn on the power and apply an audio signal of about 5 mV rms at 1 kHz to *J1* to get a full-scale reading on the meter. When the next higher scale is switched in, the meter should indicate about 1/10 of full scale. Bring the meter to full scale by adjusting the audio source. Switch to the next higher scale (0.5 V) and note that the meter goes down to 1/10 of full scale. Repeat the adjustment and check the next range.

Either a laboratory calibration standard or a dc-coupled scope can be used for final calibration and frequency-response checking. If a scope is used, start with the calibration. Use a new flashlight battery (1.55 volts). Set the scope to 0.2 volt per division, and connect the battery to the scope vertical input. Adjust the scope vertical gain until the trace is 7¾ divisions from its zero



View of interior of the Audio Detective as assembled in the author's prototype.

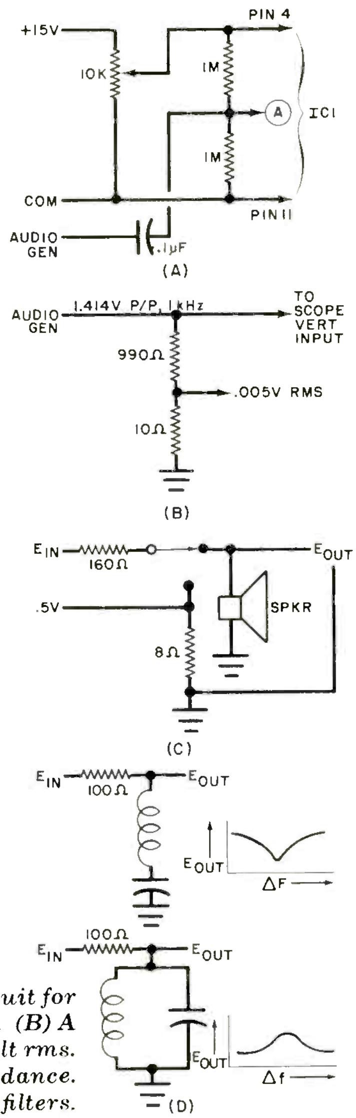


Fig. 2. (A) Test circuit for stage-by-stage checkout. (B) A source of 0.005-volt rms. (C) Measuring speaker impedance. (D) How to check filters.

position. If the scope has a different vertical range, use a range that produces a nearly full-scale deflection.

Carefully select the two resistance values shown in Fig. 2B and apply 1.414 volts peak-to-peak at 1 kHz as shown. Connect the 0.005-volt rms output of this voltage divider to *J1* of the Audio Detective, with the attenuator set for 0.005 V.

Select a value for *R13* that will give a full-scale meter indication. Keeping the output of the audio generator at this constant level, reduce the frequency until the meter indicates 0.0047 volt. The generator frequency should be lower than 20 Hz. If a slower roll-off is desired, increase the value of *C1*. In this way, it is possible to bring the flat response down to 10 Hz. If a lower frequency is required, it is necessary to increase the values of *C2*, *C3*, *C4*, and *C7*, and lower the value of *R19*.

With the output of the audio generator held at 1.414 V peak-to-peak, increase the generator frequency to 20 kHz. If the meter indicates too low a value, the high-frequency response must be adjusted. This is done by adding more capacitance across *C6*. Be careful not to add too much compensation, which will result in a "hump" near the 20-kHz point.

Like all ac voltmeters, the Audio Detective will respond to almost any waveform. However, it is calibrated for a sine wave and other waveforms will produce erroneous meter readings. For example, a 9-volt peak-to-peak sine wave will read 3.2 V on the Audio Detective. A 9-volt square wave would show up as 5 volts. However, as long as the waveform remains the same, relative measurements of nonsinusoidal waveforms can be made.

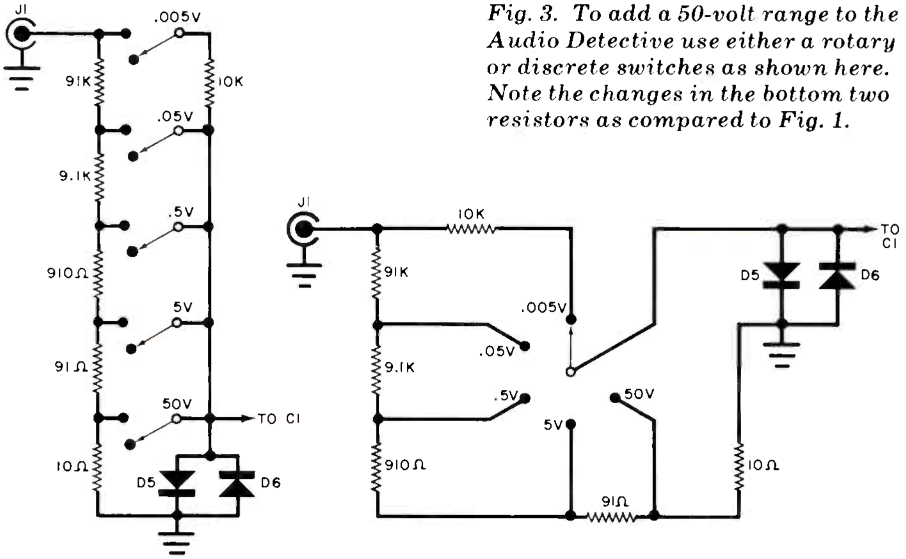


Fig. 3. To add a 50-volt range to the Audio Detective use either a rotary or discrete switches as shown here. Note the changes in the bottom two resistors as compared to Fig. 1.

Uses. The Audio Detective can be used to troubleshoot a PA system. Plug the microphone to be used into *J1* (with the correct adapter) and speak into the mike. A dynamic mike should have an output of about 1 mV, and a condenser (electret) mike should generate between 4 and 5 mV. The Audio Detective can then be connected to the mixer output to test that stage. The procedure is continued through the audio system to the speaker outputs. The signal level will get progressively higher. At the speaker outputs, five volts on an eight-ohm line indicates just over three watts.

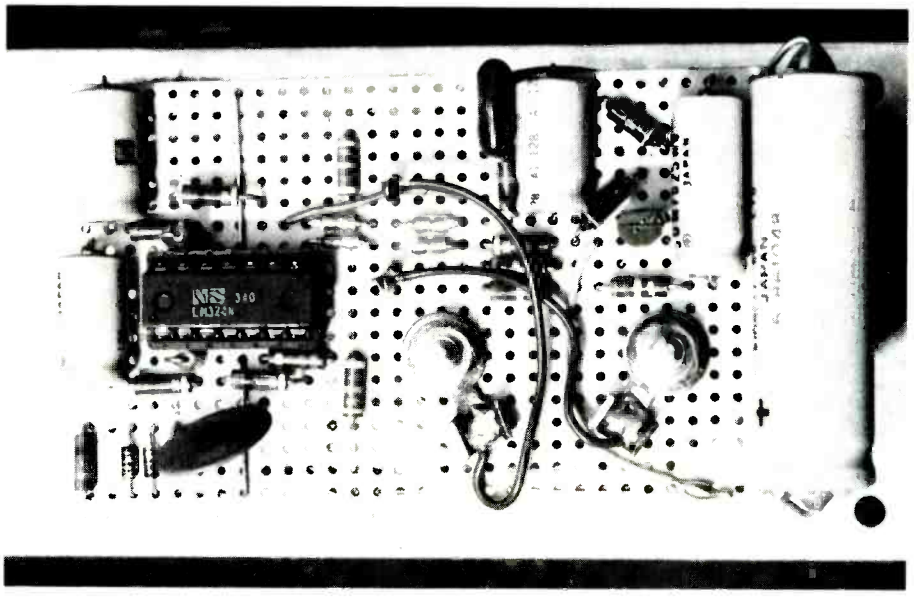
To determine the gain of an amplifier, use the Audio Detective to measure the input and output voltages. The gain is simply the output voltage divided by the input.

To test the frequency response of a tape recorder, apply a 1-kHz tone to the recorder's auxiliary input and select a level that gives a comfortable playback volume with the volume control set at midrange. Record several different frequencies at this same level. Terminate the external speaker output with an 8-ohm resistor and monitor the voltage generated across the resistor at each frequency. (For component tape decks, monitor the line output unterminated.) Plot the output voltage as a function of frequency.

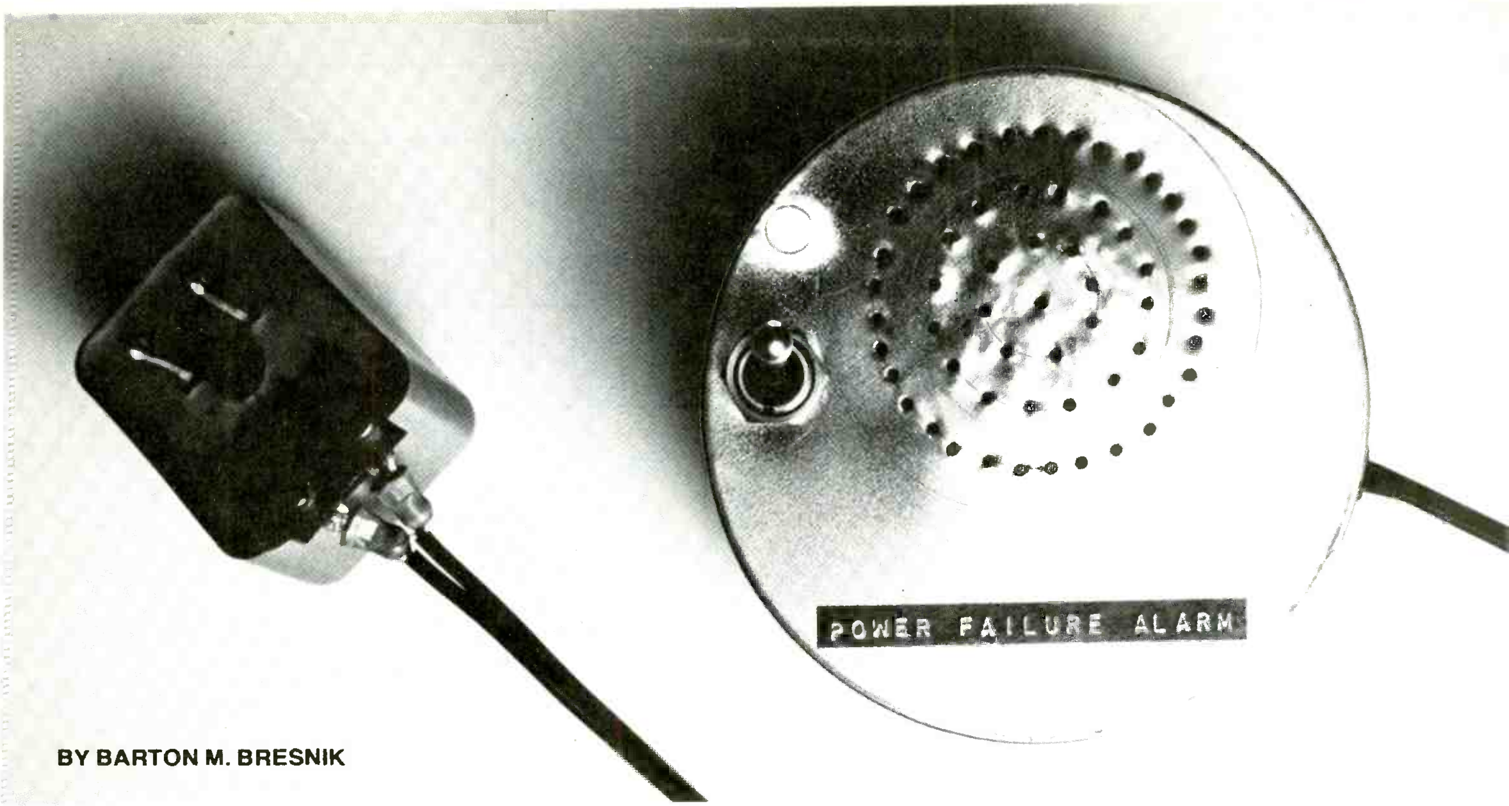
To determine speaker impedance, use the circuit shown in Fig. 2C. Select E_{in} so that 0.5 volt is generated across the 8-ohm resistor. Switch to the speaker and measure E_{out}. The speaker impedance at that frequency is $(Z_{out}/0.5) \times 8$. For example, if Z_{out} is 0.45 volt, the speaker impedance is $(0.45/0.5) \times 8$ or 7.2 ohms.

You can check the frequency response of a filter by using the circuit in Fig. 2D. Holding the input constant, vary the frequency and plot E_{out} as a function of frequency. Figure 2D also shows typical response curves for both series and parallel resonant circuits.

Modifications. The schematic in Fig. 1 shows the input attenuator spanning four ranges from 0.005 to 5 volts. If you want to extend the upper limit, use the attenuator shown in Fig. 3. Two versions are shown—one using five slide switches and one a rotary switch. Either will extend the range to 50 volts. ◇



Components assembled on the perforated board.



BY BARTON M. BRESNIK

POWER-FAILURE ALARM

Lets you know when a power outage occurs.

SUMMER or winter, night or day, a power outage in your local utility system can cause all sorts of problems in your home. Heating and cooling systems shut down, refrigerators and freezers come to a halt, and your electric alarm clock stops running, making you late for work.

The power-failure alarm is a battery-powered device that sounds an alarm when a power failure occurs. Then you can, at least, turn off devices that might blow fuses when the power returns and take what other steps are necessary to protect your property.

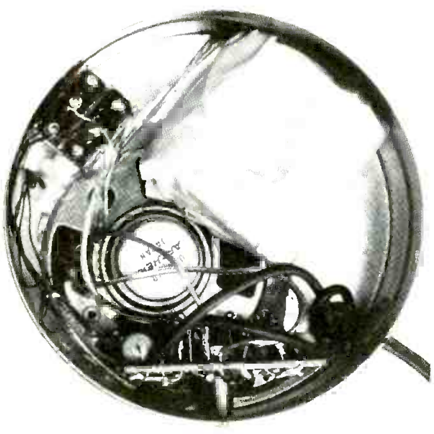
How It Worls. Battery *B1* (Fig. 1) gets a constant trickle charge from the transformer through *D1* and *R1*. As shown here, the battery is made up of two 1.25-V NiCd cells. Sealed NiCd or lead-acid storage cells with higher voltage ratings could be used. Vented secondary batteries can be used if the electrolyte is checked every few months. If carbon-zinc or manganese-alkaline cells are used, the value of *R1* should be increased to 47,000 ohms. Remember also that manganese-alkaline and mercury cells may burst when recharged.

The alarm generator consists of a two-transistor astable multivibrator and associated loudspeaker, while the trigger portion uses an SCR and related bias components. The SCR is in a feedback loop from the emitter of *Q2*. The gate of *SCR1* is biased low enough to keep it from firing as a result of the combination of *R3* and *R4*. When a power outage occurs, the voltage from the battery turns on the SCR, and the multivibrator provides an audio-frequency signal to the speaker.

The time delay provided by *C1* and *R3* is used to keep the system from operating in case there is only a brief loss of power (which can be caused by lightning) or a line transient.

In standby operation, the circuit draws less than 1 mA, which is supplied by the trickle charging current. When an outage occurs, and the SCR turns on, the current increases to 15 mA for a 2.5-V battery and 50 mA for a 4.5-V source.

The lamp circuit is optional and can be used to check the battery. The lamp can also be made to glow during a power outage by connecting a silicon diode between the LAMP position of *S1* (anode of the diode) and the anode of *SCR1* (cathode of the diode).



Author's prototype was assembled in a 35-mm film container.

Construction. The prototype of the alarm was assembled on a small piece of perforated board with point-to-point wiring. For transformer *T1*, use a standard recharging unit which plugs directly into a wall socket. This provides a safety feature in that only 6.3 volts is used in the chassis.

Mount the completed assembly in any type of enclosure with only *S1* and some speaker holes on the top. (The author used a 100-ft, 35-mm film container.) The optional "grain-of-wheat" lamp can

PARTS LIST

B1—Two 1.25-V NiCd cells (Lafayette 32F47400 or similar)
C1—100-µF, 10-V electrolytic capacitor
C2—0.05-µF disc capacitor
D1,D2—1N4001 diode
I1—2.5-to-3.0-V lamp (or #48)
Q1—2N3638 transistor
Q2—General-purpose npn transistor
R1—680-ohm, ¼-W 10% resistor (or 47,000-ohm, see text)
R2—3300-ohm, ¼-W 10% resistor
R3,R4,R5—10,000-ohm, ¼-W 10% resistor
R6—1000-ohm, ¼-W 10% resistor
R7—100-ohm, ¼-W 10% resistor
SCR1—Silicon controlled rectifier (GE-X5 or 2N5060)
SPKR—8- or 10-ohm speaker (Lafayette 99F60972 or similar)
S1—Spdt switch
T1—6.3 volt, low-current "wall-socket" transformer (Lafayette 33F37029 or similar)
Misc.—Suitable enclosure, rubber grommet, mounting hardware, circuit board, etc.

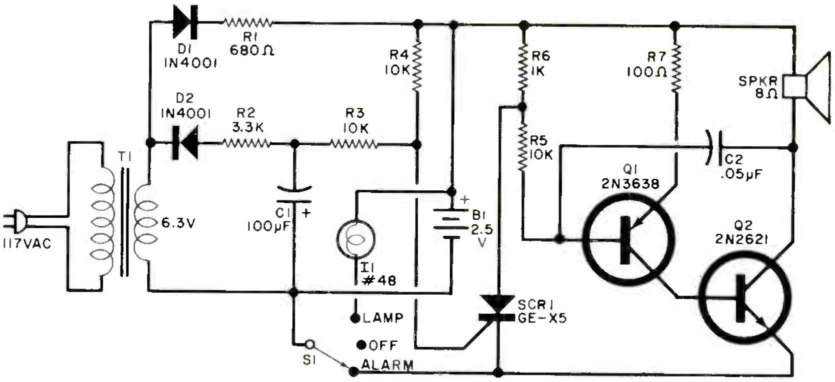


Fig. 1. The two-transistor audio oscillator is inoperable until the SCR conducts. This occurs when the power line fails and the battery voltage is applied to the SCR gate. Do not use an on-off switch with the unit.

be mounted in a hole drilled in the container, using epoxy glue to secure it in place. Since none of the parts listed is critical, feel free to experiment with "junk box" items.

To test the device, turn the switch to OFF, plug the transformer in a power outlet, and then turn the switch to ALARM. Unplug the transformer from the wall socket. After a few seconds, the alarm should sound, continuing even when the transformer is put back in the socket. This locking feature reminds you to reset clocks if you were not at home when the outage occurred.

If you are using rechargeable cells, connect a current meter in series with the battery and check that, with the transformer plugged in, the charging current is within the limits prescribed for the cell. ◇

DESIGNING OPTIMUM-Q AND SMALL INDUCTORS

BY R. E. MARTIN

Optimum Q is achieved in an inductor when its length and diameter are equal. This table will serve as a guide when designing high-Q inductors for r-f circuits. It gives maximum turns and inductance for various wire sizes when close-wound in a single layer.

Higher Q's will be obtained if the turns are spaced at one wire diameter. This results in half the turns and one quarter of the inductances listed in the table. Should an intermediate inductance or number of turns be desired, the factor, K, at the bottom of each column can be used for calculation from the formula $L = KT^2$.

Wire AWG		Diameter & Length (inches) 1/8	1/4	3/8	1/2	5/8	3/4	1
16	T			6	8	10	12	16
	L*			.233	.552	1.08	1.86	4.41
18	T		5	8	10½	13	15½	21
	L*		.108	.414	.950	1.82	3.11	7.60
20	T	3	6½	10	13	16½	19½	26
	L*	.0194	.182	.647	1.46	2.93	4.92	11.7
22	T	4	8	12	16½	20	24½	33
	L*	.0345	.276	.931	2.35	4.31	7.76	18.8
24	T	5	10	15	20½	25	30½	41
	L*	.0539	.431	1.46	3.62	6.74	12.0	29.0
26	T	6½	13	19½	25½	32½	38½	51
	L*	.091	.728	2.46	5.61	11.4	19.2	44.8
28	T	8	16	24	32	40	48	64
	L*	.138	1.10	3.72	8.83	17.2	29.8	70.6
30	T	10	20	30	40	50	60	80
	L*	.215	1.72	5.82	13.8	27.0	46.5	110
	K	.00215	.00431	.00647	.00862	.0108	.0129	.0172

*Inductance, L, is in microhenries.

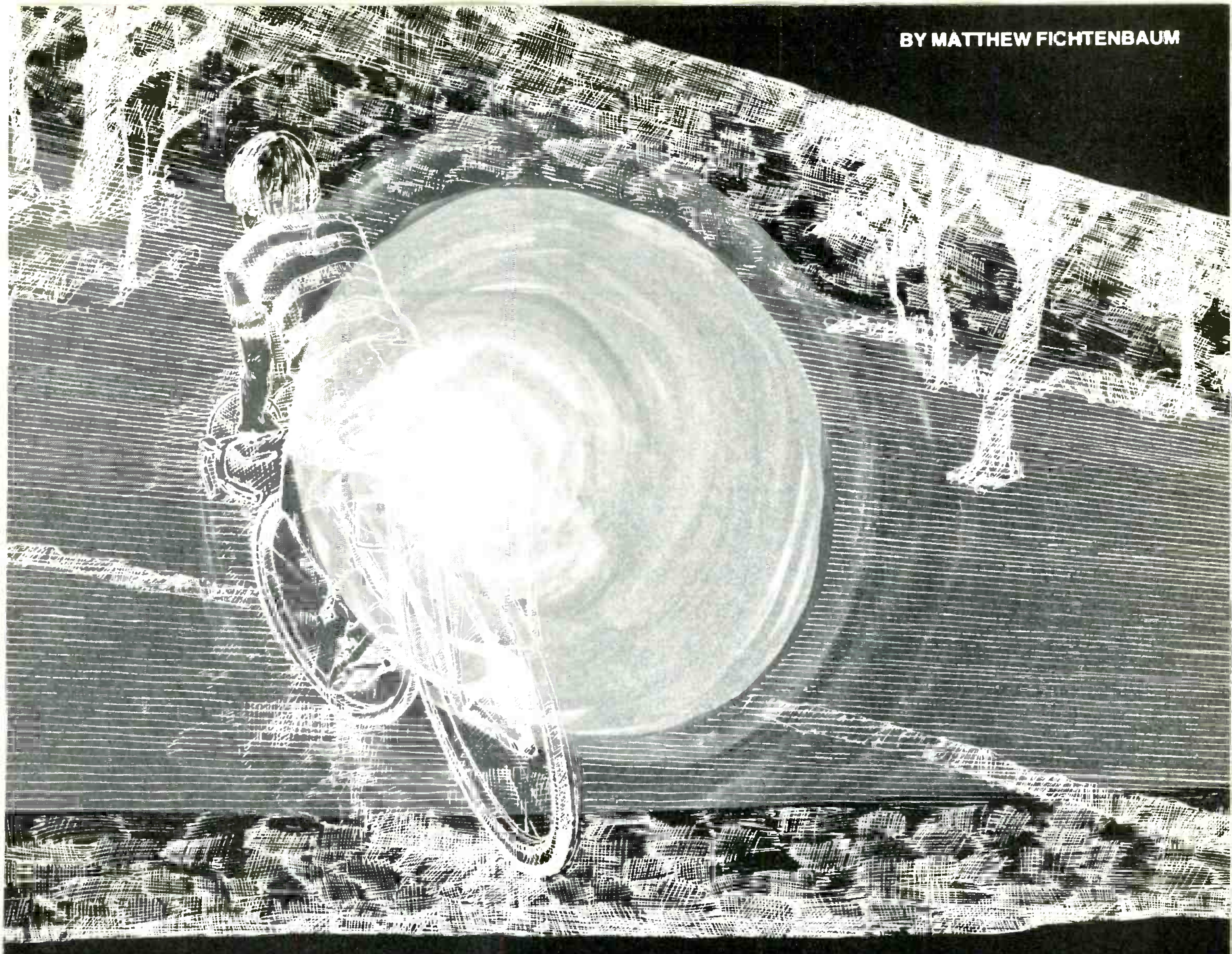
When small inductors are needed, for r-f chokes or h-f filter networks, it's frequently convenient to wind them on composition (carbon) resistors. The table shows inductances for various wire sizes when close-wound on common resistor bodies. The resistor value should be above 4.7 kilohms for the low-value inductances and above 47 kilohms for the higher values., unless low Q is desired.

The number of turns listed leaves a little space at the end of the resistor body to file small notches in order to guide the coil wire down to the resistor lead while not allowing the coil turns to fall off the ends. Do not use wire-wound resistors.

Wire AWG		Resistor Size ¼W	½W	1W	2W
20	T	3	7	11	14
	L*	.013	.097	.32	.63
22	T	4	8	13	17
	L*	.023	.13	.45	.92
24	T	5	10	17	22
	L*	.036	.20	.76	1.5
26	T	6	12	21	27
	L*	.051	.29	1.2	2.3
28	T	8	15	26	33
	L*	.092	.45	1.8	3.5
30	T	9	19	32	41
	L*	.12	.72	2.7	5.4
32	T	11	22	39	50
	L*	.17	.96	4.0	8.0
34	T	14	28	49	62
	L*	.28	1.6	6.3	12
36	T	18	34	60	77
	L*	.46	2.3	9.5	19

*Inductance, L, is in microhenries.

BY MATTHEW FICHTENBAUM



A Strobe Flasher for Night Cycling

Uses a high-voltage xenon flash tube and dc/dc converter.

ALL BICYCLISTS and car drivers are aware of the need for visibility when riding a two-wheeler at night or in fog. However, providing a clear indication of a cyclist's presense can be a real problem. Blinking incandescent lights can be used, but they put out only small amounts of light. The light described in this article uses a xenon tube to generate a bright flash that can be seen from a great distance—but is not intense enough to destroy a driver's night vision. Simple circuitry allows the project to be built at low cost, in a lightweight, compact package that can be secured to the bicycle or the rider's belt.

Principles of Operation. The light-producing element is a sealed glass tube containing two electrodes and filled with the inert gas, xenon. When a high voltage is applied to the tube, the gas ionizes. That is, some of the electrons are stripped from the xenon atoms. When the electrons and xenon ions recombine, the energy that caused them to separate is given up as light. If many atoms are ionized, the light output is intense.

Xenon flash lamps are usually operated in a pulsed mode. The intensity of their flashes gives good visibility, and their short duration keeps the average power applied to the tube low. However, the flash tubes require high voltages. In this circuit, a dc-to-dc converter supplies this high voltage, drawing power from two AA batteries. A capacitor stores charge which is needed for the large instantaneous flash current. To initiate ionization in the tube, a potential difference of about 4000 volts is required. This is developed by a trigger coil, or pulse transformer which steps up the converter output.

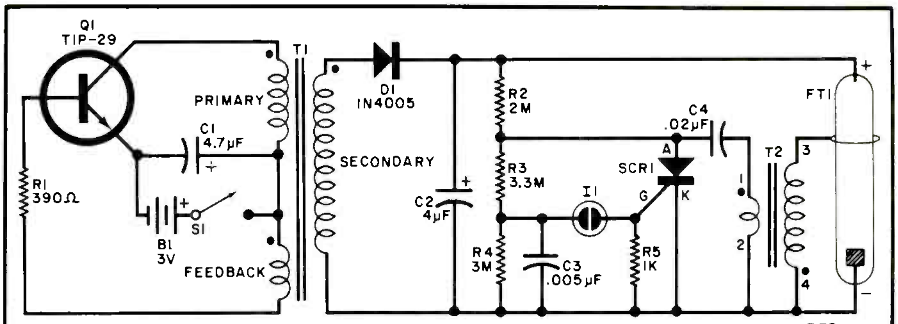
About the Circuit. Transistor *Q1*, transformer *T1*, and their associated components comprise an oscillator which is the heart of the dc-to-dc converter. When power is first applied, collector current builds up until the ferrite core of *T1* saturates. At this point, base drive is removed from *Q1*, the transistor cuts off, and flux in the core decays. Then the cycle repeats itself again.

On the other side of *T1*, high voltage pulses developed across the secondary are rectified by *D1*, and charge *C2* to +250 volts. The voltage divider composed of *R2*, *R3*, and *R4* charges *C3* to 90 volts and *C4* to 200 volts. The time constants associated with these capacitors are small, so the voltages across *C3* and *C4* can be assumed to be proportional to that across *C2*.

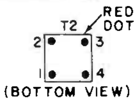
When the potential across *C3* reaches approximately 90 volts, neon lamp *I1* fires and discharges *C3* through the gate of *SCR1*. This causes *SCR1* to turn on, and the charge stored in *C4* is dumped into the primary of *T2*, the trigger coil. Because of *T2's* high step-up ratio, this surge of current induces a potential difference of several thousand volts across the secondary. In turn, the flashtube fires, creating a bright flash of light as the charge stored in *C2* flows through the tube. When *C2*'s charge is depleted, the tube stops conducting and goes dark. Then the rectified pulses from *D1* start to charge up the capacitors, and the cycle begins again.

The flasher requires only two or three volts to function. Two penlight (AA) cells make a lightweight power source, but since current drain is 250 to 300 mA, carbon zinc cells should be used only if the flasher is intended as a back-up safety device in extreme circumstances. However, two alkaline *AA* cells should provide about six hours of intermittent operation. If the flasher is to be used frequently, rechargeable nickel-cadmium batteries should be installed. They will give about two hours' use to a charge. (Of course, rechargeable or nonrechargeable *C* or *D* cells can be used if more extensive use in contemplated.

Most of the components can be obtained from any electronic parts store, including flash tube *FT1* and trigger coil *T2*. However, the converter transformer *T1* must be wound on a Ferroxcube 2616-F1D bobbin and uses two Ferroxcube 2616-PLOO-3C8 pot core halves. These parts are available from some industrial distributors, and a mail-order source is included in the parts list.



Two 1.5-V batteries power the converter which drives the flashtube and SCR trigger circuit.



PARTS LIST

B1—Two 1.5-volt cells in series (see text)
C1—4.7-µF, 10-V electrolytic capacitor
C2—4-µF, 450-V electrolytic capacitor
C3—0.005-µF, 500-V disc ceramic capacitor
C4—0.02-µF, 500-V disc ceramic capacitor
D1—1N4005 diode
FT1—Xenon flash tube (Radio Shack 272-1145 or equivalent)
I1—NE-2 neon bulb
Q1—TIP-29, HEP S5000 npn plastic power transistor or equivalent
The following are ¼-watt, 10% tolerance resistors:
R1—390 ohms
R2—2 megohms
R3—3.3 megohms
R4—3 megohms
R5—1000 ohms
S1—SPST switch
SCR1—400-volt silicon controlled rectifier (Radio Shack 276-1000 or equivalent)
T1—see text
T2—4000-volt trigger coil (Radio Shack 272-1146 or equivalent)
Misc.—Printed circuit or perforated board, solder, hookup wire, No. 34 enamelled wire, No. 28 enamelled wire, machine hardware, circuit board spacers, suitable enclosure, battery holder, standoff insulator, silicone cement, solder, etc.
Note—The Ferroxcube 2616-F1D bobbin and two 2616-PLOO-3C8 ferrite pot core halves are available for $3.00 (first class postage paid) from Elna Ferrite Laboratories, Inc., Box 395, Woodstock, NY 12498.

Construction. The flasher can be built on a printed circuit or perforated board, and housed in any enclosure of sufficient size. The prototype was built in a small plastic box with a transparent top which protects the flash tube without obscuring its light output.

No matter which arrangement is chosen, the first step in constructing the flasher is to assemble *T1*. It is wound on a nylon bobbin that will be inserted into a two-piece ferrite pot core. Begin with the secondary. Allow a few inches of No. 34 enamelled wire to extend from a slot in the bobbin, and attach a "flag" of masking tape to the end of the wire. Mark the tape with an "S." This will allow you to keep track of the start of the secondary winding, which is essential to proper phasing. Secure the wire to the bobbin with a piece of electrical tape, and then wind 350 turns, keeping each layer even. When you have finished, cover the winding with electrical tape, and leave a few inches of wire free to serve as a connecting lead for the "finish" end of the secondary.

The primary will be wound next, using No. 28 enamelled wire. Use a masking tape flag marked "P" to identify the start of the winding, and wind 16 turns in the same direction as you did for the secondary. When the primary is completely wound, cover it with a layer of electrical tape. As before, leave a few inches of wire free at both ends of the primary. Finally, wind the five-turn feedback winding in the same direction as the other two. Use No. 28 enamelled wire, identify the start of the winding with a tape flag marked "F," and cover the completed bobbin with a layer of electrical tape. Again, leave a few inches of lead length on each side of the winding.

Insert the bobbin between the two pot core halves, and mount the transformer on the project board using #6-32 machine hardware. The ferrite core is very brittle, so the mounting hardware should be no more than finger tight. Use a daub of silicone cement to secure the nut to the board.

The flashtube should be mounted so that it can be seen and is somewhat protected from shock. The author mounted his flashtube on the circuit board using its leads and a standoff insulator. Note that the electrode composed of wire mesh is the cathode. Trigger transformer *T2* should be positioned near the flashtube. The rest of the components can be mounted in any convenient manner. It is wise to leave the transformer leads long, as a mistake in the direction of a winding, or improperly identifying the start of a winding, will require a phasing change involving the reversal of one or more windings.

Checkout and Troubleshooting. When you have completed building the project, double check all wiring, and then turn the unit on. The flashtube should flash about once each second, and an audible whistle should be heard near *T1* as the dc-to-dc converter oscillates.

If no whistle is heard, measure the battery voltage and current with a high-impedance multimeter. If no current is being drawn from the battery, check the wiring to *T1*, *Q1*, *R1*, the battery, and switch *S1*. If current is being drawn, try reversing either the primary or feedback winding of *T1*, but *not* both!

The converter might oscillate but the flashtube won't flash. In that case, measure the voltage across *C2*. Although current is limited, the capacitor's voltage can give you an unpleasant shock, so be careful! A reading of 250 to 300 volts is normal. But if the voltage is below this level, disconnect *R2* and the anode of *FT1* from the positive plate of *C2*. If the voltage is now correct, the problem is located in the trigger circuit for the flashtube. If the voltage is low but not zero, try reversing the secondary winding of *T1*. Zero voltage points to incorrect wiring or a defective *D1* or *C2* component.

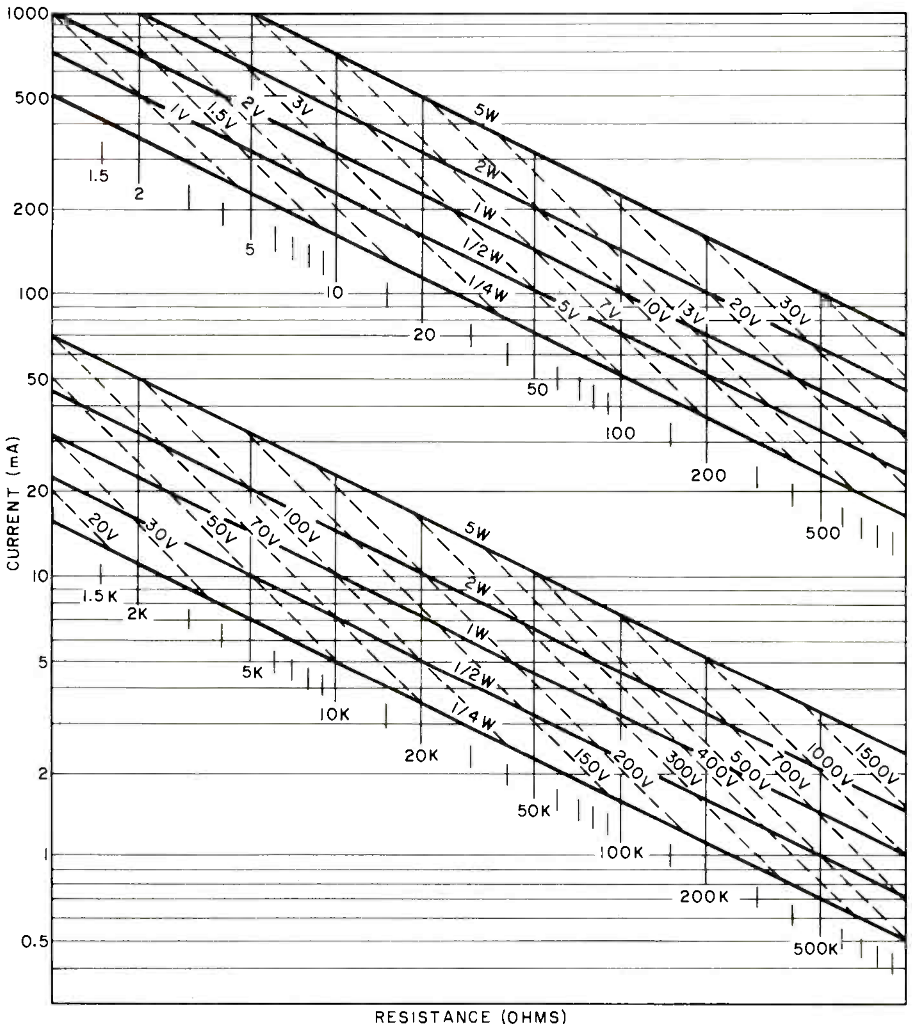
When the voltage across *C2* is correct but there is no flash, the trigger circuit must be examined. Measure the voltage between the anode and cathode of *SCR1*. You should obtain a reading of 200 volts or so. If you do, short these two points with a jumper. The tube should flash as you do this. If it doesn't, either it or the trigger coil is defective. Other possibilities are a faulty SCR or trigger component (*I1*, etc.) or incorrect wiring of that part of the circuit that generates the trigger.

Final Thoughts. If desired, small leather straps can be secured to the flasher enclosure to serve as belt loops. The unit is small enough to be mounted either on the bicycle or on the cyclist's arm or leg. It can also be taken along for hikes on dark country roads. You will probably find many other applications for this handy little bicycle flasher. ◈

A POWER NOMOGRAPH

BY MARK L. McWILLIAMS

THE NOMOGRAPH shown here can be quite a time saver when designing and/or breadboarding a circuit. It shows at a glance the maximum resistance required to safely pass a given current as well as the minimum resistance required for a given voltage drop to be applied safely across it. In addition, the nomograph tells what the wattage rating for a given resistor should be, given the voltage and current.



The nomograph is used as follows. Assume a 10-mA current is to be passed through a ½-watt resistor. Referring to the nomograph, we can see that the maximum allowable resistance is 5000 ohms. This would be a 50-volt drop across the resistor. Using another example, if 100 volts were to be applied across the ½-watt resistor, we can see that the minimum allowable resistance must be 20,000 ohms. This means that 5 mA of current would flow through the 20,000-ohm resistor at 100 volts.

Other combinations of voltage, current, resistance, and power rating, keeping two figures constant and determining the third figure, are possible.

The seemingly linear plot of the nomograph can be explained by the fact that the plot is made on log-log paper. From Ohm's Law, $P = I^2R$ (P is power in watts, I is current in amperes, and R is resistance in ohms). Hence, I versus R on log-log paper is a straight line with a slope of $-\frac{1}{2}$. This greatly simplifies plotting and makes it easy to use the nomograph in calculations. ◇

IC Multiplex Decoder Improves Stereo FM Performance

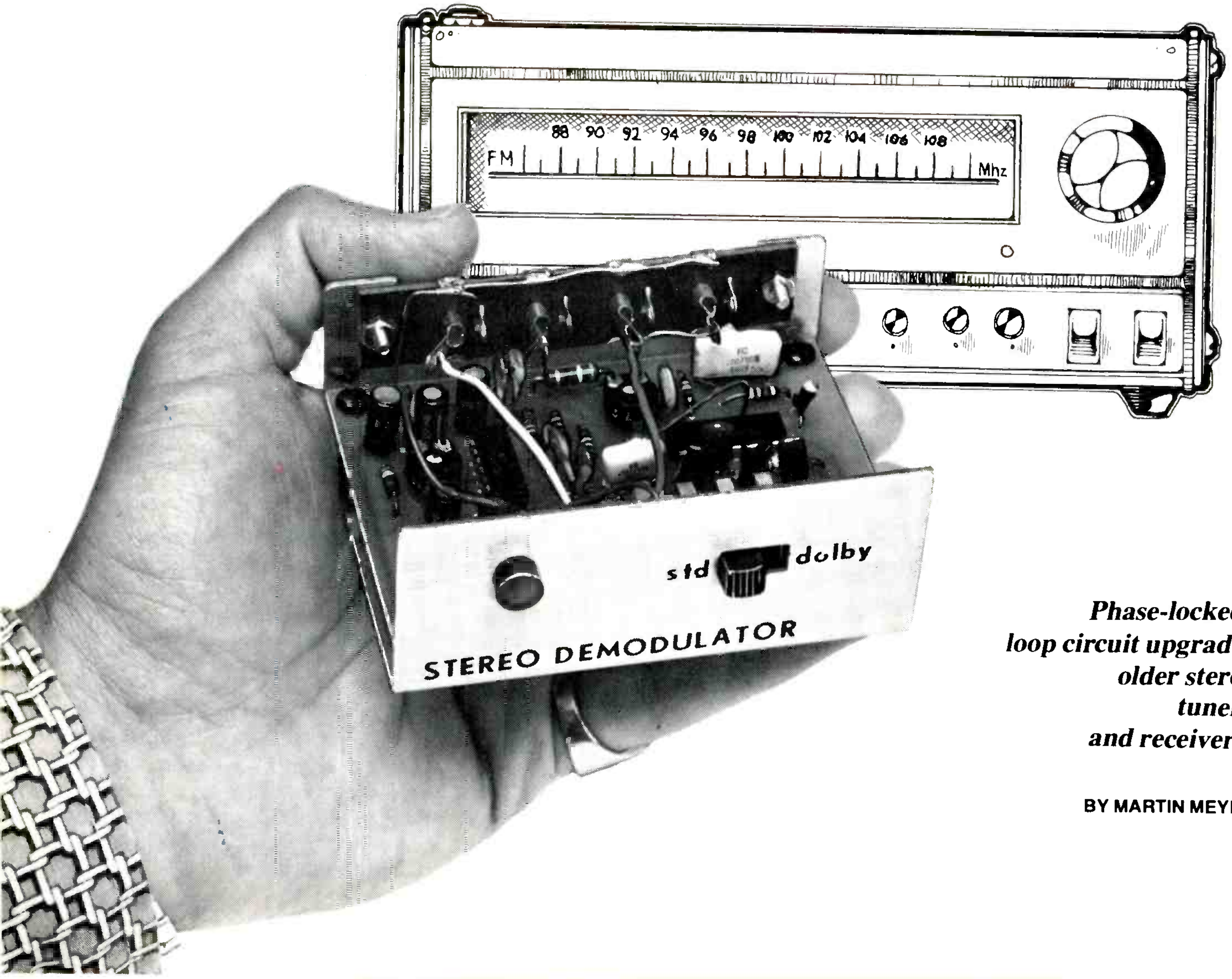
TODAY'S state-of-the-art audio components yield levels of performance unattainable a few years ago. However, most of us can't update our sound systems as frequently as technological advances are made. This project—an add-on phase-locked-loop multiplex decoder—will allow the user to improve the stereo FM demodulation of an existing receiver or tuner for about $25. Only a few hours of assembly and alignment time is required. The PLL decoder will not only improve channel separation and lower distortion levels, but will also select deemphasis time constants for standard and Dolby-FM broadcasts.

About the Circuit. The heart of the PLL multiplex demodulator is the LM1800A, an IC manufactured by National Semiconductor. A block diagram of the LM1800A is shown in Fig. 1. The phase-locked loop comprises a voltage controlled oscillator (vco), frequency dividers, phase detectors, low-pass filtering and an error amplifier. Also included are a voltage regulator allowing operation from 12-to-24-volt supplies, automatic stereo monaural switching, and use of a stereo indicator lamp.

In the absence of an input signal, no error signal is generated and the vco oscillates at a frequency designated as f_0. When a composite FM signal is applied to the input, the loop phase detector generates an error signal which is filtered and amplified. This amplified error voltage shifts the oscillating frequency of the vco to exactly 76 kHz. Filtering performed at the phase detector and error amplifier prevents modulation of the vco by the input signal.

The vco input frequency is divided by two, resulting in a 38-kHz carrier used in the synchronous demodulation of the composite signal. Passing the 38-kHz signal simultaneously through a pair of ÷*2* counters produces two 19-kHz signals which are applied to the IC's two phase detectors. If the 19-kHz pilot signal drops below the level at which a satisfactory stereo signal can be recovered, an electronic switch causes the IC to produce a monaural output.

The schematic diagram of the complete multiplex detector is shown in Fig. 2. Input signals are capacitively coupled by *C5* to level control *R5*. Capacitor *C4* passes the composite FM input to the base of *Q1*, which amplifies it to a level



Phase-locked-loop circuit upgrades older stereo tuners and receivers.

BY MARTIN MEYER

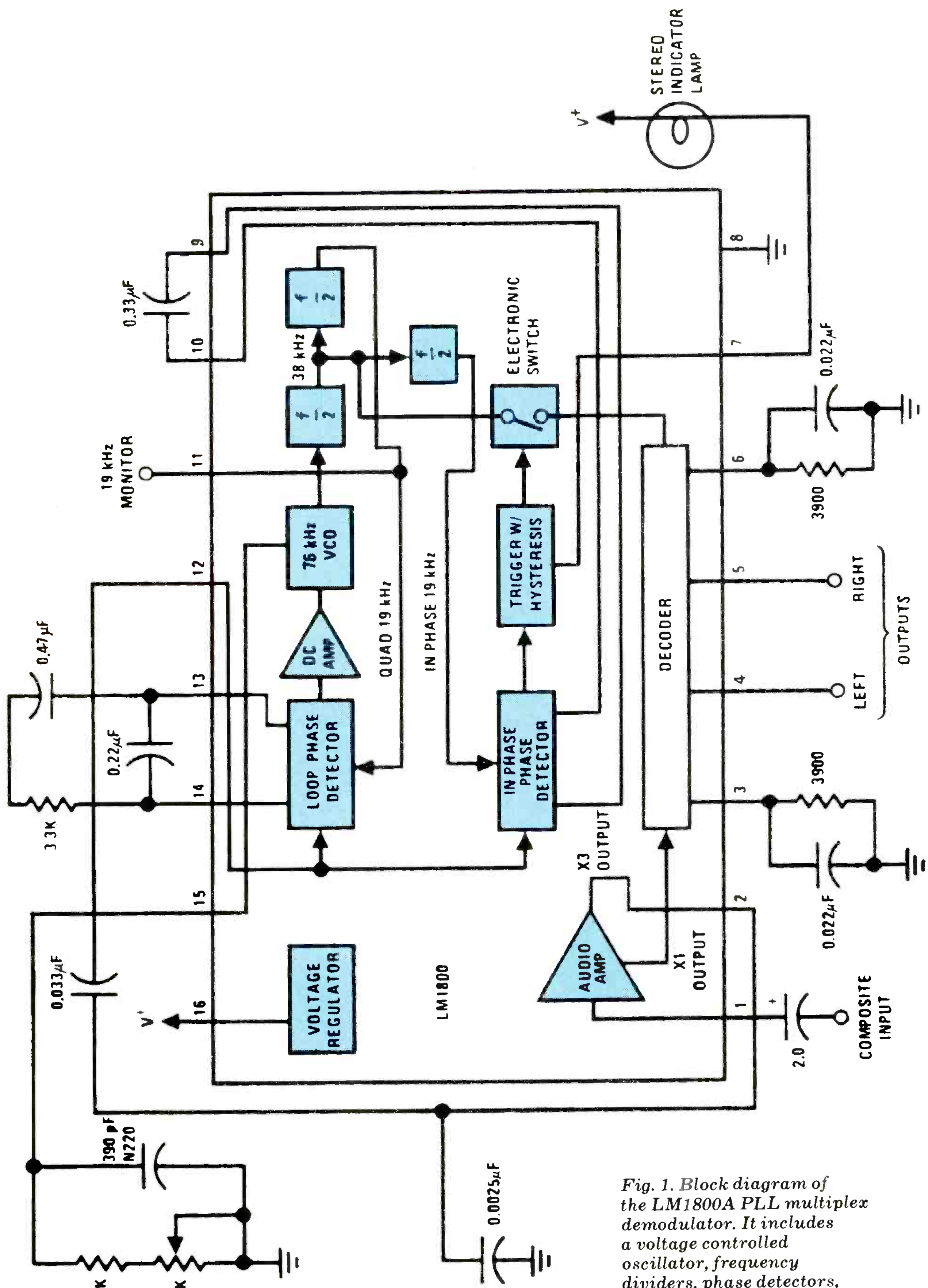


Fig. 1. Block diagram of the LM1800A PLL multiplex demodulator. It includes a voltage controlled oscillator, frequency dividers, phase detectors, low-pass filtering and error amplifier.

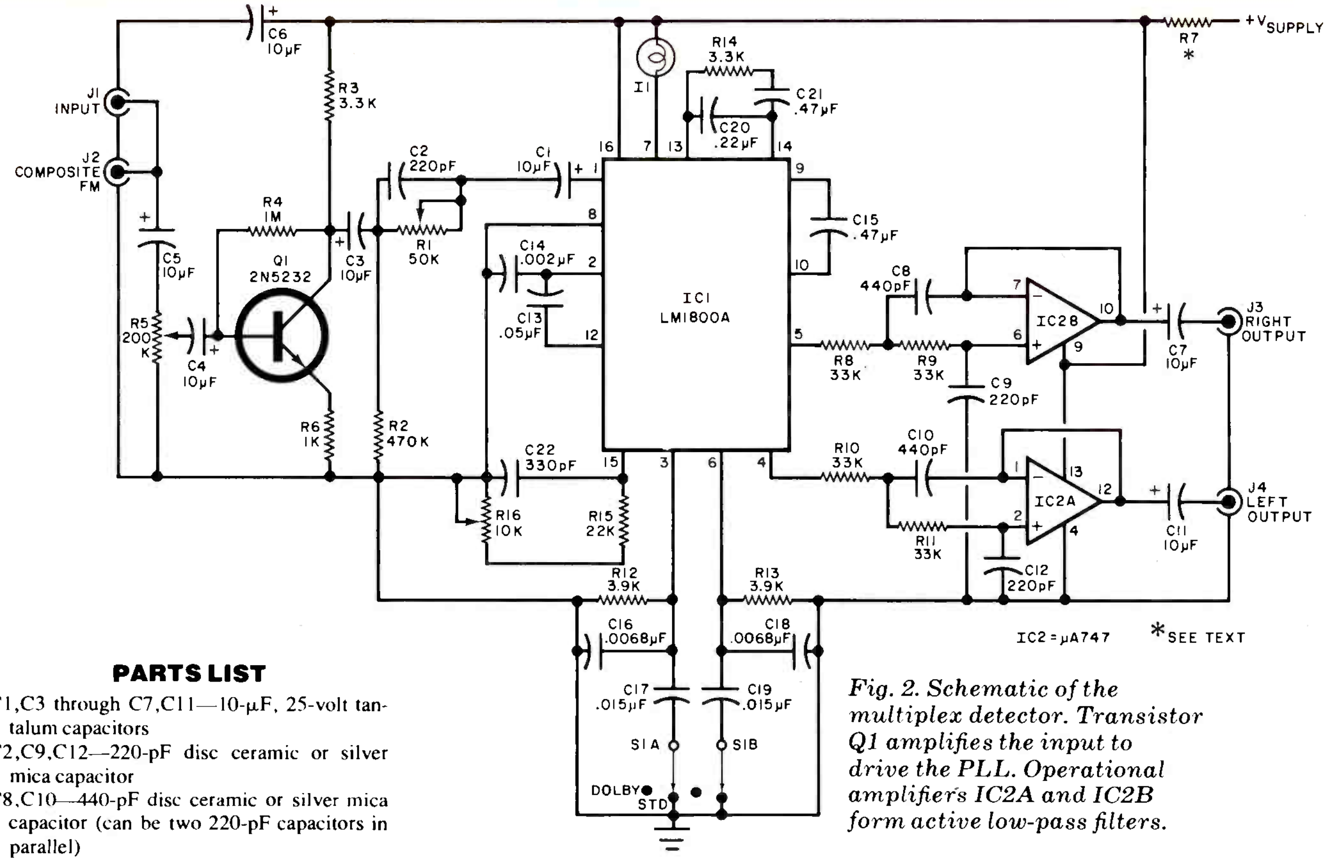


Fig. 2. Schematic of the multiplex detector. Transistor Q1 amplifies the input to drive the PLL. Operational amplifiers IC2A and IC2B form active low-pass filters.

PARTS LIST

C1,C3 through C7,C11—10-μF, 25-volt tantalum capacitors
C2,C9,C12—220-pF disc ceramic or silver mica capacitor
C8,C10—440-pF disc ceramic or silver mica capacitor (can be two 220-pF capacitors in parallel)
C13—0.05-μF disc ceramic capacitor
C14—0.002-μF disc ceramic capacitor
C15, C21—0.47-μF Mylar capacitor
C16,C18—0.0068-μF, ± 10% Mylar capacitor
C17,C19—0.015-μF, ± 10% Mylar capacitor
C20—0.22-μF Mylar capacitor
C22—330-pF disc ceramic or silver mica capacitor
I1—12-V, 35-mA pilot light
IC1—LM1800A PLL multiplex decoder
IC2—747 dual operational amplifier
J1 through J4—RCA phono jacks
Q1—2N5232 npn silicon transistor
The following are linear-taper, pc trimmer potentiometers:
R1—50,000 ohms
R5—200,000 ohms
R16—10,000 ohms
The following are 10% tolerance, ¼-watt carbon-composition fixed resistors:
R2—470,000 ohms
R3,R14—3300 ohms
R4—1 Megohm
R6—1000 ohms
R7—See text.
R8 through R11—33,000 ohms
R12,R13—3900 ohms
R15—22,000 ohms
S1—Dpdt slide or toggle switch
Misc.—Printed circuit board, suitable enclosure, hookup wire, shielded cable, pilot light jewel, hardware, solder, etc.
Note—The following are available from Netronics Research and Development, Ltd., 333 Litchfield Road, New Milford, CT 06776: complete kit including all components, pc board, screened enclosure, less audio cables, $24.95; complete kit as above but less screened enclosure, $19.95. U.S. residents add $1.50 postage and handling; Canadians add $3.00. For receiver connection info, send schematic, SAS envelope and $1 (free if purchasing kit). Connecticut residents add 7% sales tax.

that will properly drive the phase-locked loop. The parallel combination *C2R1* provides compensation for high-frequency rolloff in the tuner's i-f and detector stages. Resistors *R12* and *R13* and capacitors *C16* through *C19* provide deemphasis for multiplex decoder *IC1*. When *S1* is in the STD position, the standard 75-μs FM deemphasis characteristic appears. Placing *S1* in the DOLBY position changes the deemphasis to 25 μs, which corresponds to the reduced preemphasis used in Dolby-encoded broadcasts.

Operational amplifiers *IC2A*, *IC2B*, and their associated components form active low-pass filters with 16,000-Hz cutoff frequencies and 12-dB/octave slopes. These filters attenuate any 38-kHz carrier and 67-kHz SCA components which would otherwise appear at the left and right audio outputs. If allowed to pass, these signals could cause beats and whistles when program material is recorded on tape. Indicator *I1* glows in the presence of stereo pilot carrier. Jack *J2* is wired in parallel with input jack *J1*, providing access to the composite FM signal for such accessories as 4-channel and SCA demodulators.

Construction. Printed circuit guides for the project are shown in Fig. 3. Mount all components on the board, paying close attention to pin basing and polarities of semiconductors and electrolytic capacitors. Power can be tapped from any +12- to +24-volt dc source. The tuner's i-f stage or existing multiplex decoder is usually powered by a +15- to +20-volt supply which can be utilized for this purpose. Select the value of *R7* in kilohms according to the equation:

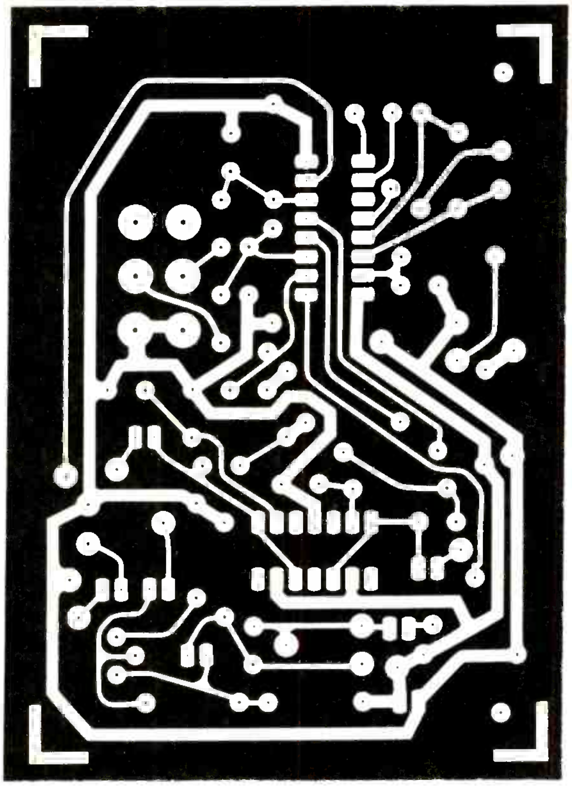
$$R7 = (V_{supply} - 12)/55$$

A one-watt carbon composition resistor will have adequate heat dissipation capability for this application.

The tuning lamp used in the author's prototype (and supplied with the kit) draws 35 mA at 12 volts. If you substitute another incandescent lamp or a LED and current limiting resistor, modify the equation for the value of *R7*. Replace the 55 mA in the denominator with the sum of 20 mA (the current required by the PLL and active filters) and the

TABLE I
LM1800A SPECIFICATIONS

Stereo Separation—100 Hz:	40 dB
1000 Hz:	45 dB
10,000 Hz:	45 dB
SCA Rejection:	50 dB
Total Harmonic Distortion:	0.2 %
Ultrasonic Frequency Rejection:	45 dB



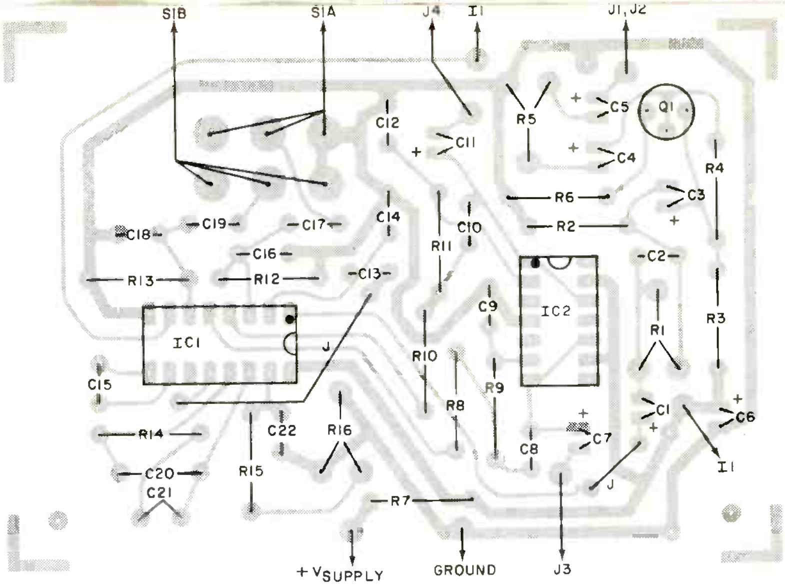


Fig. 3. Etching and drilling guide for multiplex decoder is shown at left. Component placement guide is above.

current required by the indicator. For example, if a LED and resistor drawing 20 mA are used, the denominator would be 40 mA.

The project can be mounted in the tuner cabinet or housed in a separate enclosure. If it is placed in the tuner cabinet, mount *S1* on the rear panel of the tuner and connect it to the pc board via low-capacitance shielded cable such as RG-59-U. The same type of cable should also be used to conduct the composite FM signal from the detector output to the input of the multiplex decoder.

If your tuner or receiver has a "composite FM" or "FM detector" output jack, the required signal is available there. If not, you will have to locate the FM detector and tap the signal at that point. The partial schematic of a typical FM receiver is shown in Fig. 4. The composite signal is obtained by disconnecting the existing multiplex decoder and tapping the signal at point A.

The left and right audio outputs are available at jacks *J3* and *J4*. If you are using the project in place of the multiplex decoder in a tuner, you can either use these jacks in place of those in the tuner, assuming the decoder is mounted externally. If it is mounted internally, you can disconnect the outputs of the existing multiplex decoder from the output jacks on the tuner's rear panel and connect the outputs of the decoder's active filters.

Similarly, if you have a receiver and are mounting the project in an external enclosure, you can connect the decoder's outputs to the tape monitor circuit. Mounting the decoder inside the receiver cabinet suggests an internal connection. Remove the output leads at the ex-

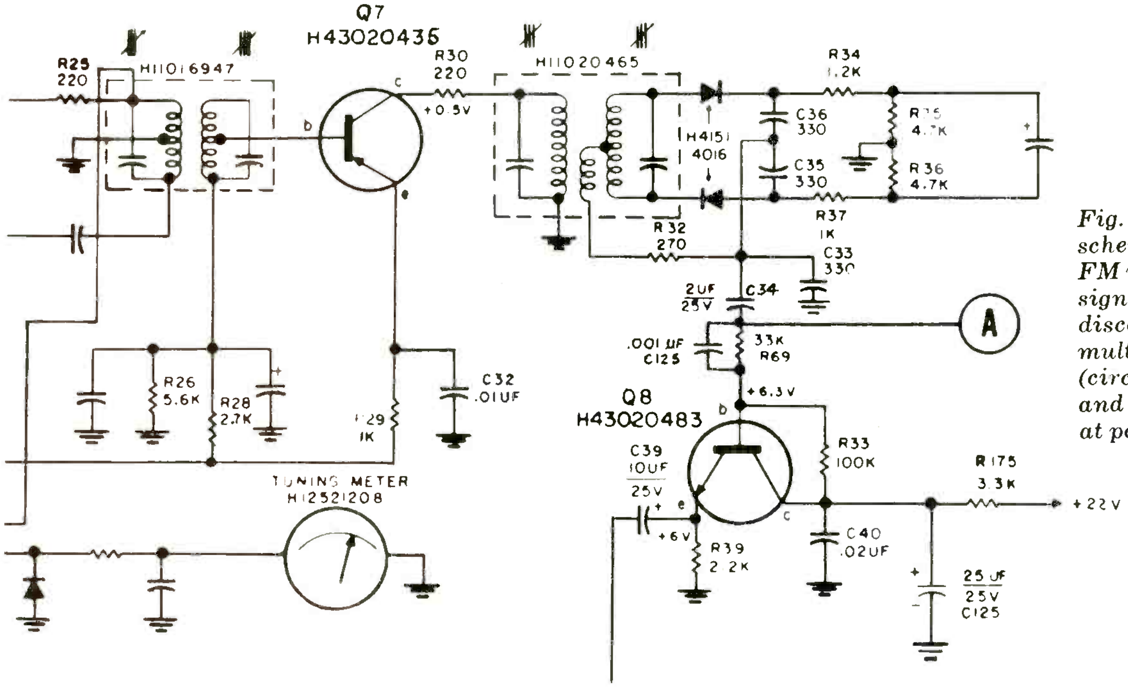


Fig. 4. Partial schematic of typical FM receiver. Composite signal is obtained by disconnecting existing multiplex decoder (circuit below C34) and tapping signal at point A.

isting multiplex decoder running to the appropriate lugs on the receiver's MODE switch. Then connect them to the decoder's active filter outputs.

Alignment. When properly aligned, the project will provide performance as outlined in Table I—assuming no degradation in the tuner's i-f and FM detector. Two typical receivers were used with the PLL decoder. Results are shown in Table II. The alignment procedure about to be described requires no test instruments, but will yield good results. The author was able to improve the stereo separation only 2 dB when instrument alignment was performed with an expensive FM stereo generator.

Rotate potentiometers *R1* and *R16* to the midpoint of wiper travel, and *R5* for maximum signal drive at the base of *Q1*. Turn on your receiver and tune in a station broadcasting in stereo. Indicator *I1* should glow. If not, adjust *R16* until it does. Then turn *R16* fully clockwise. If *I1* still glows, adjust *R5* until the indicator just goes out. Slowly rotate *R16* counterclockwise until the lamp begins to glow. Note the position of the control. (It may be necessary to adjust *R5* slightly.)

Next, turn *R16* fully counterclockwise, adjusting *R5* again if necessary to extinguish the lamp. Slowly rotate *R16* clockwise until the lamp glows, noting the position of the control. Set *R16* midway between the two positions noted. Adjust *R5* until the lamp goes dark, then slowly turn it until the lamp just starts to glow. Advance the wiper of *R5* another 10°. This will properly tailor the input level to decoder *IC1*.

Potentiometer *R1* is included in the circuit for adjustment if test equipment or a cooperative FM broadcast engineer is available. Since all stations must conduct tests and certify the quality of their signals once a year, you can easily check out adjustments. Call several local stations and ask when they will perform the tests. If it is late at night, the engineer might turn off a channel for 30 seconds or so. While only one channel is being transmitted, adjust *R1* for maximum separation at any mid-band frequency. Note, however, the setting of *R1* will not have a critical effect on the performance of the decoder and can simply be left midway between the two adjustment extremes. ◇

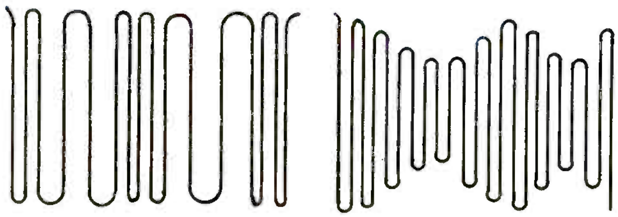
TABLE II—RECEIVER MODIFICATION RESULTS

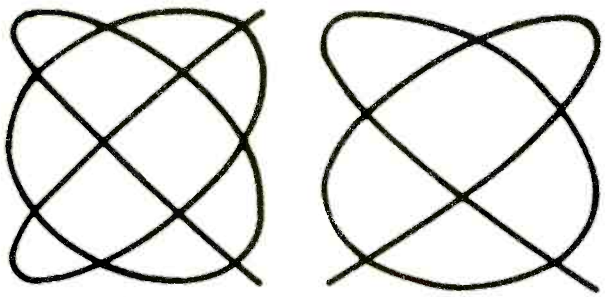
	Sony STR-6060FW		Harman Kardon SR900	
	Before	After	Before	After
Stereo Separation—100Hz:	20 dB	32 dB	25 dB	30 dB
1000 Hz:	28 dB	42 dB	32 dB	42 dB
10,000 Hz:	18 dB	30 dB	25 dB	33 dB
Total Harmonic Distortion (1000 Hz):	0.5%	0.3%	0.6%	0.25%

Quiz of Audio Basics

BY ROBERT P. BALIN

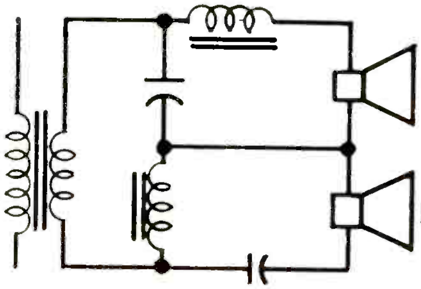
1 Which of these audio waveforms indicates the use of tremolo and which is vibrato?



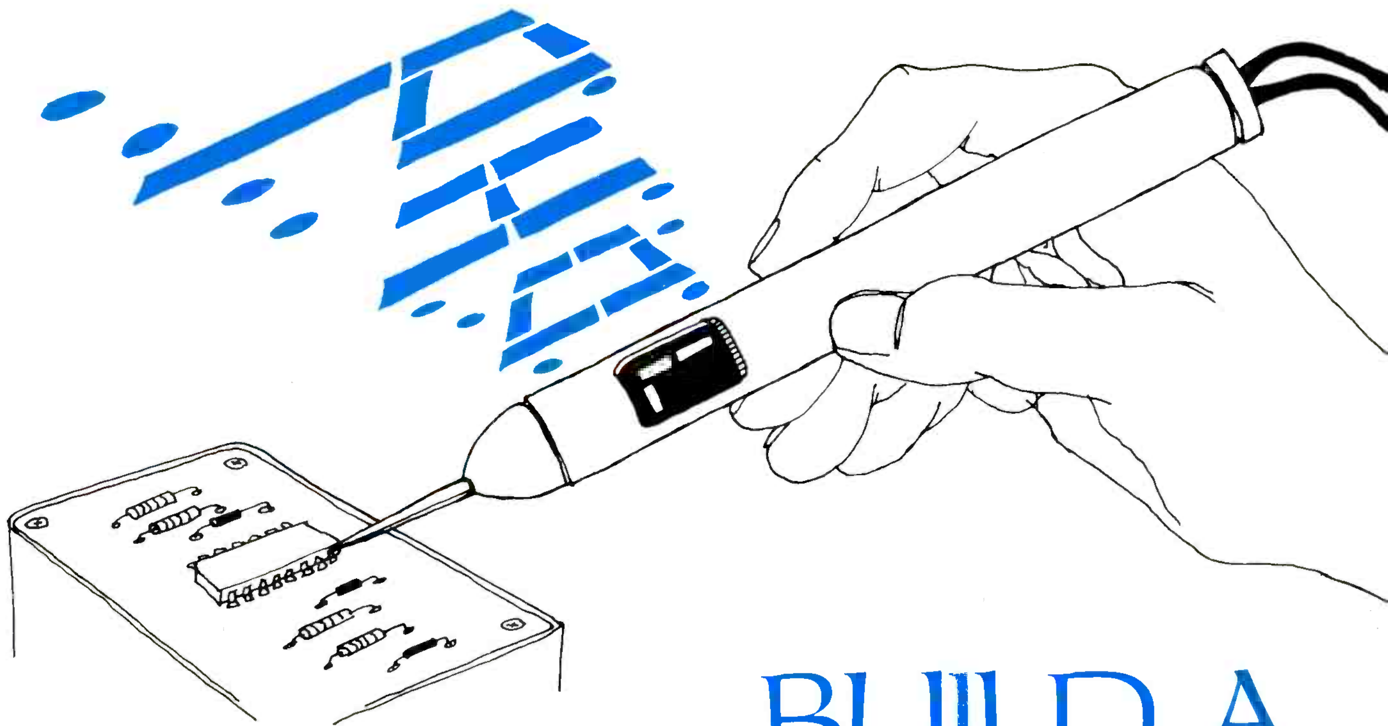


2 If the vertical frequency used to produce these Lissajous patterns is 1000 Hz, which has a horizontal frequency of 1200 Hz and which is 1250 Hz?

3 With this crossover network, which speaker is the woofer and which the tweeter?



ANSWERS
1. TREMELO, B; VIBRATO, A.
2. 1200-Hz A; 1250 Hz, B.
3. WOOFER, A; TWEETER, B.



BUILD A DIRECT-READING LOGIC PROBE

Seven-segment readout displays high, low, open, and pulse.

By R.M. STITT

THE LOGIC probe is almost a necessity in checking digital circuits. Usually the probe detects and discriminates between high-level, low-level, and pulse conditions at various points in a digital circuit. The results are then displayed on miniature lamps or discrete light-emitting diodes.

If you want a more advanced logic probe, try the one described here. It does what the conventional probe does, but has the additional capability of being able to sense an open circuit or an out-of-tolerance high or low logic level. And the indicator is a single seven-segment LED display. The four possible test conditions are shown as actual letters on the seven-segment display.

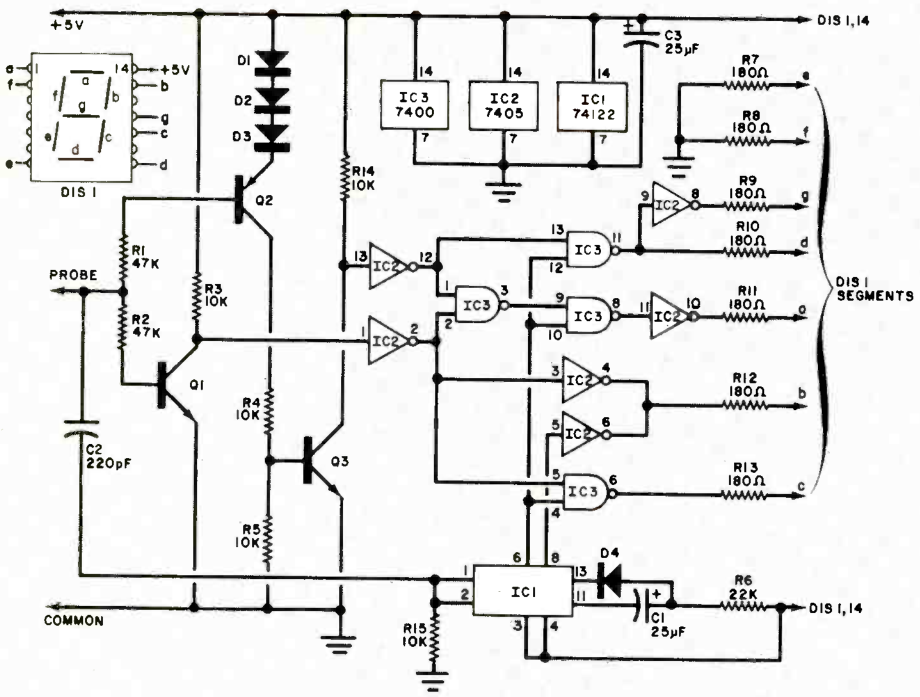
The letters are: H (high logic level), L (low logic level), O (open), and P (pulse). This type of display makes testing faster and improves accuracy in reading the results.

How It Works. Shown in Fig. 1 is the logic probe's schematic diagram. Transistor *Q1* functions as a voltage comparator and buffer with a threshold of approximately 0.6 volt. Transistor *Q2* and diodes *D1*, *D2*, and *D3* function as a voltage comparator and buffer with an approximate 2.4-volt threshold. These thresholds are slightly wider apart than is standard for TTL devices, thus providing a safety margin.

Resistors *R4* and *R5* and transistor *Q3* shift the level of *Q2* to make it TTL compatible. The outputs of the two comparator circuits are further buffered and conditioned by *IC2*, the high (H) and low (L) outputs of which are decoded by the remaining circuitry. Assuming that the point under test is either at a constant high or a constant low, the end result will be an H or an L displayed on *DIS1*.

In the event of any pulse activity at the point under test, one-shot multivibrator *IC1* will trigger and generate a P (for pulse) on *DIS1*. If a single pulse occurs at the test point, *IC1* will still cause a P to be displayed, but only for about 0.5 second. (The probe is capable of "capturing" pulses as short as 10 ns in duration.)

Any time the probe tip is not touching a point in the test circuit or is



PARTS LIST

C1,C3—25-µF, 6-volt tantalum electrolytic capacitor
C2—220-pF ceramic disc capacitor
D1 thru D4—Signal diode (1N914 or similar)
DIS1—Common cathode seven-segment LED display (Opcoa SLA-7 or similar)
IC1—Retriggerable monostable multivibrator (74122)
IC2—Hex inverter (7405)
IC3—Quad two-input NAND gate (7400)
Q1,Q3—Npn silicon switching transistor (2N3904 or similar)
Q2—Pnp silicon switching transistor (2N3906 or similar)
The following are ¼-watt, 5% tolerance resistors
R1,R2—47,000 ohms
R3,R4,R5,R14,R15—10,000 ohms
R6—22,000 ohms
R7 thru R13—180 ohms
Misc.—Printed circuit board; 7¼" × ½" inner diameter CPVC plastic tubing; ⅝" or ½" diameter hardwood dowel stock (see text); one red- and one black-booted alligator clips; 72" length of No. 18 test lead cable; 6d finishing nail; solder; etc.

Fig. 1. Schematic diagram of the logic probe. Transistors Q1 and Q2 are in comparator circuits which set the logic levels. IC2 and IC3 decode the signal.

touching a point that is electrically isolated from the circuit, *DIS1* will display an O. Furthermore, any logic level that is within the range set by the comparators will also result in an O being displayed.

In operation, H indicates a high TTL state (greater than 2.5 volts); L indicates a low TTL state (less than 0.6 volt); O indicates an open circuit or an out-of-tolerance TTL state (high impedance or less than 2.5 volts but greater than 0.6 volt); and P indicates a pulse train or single pulse.

Construction. When assembling the probe, parts layout and lead dress are not particularly critical. The test prod lead should be kept as short and direct as possible through the junction of *R1* and *R2*.

To keep the electronic assembly as compact as possible, a printed circuit board is a must for component mounting. The etching and drilling and component placement guides are shown in Fig. 2. Since you will be making your own double-sided board and will not be able to plate through the holes, it is important to solder connections on *both* sides of the board. Consequently, you must install the components in a set sequence. Install and solder into place *R7, R9, R13,* and *R15* before you install *R8, R10, R11,* and *R12*. Likewise, install *C2* before *C1*. All remaining components can be installed in whatever sequence you desire. (Note: The component placement guide shown in Fig. 2 is the view from the top, or component, side of the board. The items to be installed first are indicated in phantom in Fig. 2.)

After wiring the circuit board, solder a 1" (25 mm) length of insulated wire to the pad under *DIS1* nearest the end of the board. The free end of this wire goes to the probe's test tip. Prepare the ends of two 36" (about 1-m) lengths of test-lead cable, and solder one end to the +5-volt and ground pads on the board.

Now, cut a ¾" long by 5/32" deep (19 × 3.8-mm) window ½" (13 mm) from one end of the tube. Use CPVC tubing; it has thinner walls to provide a slenderer assembly than is possible with ordinary PVC tubing. CPVC tubing is available from most hardware and building supply stores.

You can fabricate the end caps for the tube to the dimensions given in Fig. 3 by turning on a lathe or whittling with a knife ⅝" (16-mm) diameter hardwood dowel stock. If you don't have access to a wood-turning lathe or don't relish whittling, you can fashion blunt end caps from ½" hardwood dowel stock and use small screws to hold them in place. In either case, drill a ¼" (6.5-mm) diameter hole through the rear end cap and a hole just large enough to require force fitting a 6d finishing nail into it through the front end cap.

Pass the power leads for the probe through the hole in the rear end cap. Connect and solder a red-booted alligator clip to the +5-volt and a black-booted alligator clip to the ground cables.

Test the probe by connecting its power cables to the +5-volt and common buses of a known good circuit and touching the probe lead to the +5-volt bus, common bus, and a point in the circuit where there are pulses. When the power leads are initially hooked up, the display should indicate 0. Touching the probe lead to the +5-volt and common buses should cause an H and an L to be displayed, respectively. With the probe lead touching a point in the circuit where pulse activity is taking place, the display should indicate a P.

The circuit board is deliberately wider than the inside diameter of the plastic tube. To get the board into the tube, you will have to deform the latter. To do this, place the tube between two blocks of wood in a vise and very carefully close the vise just enough to permit the board to slip into place. Before opening the vise, make certain that the display is centered in the window of the tube.

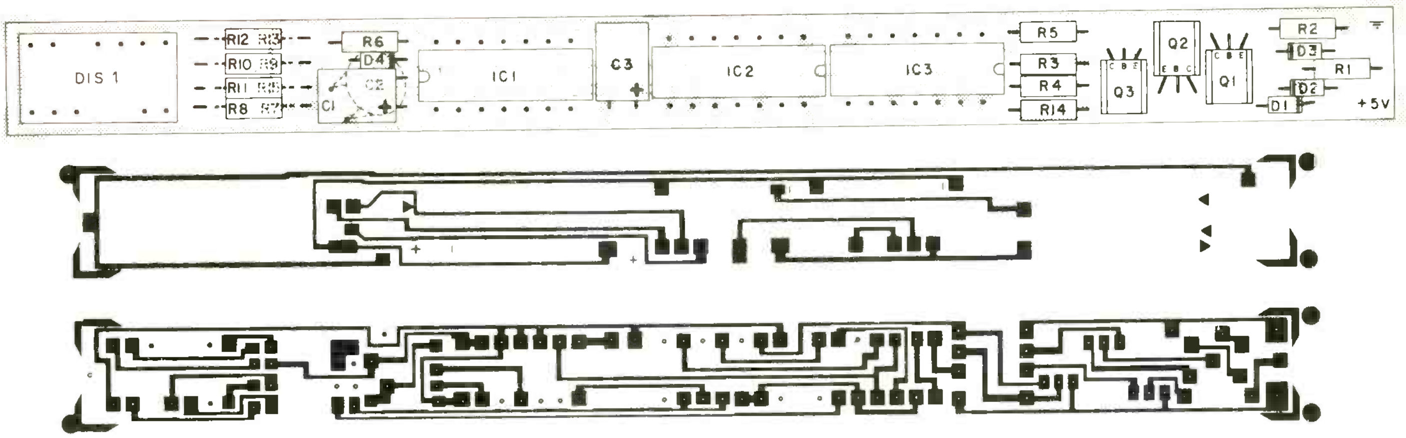
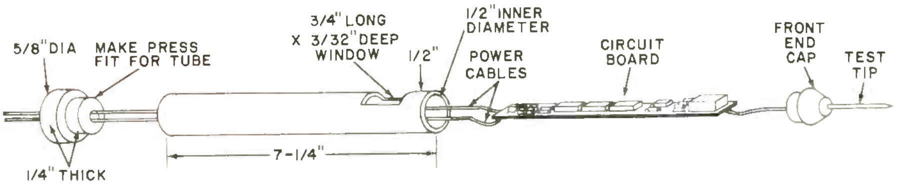
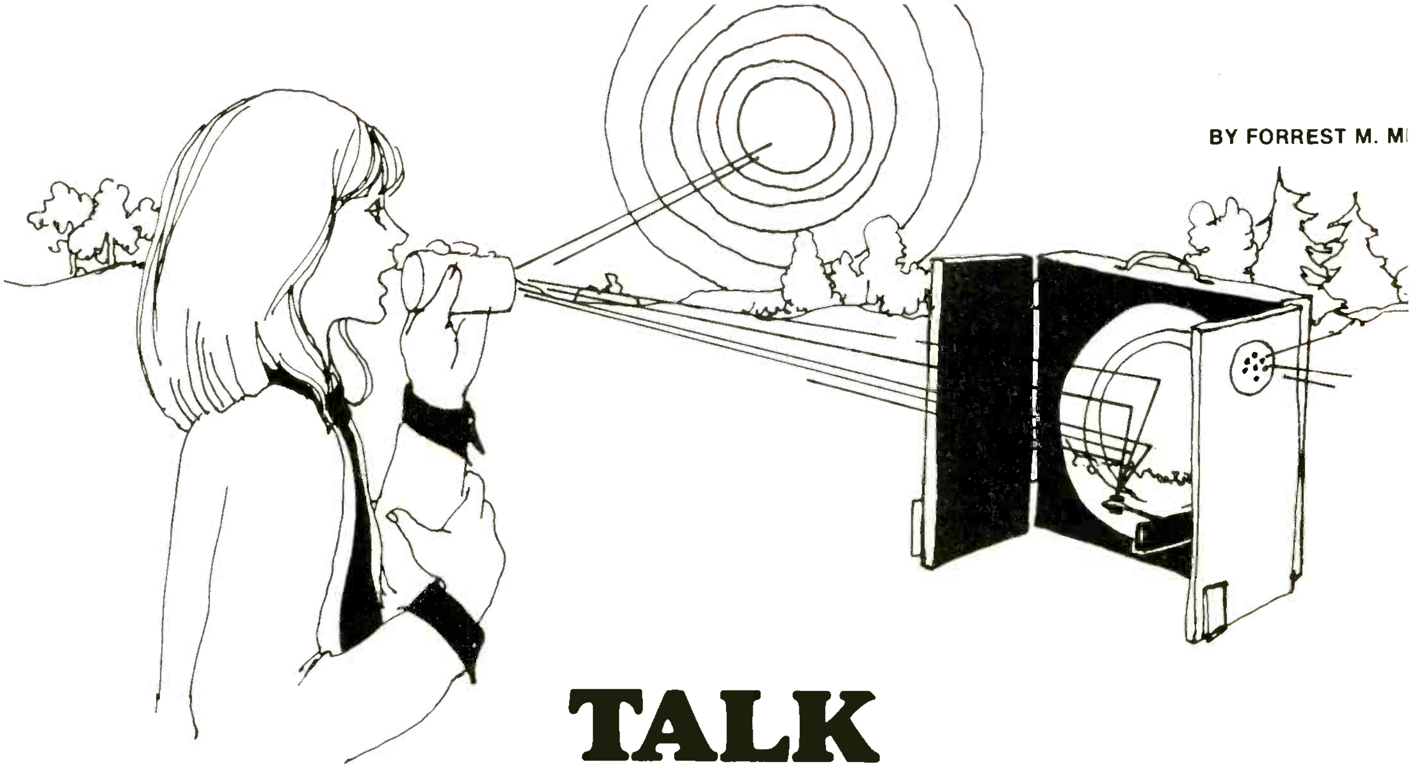


Fig. 2. Etching and drilling guides and component layout for pc board are above.

Fig. 3. Diagram shows how to assemble the probe. Be sure display shows in the window.



File or grind the point of the finishing nail to a sharp tip, contouring it like a standard test-probe point. Drive the nail into the front end of the cap, leaving about 1/4" of the nail head free. Locate the free end of the probe tip wire coming from the circuit board. Strip away about 3/8" of insulation from the wire, wrap the exposed wire around the nail head, and drive the nail home in the end cap. Push both end caps into the tube (and secure them with small screws if necessary), and the probe is ready to use. ◈



BY FORREST M. MI

TALK OVER A SUNBEAM WITH A "PHOTOPHONE"

Modernized version of Alexander Graham Bell's sunlight communicator provides some 1880 electronics nostalgia—that works.

A LITTLE-KNOWN fact about the inventor of the telephone is that Alexander Graham Bell considered an electro-optical communicator he called a "Photophone" to be his greatest invention, greater even than his telephone. In 1880, Bell and Sumner Tainter communicated by voice over a beam of reflected sunlight. This was 19 years before A. Frederick Collins conducted the first feeble voice transmissions over a distance of three blocks in Narberth, Pennsylvania. So, the first "wireless" voice transmissions were *not* by radio, as history would have us believe.

Compared to the power-hungry radio-telephone medium that developed 25 years after Bell's discovery, the Photophone was an elegantly simple technological marvel.

Bell and Tainter succeeded in developing more than 50 ways of voice-modulating a beam of light, including variable-polarization schemes used today in sophisticated laser communication systems.

Photophone Details. The simplest of Bell's and Tainter's modulators consisted of a small flat mirror cemented to a hollow cylinder. Voice energy directed into the open end of the cylinder caused the surface of the mirror to flex in step with the speech patterns. Thus, by shining a continuous beam of light onto the mirror's surface, a variable beam impressed with the voice modulation was produced.

Most of the light-beam receivers used with the Photophone employed selenium detectors. (In 1873, it was discovered that the resistance of bulk selenium changed in response to varying light intensity.) It was after Bell had read about selenium experiments that, in 1878, he conceived his Photophone idea.

One of Bell's detectors consisted of a circular array, while another consisted of a cylindrical array of selenium cells. the first was designed to be used with a collector lens, while the latter was designed to be used with a parabolic reflector. Both detectors were connected in series with a battery and a telephone receiver to make up the receiving equipment for the Photophone.

On April 1, 1880, Tainter voice-modulated a beam of sunlight from a mirror and talked to Bell over a 699-ft (213-m) range. After this, Bell made optimistic predictions about the future of his Photophone, none of which materialized during his lifetime. In fact, shortly after Bell's death, in 1921, the Photophone was used mainly in a few military applications. Bell was criticized and even mocked for his opinions and predictions. Today, as we are poised on the threshold of large-scale light-beam communication, the inventor has been vindicated. In short, his predictions after all these years are finally materializing.

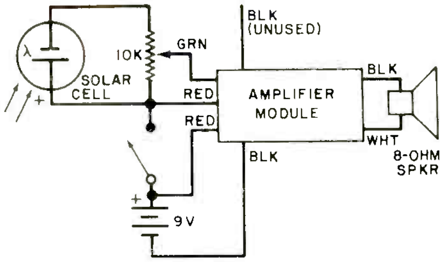


Fig. 1. Schematic diagram of a simple Photophone receiver.

BILL OF MATERIALS

Transmitter:

1—25-mm diameter mirror (see text)
1—2"–3" length of 1" outer-diameter rigid tubing
White glue

Receiver

1—16" diameter parabolic mirror (see text)
1—Audio amplifier module (see text)
1—Miniature 8-ohm loudspeaker
1—10,000-ohm potentiometer with spst switch
1—2 × 2-cm silicon solar cell
1—9-volt battery
1—Miniature phone plug and jack
1—17" × 17" piece of ½" plywood (rear panel)
2—17" × 3" pieces of ½" plywood (side panels)
2—16" × 3" pieces of ½" plywood (top and bottom panels)
2—3" lengths of ¾" × ¾" pine (cabinet feet)
2—3" × 1½" pieces of ½" plywood (door legs)
1—12" length of 1½" × ⅜" piece of hardwood lumber (detector arm)
1—3" length of 1½" × ⅜" piece of hardwood lumber (detector arm)
1—1½" length of 1½" × ⅜" piece of hardwood lumber (detector arm)
1—6" length of 1" × 1" pine (door-opener block and mirror retainers)
1—16" length of ¼"-diameter hardwood dowel (door opener and solar cell)
5—Metal hinges (doors and detector arm)
1—Drawer pull (cabinet handle)
1—Hasp and lock, or hook and eye
Misc.—Flat black and white enamel paint; resilient foamed plastic; white glue; #6 machine hardware; 1" finishing nails; vinyl electrical tape; battery clip and battery holder; metal spacers (4); stranded hookup wire; solder; etc.

Build a Photophone. In this Photophone Centennial year, Bell's sunlight communication experiments can easily be bettered and duplicated with modern solar cells and audio amplifier modules. You can start with Bell's simple mirror-and-cylinder transmitter. An excellent choice for this purpose is the $1.65 Cat. No. 30,626 mirror from Edmund Scientific Co. (300 Edscorp Bldg., Barrington, NJ 08007). This mirror measures 25 mm in diameter and nicely mates with a 1" (25.4-mm) diameter tube.

Cut the tube to a length of about 2" (50.8-mm). Then, use white glue to cement the mirror to one end of the tube. Make certain that the aluminized surface of the mirror is facing outward to obtain best results. (You can determine which is the mirror's aluminized surface by touching both surfaces with the point of a pencil and observing the reflections. The side that shows *no* gap between the real and the image points is the aluminized surface of the mirror.) True, the uncoated surface of the mirror is more resistant to scratches and abrasion, but if this surface faced outward, 5% less light would be reflected, which means you would have a shorter communication range.

For more transmitter power, remove both ends from a metal can and tape aluminized mylar or aluminum foil over one end. Or tape a square sheet of either of these reflective materials over a circular hole cut in a sheet of corrugated board. It is important that the surface of the reflector be smooth and taut for best results.

The Photophone receiver can be as simple as a single silicon solar cell connected to the input of a portable audio amplifier. You can salvage an amplifier from a discarded cassette recorder (Fig. 1 shows typical connections) or use a preassembled version such as Radio Shack's new Pocket Speaker Amplifier (277-1008A).

A convenient housing for a basic receiver can be had by modifying a flashlight, such as the Burgess "Dolphin." This flashlight's built-in reflector is an ideal place for mounting a pair of solar cells because it would reflect far more light onto the cells than would be possible if the cells were used by themselves.

Mount two solar cells, back-to-back

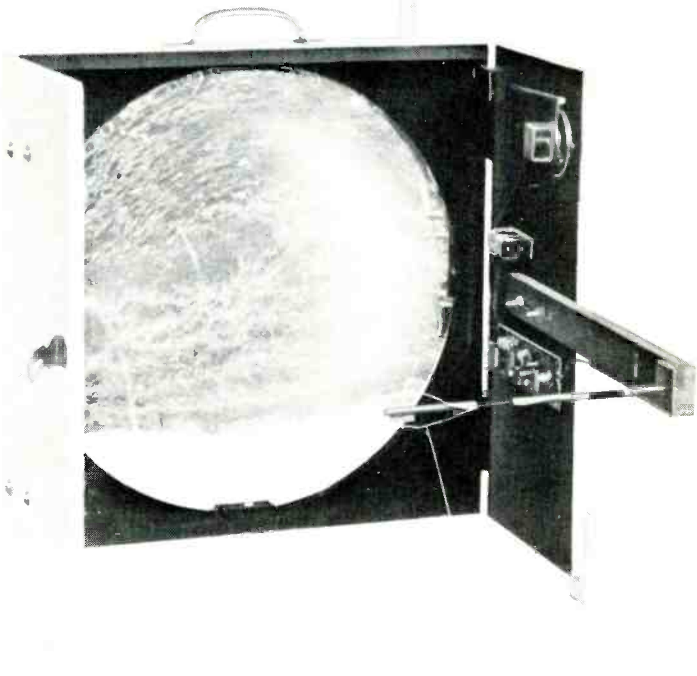


Fig. 2. This receiver can pick up good signals as far as ½ mile.

and connected in series with each other, by their leads with their plane lying along the axis of the reflector. Focus the detector by adjusting the mounting leads while observing their reflections. When the dark surfaces of the two cells fill the entire area in the reflection, the cell detector is properly aligned.

Getting Greater Range. The Photophone receiver described above will have a range of up to 550′ (168 m). For really long-range communication by sunlight, you can use a large Fresnel lens or parabolic mirror to increase the optical gain of the receiver's detector. A 16″ (40.2-cm) reflector—complete with detector, amplifier, battery, and loudspeaker—is shown in a plywood cabinet in Fig. 2. This receiver can pick up good-quality voice and music from as far away as a half mile. Increasing the transmitter's mirror as well, will increase the communication range even more.

You can duplicate this receiver by following the construction details given in Figs. 3 and 4. Make the cabinet from ½″ (1.27-cm) thick plywood, but don't install the doors until later. Paint all inside surfaces of the cabinet flat black and all outside surfaces white enamel. The black in the interior reduces stray light reflections, while the white exterior makes for good visibility during alignment.

The 16″ parabolic mirror is available from Edmund Scientific for $19.95 as Cat. No. 80,097. It is aluminized on its rear surface, which prevents it from being a perfect reflector. But the mirror's ½″ circle of reflected light at the focal point is about the same size as the photocell, which at least partially makes up for its shortcoming.

Four wood retainers hold the mirror in place inside the cabinet. After cutting these retainers to size, use white glue to cement strips of resilient foamed plastic along one entire narrow face of each. Then, while the glue is setting, locate and drill the mounting holes for the retainers. By this time, the glue should have set. Paint each retainer block—not the foamed plastic—flat black and let them dry.

Meanwhile, mount a pair of pine legs on the bottom of the cabinet. install the carrying handle on the top of the cabinet, and use white glue to cement a 1″-square piece of resilient foamed plastic in the center of the inside rear wall of the box.

Mount the hinges on the cabinet's doors. Carefully align the doors with the front edges of the side, top, and bottom panels, and mark the locations of the remaining hinge holes. Remove and set aside the doors and drill the holes at the points indicated.

Now, lifting the mirror only by its edges, carefully position it in the cabinet. Mount the four retainer blocks in place with their foamed surfaces against the mirror's edge. The foamed plastic should be lightly compressed, holding the mirror firmly but gently in place, when all four retainers are fastened down with machine hardware. Once the mirror is in place, exercise care when working around it. Always place a thick bath towel or a blanket over the mirror when you are working on the cabinet.

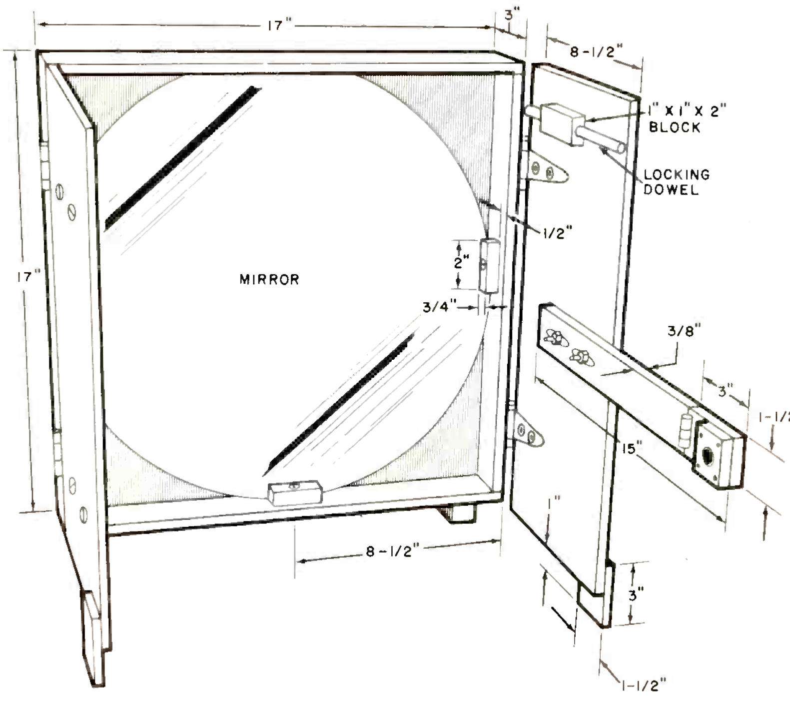


Fig. 3. Dimensions of the plywood cabinet for the Photophone. Mirror is held in place by wood blocks.

The detector used in this receiver should be a single 2 × 2-cm silicon solar cell mounted at the end of a hardwood dowel (see Fig. 4). The dowel plugs into a two-section arm made from hardwood stock and hinged at the joint. (The arm is in two sections so that it can be folded to permit the doors to close without obstruction.)

Strike a pencil line down the length of the long arm section, centering it on the wide side. Then strike cross lines 1″ from one end, and three more lines spaced 1¼″ (32 mm), 2″ (51 mm), and 3¼″ (83 mm) from the first cross line. At each line crossing, drill a ³⁄₁₆″ (4.76-mm) hole through the wood. Then use a router, coping saw, or wood chisel to remove all the wood between the first and second and third and fourth holes, making the slots only as wide as the diameter of the original holes.

Butt together the two arm pieces as shown and mount a small hinge at the joint. Use glue and finishing nails to mount a square wood block at the free end of the short arm section. Paint the entire arm assembly flat black. When the paint has dried, drill a hole through the block and arm section, connect 12″ (30-cm) lengths of stranded hookup wire to the lugs of a miniature phone jack, and mount the jack in the hole.

After painting an 8¼″ long by ¼″ diameter (21 cm × 6.35 mm) hardwood dowel flat black and allowing it to dry, mount the 2 × 2-cm silicon solar cell at one end with white glue. Solder stranded hookup wires to the cell's contacts at one end, and connect and solder the free ends of the wires to the lugs on a miniature phone plug. Cut a groove in the side of the dowel to permit the plug's plastic cap to slide over the wire leads. Remove enough wood from the dowel at the end opposite the cell to permit it to be force-fitted into the end of the plug's cap. With a little care, the dowel will be locked into place when the cap is screwed onto the plug. Use black electrical tape to bind the wires to the dowel in a couple of places.

Mount the dowel-and-block assembly that holds the door open at the top of the right door. Position it so that it will not interfere with door closure, and use glue and finishing nails, the latter driven through the door panel into the block. Make sure the nails do not interfere with free movement of the dowel and the dowel moves freely in the block.

Locate and drill the holes for the detector arm as follows: First, strike a line across the panel midway between the top and bottom of the panel. Mount the door on the cabinet via its hinges. Slide the dowel in the block forward to lock the door open. Direct a strong beam of light on the mirror's surface. Now, plug the detector dowel assembly into the arm assembly and place the arm against the door panel. Center the slots in the arm over the line on the door. Standing out of the way of the light beam, move the arm closer to or farther from the mirror until the reflected light from the mirror just fills the detector cell's active surface area. Indicate on the door panel's line the points that mark the centers of the slots in the arm. Remove the arm, unplug the detector dowel assembly, and set both aside. Finally, drill a hole at each location indicated. Make the holes just large enough to require that you use a screwdriver to drive a pair of No. 6 × 1½" screws into the holes.

Remove the door panel from the cabinet. Mount plywood legs on the front of both door panels. Then paint the panels, flat black on their inside surfaces and white enamel on their outside surfaces. When the paint has thoroughly dried, drill perforations for the speaker grille, and mount the speaker on the inside of the panel. Use a metal L bracket for the switched potentiometer and spacers for the amplifier module when mounting them in place. Then refer back to Fig. 1 and interconnect all components.

Anchor the detector arm to the door with large flat washers and wing nuts. (The wing nuts will facilitate easy focusing of the receiver during field operation.) Bolt the doors to the cabinet with No. 6 machine hardware. Use large flat washers under all screw heads and nuts. Finally, install a hook and eye or lock and hasp on the doors to keep them closed when the receiver is not in use.

Range Testing. Start your testing by fastening the transmitter mirror assembly directly over the speaker of a small portable radio receiver. Aim the beam from the transmitter down a range of several thousand feet where it will not be obstructed. Take the receiver several hundred feet downrange and align its mirror with the transmitter's reflected beam. Plug the detector dowel assembly into the arm on the door and adjust the focusing for the best possible received signal. With proper beam alignment and receiver focusing, you should be able to hear good-quality voice and music transmissions.

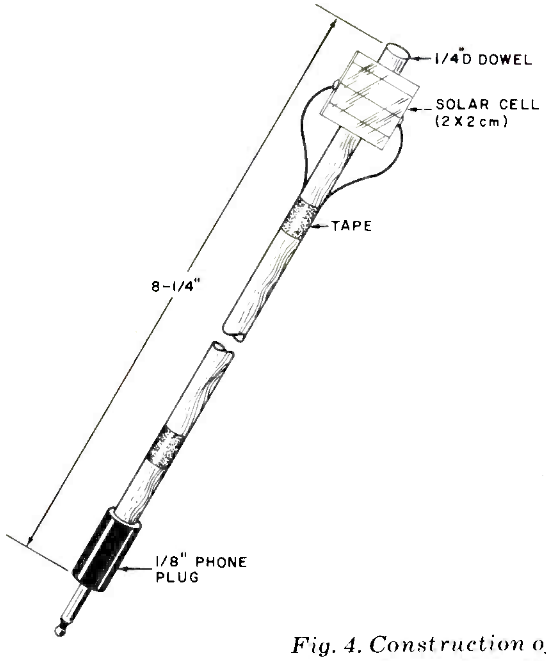


Fig. 4. Construction of final section of detector arm, which is folded to permit door closing.

Continue to move the receiver away from the transmitter and make reception tests every 50′ (15 m) or 100′ (30 m) until the signal becomes too weak to "copy." Bear in mind that the earth's rotation will cause the sunlight reflected from the transmitter's mirror to move away from your original alignment point. So, you will occasionally have to adjust the transmitter's orientation to assure proper receiver/transmitter alignment. It helps if you can recruit one or two friends for the alignment procedure as distances can become quite great.

The maximum range of your system is dependent on the areas of the transmitter's and receiver's mirrors, overall gain of the receiver's amplifier, atmospheric condition, and angle of the sun in the sky. The last is of particular importance because high angles yield far more light intensity than do low angles. Offsetting this is the fact that at high angles, less of the transmitter's mirror surface is utilized than at the lower angles. Consequently, there is no way of predicting, with absolute assurance, what the range of your system will actually be.

When the system is not in use, keep the transmitter in a covered box and close the receiver cabinet's doors. Also, avoid pointing the receiver toward the sun since concentrated direct sunlight will destroy the solar cell and the detector arm and pose a fire hazard to nearby combustible objects.

Some Modifications. The Photophone can be modified in a number of ways to make it perform better. For example, you can increase sensitivity by using light shields and baffles to cut out extraneous light reflections, or you can use a preamplifier to boost the signal level from the solar cell. A large Fresnel lens can also considerably improve receiver operation. Edmund Scientific's No. 70,717 ($39.50), 24¾" × 19¼" (63 × 49 cm) lens has more than twice the collecting area and yields a smaller blur circle of light at its focus than does the 16" mirror.

By using an amplifier module, microphone, and 49-mm-square mirror (Edmund Scientific No. 41,619 at $1.50 each) cemented to the cone of a 2" miniature speaker with white glue, you can put together an excellent voice transmitter that will greatly increase the range of your system.

There are many more possible modifications you can use. With a little ingenuity, you can push the range of your system out to several miles.

For more information about light wave communication systems employing sunlight, LEDs and lasers, refer to "Light Beam Communications" (Howard Sams & Co., 1975). ◇

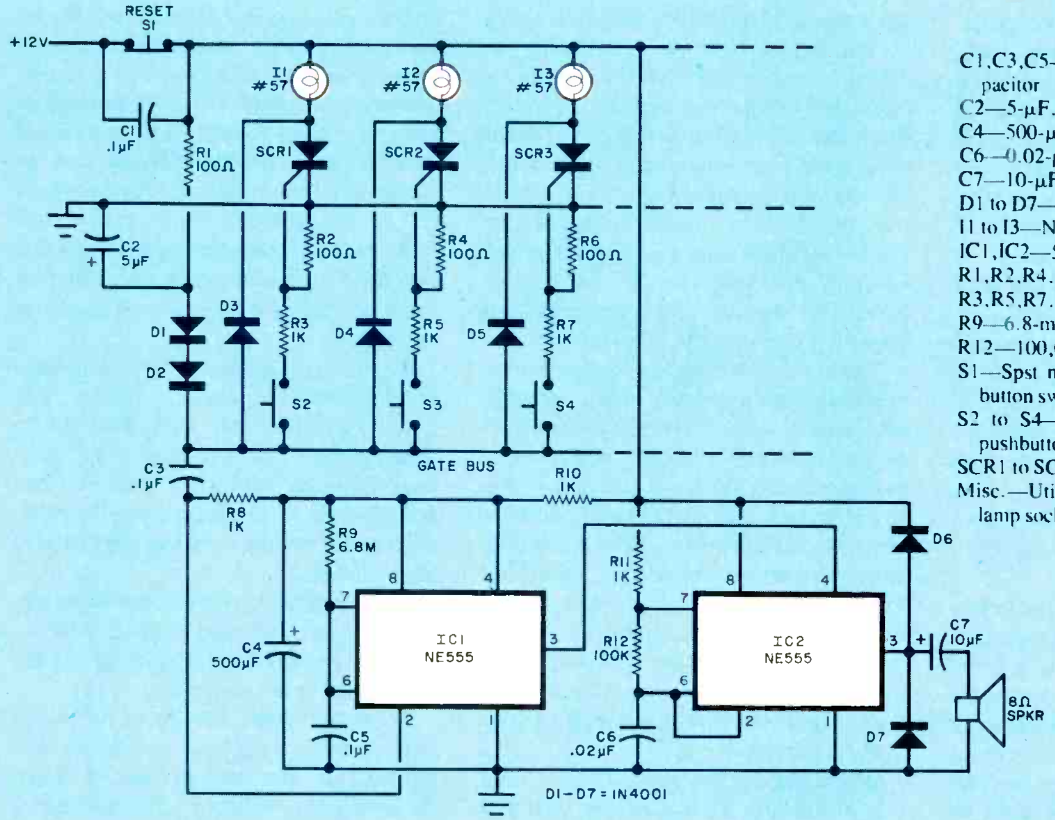
QUIZ-GAME ELECTRONICS

BY MICHAEL S. ROBBINS

Here's a player-response circuit that will enable you to imitate quiz shows at home or with larger audiences.

POPULAR TV quiz shows use electrical or electronic apparatus to determine which contestant makes the first response, thereby getting first crack at a question. Here's a simple circuit that will enable high school and college groups to emulate the quiz shows. It can be used for fun at home, too.

The circuit shown will energize a lamp to identify which player pushes his button first, sound an audible alarm, and lock out the buttons of the other players.



Schematic diagram for the game circuit. By adding SCR networks, the circuit can be expanded to include any number of players.

PARTS LIST

C1,C3,C5—0.1-µF, 50-volt disc ceramic capacitor
C2—5-µF, 25-volt electrolytic capacitor
C4—500-µF, 25-volt electrolytic capacitor
C6—0.02-µF, 50-volt disc ceramic capacitor
C7—10-µF, 25-volt electrolytic capacitor
D1 to D7—1N4001 diode
I1 to I3—No. 57 pilot lamp
IC1,IC2—555 IC timer
R1,R2,R4,R6—100-ohm resistor
R3,R5,R7,R8,R10,R11—1000-ohm resistor
R9—6.8-megohm resistor
R12—100,000-ohm resistor
S1—Spst normally closed, momentary pushbutton switch
S2 to S4—Spst normally open, momentary pushbutton switch
SCR1 to SCR4—HEP R1221 or equivalent
Misc.—Utility boxes, pc or perforated board, lamp sockets, wire, solder, hardware, etc.

The solid-state design is inexpensive to build and can be expanded to include any number of players and a combination of alarms could be used.

Circuit Operation. The heart of the system is an inexpensive SCR. When a contestant presses his button, the gate of his particular SCR (one for each player) is connected to the positive gate bus. The SCR turns on and the indicator is lit. Since the voltage across the SCR is nearly zero during conduction, the normally positive gate bus will be pulled down to almost 0 volts through the diode which ties the bus to the SCR's anode. When this happens, the bus will not be able to supply enough gate current to turn any other SCR on. Thus the other players' buttons are locked out until the referee resets the circuit.

This dip in voltage on the bus activates *IC1*, a 555 unit operating as a one-shot. A one-second pulse from *IC1*'s output activates *IC2*, a 555 in the astable mode, producing a tone in the speaker for the same length of time. Since the output of *IC2* is a square wave, an appreciable inductive "kick" can appear across the speaker coil. Two clipping diodes are connected across the output of *IC2* to protect the transistors inside the 555 from excessive voltage spikes.

Once a pulse of current flows into an SCR, it will conduct indefinitely (the player need not keep his button continuously depressed) until the anode current falls below the holding current, I_H. When this happens, the SCR turns off. In this circuit, the indicator lamp will continue to glow and all other pushbuttons will be locked out until the referee pushes the RESET button, *S1*.

The duration and pitch of the tone may be adjusted by changing the values of the timing components associated with *IC1* and *IC2*. For example, changing *R9* from 6.8 megohms to 1 megohm will shorten the duration to about 0.2 seconds, while substituting a 10-megohm resistor will extend the interval to about two seconds. Replacing the 100,000-ohm *R12* with a 500,000-ohm resistor will raise the frequency of the tone from 350 Hz to about 1000 Hz. Since tastes vary, you might install potentiometers in place of these two fixed resistances, and adjust them to produce the desired pitch/duration combination.

Any small 8-ohm speaker will be sufficient for this application. Power can be obtained from any source capable of producing 500 mA at 9 to 12 volts dc. A lantern battery or a small full-wave power supply will work fine.

Construction. The system can be constructed in several different configurations. One of the most versatile arrangements is to mount each contestant's pushbutton, indicator lamp, and SCR network in a small utility box, which is placed before him. All of the boxes are connected together by a three-conductor cable. The tone generator, RESET button, and power supply can then be installed in a utility box mounted at the referee's position.

An alternative arrangement is to mount all of the circuitry behind a panel on which the indicator lamps are installed. Twisted-pair or zip cord can be used to connect the circuitry to pushbuttons at the contestants' and referee's positions. Other configurations might be suggested by your own particular situation.

Parts placement is not critical, so the circuitry can be assembled on a printed circuit board or a piece of perforated board, mounted in any small, convenient utility box.

All you need now to use the system are contestants, brain teasers and prizes to be won! ◇

"GEE! MY FIRST COMPUTER DATE! I WONDER WHAT HE'LL BE LIKE?"

A "JUNK-BOX" 5-VOLT POWER SUPPLY

BY R. C. FOSS

Discrete circuit made from spare parts gives IC-regulator performance.

WHEN a breadboard project calls for a regulated 5-volt supply, most experimenters instinctively reach for a 109-type IC. But suppose you're fresh out of 109's? The circuit described here can be built from junk-box parts, offers 0.15-volt stability, 5-mV noise and ripple, automatic current limiting, and an overload indicating light!

No transistor types numbers are shown in the schematic diagram, as almost any will do. The pnp series-pass transistor, *Q1*, is a power type with a rated BV_{CEO} of 15 volts, and a minimum current gain of about 30 at 1 A. If the power device you have on hand has a gain a bit lower than 30, *R3* can be reduced to compensate. Enough heat sink should be provided to dissipate 7 or 8 watts under worst-case overload conditions. As shown, the collector is the positive output rail. A piece of aluminum bolted to the + terminal will do nicely. If you want to use an npn power transistor, invert the entire circuit into its complementary form. Thus the transistor's case is conveniently grounded, and the chassis can be used for heat sinking. It's even possible to use a germanium transistor if *R2* is lowered to about 22 ohms to allow for the lower V_{BE}.

The other two transistors are general-purpose, small-signal silicon devices. Similarly, resistors are not critical. A two-watt wirewound component should be used for *R1*. A length of resistive wire wrapped on the body of a higher-value resistor can form *R1*. Resistor *R3* should be a carbon half-watt component.

About the circuit. The LED is used as a reference voltage source with an output of about 2 V. (The forward voltage drop of most GaAsP yellow, green, or orange LED's will vary from 2.0 to 2.2 volts. Select one with a V_0 close to 2.0 V.)

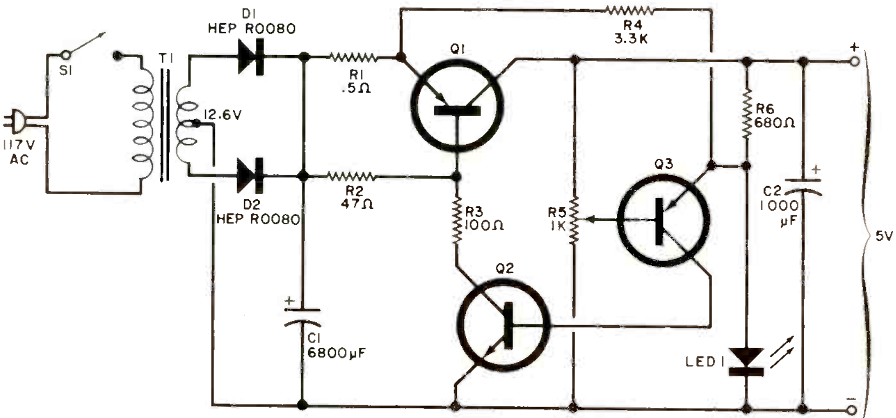
Feedback action sets the base of *Q3* to about one V_{BE} below the reference voltage on its emitter. So, *R5*, the 1000-ohm trimmer potentiometer, will generally be set about ¾ of the way "down" for a 5-volt output. Since the V_{BE} of *Q3* and the turn-on voltage of the LED usually have similar temperature coefficients, this simple reference-comparator combination works surprisingly well.

The collector provides base current for *Q2*. This transistor's collector resistor, *R3*, together with *R1* and *R2*, limit the maximum (overload) current of *Q1*. As more output is demanded, *Q3* and, in turn, *Q2* turn increasingly "on," grounding the bottom of *R3*. This action sets up a voltage divider, *R2* and *R3*, limiting base drive to *Q1*.

A variable resistor in series with *R3* can be inserted to set lower current limits. This is especially desirable when the supply is feeding easily damaged, low-power devices. Maximum current output of the series pass transistor is set by *R1* and *R2*, and *R3* limits the base current into it. Thus, there is current-limiting action.

Because *Q3* and the reference LED are fed from the stable side of the supply, the circuit gives excellent rejection of ripple and input variations. If *R4* is excluded, complete current shut-off will occur when the supply is short circuited. Although this is very desirable in protecting the load, it also means that the circuit will not self-start! At the specified value, *R4* bleeds enough current into the error amplifier (*Q3*) to allow start-up against a 5-ohm load. If desired, a normally open pushbutton switch can be placed in series with *R4* to get the best of both configurations.

The LED also acts as a pilot light—it will extinguish when the power supply is shut down by overload trip-out.



In this simple circuit, LED1 acts as a voltage reference and pilot light.

Construction. The builder has as much flexibility in choosing construction techniques as he has in selecting semiconductors. Perforated or printed circuit board can be used. The project can be installed in any suitable enclosure. The only adjustment that must be made is the setting of *R5*. Adjust it so that the output is 5 volts. Once the setting has been determined, fixed resistors can be substituted for both sides of the potentiometer for stability. ◈

PARTS LIST

C1—6800-μF, 15-V electrolytic capacitor
C2—1000-μF, 15-V electrolytic capacitor
D1, D2—HEP R0080 rectifier or equivalent
LED1—See text.
Q1—Pnp power transistor. (See text.)
Q2, Q3—General-purpose silicon transistors
The following fixed resistors can be 5 or 10% tolerance.
R1—0.5-ohm resistor. (See text.)
R2—47-ohm, ½-W resistor
R3—100-ohm, ½-W resistor
R4—3300-ohm, ½-W resistor
R5—1000-ohm, linear-taper potentiometer
R6—680-ohm, ½-W resistor
S1—Spst switch
T1—12.6-volt, 3-A center-tapped transformer (Radio Shack 273-1511 or equivalent)
Misc.—Perforated or printed circuit board, machine hardware, hookup wire, binding posts, solder, line cord, suitable enclosure, etc.

BY RUSSELL J. BIK

BUILD DYNADIM II

DELUXE HOME-LIGHTING CONTROL

Featuring an automatic dim-to-off mode from a few seconds to a slow 40 minutes, as well as conventional preset-level dimming.

THE INTRODUCTION of SCR's and triacs into light-dimmer design advanced the state of the art from the dark ages of the giant rheostat to the compact home devices of today. The Dynadim II project described in this article represents the next logical step in dimmer development. It performs all the functions of standard light dimmers and also provides automatic dimming of room lighting at adjustable rates.

As a mood setter at parties, the Dynadim II can dim lighting from full on down to any preset holding level or all the way off at dim rates ranging from a few seconds to an imperceptibly slow 40 minutes. The same slow dimming can serve as a sleep inducer by helping you to relax. It's especially handy to have around when the kids insist that the lights be left on after they are put to bed.

Shorter timing cycles can be applied to applications like providing a professional touch to the presentation of home movies and slides by bringing down the "house" lights while you attend to the projector.

How It Works. The Dynadim II circuit shown in Fig. 1 is designed to work in series with the ac power source and the load via the ac input terminals. The power to the load is regulated by triac Q3 that acts as an ac switch that closes at some point during each alternation of the input power and opens automatically each time the voltage passes through the zero point. The point in the alternation where Q3 is triggered into conduction determines how much power is supplied to the load. If triggering occurs early in the cycle, the controlled light glows at a higher average intensity than if triggering occurs later.

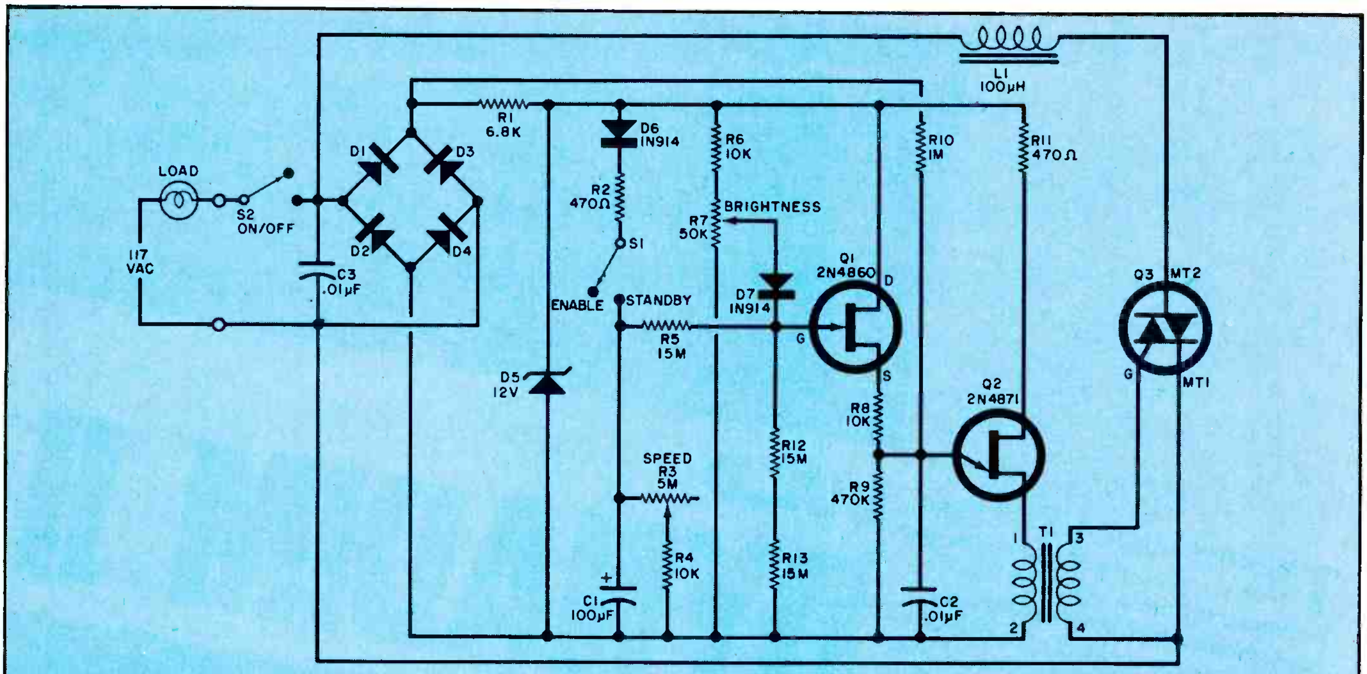


Fig. 1. Unlike a conventional light dimmer, the triac (Q3) is gated later and later in the power-line cycle as C1 discharges. Dimming time is controlled by varying discharge time to C1

PARTS LIST

C1—100-µF, 15-volt electrolytic capacitor
C2—0.01-µF, 50-volt capacitor
C3—0.01-µF, 200-volt capacitor
D1 through D4—1-ampere, 200-PIV rectifier diode
D5—12-volt zener diode (1N4742 or similar)
D6,D7—1N914 diode
L1—Line filter inductor approximately 100 µH at 4-amperes)
Q1—2N4860 field-effect transistor
Q2—2N4871 unijunction transistor
Q3—200-volt, 6-ampere triac ECC Q2006L4
R1—6800-ohm, ½-watt, 10% resistor
R2,R11—470-ohm, ½-watt, 10% resistor
R3—5-megohm slide potentiometer
R4,R6,R8—10,000-ohm, ½-watt, 10% resistor
R5,R12,R13—15-megohm, ½-watt, 10% resistor
R7—50,000-ohm slide potentiometer
R9—470,000-ohm, ½-watt, 10% resistor (see text)
R10—1-megohm, ½-watt, 10% resistor
S1,S2—Spst slide switch
T1—Pulse transformer with 1:1 ratio (Sprague No. 11Z12)
Misc.—Printed circuit board; suitable chassis box with cover; insulator (goes between pc board and box); felt strips; knobs for slide pots; bus wire; machine hardware; solder; etc.
(The following items required only for portable table version of dimmer: 12′ "remote-control" extension cord; right-angle strain relief; four rubber feet.)
Note: The following items are available from The Dynadim Company, P.O. Box 1228, Cupertino, CA 95015: Etched and drilled pc board for $5.50; complete kit of parts, including chassis box, in wall-mount version for $24.95 and in table version for $27.95. California residents please add sales tax.

To send *Q3* into conduction, a trigger pulse is applied to the gate of the triac by the discharge of *C2* through *Q2* and the primary of *T1*. The time constant of *C2* and its resistors is rather long compared to the period of a single ac alternation. The values given in Fig. 1 were selected so that the potential across *C2* just barely attains an amplitude sufficient to drive *Q2* into conduction when the voltage across *C1* is zero and *R7* is set for minimum bias on *Q1*.

Closing *S1* causes *C1* to charge through *R2* and *D6*, thereby increasing the bias on *Q1* and allowing *C2* to charge more quickly with each alternation of the ac power cycle. As a result, the *Q2* oscillator circuit produces the triggering pulses for the triac earlier in the cycles, and the controlled lights brighten.

An earlier triggering can also be obtained by adjusting the *R6-R7* voltage divider. The effect on the bias of *Q1* is the same as raising the potential across *C1*, except that a static control over lighting intensity is obtained to set threshold levels.

The automatic dimming feature is obtained by opening *S1* and allowing *C1* to slowly discharge through *R3* and *R4*. This causes the lighting to diminish gradually as the triggering pulses to the triac are produced later and later in each cycle.

The high resistance required to prevent the voltage from being too rapidly shunted away from *C1* is provided by using a field-effect transistor as *Q1* and a very high resistance in its gate circuit.

The rectified power applied to the timing circuit by the diode bridge made up of *D1* through *D4* is maintained at a constant 12 volts, regardless of load, by zener diode *D5*. The filtering network made up of *C3* and *L1* reduces interference to the AM broadcast band caused by triac switching transients.

Construction. To keep the dimmer as slim and compact as possible, it is recommended that you build it on a printed circuit board. An actual-size etching and drilling guide and component placement diagram are shown in Fig. 2. Note that the entire circuit, including controls and switches, mount directly on the pc board. To avoid lead breakage from vibration, it is best to epoxy *T1* to the board. It is also advisable to mount *R1* about ¼″ (6.4 mm) above the surface of the board to assure good heat transfer.

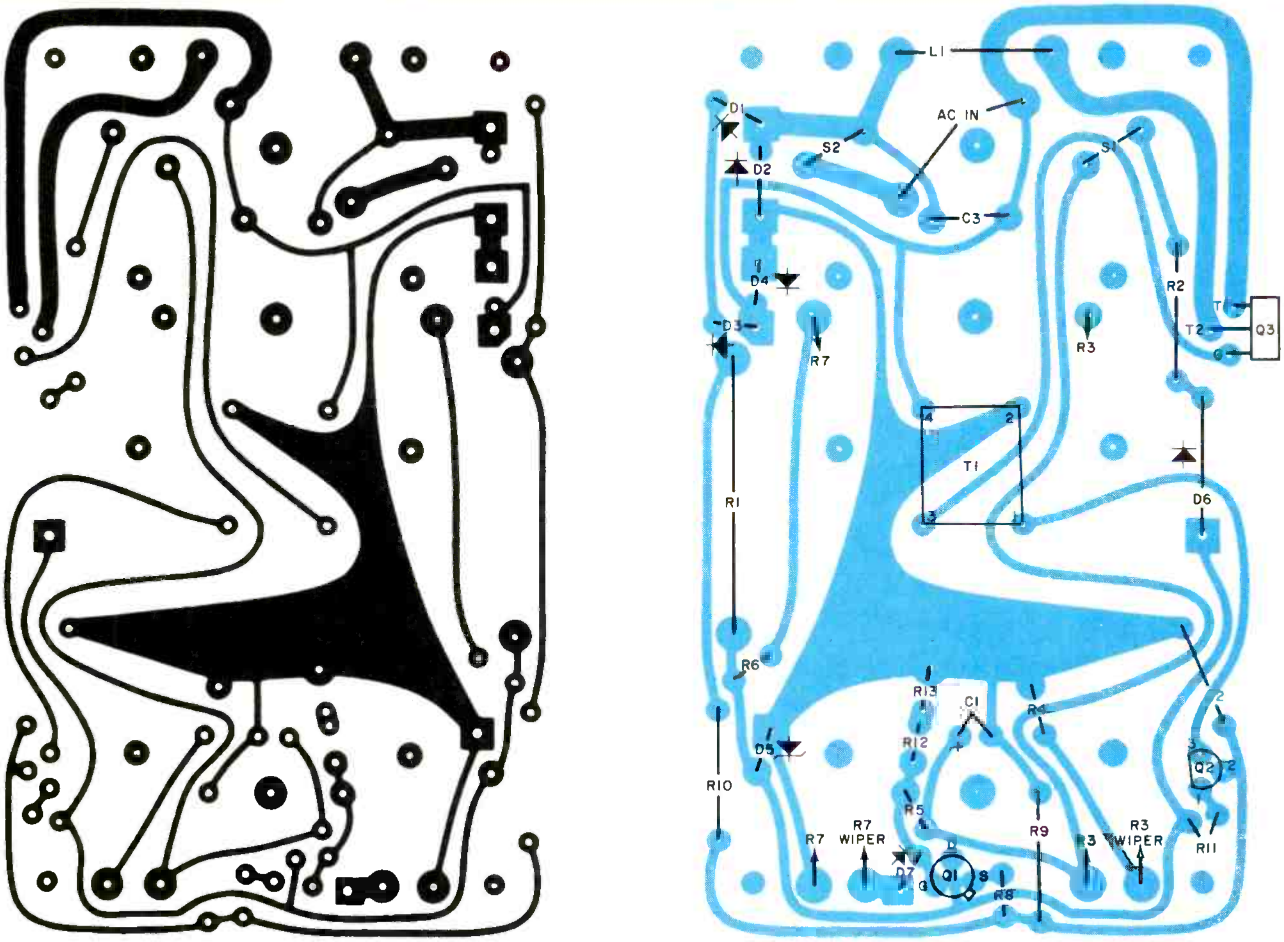


Fig. 2. Actual-size etching and drilling guide is shown above left, with component layout guide above right.

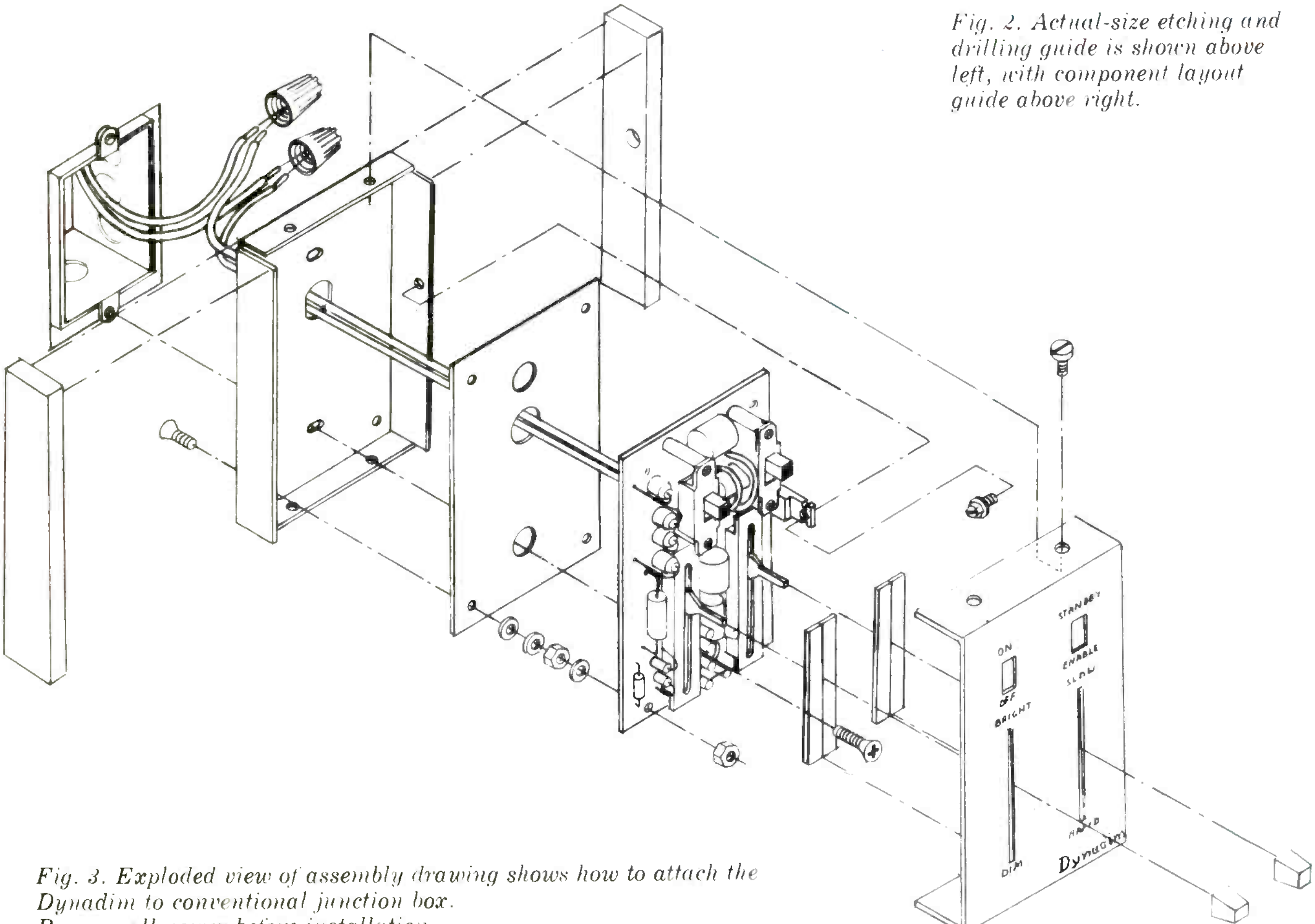


Fig. 3. Exploded view of assembly drawing shows how to attach the Dynadim to conventional junction box. Remove all power before installation.

The triac (*Q3*) specified in the Parts List has an electrically isolated heat-sink tab that can be bolted to the metal cover to provide good heat sinking. If you use any other type of triac, an insulating mounting kit will be required.

After wiring the board, check it over for possible solder bridges between foil traces and to ascertain that all components are properly installed and polarized. To avoid leakage problems in the high-impedance circuit around the two transistors, remove all rosin and clean the board thoroughly with alcohol.

It is important that the leakage of *C1* be minimized and that *Q1* be properly biased to obtain the full 40-minute time delay. The leakage through an electrolytic capacitor is inversely proportional to the number of hours it is charged. This process is cumulative over the life of the capacitor. A dramatic reduction in leakage will occur during the first few hours of operation; improvement continues into the thousands of hours. (Note: The capacitors supplied with the kit listed in the Note under the Parts List come burned in. If you buy new capacitors locally, you can burn them in once they are mounted in the project simply by leaving the dimmer turned on in the standby mode.)

The value of *R9* was selected to provide optimum bias for the nominal specifications of *Q1*. However, differences in individual transistors may have to be compensated for by changing *R9*'s value. Raising the resistance increases the apparent length of the timing cycle until a point is reached where the controlled light will not turn off even if *C1* is discharged. The ideal value for *R9* is just below the point at which this begins to occur.

You can mount the dimmer in a permanent wall mounting (at a light-switch junction box) or in a separate box for portable table use. The assembly details for the junction-box approach is shown in Fig. 3. Note that the dimmer is connected in *series* with the load. Make sure that all electrical power is removed from the junction box before attempting to install the dimmer.

Mount the pc board assembly inside a form-fitting enclosure, with a thin insulator between the bottom of the board and the metal rear section of the box. The metal cover should have cutouts for the slide shafts of the potentiometers and switch toggles. Short lengths of felt fabric can be used between the inside of the front panel and the tops of the slide pots to keep out dust and other foreign material. Cement these strips in place so that they just touch each other in the two slider hole locations.

When you make the hookup to the ac line in the junction-box installation, be sure to use wire nuts for the connections.

Drill the rear wall of the dimmer's box so that it can be mounted directly on the junction box via the latter's switch mounting screws. (The original junction-box switch will no longer be needed.) In this manner, the complete dimmer can be affixed to the wall to eliminate the crowding that would exist if the entire circuit were to be "squeezed" into the junction box.

If you prefer to make your dimmer a table model, the same four screws that mount the circuit board to the box can be used to secure rubber feet to the bottom of the box in which the project is housed. In this configuration, a 12' (about 4-m) long "remote-control" extension line cord should be used to allow maximum flexibility. The lamp to be dimmed then plugs directly into the cord, which also plugs into the ac receptacle.

Using the Dimmer. For conventional control of lighting, it is recommended that the dimmer control be left in the full BRIGHT position and that the lights be controlled with the ON/OFF switch. When the dimmer is left on for long periods of time, a slight warming of the chassis will be noted. This is normal and should cause no apprehensions.

For dimming action, if you wish the lights to be full on and extinguish automatically to a very dim glow over a period of, say, 10 minutes, the procedure would be: First set the timing and dimming controls to DIM and RAPID and the STANDBY/ENABLE switch to ENABLE. The lights will extinguish quickly. Adjust the dimmer control to the position that gives the desired minimum illumination. Set the timing control to a position about four divisions above RAPID, *S1* to STANDBY, and (when ready to initiate the dimming action) switch to ENABLE. The lights will begin slowly to dim to the preset level.

Although the Dynadim II itself draws very little power (about as much as an electric clock), it is advisable to turn it off when convenient. This will ensure maximum component life. ◈

TEST YOUR ELECTRONICS INGENUITY

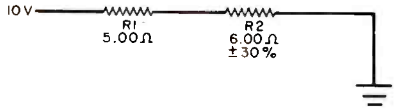
By Robert G. Fleagle, Jr.

LIKE Archimedes, most of us have at one time or another wanted to shout "Eureka" when we have found a simple solution to a baffling problem. Three such problems make up this quiz, one each on math, circuit theory, and "rules of thumb." Most of you know the facts needed to solve these problems. The quiz, then, is to test your ability to use the facts. It is simple, even trivial, but "simple" does not always mean "easy."

Here are the problems:

1. Solve for C in the following equation: $A = B^C$.

2. Find the greatest possible power dissipation for *R2* in this circuit:



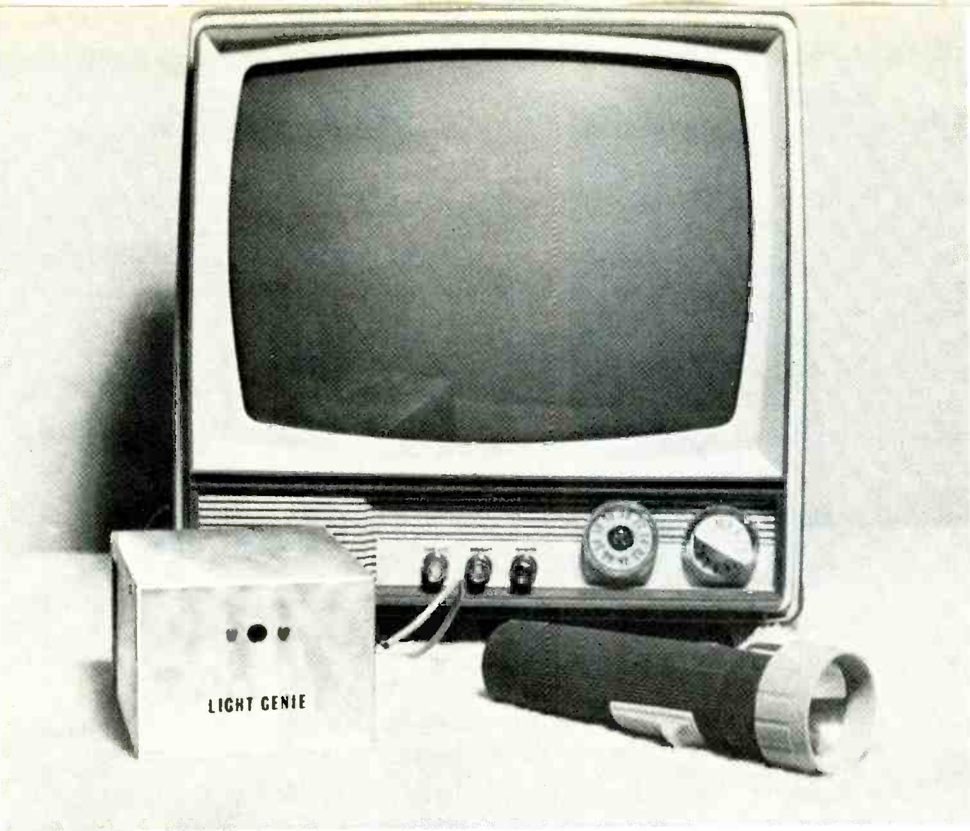
3. You are given a faulty printed-circuit board assembly on which only TTL integrated circuits are mounted. You find that the pc assembly draws 1 ampere of current when it should normally draw only 200 mA. How can you quickly pinpoint the faulty IC, using no unusual test equipment?

ANSWERS

1. $C = \log A/\log B$. Starting with $A = B^C$, take the logarithms of both sides—$\log A = \log (B^C)$. Remembering log rules, $\log A = C \log B$. Divide by log B and cancel—$C = \log A/\log B$.

2. 5.000 watts (not 4.96 watts). Remember the theorem that greatest power transfer occurs when the source and load impedances are equal? In this case, *R1* is the source impedance and *R2* is the load. Hence, *R2* must be set to 5.00 ohms, which is within 30% of 6 ohms, instead of to either extreme. With *R2* set to 5 ohms, Ohm's Law gives us 1 ampere and I^2R gives us 5.00 watts.

3. The board is drawing 5 amperes at 5 volts instead of its normal 200 mA. Therefore, power dissipation is an extra 4 watts. Since a good digital IC should never dissipate anywhere near this amount of power, it is a safe bet that the excess is going to the faulty IC, which must be getting very hot. Turn off the power after about a minute and touch your fingertip to the case of each IC in turn. The IC that feels the hottest is the faulty one.



BY MAYNARD GRADEN

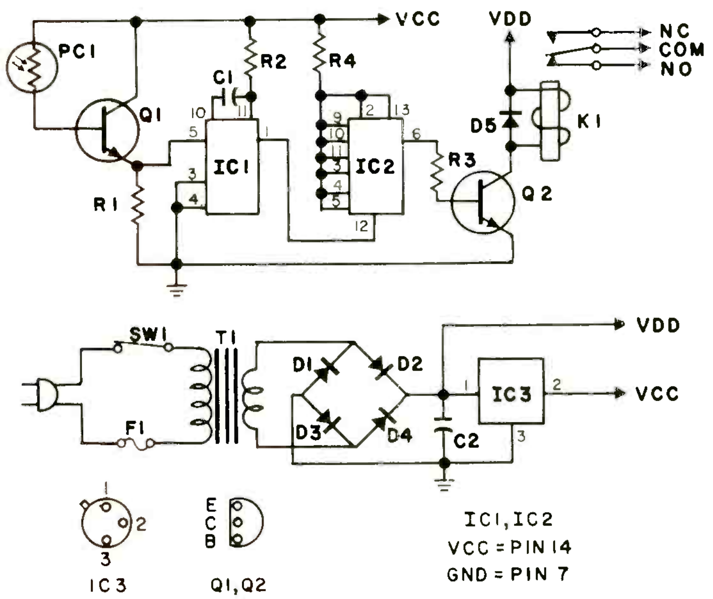
Handheld photoelectric system turns electrical equipment on or off.

BUILD THE "LIGHT GENIE"

ALADDIN was a lucky fellow. When he wanted a job done, all he had to do was rub his magic lamp and a genie would do his bidding. With the "Light Genie," you can do almost the same thing. You can use it to silence annoying TV commercials or change your stereo system from tuner to tape deck. In fact, the Genie will control just about anything that has a switch.

A small penlight will operate the Genie at distances up to 12 feet (3.6 m), while a regular flashlight extends the range to greater than 30 ft (9.1 m). High ambient room light will not interfere with the Genie's operation.

Circuit Operation. The schematic diagram of the Genie is shown in Fig. 1. A light shield is used to prevent random ambient light from striking the photocell, *PC1*. The latter provides base bias for emitter follower *Q1*. Small, relatively constant amounts of light only vary the quiescent operating point of the circuit



PARTS LIST

C1—10-µF, 10-volt electrolytic capacitor
C2—500-µF, 15-volt electrolytic capacitor
D1 through D5—1N4001 rectifier diode
F1—¼-ampere fuse (see text)
IC1—74121 integrated circuit
IC2—7472 integrated circuit
IC3—LM309H 5-volt regulator IC
K1—6-volt dc relay with spdt contacts (Sigma No. 65F1A-6DC or similar—see text)
PC1—Clairex CL702L photoresistive cell
Q1,Q2—2N3704 transistor
The following resistors are ¼-watt, 10%:
R1—470 ohms
R2—39,000 ohms
R3—220 ohms
R4—1000 ohms
SW1—Spst toggle or slide switch
T1—6.3-volt, 1.2-ampere transformer (see text)
Misc.—Metal utility box; fuse holder; line cord with plug; 9-pin shielded tube socket; ¾" flat washers (2); matte black construction paper; tape; glue; hookup wire; solder; machine hardware; etc.

Fig. 1. Circuit is activated to energize K1 when light beam strikes PC1 directly.

However, when a beam of light is directed at the Genie so that it falls directly on the photocell, the resistance of *PC1* rapidly decreases and sends *Q1* into conduction.

Integrated circuit *IC1* is a monostable multivibrator. A time constant of 250 ms, which prevents multiple triggering from a slowly changing light source, is provided by *C1* and *R2*. The output from *IC1* is a clean square pulse that is used to clock *IC2*. As flip-flop *IC2* toggles, transistor *Q2* is either driven into saturation or cut off to energize or de-energize relay *K1*, respectively.

The power supply is also shown in Fig. 1. It provides power for the relay and regulated 5 volts, through *IC3*, to operate the logic.

Construction. To construct the light shield, use a piece of 8″ × 4″ (20.3 × 10.1 cm) matte black construction paper. Form a tube by rolling it around two ¾″ flat washers. Insert a washer inside the paper tube at the halfway point and perpendicular to the central axis. Drop in a small amount of glue to secure it in place. Use tape to hold the tube together, as shown in Fig. 2.

Remove the Bakelite base from the frame of a nine-pin shielded tube socket. (The two pieces are usually held together by small metal tabs that can be bent to separate the two parts.) Using the frame as a template, mark and drill mounting holes on the front of the box. Locate the center of the frame and drill a third ¼″ (6.35 mm) hole at this point. Attach the frame to one end of the paper tube. This will be the mounting bracket for the light shield.

Mount the photocell and two 12″ (30.5 cm) lengths of wire on the tube base using two of the pins as tie points. Adjust the photocell so that it is parallel to the base of the tube. Complete the light shield by cementing the photocell assembly to the other end of the paper tube.

The circuit can be assembled using perforated board and point-to-point wiring or a printed circuit board that can be made using Fig. 3. In either case, the board should be mounted vertically on one side of the box so that ample space remains for installing any additional parts that may be required for various switching applications.

Uses. The Light Genie can be used to silence television commercials as shown in Fig. 4. The value of *RL* should be equal to the impedance and wattage of the speaker. If there is enough room

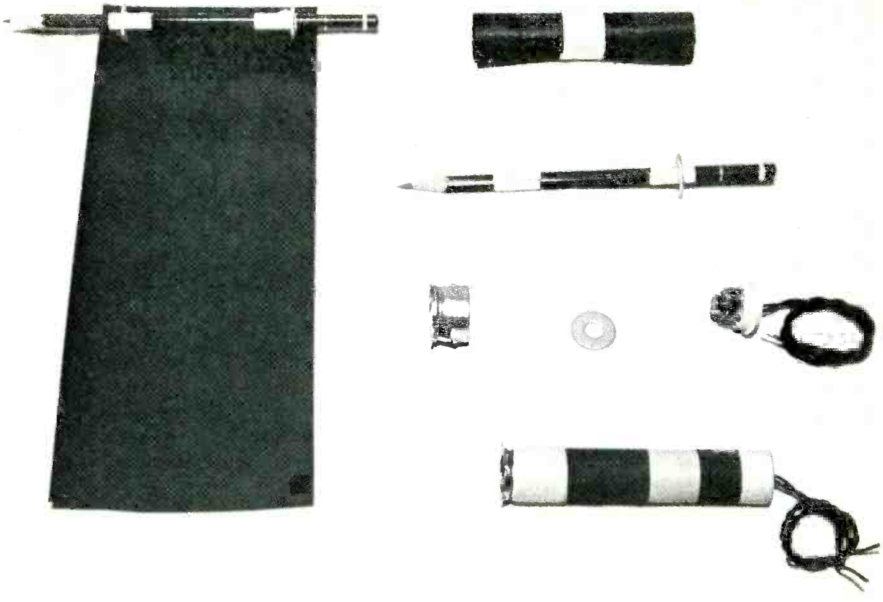


Fig. 2. Photo shows how to make light shield out of black construction paper. Base from a 9-pin shielded tube socket is used as a mounting bracket.

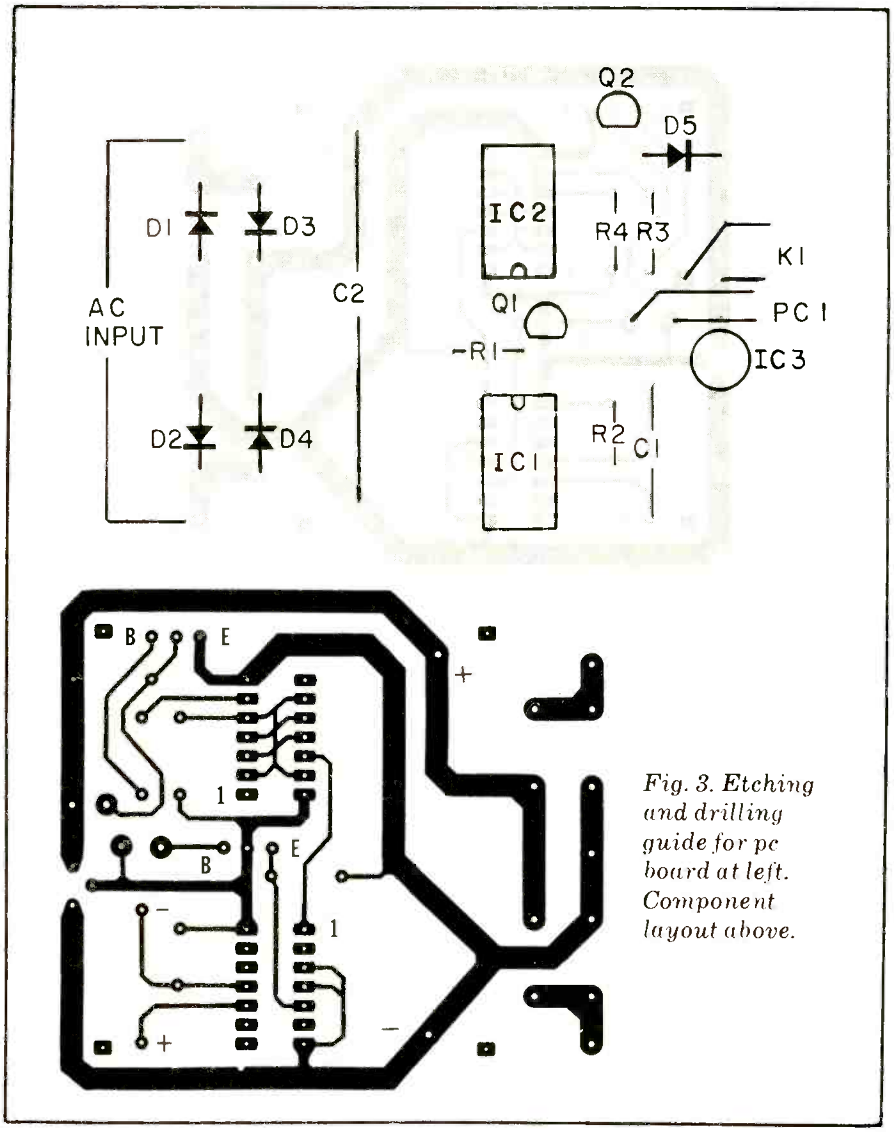


Fig. 3. Etching and drilling guide for pc board at left. Component layout above.

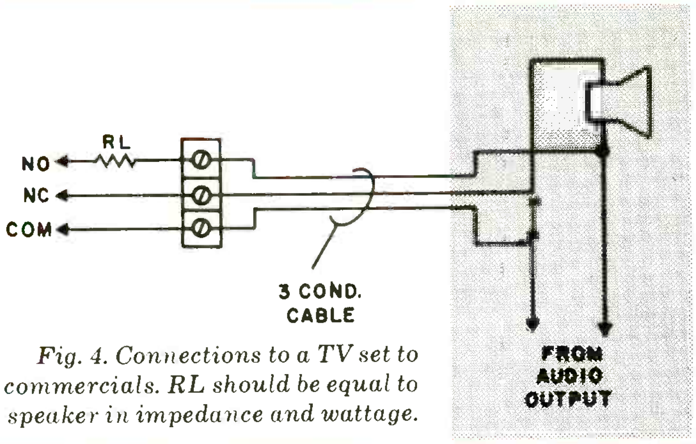


Fig. 4. Connections to a TV set to kill commercials. RL should be equal to speaker in impedance and wattage.

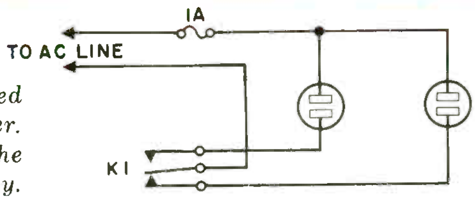


Fig. 5. Using two chassis-mounted ac receptacles to switch power. Fuse shown is separate from the one in Genie power supply.

inside the TV receiver, the entire circuit can be placed inside the cabinet behind a small hole that allows unobstructed access to *PC1* for the light beam. If the Genie is to be an outboard unit, mount a terminal block on the outside of the box and use a length of three-conductor wire to make the interconnections.

An application using two chassis-mounted ac receptacles to switch power is shown in Fig. 5. The relay specified in the Parts List will handle a 1-ampere resistive load. If a heavier load is to be controlled, substitute a relay with a higher contact rating, or have the specified relay drive a 117-volt ac relay with sufficiently heavy contacts. The fuse is separate from the power supply fuse and should be equal to the current capacity of the relay contacts.

It is possible to perform complex switching functions by using one relay to control several other relays as shown in Fig. 6. Here, relay *K1* is used to control two other relays, which choose between two components in a stereo system with the same output level, impedance, and required equalization characteristics.

The preceding examples begin to demonstrate the versatility of the Light Genie in two-state switching applications. Sequential switching functions can just as easily be implemented using stepping relays. ◇

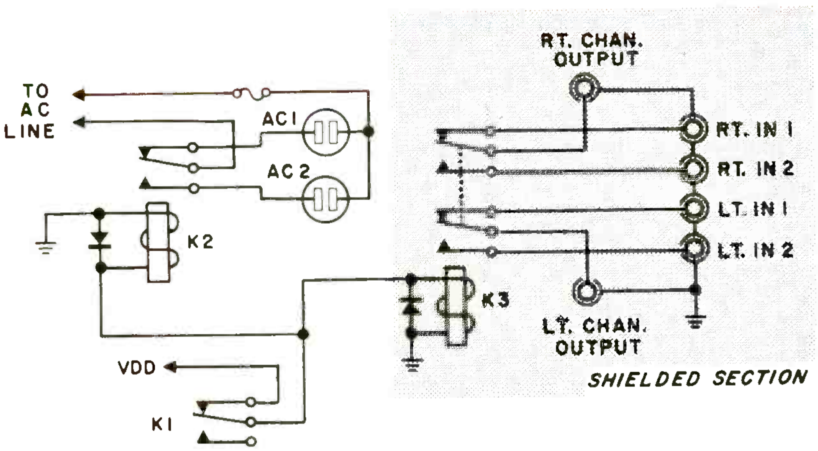


Fig. 6. Performing complex switching functions by using one relay to control several others.

BUILD A STATE-OF-THE-ART BATTERY CHARGE MONITOR

Prevents early failure of Ni-Cd batteries by determining proper time to recharge.

BY W.J. PRUDHOMME

THE PRIMARY cause of early cell failure in nickel-cadmium batteries is internal shorting that results from allowing the battery to become too deeply discharged in service. Therefore, any electronic device that uses Ni-Cd cells should contain a low-battery indicator that trips and warns you to recharge long before the battery's "critical" voltage is reached. Though there are a number of different types of charge monitors you can incorporate into your battery-powered equipment, the lambda-diode monitor described here is more advanced than other monitors in use.

Most low-battery indicators use a transistor to switch on the drive current for a LED or meter movement. The disadvantage here is that the monitor circuit places a constant drain on the battery, even when the LED is extinguished. In low-power applications, this drain can drastically reduce the available operating time of the battery. The ideal solution is to use a circuit that draws no current from the battery as long as the supply voltage is greater than the critical potential of the battery. This is what the lambda-diode monitor does. In addition, the trip potential is adjustable over an 8-to-20-volt range, and cost is low.

Technical Details. The output potential of most batteries varies in relation to the state of charge. This relation is different for each type of battery. Lead-acid batteries, for example, exhibit an almost linear dropoff in output voltage as the cells become discharged. The same is generally true for dry cells. For Ni-Cd batteries, however, the dropoff is not quite linear.

A fully charged Ni-Cd cell has an output potential of typically 1.25 volts. The cell maintains an almost constant output potential until it is almost completely discharged, at which point, the potential drops rapidly to about 1.0 to 1.1 volts, or 1.05 volts average. A precise voltage monitor set to trip at this "critical" voltage level (or at a multiple of this potential if more than one cell is in series) can be very useful in determining the charge level of the battery.

An eight-cell Ni-Cd battery pack, for example, would have a fully charged output potential of 10.0 volts. When nearly completely discharged, the battery would have an output of 8.4 volts. If the lambda-diode monitor circuit shown in Fig. 1 were set to trip at 8.4 volts, we have a useful state-of-charge monitor for a Ni-Cd battery system.

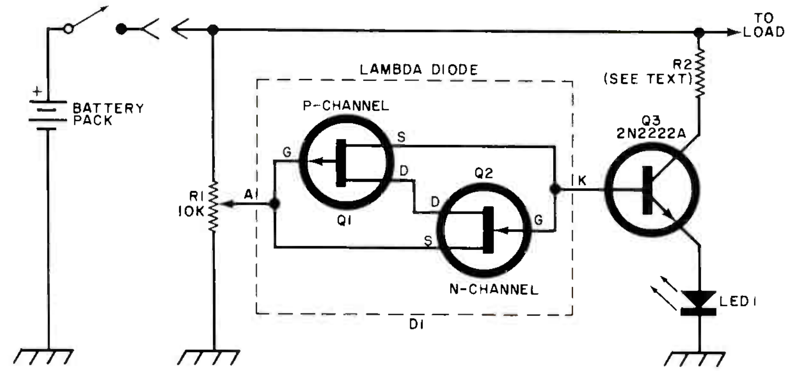


Fig. 1. Battery charger uses a lambda diode made of 2 FET's.

PARTS LIST

LED1—Any discrete light-emitting diode
Q1—P-channel junction field-effect transistor (2N4360 or similar)
Q2—N-channel junction field-effect transistor (2N3819 or similar)
Q3—Silicon switching transistor (2N2222A or similar)
R1—10,000-ohm, 1/5-watt miniature pc potentiometer
R2—Current-limiting resistor (see text for details on how to calculate value; typically about 150 ohms, ½-watt)
Misc.—Printed circuit board or perforated board and solder clips; relay (substitutes for LED1; see text); hookup wire; solder; etc.

The two-terminal, negative-resistance lambda diode shown inside the dashed box in Fig. 1 consists of one each n- and p-channel FET's. (There is no "lambda" diode available commercially.) Note that in this configuration there are only two terminals, which can be labelled "anode" (A) and "cathode" (K).

If the lambda diode is biased into cutoff, transistor *Q3* is also cut off and *LED1* is off. As battery voltage drops, a point is reached where the lambda diode abruptly conducts. This biases *Q3* into conduction and turns on *LED1* to indicate a low-battery condition. (The operating characteristic of the lambda diode is shown in Fig. 2.)

The potential at which the lambda diode conducts can be adjusted by potentiometer *R1*. Resistor *R2* is a current limiter for *LED1*. Its value is determined by Ohm's Law (*R2* = E/I, where *R2* is in ohms, E is the potential of the battery at the point *LED1* turns on, and I is the operating current of the LED used.

Construction Details. The lambda-diode battery-charge monitor is small enough to be built into the equipment in which a Ni-Cd battery pack is used for power. Alternatively, it can be assembled as an external low-battery indicator accessory and housed in a small utility box. In either case, printed-circuit (Fig. 3) or perforated board construction can be used.

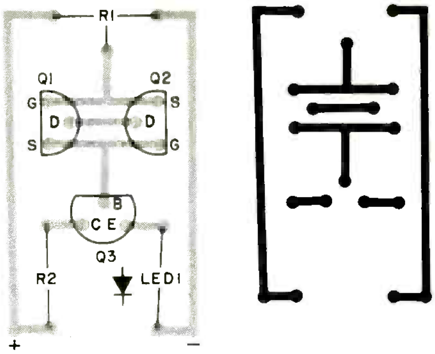


Fig. 3. Etching and drilling guide (right) with component layout (left) can be used or a perforated board will do.

The choice of JFET's for making up the lambda diode is not critical. Almost any combination of n- and p-channel devices will work as well as those specified in the Parts List.

You may want to consider substituting a small relay for *LED1* to disconnect the battery pack from the load when the potential falls low enough to trigger the system. This setup will automatically protect the battery pack from polarity reversal during discharge. ◇

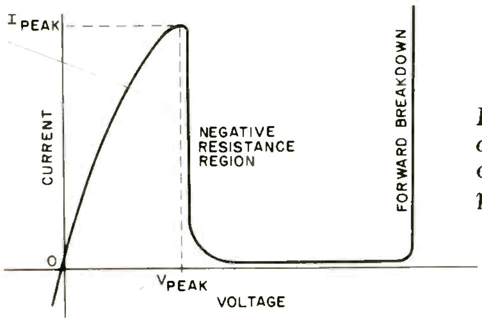


Fig. 2. Operating characteristics of the lambda-diode portion of circuit.

QUICK HEX-DECIMAL CONVERSIONS

BY RAYMOND J. BELL

CONVERSION from hexadecimal to decimal or vice versa is sometimes required in microcomputers. The table presented here offers a rapid and efficient solution to this problem. It is suitable for integers between 0 and 65,535 (O_{16} to $FFFF_{16}$). It can also be easily expanded.

Here's an example of how to use the table. Say the hexadecimal number, $A7BD_{16}$, is to be converted to decimal. Starting with the right-most digit, D, look at the table's fourth-place digit and read down to D in that column. The decimal equivalent is 13. Repeat for the next digit in the third column. Here, the original number, B, corresponds to 176. Continuing with the next two digits, we read 1792 and 40960, respectively. Add these numbers, and the total is 42941, which is the decimal equivalent of $A7BD_{16}$.

The table can also be used in reverse to convert decimal numbers to hex. To convert 800_{10} to hex, for example, look in the table for the highest entry which does not exceed the number, which is 768. This corresponds to a 3 in the third hex digit. (The fourth digit is 0, so it can be ignored.) Next, 768 is subtracted from 800, yielding a remainder of 32. The highest table entry that does not exceed 32 is 32, which corresponds to a 2 in the second hex digit. Subtracting 32 from 32, the remainder is zero, which means the conversion is complete. (Note: to maintain proper relationship of the hex digits, we put 0 in the first hex digit, giving 320_{16} as the hex equivalent of 800_{16}, *not* 32_{16}, which is 50_{10}.)

The table can be expanded by multiplying the digits of 0 to 15 by the appropriate power of sixteen. To construct the fifth column of the table, multiply 16^5 (65,536) by 0, 1, 2 to 15. ◇

HEX-DECIMAL NUMBER TABLE

1st Place		2nd Place		3rd Place		4th Place	
Hex.	Dec.	Hex	Dec.	Hex.	Dec.	Hex	Dec.
0	0	0	0	0	0	0	0
1	4096	1	256	1	16	1	1
2	8192	2	512	2	32	2	2
3	12288	3	768	3	48	3	3
4	16384	4	1024	4	64	4	4
5	20480	5	1280	5	80	5	5
6	24576	6	1536	6	96	6	6
7	28672	7	1792	7	112	7	7
8	32768	8	2048	8	128	8	8
9	36864	9	2304	9	144	9	9
A	40960	A	2560	A	160	A	10
B	45056	B	2816	B	176	B	11
C	49152	C	3072	C	192	C	12
D	53248	D	3328	D	208	D	13
E	57344	E	3584	E	224	E	14
F	61440	F	3840	F	240	F	15

COMPUTER GLOSSARY

ACCUMULATOR—In a microprocessor, the internal register in which logical operations are performed and the results initially stored; characters may also be input to or output from the accumulator.

A-D—Conversion of continuous, analog data (like meter readings) into digital form that computers can read.

ADDRESS—The number used to refer to a specific byte in memory or to an input or output port.

ALPHANUMERICS—Computer output or input in the form of letters and numbers rather than graphs or drawings.

ANALOG—Originally, the physical representation of numerical quantities in terms of motion, voltage, resistance, etc. By extension, any data which changes in a smoothly varying way, rather than changing in discrete steps as digital data does.

ASCII—American Standard Code for Information Interchange, a seven-bit code used by most microcomputer equipment to represent alphanumeric characters.

ASSEMBLER—A program that converts assembly-language into machine language.

ASSEMBLY-LANGUAGE—A computer language that uses easily remembered groups of letters as commands instead of the "ones" and "zeros" a computer understands, e.g., JNZ (jump if not zero) instead of 11000010.

BASIC—Beginners All-purpose Symbolic Instruction Code, the most common high-level language used on home computers.

BAUD RATE—The number of signal elements transmitted per second. With the transmission systems used in microcomputers, equal to bits per second (bps).

BINARY—The number system with base 2. There are only two digits in the system: "0" and "1".

BIT—A binary digit. The smallest bit of information possible.

BUS—A group of wires connecting CPU, memory and I/O for exchange of information.

BUS STRUCTURE—A fixed arrangement of the wires of a bus.

BYTE—A computer word eight bits long; it has 2^8 (256) possible values. Most home computers use one-byte instructions, and a data bus one byte wide.

COBOL—Common Business-Oriented Language, a computer language designed for business programming.

COMPILER—A program that converts programs written in high-level languages, like BASIC, into a program that a computer can run directly or with the aid of a shorter "runtime" program.

CPU—Central Processing Unit, the circuit or subsystem which actually does the computing.

CRT—Cathode Ray Tube, a TV-type screen which may be used by a computer to display its alphanumeric and graphic output.

D-A—Conversion of digital data to be continuous, analog form; a circuit to perform this conversion.

DATA—The information in a computer program that the computer processes, as opposed to the information that tells the computer what process must be done.

DISPLAY—A device that shows the computer output or status visually instead of on paper. The most frequently used displays are CRTs, or multi-segment LEDs (like calculators).

EPROM—Erasable PROM, a type of PROM which can be erased with ultraviolet light and then re-programmed.

FIRMWARE—Software (programs) stored in ROM or PROM memory.

FLOPPY/FLOPPY DISK/FLOPPY DISKETTE—A thin disc of magnetic material like recording tape that is used for recording and storing computer programs and data.

FORTRAN—FORulat TRANslator, a high-level language designed for scientific programming.

GRAPHICS—The processing, input and output of data other than alphanumerics or control or status functions (for example, pictures, images and graphs).

HARD COPY—Computer output that is printed rather than output on a display.

HARDWARE—The computer equipment itself, as opposed to its programs (software).

HEX/HEXADECIMAL—A number system with base 16. The sixteen digits are: 1, 2, 3, 4, 5, 6, 7, 8, 9, 0, A, B, C, D, E, and F.

HIGH-LEVEL LANGUAGE—A computer language that humans can understand easily and that a computer can translate into the machine-language form it understands, in one or more steps. Many instructions in a high-level language require that the computer perform more than one computer operation. Some of the more common high-level languages are: BASIC, COBOL, FORTRAN, and PASCAL.

INPUT—The information that is fed into a computer; it may contain data, instructions, or both.

INSTRUCTION—The portion of the information fed into a computer that tells the computer what to do with the other information (data) it receives.

INTERFACE—A circuit to form the proper connection between a computer and some other device.

INTERPRETER—A program which both decodes and executes a high-level program. Unlike Compilers, Interpreters must be loaded into a computer both when the user program is being entered and when it is run.

I/O—Input/output. A) The equipment used to put information into or take information out of a computer. B) The information itself that is given to or taken from a computer.

KEYBOARD—A group of keys. Among those who work with computers, it is usually used to mean a typewriter-like layout of keys (for numbers, letters, punctuation and other symbols) plus the accompanying electronics, that is used to input information into a computer. Other arrangements of keys are usually referred to as keypads.

"K"/KILOBYTE—2^{10} (1024) bytes. Memory is usually reckoned in kilobytes. "K" stands for "binary thousand" (1024), while ordinary decimal thousands are represented by lowercase "k".

MACHINE CODE/MACHINE LANGUAGE—Instructions that are in binary form and actually understood by a computer without further decoding. These instructions are usually in the form of 8-bit (one byte) words in home computers; however some instructions, incorporating data or addresses, may be two or three bytes long.

MASS STORAGE—Recording systems for holding or storing programs or data not required for immediate use. Such information must be read into the computer before it can be used. Common forms of mass storage used with home computers are cassettes and floppy disks.

MEMORY—The part of a computer dedicated to storing programs and data. Memory is organized as words (usually 8 bits) each of which has a unique address so that the computer may select any word it needs by using the address of that word.

MINI FLOPPY—A 5¼-inch floppy disk. Standard floppy disks are 8 inches in diameter.

MODEM—An I/O device that permits the computer to receive or transmit information over telephone lines.

MONITOR—A) A CRT screen and associated electronics which may be used for computer display. B) A program that instructs the computer how to do "housekeeping" tasks such as: handling input or output; changing, storing (writing), or reading the contents of memory; etc.

NON-VOLATILE—Memory that retains its contents even if no power is supplied to it. (See RAM.)

OCTAL—A number system with base 8. The eight digits are: 0, 1, 2, 3, 4, 5, 6, and 7.

OUTPUT—The information sent out by a computer. It may be visual (printed or displayed), aural (sound or music), electrical (control for a motor), etc.—any communication from a computer to the outside world.

PAPER TAPE—A mass storage system using paper tape with eight hole-positions representing the eight bits of each byte stored.

PARALLEL—A type of I/O in which each bit of a computer word is transmitted over a separate wire simultaneously. (See serial.) A computer's internal information flow is also normally in parallel form.

PASCAL—A comparatively new computer language, now becoming available for home computers.

PERIPHERALS—The parts of a computer system outside of the computer proper, such as: terminals, displays, printers, etc.

PORT—The I/O circuit that connects a computer with a peripheral. Each port has an address (number) by which the computer can distinguish it from other ports. Ports may be serial or parallel.

PRINTER—A mechanism that prints the output of a computer. Printers with keyboards are called printing terminals.

PROCESSOR—A set of circuits capable of performing the essential functions of a computer CPU. In the case of a microprocessor (MPU), these circuits are combined into one or a few integrated circuits.

PROM—Programmable ROM, non-volatile memory which can be programmed by a user. Two subdivisions of this class are EPROM (Erasable PROM) and EAROM (Electrically Alterable ROM) which are erasable with ultraviolet light or electrical impulses respectively. EPROM and EAROM may be re-programmed after they are erased.

RAM—Random Access Memory, any type of memory that may be written into or read from. It is randomly accessible if it takes the same quantity of time to reach any address, independent of location. In contrast, a Serial Access Memory is one in which the time required to get to one address from another is dependent on how far the addresses are from each other. Information stored on cassette is serial, for example. Most RAM is volatile in that the contents rearrange themselves randomly when the power is shut off.

R-F MODULATOR—Radio-Frequency Modulator, a device that converts video information into frequencies acceptable to a TV set so that the TV may be used as a substitute for a video monitor.

ROM—Read Only Memory, memory that can only be read from, not written into, because its contents have been fixed during manufacture. The term is often loosely applied to any non-volatile memory, especially members of the PROM (user programmable) family.

SERIAL—A type of I/O port in which all data is transferred over a single pair of wires, one bit at a time. In practice, the data words are sent in a specific pre-selected format to make each word distinguishable from the others that precede and follow it.

SOFTWARE—Computer programs, sets of instructions that tell the computer what to do and how it is to be done.

SYSTEM—The set of electronics and machinery that is assembled for the computer to perform its tasks. It includes not only the CPU or MPU, but the memory, I/O and peripherals.

TERMINAL—A peripheral device combining a keyboard for human input to the computer with a display or printer for the computer's output.

WORD—A computer word, the largest number of binary digits that a computer can handle simultaneously. Most home computers can handle a maximum of eight bits (one byte) of data at the same time. Some newer microcomputers can handle words of up to 16 bits.

WORD PROCESSOR—A system which accepts words and text as input, and which allows that text to be modified, merged with other texts, and output in a desired format.

". . . so I said, SZE and PR then GOTO or at least GOSUB . . ."

Digital Electronics/Microcomputers

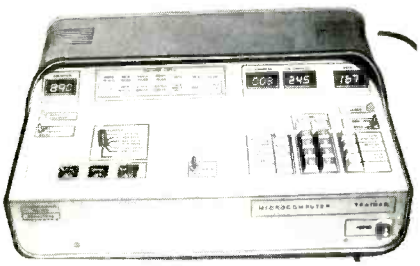
PRODUCT DIRECTORY

The listing covers only computers and those peripherals and module boards made by a manufacturer for its own computers and not fitting other makes. Modules, peripherals and accessories made for those computers by other companies, or fitting several makes of computer, will be found in the appropriate sections of this directory.

Wherever possible, we have indicated mutual compatibility among products of different manufacturers by one of the following bus symbols: (AP)=Apple II,(DG)=Digital Group, (EX)=Motorola EXORcisor M6800, (H8)=Heathkit H-8, (I8)=Intellec 8, (IEE)=IEEE-488 bus, (KM)=KIM-1; (LS)=LSI-11, (MB)=Intel SBC Multibus, (PT)=PET, (RS)=Radio Shack TRS-80; (S1)=S-100 (Altair) bus, (S3)=SWTP 6800 30-pin I/O bus, (S5) SWTP 6800 SS-50 50-pin bus, (UB) DEC Unibus.

ALLIED COMPUTERS

MCT-1 MICROCOMPUTER TRAINER
8080A MPU with 512 bytes EPROM (256 dedicated) and 512 bytes RAM expandable to 4K; 4 paral-



lel ports; displays in octal for hi and lo address, data and counter; octal keypad; function keys as switches; 256 byte executive program in EPROM. $900

ALPHA MICRO SYSTEMS

AM-100 16-BIT CPU (S1)
Two-board MPU implementing WD-16 16-bit processor on S-100 bus. Supports most S-100 peripherals, including static memory, I/O and video. MPU features 11-digit floating-point arithmetic in hardware; eight 16-bit general registers; real-time clock; multiple-level DMA and vectored interrupts, up to ten times the throughput of most 8-bit systems. Software provided includes AMOS operating system with time-sharing, multi-tasking, multi-user, disk-management and memory-management (to 256K bytes) capabilities, device-independent I/O structure; macro assembler, ALPHABASIC with special business features, ALPHALISP, ALPHAFORTH and ALPHAPASCAL
AM-00100-0 .... $1495

APF

IMAGINATION MACHINE
Two-part system, consisting of MP-1000 programmable TV game with color display, and two remote keyboard/joystick controls, plus larger

computer module with full typewriter keyboard, cassette deck, 10K ROM, 9K RAM, expansion provisions. Modulated TV output, 32 char × 16 lines, alphanumerics in three color modes; 64 × 32 graphics, eight colors, intermixed with alphanumerics; high-resolution graphics modes 128 × 192 8-color, 256 × 192 1-color; built-in tape deck for standard cassettes with 1200-baud transfer, computer controlled motor, three-digit counter; built-in three-octave music synthesizer with accidentals; BASIC; RAM, I/O, printer, floppy and modem expansions to come.
IM-1 .... $595

PECOS 1
6502-MPU computer with built-in typewriter keyboard, dual audio cassette drives with computer start-stop (up to four tapes addressable to tape number and file name); 800-baud recording; 16K RAM, 24K ROM with PeCos interpreter (JOSS-derived) and OS; includes separate, 9-in B&W monitor, 40 chars × 16 lines, upper/lower case . $1695

APPLE COMPUTER

APPLE II (AP)
6502-MPU computer with built-in keyboard, 8K BASIC and 2K monitor in ROM, 4K-48K RAM, inter-

faces for cassette (1500 char/sec), color video (text, graphics, or mixed) and video-game paddles or joysticks. Video output: 40 characters × 24 lines, upper-case; normal, inverse, or flashing; full cursor control. Graphics 40 × 48 resolution (40 × 40 with four lines text) in 15 colors; high-resolution graphics (requires 12K memory), 280 × 192 (280 × 160 with four lines text) in black, white, and two colors. Apple BASIC has special color, graphics, and game commands. Assembled, in case. Weight 10 lb. With 16K/32K/48K .... $1195/$1345/$1495

APPLE II PLUS (AP)
Similar, but with ROM-resident Applesoft Extended BASIC. Prices as above.
See also: Module Boards, Peripherals.

ATARI

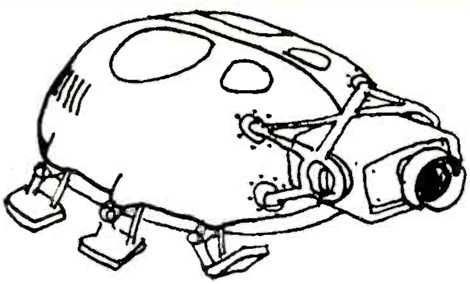
400
6502-MPU; 8K RAM; 8K ROM, expandable to 16K with plug-in program cartridges; 57-key, monopanel flat keyboard; upper/lower-case, graphic symbols; full screen editing functions; four-function keys; four audio channels; built-in speaker; inputs for four controllers (joystick, paddle, etc.); BASIC; TV output, channel 2 or 3; color graphics, 16 colors, eight luminance levels; graphics resolution 320b192.
Atari 400. Wired $550
Atari 410. Program Recorder. With program track, plus audio track for voice accompanied programs $90

800
Similar to 400, but with typewriter-keyboard; accepts accessory floppy system, printer; composite

video as well as r-f output; power indicator/low-voltage light; two externally accessible cartridge slots for rapid program loading, four internal for user-replaceable memory cartridges; serial I/O; includes 410 cassette unit; 8K RAM, expandable to 48K; 8K internal ROM plus 8K BASIC in ROM cartridge.
Atari 800. Wired $1000
CX852. 8K RAM for 800 .... $125
CX853. 16K RAM for 800 .... $250
Atari 810 Disc Drive. For 5¼-in mini-floppy; 92K per diskette side; 236-msec average data access time; for 800 system, up to four drives supported by 800 .... $750
Atari 820 Printer. Impact, dot-matrix; 40 char/sec; 1 line/sec; for Atari 800 .... $600

CGRS MICROTECH

SYSTEM 6000 (S1)
6502-MPU computer system using S-100 bus. Modular system, all parts available separately.
6000 Level I: Tutorial. 6502 MPU; 256 bytes RAM; front panel with 7-segment hex displays, single-step, memory protect. Kit/wired .... $200/$240
6000 Level II: Introductory. All features of Level I, except 1K RAM, plus TTL support logic for S-100 interface. Kit/wired .... $260/$330
6000 Level III: Standard. All Level II features except front panel, plus I/O board with T.I.M. "Terminal Interface Monitor" ROM for use with terminals; S-100 motherboard, power supply (± 16 V @ 1 A, − 8 V @ 10 A). Kit/wired .... $370/$470
6000 Level IV: Advanced. Level III features plus front panel; 2K RAM. Kit/wired .... $500/$600
6000 Level V: Professional. Level IV features plus cabinet and EXOS extended operating system firmware. Kit/wired .... $795/$995



Have You Been Bitten By The Computer Bug?

Basic Computer Games

Edited by David Ahl, this book contains 101 imaginative and challenging games for one, two, or more players — Basketball, Craps, Gomoko, Blackjack, Even Wins, Super Star Trek, Bombs Away, Horserace. Simulate lunar landings. Play the stock market. Write poetry. Draw pictures.

All programs are complete with listing in Microsoft Basic, sample run and description. Basic conversion table included. 125,000 copies in print. 192 pages softbound. [6C] $7.50.

The Best of Creative Computing

The first two years of **Creative Computing** magazine have been edited into two big blockbuster books. **American Vocational Journal** said of Volume 1, "This book is the 'Whole Earth Catalog' of computers." [6A] Volume 2 continues in the same tradition. "Non-technical in approach, its pages are filled with information, articles, games and activities. Fun layout." —**American Libraries.** [6B] Each volume $8.95.

Creative Computing Magazine

Creative Computing has long been Number 1 in applications and software for micros, minis, and time-sharing systems for homes, schools and small businesses. Loads of applications every issue: text editing, graphics, communications, artificial intelligence, simulations, data base and file systems, music synthesis, analog control. Complete programs with sample runs. Programming techniques: sort algorithms, file structures, shuffling, etc. Coverage of electronic and video games and other related consumer electronics products, too.

Just getting started? Then turn to our technology tutorials, learning activities, short programs, and problem solving pages. No-nonsense book reviews, too. Even some fiction and foolishness.

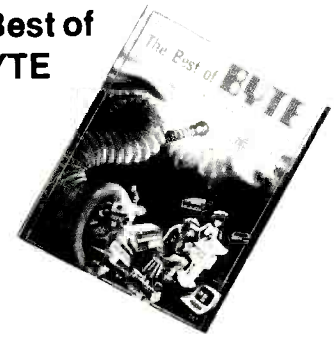
Subscriptions: 1 year $15, 3 years $40. Foreign, add $9/year surface postage, $26/year air.

More Basic Computer Games

Contains 84 fascinating and entertaining games for solo and group play — evade a man-eating rabbit, crack a safe, tame a wild horse, become a millionaire, race your Ferrari, joust with a knight, trek across the desert on your camel, navigate in deep space.

All games come complete with program listing in Microsoft Basic, sample run and description. 192 pages softbound. [6C2] $7.50.

The Best of BYTE



This is a blockbuster of a book containing the majority of material from the first 12 issues of **Byte** magazine. The 146 pages devoted to hardware are crammed full of how-to articles on everything from TV displays to joysticks to cassette interfaces and computer kits. But hardware without software might as well be a boat anchor, so there are 125 pages of software and applications ranging from on-line debuggers to games to a complete small business accounting system. A section on theory examines the how and why behind the circuits and programs, and "opinion" looks at where this explosive new hobby is heading.

Softbound, 386 pages, $11.95.

Adventure

Adventure is an astonishing new innovative game for your TRS-80, Sorcerer or PET. Search for hidden treasure while avoiding exotic wild animals.

For 16K Level II TRS-80 and 16K Sorcerer: (1) **Adventureland,** (2) **Pirate Adventure,** (3) **Mission Impossible,** (4) **Voodoo Castle,** and (5) **The Count.** Adventureland and Pirate Adventure are available for 24 PET too. $14.95 per cassette.

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800/631-8112 (in N.J. 201/540-0445.

CIRCLE NO. 3 ON FREE INFORMATION CARD

6000 Level X: Turnkey. Keyboard input and video output; no front panel. 1K RAM, "VIP" operating system with screen control; other features as for Level V. Kit/wired .... $895/$995
6800 Level VI: Same as Level X, but with 8" disk drive. Wired only $1550
6000 Level XI: Portable. Similar to Level X, but in portable briefcase; power supply ±16 V @ 1 A, −8 V @ 6 A; S-100 motherboard, with room for additional cards. Kit/wired .... $745/$895

6502 PROFESSIONAL DEVELOPMENTAL SYSTEM (S1)
Complete microcomputer laboratory with advanced system development capability. Features the CGRS Multiple I/O board, a S-100 Disk Controller Board, and 16K RAM and dual floppy drives.
6502 PDS. With two 5¼" drives $2500
6502 PDS. With two 8" drives $3300
DMA. Front Debug Panel $250
DBM-1. ROM simulator $270
Video Terminal (internal) $650
9-digit BASIC interpreter $250
Accessories available: printer, dual 5¼" floppies, dual 8" floppies.

COMMODORE

PET COMPUTER 2001 (PT)(IEE)
6502-MPU, self-contained computer, includes built-in keyboard with 64-character ASCII uppercase plus 64 graphics-related characters; 9-in video dis-

play for graphics, 40-character × 25-line alphanumerics or both; 8K RAM memory, expandable to 32K; 12K ROM including 8K BASIC interpreter and 4K operating system, built-in audio-cassette recorder (file management system in BASIC); interfaces for additional recorder and IEEE-488 instrument interface bus. Wired.
PET 2001-8 .... $795
PET 2001-16N. Similar, with 16K RAM memory, larger keyboard; requires external cassette (optional) $995
PET 2001-32N. Same, except 32K RAM $1295

CBM BUSINESS COMPUTER SYSTEM (PT) (IEEE)
Similar to PET, but with typewriter-style keyboard and numeric pad, no graphics keys, no cassette.
CBM 2001-16B. With 16K RAM $995
CBM 2001-32B. With 32K RAM $1295
C2N. Cassette player/recorder for PET $95

CBM PRINTER (PT)
80-column, dot-matrix impact; 7×6 matrix; 80 char/line; 70 lines/min, character set includes PET graphics.
CBM 2023 .... $849
CBM 2022. Same, with tractor feed, upper/lower-case $995

CBM MINI-FLOPPY DISK (PT)
Intelligent mini-floppy; 170.5K per disk net user storage. Includes cabinet and power supply. Requires retrofit kit with PET 2001-8.
CBM 2040A. Single disk $895
CBM 2040. Dual disk $1295

COMPUCOLOR

COMPUCOLOR II
8080-MPU intelligent-terminal type computer with 8-color integral display on 13-in CRT; 72-key keyboard with 3-key rollover; 8K to 32K user RAM; built-in mini-disk drive; 32-line × 64-char display;

17K PROM with sockets for additional firmware; supplied with extended disk BASIC in ROM, file control system, and terminal software designed for up to 512 ports; 128 × 128 pixel graphics; vector plotting; upper-case alphanumerics plus 64 graphic characters; RS-232 interface; terminal-mode software supplied; disk capacity 51.2K/disk side (formatted); both sides of disk usable by flipping disk over. Wired.
Model 3. 8K RAM $1495
Model 4. 16K RAM $1695
Model 5. 32K RAM $1995

OPTIONS
CCN. 101-key keyboard with color and numeric clusters $135
CCF. 117-key keyboard, with 16 additional function keys $200
Single Disk Add-on $400
16K RAM add-on for Models 3,4 .... $375

CROMEMCO

SYSTEM THREE (S1)
Z-80A-MPU with dual-disk drive (4-drive controller), 32K RAM with bank select (expandable to 512K). 30-A power supply; 21-board capacity; jump-on-reset to 1K PROM monitor; includes serial (110-76,800 baud) and parallel interface. Rack mount $5990
Option 001. Front-panel PROM programmer for 2708 .... $495
Option 002. Additional dual-disk drive $2395
Option 004. Additional 32K memory $595
Z3-WCB. Walnut floor cabinet, 29"×21"×30" ... $595
Z3-CAB. Aluminum cabinet with fold-away handles, 13" × 20" × 26" $195
Software available: 16K Z-80 BASIC, FORTRAN IV, Z-80 macro assembler and linking loader.

Z-2 (S1)
Z80 MPU "black-box" computer with no external controls. Features 21-slot Blitz-Bus motherboard for lower noise; PROM programmer; power-on jump; ROM, RAM and I/O not included. Rack-mount design (other cabinets optional), with front-accessible card slots and card retainer; 60-A power supply for cards and other peripherals.
Z-2W. Wired $995
Z-2WX. Same, less processor board $795

Z-2D (S1)
Similar to Z-2, but with built-in, mini-floppy (5 ¼ in) disk drive, space for second drive, 4-drive controller; includes 1K ROM monitor, 1 serial port.
Z-2DW. Wired $1990
Z2D-FDD. Additional disk drive $495
Z2-RPW. Retro kit converts Z-2 to Z-2D $995

SYSTEM TWO (S1)
Consists of Z-2D with 2 drives, RS-232 interface, 64K RAM, PRI printer interface.
Model CS-2 .... $3990

SINGLE CARD COMPUTER (S1)
Z-80 MPU plus 8K 2716 PROM; 1K RAM, serial (RS-232 or 20 mA) port; 24 bits parallel I/O; vectored interrupts; five programmable timers. Requires +8 V @ 1.4 A, + 18 V @ 70 mA; − 18 V @ 25 mA.
SCC. Kit/wired .... $395/$450
MCB-216. 12-command monitor and 3K Control BASIC in two 2716 PROMs $90
Z80-CPU. MPU replacement only, no on-board memory or I/O. See Module Boards section. Kit/wired .... $295/$395

Z-2H HARD DISK COMPUTER (S1)
Similar to Z-2, but incorporates 11-megabyte hard disk system plus dual 5 ¼-inch floppy drives; 12-

slot motherboard (5 slots occupied); 64K RAM, expandable to 512K; PRI printer interface; includes CDOS for hard and floppy disks. Wired $9995

DIGITAL SPORT SYSTEMS

INFORMER 1 (S1)
Z80-MPU "black box" computer with RS-232 serial interface for terminal; 8K PROM board with 1K monitor; 16K RAM; 9-slot motherboard; uses modified S-100 boards $858

INFORMER 2
Similar, with built-in, single-drive mini-floppy, separate 63-key keyboard and video controller (16 lines

× 64 char); includes 32K RAM, two RS-232 interfaces; disk with extended-DOS BASIC $1999

INFORMER 3
Similar to Informer 1, but with CRT terminal (24 lines × 80 char), separately-housed 8-in floppy drive; 48K RAM, two RS-232 ports, heavy-duty power supply $3999
Options available: 16K RAM, 1-port and 4-port RS-232; 1-port and 4-port parallel; 8K PROM; PROM burner; mini and standard disk controllers; r-f modulator; 80-column electrostatic screen printer; 132-column impact printer; software.

S-MS ADAPTER (S1)
Adapts standard S-100-bus interface boards to Informer-modified S-100 bus $44

ELECTRONIC CONTROL TECHNOLOGY

ECT-100 COMPUTER (S1)
In card cage for 19" rack mounting. Choice of 8080 or Z-80 MPU with jump on reset. 20-slot motherboard standard. Unregulated ± 16 V @ 3 A ea., +8 V @ 30 A; 115 V input, with taps for 105 V and 125 V (220/208/240 V on special order).
ECT-100-F-8080. With 8080 MPU, 20 sets connectors and guides. Kit/wired .... $425/$595
ECT-100-F-Z80. Same, with Z-80 MPU . $525/$695

TABLE-TOP COMPUTER
Similar, but in table-top cabinet with 10-slot motherboard, 16K RAM optional, 15 A power supply.
TT-8080-S. 8080, with RAM. Kit/wired . $995/$1145
TT-8080. Less RAM .... $440/$570
TT-Z80-S. Z-80, with RAM .... $1095/$1245
TT-Z80. Less RAM .... $540/$670

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7BB9

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CIRCLE NO. 1 ON FREE INFORMATION CARD

ELECTRONIC PRODUCT ASSOC.

MICRO-68b (EX)
6800-MPU computer with 16-key hex keypad, six-digit hex LED display; 8K RAM memory expandable

to 64K; 25-A power supply; ROM monitor, editor, and I/O; TTY/RS-232 and Kansas-City-standard cassette interfaces. In fan-cooled cabinet with 13-slot motherboard (also accepts Motorola EXORcisor cards). Available with extra I/O and bus connections at front panel. M68b. Wired $1915

MICRO-68
6800-MPU, with hex keypad and display, 128 bytes of RAM, 512-byte ROM monitor/editor, power supply, one I/O port. In wood/plexiglass cabinet with room for 640 words additional ROM; other options below.
M68C. Wired $495
X68C. Expanded version with 8K RAM, 3.5-A power supply, additional ROM for TTY, TTY/RS-232 and cassette interface, expansion cabinet $1186
RAM8K. 8K static memory $429
RAM4K. 4K static memory $319
R6810. Additional 128-byte RAM for Micro-68 .... $6
PEB1. 16K PROM board for 7641/3624 PROMs $264
PROM5-12. 512-byte PROM for above (programming available) $24
PEB2. 512-byte PROM board for Micro-68 .... $21
PROM256. 256-byte PROM for above (programming available) $10
MB6830L7. MIKBUG ROM for TTY $29
TTY4. TTY PROM $24
GP1. General purpose prototyping board $30
TCC3. I/O for Byte-standard cassette, RS-232 terminal and TTY (requires TTY4 or MIKBUG ROM) $142
TVA-1. Video interface and TV adapter for 29-line, 30-character display. Includes keyboard input and RS-232 interface. For X68C $245
IMP-68X. Interface for IMP1 printer (see Peripherals) $22
ADC-1. 12-bit analog-to-digital converter $420

EXIDY

SORCERER (S1)
Z-80 MPU; intelligent-terminal type computer, with keyboard and video output. Memory 8K RAM ex-

pandable to 32K; 4K ROM standard, ROM cartridges up to 16K available. Dual cassette I/O at 300 or 1200 baud, remote motor on/off; RS-232 serial I/O at 300 or 1200 baud; edge-card connection for S-100 bus expansion unit. Video output 30 lines × 64 char (1920 char/screen), full 128-character ASCII set; 64 pre-defined and 64 user-defined graphic characters (all 128 may be user-defined); 512(h) × 240(v) graphic resolution; automatic scroll, delete character, erase end-of-line, end-of-screen; clear screen; full cursor control $995
DP-1001-1. .... $995
DP-1000-2. W/16K RAM $1145
DP-1000-3. W/32K $1295
DP-1000-4. W/38K $1445

S-100 Expansion Unit. Self-contained six-slot chassis, Sorcerer styled, with interconnect cable and S-100 translation interface; for use of S-100 module boards with Sorcerer.
DR-1004 .... $349
S-100 I/O Kit. For connection of Sorcerer to S-100 computer chassis; interface card and interconnect cable.
DP-4004 .... $199
16K RAM Expansion Kit. Fits within Sorcerer (max. internal RAM capacity, 48K).
DP-1001 .... $160

VIDEO DISPLAY UNIT
12-in CRT with 20-MHz bandwidth; Sorcerer-style cabinet; with cable for video connection to Sorcerer.
DP-1005 .... $399

VIDEO/DISK UNIT
12-in, 20-MHz video display and dual mini-floppy system in swivelling, tilting enclosure; includes CP/M DOS, Z80 assembler, text editor, linking loader, Microsoft disk extended BASIC; plugs directly into Sorcerer, no S-100 unit required; holds 630K formatted.
DP $2995

Also available: ROM Pac plug-in formwire (including user EPROM pac), parallel data cable, serial/cassette data cable.

F&D ASSOCIATES

STM-1
6502-MPU stand-alone computer, also usable as simulator for development work on 6502 systems. For details, see Module Board Section.

GIMIX

GIMIX GHOST 6800 (S5)
6800-MPU system with SS-50 bus. Has fifteen 50-pin slots plus eight DIP-switch-addressable, 30-pin I/O slots configurable to four or eight decoded addresses; DMA capability through cycle-stealing or halt; separate crystals for CPU and baud-rate generator; sockets for 4K 2708 PROM; DIP-switch-addressable for SWTP or MSI software. In cabinet with keylock power/reset switch, cooling fan, video board, GMXBUG 2K ROM monitor, two-port buffered parallel I/O board. 16K RAM; space and power for dual mini-floppy (not included). Options include: three independent software-programmable timers; additional RAM with or without software-programmable RAM address, write protect, disable/enable.
16K System with unsocketed RAM, "GHOSTable" software control of RAM, or timers $1294
16K System with socketed "GHOSTable" RAM (blocks of memory at same addresses, with software enable/disable, for multi-user, multi-tasking, etc.) $1398

HEATHKIT

ALL-IN-ONE COMPUTER
Z80-MPU system with built-in terminal and mini-floppy. Features dual Z80 processors (one for terminal overhead), 16K RAM (expandable to 48K), on-board, built-in memory diagnostics; terminal section includes full typewriter keyboard plus numeric keypad, 8 user-definable keys, direct cursor addressing; 12"-diagonal screen with 25 li by 80 char., line graphics, upper/lower case with descenders; includes audio cassette interface; blinking, non-destructive underline cursor; edit functions include insert/delete character/line, erase page, to end of line, to end of page; 5¼" floppy drive has 102K storage.
H89/WH89. Kit/Wired .... $1595/$2295
H88. As above, less floppy. Kit $1195
H88-2. 16K RAM Chip Expansion Set $150
H88-3. Two-port Serial I/O $85
H88-4. Floppy Disk System for H88 .... $450

H11A (LS)
LSI-11/2 MPU, runs DEC PDP-11/03 software; new, smaller MPU board leaves more space for options; directly addresses 32K RAM, ROM or I/O (0-28K RAM/ROM, 28-32K I/O); backplane with eight, 2-wide module slots; 120/240-V power supply, outputs +5 V @ 15 A, +12 V @ 3 A.
H11A/WH11A. Kit/wired .... $1095/$1895
H11-1/WH11-1. 4K × 16-bit word memory expansion, static, with decode circuitry for 4K address boundaries, card lifters. Kit/wired ..... $125/$150
H11-2/WH11-2. Parallel interface. 16 input and 16 output lines, for 16-bit or 8-bit data transfers; LSI-11 bus interface and vector interrupt logic; required for H10 Paper Tape Reader/Punch. Kit/wired .... $95/$150
H11-5/WH11-5. Serial interface. Opto-isolated, 20-mA or RS-232; 50-9600 baud; with mating connectors. Kit/wired .... $105/$150
Adapter Cable. For EIA-standard interface from H11-5 to peripherals.
WH11-51. Wired $15

H11-6 EXTENDED ARITHMETIC CHIP
Adds hardware arithmetic instructions to LSI-11, including fixed-point ×, ÷ and extended shifts, plus floating-point +, −, ×, ÷. DIP 40-pin package plugs into socket on LSI-11 boards $159
Also available: 16K and 32K word memory module.

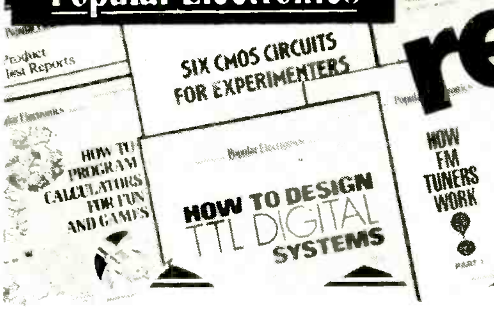
H8 (H8)
Computer with 8080A MPU; 1K ROM monitor for load-dump and front-panel operations; front panel

with octal keypad and digital display. With 10-slot cabinet using Heath 50-pin bus; power supply capable of handling up to 32K of memory and two I/O interfaces; programmable speaker and LED status lights. Kit, with wired and tested CPU; BASIC, assembler, editor and debug programs on audio cassette. Requires H8-1 memory board (see Module Boards) to operate. Kit $289
WH-9. Wired version $349

MICROPROCESSOR TRAINER
6800-MPU computer kit designed for circuit-training purposes. Includes 1K ROM monitor, 6-digit hex LED display, 17-key hex keypad, 256 bytes RAM (expandable to 512), breadboarding socket, 8 buffered LED's for display of breadboard logic states, DIP switches for binary input to breadboard, power supply (+5, ±12 V), all buses buffered and terminated on front panel, provision for 40-pin external connector for extending memory and I/O.
ET-3400/ETW-3400. Kit/wired .... $200/$275
Memory I/O Accessory. Adds audio cassette interface, 1K RAM (expandable to 4K), serial I/O (requires terminal), ROM monitor/debugger and tiny BASIC.
ETA-3400/EWA-3400. Kit/wired .... $150/$250
ETA-3400-1. 3K RAM for ETA-3400 .... $47

HEATH DATA SYSTEMS

Heath Data Systems products are identical to factory-wired Heathkit products, but available through computer stores, not directly from Heath. For product details, see Heathkit listing.
WH89. All-in-one Z80 computer/terminal with 18K, 5¼" floppy disk $2295
H88-2. 16K RAM chip add-on set $150
H88-3. 2-port serial I/O $85
WHS89. WH89 system with 48K RAM, 2 serial ports, HDOS operating system $2795
(FORTRAN, BASIC and word processing available)
WH11A. 16-bit, LSI-11/2 computer (requires terminal) $1895
Available options: 16K × 16-bit memory card, serial I/O, dual floppy disk; see Heathkit listings.



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40886* Stanton Model 681EEE Stereo Phono Cartridge
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40889* Thorens Model TD-126C Record Player
40969* Akai Model GX-270D-SS Four-Channel Tape Recorder
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40972* Dual Model 1245 Automatic Turntable
40973* Burwen Model DNF 1201A Noise Reducer System
41105 Yamaha Model CR 2020 AM/Stereo FM Receiver
41106* Optonica Model RT-3535 Stereo Cassette Deck
41107* dbx Model 128 Dynamic Range Enhancer
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41109* Sansui Model AU-717 Integrated Amplifier
41110 Sherwood Micro/CPU 100 FM Tuner
41111* Sony Model PS-X5 Turntable
41112* JVC Model P-3030 Stereo Preamplifier
41113* Dahlquist Model DQ-1W Low-Bass Module
41315 Sony "Class D" Amplifier
41316 Electrovoice "Series II" Speakers
41317 AR 9 Speakers
41318 JVC Jt-V77 FM Tuner
41319 Pioneer CT-F900 Cassette Deck
41320 Luxman R-1120 Receiver
41321 Dual C-819 Cassette Deck
41322 B.I.C. 2-speed Cassette Deck
41323 SAE Two Amplifier and Tuner
41324 Hitachi Mosfet Power Amp
41325 Akai PO-1000 Open-Reel Tape

COMMUNICATIONS

40890* Cobra Model 29XLR 40-Ch. AM CB Mobile Transceiver
40891* Drake Model SSR-1 AM/SSB Communications Receiver
40892* Kenwood Model TS-820 Amateur Radio Transceiver
40893* Kris Model XL-50 40-Ch. AM CB Mobile Transceiver
40894* President Model "Washington" 40-Ch. AM/SSB CB Base Station
40971* General Electric Model 3-5825 AM/SSB CB Transceiver
40974* Realistic Model TRC-449 Mobile AM/SSB CB Transceiver
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40933* Sencore Model DVM-32 Digital Multimeter
40934* Sencore Model TF-70 Portable Transistor Tester
40935* Triplet Model 60 Analog Multimeter
41115 B&K Precision Model 1820 Universal Frequency Counter

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INTERACT ELECTRONICS

16K MODEL ONE STANDARD
8080A-based single-unit computer; includes MPU, cassette deck, 2K ROM, 16K RAM, r-f audio/video

output to conventional TV; power supply. Color output on TV channel 3, r-f switchbox included; audio software and hardware includes three-octave music synthesizer, tape generation. Cassette interfaces up to 2000 byte/sec, can output sound from tape. Keyboard 53-key, typewriter-layout. Includes joystick X/Y controls. Software available includes BASIC, calculator, data management, mailing list, account ledger, music, educational and games.
With 2 programs ... $500

16K MODEL ONE PROFESSIONAL
Similar, but with two-port RS-232 serial interface ... $600

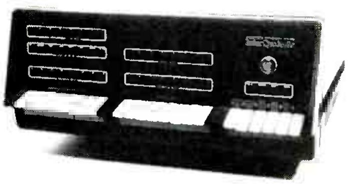
16K MODEL ONE PROFESSIONAL-PLUS
Professional, with additional 14K ROM containing Level II BASIC, program editor, printer and communications software ... $700
E-101. Peripheral Interface RS-232 serial ... $130
E-102. ROM retrofit contains Level II BASIC, editor, printer and communications software ... $100
AS-1001. Entertainment Controller. Joystick with pot, firing button and lever ... $20
QQG-103. Controller Pack. Two Controllers, plus game software ... $20

INTERTEC

SUPERBRAIN INTELLIGENT TERMINAL (S1)(RS)
Z80-MPU system with dual-drive, double-density mini-floppy system (320K total storage), 64K RAM, CP/M DOS; twin Z80 processors; built-in ASCII keyboard plus 18-key numeric pad; built-in 12-in CRT, 80-char 24-line display with half-intensity 25th status line; RS-232 serial I/O, parallel interface compatible with TRS-80, S-100 bus adapter optional. For further details, see Peripherals section ... $2995

ITHACA INTERSYSTEMS

INTERSYSTEMS DPS-1 (S1)
Z80-MPU, S-100-bus mainframe computer with front panel. Keylock ac power switch, 30-slot,



shielded, terminated motherboard; front-panel has address and data breakpoints, slow step, automatic stop, test points and internal diagnostics; binary LED indicators for address and data busses, status byte, programmed output and command status; power supply delivers 25 A @ 8 V, ± 15 V @ 5 A, all lines separately fused; IEEE-standard S-100 bus; supplied less memory, but with 1K PROM (2708) socket on MPU board ... $1145

JADE

FOUNDATION SYSTEM (S1)
Z80-MPU, S-100 computer system; Iso-Bus 12-slot motherboard; Tarbell Cassette Interface; Leedex video monitor; 1K EPROM monitor; Expandoram board with 32K; KTM-2 Keyboard Terminal Module with video output, upper/lower case, 40 char. × 24 li.; one serial port; power supply; Tarbell BASIC on cassette.
SYS-101A. Wired ... $1500

PIGGY SYSTEM (S1)
Z80-MPU, S-100 system, with dual mini-floppies; incorporates SDS SBC-100 CPU board with on-board serial and parallel I/O, software-programmable baud rates; three counter/timer circuits usable as real-time clocks or interval timers; Expandoram board with 48K; double-density disk controller; CP/M; BIOS and monitor PROMS; space for 32K added EPROM, 1K added ROM; Piggy mainframe.
SYS-302. Memory-mapped video. Kit/wired ... $2395/$2900
SYS-301. With Hazeltine 1410 terminal. Kit/wired ... $2915/$3315

MACRO MICRO (S1)
Similar in features to Piggy System, but with 8-in CP/M dual floppies, different cabinet.
SYS-201. With keyboard, video monitor, memory-mapped video. Kit/wired ... $2995/$3495

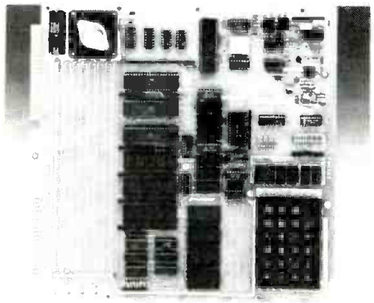
MICRODASYS

SYSTEM 8 (S1)
6809-MPU with 16-bit instructions and internal registers, extended addressing and hardware multiplication. System includes built-in keyboard, S-100 motherboard, 16 A power supply, 80×24 video/graphics card; MD-690b CPU card (see Module Boards section for details); includes 10K PROM space, 1K RAM, 20 I/O lines, RS-232 interface and cassette interface; 8-color video generation available as system option. Kit/wired ... $648/$798

SYSTEM 9 (S1)
Same as above, but with 32K RAM card, 8K-populated; additional RAM chips plug into board.
Kit/wired ... $798/$998
8K RAM chip set ... $129

MICROPRODUCTS

SUPERKIM (KM)(AP)
6502-MPU, single-board computer with detachable hex keypad and 6-digit hex display. Modeled after



Commodore/MOS KIM-1, but more RAM, EPROM and prototype area in approximately same size. Software-compatible with KIM-1; compatible with most KIM-1 and Apple II hardware interfaces; can use Apple II as software development system. Includes: 4K RAM sockets, 1K RAM, 2K KIM ROM monitor; 4 EPROM sockets for 16K 2732, or 8K 2716; power-on reset; interface and jacks for cassette (KIM-compatible); serial RS-232 interface; on-board regulator; rectifier and filters, requires only 12 V ac, C.T. @ 2 A; sockets for 4 6522 I/O chips, 1 provided; can support up to 9 bi-directional 8-bit parallel ports with handshaking; 8 counter timers; 8 latched priority interrupts, software re-settable; DMA possible; EPROM addressable anywhere from 2000 to FFFF; large prototyping area for A/D chips, etc. ... $395

NESTAR SYSTEMS

CLUSTER/ONE
Distributed computer system based on interlinking common personal computers. See Peripherals section for details.

NETRONICS

ELF II
1802 MPU, single-board, animated graphics computer, on five-slot motherboard. With hex keypad video 64 × 32 graphics display output, 256-byte RAM. 60-terminal ELF bus for expansion of memory (to 64K) and I/O. Requires 6.3-V ac. Kit/wired ... $100/$150
Power Supply. (6.3 V ac, 1.5 A) ... $5

ELF II GIANT BOARD
Plug-in expansion board with cassette, RS-232/TTY and 8-bit parallel I/O; decoders for 14 I/O instructions; system monitor/editor. Kit/wired ... $40/$60

4K STATIC RAM
Addressable to any 4K page; chip-select circuit allows original 256 bytes to be used; buffered; regulated. Kit/wired ... $90/$115

PROTOTYPE (KLUGE) BOARD
Accepts up to 36 IC's, all sizes; space for on-board regulator ... $17

ELF II FULL ASCII KEYBOARD
Kit/wired ... $65/$90
Case for ASCII keyboard ... $20

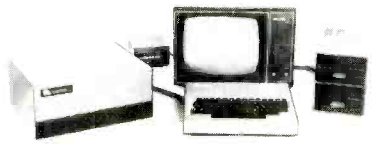
COLOR GRAPHICS & MUSIC BOARD
Permits color graphics with simultaneous computer generated music. Kit/wired ... $50/$70

VIDEO DISPLAY BOARD
64 or 32 character by 16 line upper and lower case format; with ASCII keyboard plugged-in board becomes stand alone terminal requiring no memory or I/O mapping; 1K RAM on-board; cursor control; ASCII/Baudot to serial and serial to video ports on board. Kit ... $90

DUAL TAPE CONTROLLER BOARD
For control of two cassette recorders needed when using Text Editor or Assembler. Kit ... $18

EXPANSION POWER SUPPLY
5-A; powers entire Elf II; required if adding 4K RAM boards. Kit ... $35
CASE for ELF II with all expansions ... $30

EXPLORER/85 LEVEL "A"
8085 based system with on-board S-100 expansion; will run machine code 8080A programs; serial



and parallel I/O, total of four 8-bit and one 6-bit ports; 256 bytes RAM expandable to 4K on board and to 60K total; 2K monitor/operating system in ROM.
Level "A" Kit. ASCII/keyboard/Terminal version ... $130
Level "A" Kit. Hex keypad/Display version ... $130
Level "B" Expansion Kit. Parts for on-board address decoding and bus buffering ... $50
Level "C". Card cage for up to six cards; bus extension motherboard and all hardware ... $40
Level "D". Components and sockets for 4K RAM (2114) expansion. Requires Level "B" plus +8 V @ 600 mA ... $70
Level "E". All parts for adding 8K of EPROM except the EPROM (Intel 2716 or TI 2516). Requires +8 V @ 700 mA ... $6
Accessories include: ASCII keyboard/terminal,

with built-in video display board; Hex keypad/display; power supply; and double density floppy disk kit.

NORTH STAR

HORIZON-1 (S1)
Z-80-MPU computer with mini-floppy disk drive, 4-MHz processor, 16K-32K RAM, one serial I/O port, and North Star extended disk BASIC and DOS. Motherboard has slots for up to 12 S-100 boards (three slots used in normal configuration); serial I/O, real-time clock and disk power on motherboard; other ports may be added to motherboard. Power supply 8 V @ 15 A, ±16 V @ 6 A; panel space for up to 3 mini-floppy drives. Options include serial and I/O ports on motherboard. 1K PROM (on processor board), additional disk drives. With three 100-pin connectors on motherboard, space for nine more. In wood or blue metal cabinet.
Horizon 1-16K. With 16K RAM, one single-density (90K-byte) mini-floppy drive. Kit/wired ... $1599/$1899
Horizon 1-32K. Same, with 32K RAM ... $1849/$2099
Horizon 1-32K-D. Same, with double-density drive (180K). Wired ... $2099
Horizon 2-32K. With 32K RAM, two double-density drives (180K). Kit/wired ... $2249/$2549
Horizon 1-32K-Q. With quad-capacity (double-density, double-sided, 360K) drive. Wired ... $2349
Horizon 2-32K-D. With two double-density, single-sided drives (360K) ... $2549
Horizon 2-32K-D. With two quad-capacity drives (720K) ... $2999

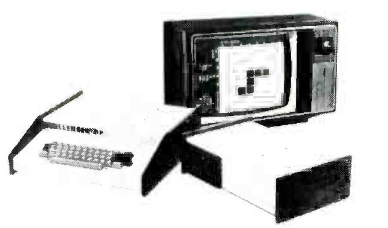
OHIO SCIENTIFIC

CHALLENGER
6502-MPU computer using Ohio Scientific OSI 48-line bus, Microsoft BASIC in ROM or on disk, PROM monitor. Additional, non-6502 MPUs available on some models. Assembled.

SUPERBOARD II
6502-MPU single-board computer, includes 8K BASIC in ROM; 4K static RAM expandable to 8K; 53-key, user-programmable, upper/lower-case keyboard; K.C.-standard cassette interface; video display with upper/lower-case, gaming and graphics characters; displays 24 char × 24 li on TVs with overscan display, 30 × 30 on TVs without, 256 × 256-point graphics. Options include extender board with 24K RAM, dual mini-floppy interface, serial ports and software. Requires +5 V @ 3 A ... $279
Challenger 1P. Superboard II with power supply and case ... $349
Challenger 1P MF. C1P with disk BASIC, 12K RAM expandable to 32K; mini-floppy disk; no cassette interface ... $995
Challenger C2-4P. Similar to C1PMF, but portable; no disk; 4K RAM expandable to 32K; cassette interface; 32×64-char video display; 256×512 graphics ... $598
Challenger C2-4P MF. Similar to C2-4P, but with mini-floppy disk; 20K RAM expandable to 36K; no cassette interface ... $1533
Challenger C2-8P. Similar to C2-4P, but RAM expandable to 36K; 8-in floppy disk available as accessory ... $799
C2-8P DF. Similar to above, but with disk BASIC, 32K RAM expandable to 48K; no ROM BASIC; dual 8-in floppy ... $2599

CHALLENGER 3
Large, highly-expandable system with many options; many configurations; write for details ... $3590-$11,900

CHALLENGER 4P
Portable computer with 32×64-character, 256×512-pixel 16-color display; audio output; digital-analog converter for voice and music generation; keypad and joystick interfaces; ac remote-control interface over household power lines, using BSR X-10 control modules; four-slot OSI bus (two slots filled); 8K ROM BASIC; 8K RAM; audio cassette interface ... $695
C4P MF. Similar, but with addition of real-time clock; interfaces for home security system, modem, print-



er, accessory OSI bus, plus 16-line parallel interface; 24K RAM expandable to 48K; mini-floppy ... $1695
C8P. Features similar to C4P, but in expandable mainframe package; expandable to 48K RAM, dual 8-in floppies, hard disks and multiple I/O including voice and telephone ... $895
C8P DF. Similar to C8P, but with 32K RAM, dual 8-in floppy ... $2597

Module Boards and Accessories: Available from OSI. Include 4K-24K static RAM, 16K-48K dynamic audio cassette ports, serial and parallel ports, voice I/O board with Votrax module; 32 × 32-char and 64×64-char video interfaces, 8-in. floppy-disk and Winchester hard-disk systems; prototyping boards, card extenders, etc. Special options include 12-bit memory, multi-processor board with PDP-8 and Z-80 compatibility, RAM with 20-bit addressing; multi-terminal operating system.

RADIO SHACK

TRS-80 MICROCOMPUTER (RS)
Z-80-MPU computer in compact keyboard housing; basic system includes 4K ROM with monitor and

Level 1 BASIC with string variables, video graphics and cassette save and load; 4K RAM; internally expandable to 12K ROM plus 16K RAM; total memory capability 62K; includes cassette I/O and video output interfaces; TRS-80 expansion bus for future peripherals; has cursor control, automatic scrolling and rubout ... $400
With 12-in CRT monitor (16 lines × 64 char), 300-baud cassette recorder, and backgammon/blackjack software cassette ... $599
With 16K RAM and numeric keypad. With/without video monitor and cassette ... $690/$889

TRS-80 LEVEL II (RS)
With more powerful BASIC, in 12K ROM. Additional features include print formatting, keyboard rollover, string functions, more arithmetic functions, user control of program errors, faster graphics, editing, and 16-digit accuracy. With 4K RAM ... $698
With 4K RAM, CRT monitor, and cassette ... $988
With 4K, less monitor and cassette ... $499
With 16K and numeric keypad, less monitor and cassette ... $789

TRS-80 "ENGINEER" SYSTEM
Includes TRS-80 with 16K RAM, numeric keypad, quick printer, printer interface cable ... $1616

TRS-80 "PROFESSIONAL" SYSTEM
As above, plus mini-disk drive, expansion interface, and system desk ... $2523

TRS-80 "BUSINESS" SYSTEM
Includes 32K RAM (16K in expansion interface), two mini-disk drives, line printer with pinch feed ... $3822

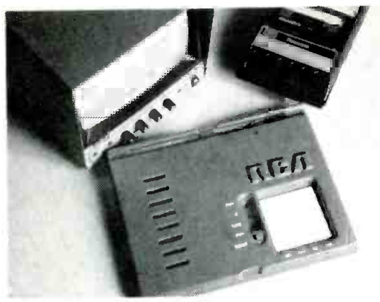
TRS-80 "DELUXE BUSINESS" SYSTEM
As above, but with tractor-feed printer and stand, plus system desk ... $4380

TRS-80 SYSTEM EXPANSION KITS
(Prices include installation)
16K RAM plus Numeric Keypad ... $290
Numeric Keypad ... $89
Level-II BASIC ... $99

TRS-80 MODEL II
Z80-MPU system. Includes 32K or 64K RAM; one 8-in disk drive (expandable to 4 drives); 12-in upper/lower-case CRT display with 24 lines × 80 normal or 40 expanded characters; full keyboard plus keypad; two user-programmable function keys; disk drive in video monitor housing, keyboard/MPU unit detachable; Level III BASIC, upward-compatible from Level II, loaded from disk to preserve memory space when not in use; automatic self-test on power-up; Direct-Memory Access allows processing to continue during disk transfers; two RS-232 serial, one Centronics parallel port; four slots for optional future expansion boards.
With 32K RAM ... $3450
With 64K RAM ... $3899

RCA

COSMAC VIP
1802 MPU, single-board computer with on-board graphic video output, audio cassette interface, hex



keypad, status indicators, 2K RAM, 512-byte ROM. With case and power supply. Wired ... $249

VIP COLOR BOARD
Displays VIP output in color. Program control of four

NOTICE TO READERS

Prices of items described are suggested prices only and are subject to change without notice. Actual selling prices are determined by the dealer.

background and eight foreground colors under CHIP-8X language; includes two sockets for VP-580 expansion keyboards.
VP-590 .... $69

VIP SIMPLE SOUND BOARD
Provides 256 different frequencies in place of VIP single-tone output.
VP-595 .... $30

VIP SUPER SOUND BOARD
Provides two independent sound channels as well as control of frequency, duration, and amplitude envelope (voice) under program control; On-board tempo control; output drives audio preamp; does not permit simultaneous video display.
VP-550 .... $49

VIP EPROM PROGRAMMER
Programs Intel 2716 EPROMs; complete with software to program, copy and verify; on-board generation of all programming voltages.
VP-565 .... $99

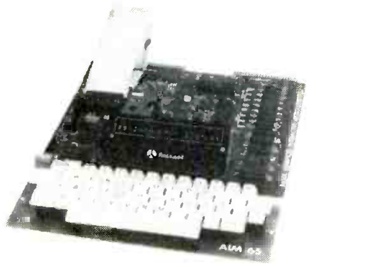
VIP TINY BASIC ROM BOARD
Integer BASIC in ROM with Standard BASIC commands, VIP oriented commands, and diagnostics. Requires ASC11 keyboard (see Peripherals).
VP-700 .... $39
Other boards available include: EPROM, RAM, bus expander and I/0 boards. Accessories include dedicated keypads and ASC11 keyboards.

EVALUATION KIT
1802 MPU, single-board computer, 256-byte RAM (expandable on board to 4K), 512-byte ROM monitor, serial (20 mA or RS-232) interface, binary LED display, battery backup option made possible by CMOS circuitry; byte input and output ports; continuous and single-step operation; breadboarding space for user circuits.
CPD18S020. Kit $249

COSMAC MICROTUTOR II
1802 MPU, compact system with regulated power supply, 8-bit binary switch input; 2-digit LED hex display plus Q-line logic-state LED; additional switches for load, run, input, and memory protect; 256 bytes CMOS RAM; prewired socket and connector holes for system expansion; DMA eliminates need for bootstrap.
CDP18S012. Wired $195

ROCKWELL

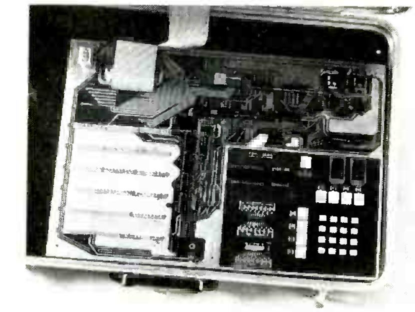
AIM 65 PRINTING COMPUTER (KM)
6502-MPU. Single-board computer with built-in 20-character alphanumeric display and 20-column



dot matrix printer, separate 54-key terminal-style keyboard. Includes: dual cassette and TTY interfaces; 8K ROM with text editor, monitor and debug, sockets for 16K ROM; 1K or 4K RAM; two bi-directional 8-bit ports; expansion and I/O connectors compatible with KIM-1. Wired, 1K/4K .. $375/$450
ROM Assembler $85
ROM BASIC (8K) $100
A65-009 Expansion Motherboard $195

SDS TECHNICAL DEVICES

TDS-M68 (S5)(S3)
6800-MPU. Incorporates SWTPC processor and 8K RAM boards, plus console board with SWTPC-compatible I/O, in attache case. Can hold up to 16K



RAM, 8K EPROM; console board includes hex keypad and display, plus indicators, six I/O slots.
TDS-M68. Kit/wired .... $750/$895
TDS-M68b. Naked kit, less attache case and documentation $650

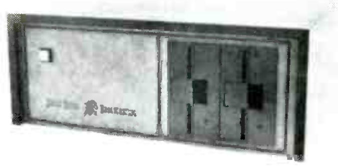
SD SYSTEMS

SDS-100 COMPUTER
Over 1 Megabyte of disk storage; 64K RAM; Z-80 CPU, full keyboard and cursor control; video; field enhancements; compatible with CP/M software, C-Basic, Cobol, Disk Fortran and Microsoft Basic $7995

SDS-200
Similar to SDS-100 but expandable to 256K RAM; with 2 Megabytes of disk storage expandable to 4 Megabytes; 4 Megahertz operation; page mode operation with multiple RAM boards $8995
Other systems include the SBC-100 Single Board Computer and the Z-80 Starter Kit.

SMOKE SIGNAL BROADCASTING

CHIEFTAIN (S5)(S3)
6800-MPU computer; nine-slot, SS-50 motherboard; 32K RAM; 2K monitor EPROM; two serial I/O ports; dual floppies, with DOS and Disk File BASIC.
Chieftain I. Dual 5¼-in single-sided floppies; 160K



total $2595
Chieftain II. Dual 5¼-in double-sided floppies; 370K $2950
Chieftain III. Dual 8-in, single-sided; 500K $3495
Chieftain IV. Dual 8-in, double-sided; 1 Megabyte $3895

SOUTHWEST TECH. PRODUCTS

6800 (S5)(S3)
Based on Motorola 6800 MPU and its family of support devices. Chassis; motherboard; memory card

with 4K bytes of eight-bit static RAM; serial 20-mA TTY/RS-232 interface card; power supply; crystal-controlled clock for baud rates from 110 to 1200; 6820 peripheral interface adapter (PIA); ROM-stored mini-operating system features tape load/dump routine, memory, and register examine and/or change function, and execute user's program command. Documentation package includes Motorola 6800 Programming Manual plus SWTP 200-page notebook, diagnostic and game programs, and application to join Motorola 6800 User Group. All boards are "plug in" type and contain on-board voltage regulators. Any combination of up to seven serial/parallel interface boards may be plugged in.
6800/2. With 4K RAM (expandable to 8K on board), sockets for up to 8K EPROM, easier address assignments, SWTBUG monitor, faster serial baud rates. Kit/wired .... $439/$495
Wtih 8K. Wired $595
With 40K. Wired $1195

SYSTEM B (S3)(S5)
Includes 6800/2 with 40K RAM, dual 8" floppy-disk system with 1.2 megabytes storage; CT-64 terminal with upper/lower-case and full control-character decoding (see Peripherals section for details), DOS and BASIC with random and sequential files; in desk with laminated plastic surface $4495

MP-R EPROM PROGRAMMER OPTION
Plugs into socket near top edge of motherboard; for programming 2716 EPROM's; on-board dc-to-dc high-voltage supply; requires 0.4 A while programming, 0.15 A when idle. Kit $45

S/09
Built around an MC6809 microprocessor, the S/09 can address 768K of memory directly using the chips' 20-bit address bus. The processor has more addressing modes than other MPUs and a powerful instruction set. The S/09 has built-in multi-user capability and dynamic memory management. Its dual bus motherboard makes adding I/O ports very easy. Multitasking software is available.
S/09 with 128K bytes RAM, 1 parallel and 2 serial ports $2995
128K memory expansion card $1995

TECHNICO

SUPER STARTER SYSTEM
Based on TI9900, 16-bit MPU; single-board computer with 1K PROM, 512 bytes RAM, EPROM programmer, serial (RS-232/20 mA) I/O on-board. Expandable to 2K RAM, 2K PROM, 2K EPROM on-board, to 65k total memory with expansion boards. Peripheral boards available include 32-byte memory expansion board, video audio cassette interface, keyboards, floppy disk, power supply, interface board, chassis with limited or full front panel, CRT, printers. Kit/wired .... $299/$399

EDUCATOR 910 SYSTEM
Includes Super Starter, plus 2K RAM, 4K EPROM with debug monitor, assembler and BASIC; one serial port; 16-line parallel I/O; EPROM programmer; Technico dual-61 bus; six-slot chassis; power supply $895

EDUCATOR 920 SYSTEM
Similar to 910, but with 8K RAM (expandable to 72K in chassis); black & white "video module" with 16-line × 64-char output, r-f modulator, ASCII keyboard interface, speaker output, microphone input, 16K/32K EPROM expansion area; ASCII keyboard; three-LED I/O bit indicator; 8-ohm speaker; expandable to multi-user, FORTRAN disk system $1895

EDUCATOR 930 SYSTEM
Similar to 920, but with dual 8-inch floppy; 40K RAM; one serial port, software including 2K BASIC plus Super BASIC, Level 2.0 Editor, Assembler, Relocatable Link Loader; ANSI FORTRAN $5895

"COLOR VIDEO MODULE"
For Technico Dual-61 bus; includes video interface plus audio cassette interface (300 baud), 2K RAM sockets, ASCII keyboard interface; video output 16

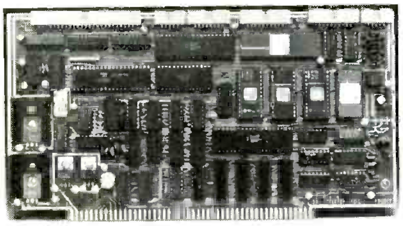
lines × 64 char (B&W), 32×32 (color); eight colors and intensities; three character sets. Wired $429

128-BIT PARALLEL MODULE
128 bits of bi-directional parallel I/O; each bit individually addressable as input or output $329

OTHER MODULES:
For Technico dual-61 bus; 16K,32K RAM; 18K,32K EPROM, serial/parallel I/O, floppy controller; six-slot chassis. For power supplies, see Accessory section.

TELETEK

FLOPPY DISK CONTROLLER-I
Smart floppy disk controller that may be configured



as central processor in an S-100 system. (See Module Boards.)

TEXAS INSTRUMENT

TI-99/4
TMS9900 MPU (16-bit) computer with built-in keyboard, including 13-in color monitor screen; total memory, 72K bytes, including 26K internal ROM, 16K internal RAM, up to 30K external ROM in plug-in "Command Modules; 40-key typewriter keyboard with overlay for additional functions; 5-octave, 3-simultaneous-tone sound, plus noise generator, 110-40,000 Hz; composite video and audio output for monitor supplied, interface for up to two audio cassettes, 44-pin peripheral connector allowing up to three peripherals on system; system memory and address signals available at peripheral connector; remote control interface; ROM provided includes 14K BASIC interpreter, internal graphics language interpreter (not user-accessible), calculator, 4.4K monitor (not user-accessible); displays 24 lines × 32 chars, 8 × 8 matrix, 16 colors (32 sets of eight chars each with different foreground/background colors); addresses up to 16K RAM for CPU or displayed. Available peripherals include: remote controllers with eight-direction joystick and control button; Solid-State Speech Synthesizer using SPeak "NY Spell" technology, 250 words in unit with plug-in vocabulary expansion, interface via I/O port, dual RS-232 interface $1150

VECTOR GRAPHIC

VECTOR MZ (S1)
Z80-MPU system; built-in, dual Micropolis mini-floppies (630K bytes, formatted), 18-slot S-100 motherboard, 12K PROM board; one serial, two parallel ports; 16K RAM expandable to 48K; with Micropolis MDOS, 20K disk BASIC, Editor, Z80 assembler, debugger, routines for Qume, Centronics, Teletype and other printers; power supply delivers +8 V @ 22 A, ± 16 V @ 4 A $3750
SYSTEM B: Similar, with addition of 24×80 Flashwriter video board, terminal; additional Micropolis CPM and North Star-compatible DOS $4750

MEMORITE WORD PROCESSOR (S1)
Consists of Vector 1 with drive, Hitachi 12" CRT monitor, Diablo HyTerm printer with 1620-3 serial print mechanism, word-processing software, disk BASIC. Wired $8500

COMPUTER PERIPHERALS

ALF PRODUCTS

APPLE MUSIC SYNTHESIZER
Offers three simultaneous voices; full eight-octave piano range with 24 notes per octave; interactive graphics music entry; expandable to 6 or 9 voices by using two or three units; control of pitch, volume and envelope; no tuning required; no "music languages" to learn; stereo output. Plugs directly into your Apple II I/O bus and stereo system with cables supplied $265

APPLE COMPUTER

DISK II FLOPPY-DISK SUBSYSTEM (AP)
Interface card, mini-floppy drives. (Computer handles up to 7 cards, 14 drives); up to 116K bytes per disk (formatted), soft-sectored; 32K min. RAM recommended.
With drive and controller $595
Additional drives $495

PRINTER II (AP)
Printer interface, plus Centronics Micro P1 printers; 30 char/line, 150 lines min., dot-matrix, electric discharge on aluminized, 4.75-in paper $695

PRINTER IIA (AP)
Interface plus Centronic 779, tractor-feed printer; 132 char/line, 60 char/second, dot-matrix, impact, paper widths to 9.8-in; upper-case $1545

MODEM IIB (AP)
Acoustic coupler modem, with serial interface card for Apple II. Originate/answer modes; 110/300 baud; specify whether for U.S. or Europe; software included $390
Modem. Without interface $200

ATV RESEARCH

MICRO-VERTER
Interfaces computer video signals to any unmodified TV with UHF reception, avoids low-band VHF

interference from computer circuits. Tunable over four UHF channels. Usually requires no direct connection to antenna terminals. Color-compatible (Apple-approved). Operates 1000 hours on 4 AA batteries (not supplied). MVX-500 .... $35

PIXE-PLEXER
Modulator/r-f oscillator for interfacing computer video signals to VHF TV channels 2-6. Accepts analog or digital signals. May be operated as monochrome character display or as multiplexer-modulator for color-difference plus audio-subcarrier inputs. Uses 3.5 MHz color-subcarrier, 4.5 MHz audio subcarrier with varactor diode modulator for FM sound insertion. Circuit board 1.6 × 3-in. Requires +15 V or −12 V/+5 V; max current 50 mA; no power supply or case provided. PXP-4500 Kit ..$25
Pixe-Verter. Similar to Pixe-Plexer, but without audio and 3.5-MHz color subcarriers or color-difference inputs.
PXV-2A. Kit $9
***Note:** Use of above devices may not meet FCC requirements.*

CENTRONICS

MICROPRINTER
Non-impact, discharge printers; 5×8 dot matrix

characters, 150 lines per minute; uses aluminized

paper 4.75-in wide, requires no toners or ribbons; 96-character upper/lower case ASCII; software selection of 5, 10, or 20 char/in; elongated characters and underlining; only four moving parts; five lines/in vertical; audio alarm for paper empty; auto motor control turns motor off when no data received; available in serial and parallel versions.
P1. Parallel interface. TTL-compatible I/O, 7-bit ASCII. Wired $495
S1. Serial interface, RS-232C, with parity selection; switch selectable 50-9600 baud; 192-char FIFO buffer. Wired $595

730 MINIPRINTER
Impact; 7×7 dot matrix; 21 lines/min with 80-char line; uses roll paper 3.5-8.5-in wide, fan-fold paper 9.5-in wide (9.0-in pin-to-pin), plus cut sheets; mo-ebius-loop continuous ribbon; 96-character upper/lower case ASCII; six lines/in vertical; ten char/in horiz. spacing; 80-char line buffer; parallel or serial input versions avail.; weighs under 10 lb. .... $995-$1095

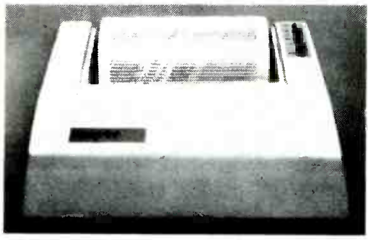
700 SERIES PRINTERS
Impact dot-matrix, similar to above but for wider paper (to 132 char/line on 17.3-in paper); variety of character sets avail; 60 char/sec printing rate, bi-directional and incremental; 7×7 matrix; tractor feed; immediate viewing of typed/printed data; auto motor control; single/double line feed, switchable; switchable for auto line feed on return; ten char/in horizontal, six lines/in vertical.
761 RO. Serial, no keyboard. RS-232 or 20-mA $1600
761 KSP. Same, with keyboard and numeric pad $1700
700. Similar, but uni-directional; 5×7 matrix; parallel input $1760
701. Similar, but bi-directional, 25-120 lines/min; 5×7 matrix; bi-directional logic seeking $1945
702. Similar, but 120 char/sec; 50-260 lines/min.; 7×7 matrix standard, 7×9 and 9×9 optional $2290
Other models available; contact manufacturer for details.

COMPUTALKER

SPEECH SYNTHESIZER (RS)(AP)
Speech synthesizer, in cabinet with 110 V power supply, 2 W audio amplifier; cables provided for connection to host computer; requires speaker and hi-fi amp; for 16K systems minimum, 32K recommended. Includes software.
CT-1A (AP). Apple version $595
CT-1T. (AP). TRS-80 version $595

COMPUTER PRINTERS INTERNATIONAL

COMPRINT PRINTER
Non-impact; high-density 9×12 dot matrix; uses 8½-in wide, electrosensitive paper rolls; 225 char/



sec, 170 lines/min; 96-char ASCII upper/lower case; 11 char/in, 80 char/line, 5.8 line/in; inserts seven blank lines after each 11-in page; 256-char; buffer (2K buffer optional).
912-P. Parallel interface $560
912-S. Serial, RS-232 and 20-mA $599

CROMEMCO

JOYSTICK CONSOLE
Joystick (2-axis) with speaker and amplifier, plus four user-defined pushbutton switches. Joysticks ±2 V each axis, spring return to center. For games, graphics and similar applications. For use with Cromemco D + 7A or similar analog interfaces. Joystick console. Kit/wired .... $65/$95

3779 DOT-MATRIX PRINTER
60 char/sec; 12-in platen; continuously-variable character pitch allows up to 132 char/line; tractor feed $1495

3703 DOT-MATRIX PRINTER
180 char/sec; 18-in platen; 132 columns. Form feed, bi-directional printing, double buffering; tractor feed $2995

3355 DAISY-WHEEL PRINTER
55 char/sec; 15-in platen; tractor feed and friction platen $3995

PR1 PRINTER INTERFACE (S1)
Interfaces one daisy-wheel, one dot-matrix printer to S-100 bus $195

WFD MINI DISK DRIVE
5-in minifloppy drive; soft-sectored IBM format; 92 KB/side. Operates from 4FDC Disk Controller $495

PFD DUAL DISK DRIVE
8-in floppy drive; holds two disks, 256 KB each (512 KB total); soft-sectored IBM format; includes power supply and cables, oiled-walnut case. Wired $2495

SOFTWARE DISKS: FORTRAN IV, 16K BASIC, Z-80 assembler, Dazzler games; specify 5" or 8". Per disk $95

3101 CRT TERMINAL
Solid-state capacitive keyboard; separate numeric and cursor keypads; 16 software-assignable function keys; local editing mode; screen formatting including dual-intensity characters, blinking characters, protected fields; block-transfer mode transmits entire screen of characters to computer. 80 char x 24-line display; upper/lower case; remote video output jack; auxiliary I/O port; RS-232 interface. With 10-foot cable. Wired $1995

HDD HARD DISK DRIVE (S1)
Single or dual-drive versions, 11 megabytes/drive. Non-interchangeable hard disk. Data transfer at 5.6 megabits/second with DMA controller provided.
HDD-11. Single drive $6995
HDD-22. Dual drive $11,995

D. C. HAYES

MICROMODEM 100 (S1)
S-100 modem board and external Microcoupler for telephone data communications. Auto-dial auto-answer; originate or answer modes; 110-300 bit/sec data rates; compatible with teletype and time-share modems; all digital modulation and demodulation. Built-in FCC registered DAA; plugs into modular type phone jack $400

MICROMODEM II (AP)
Same as Micromodem 100 but plugs into Apple II $400

DIGITAL SPORT SYSTEMS

VCNT-1 SEMI-TERMINAL
Stand-alone keyboard and video controller with built-in SC/MP microprocessor to handle keyboard and TV interface overhead; video output 16 lines × 64 char.; cursor addressing and movement, clear-screen, display-block; 7×9 matrix display; RS-232, 1200-baud interface $313
TVR-1. RF modulator (Ch. 3 std., but adjustable); fits back of VCNT-1 video controller case $45

ELECTRONIC SYSTEMS

UART & BAUD RATE GENERATOR
Converts parallel data to TTL-level serial, TTL serial to parallel; on-board baud-rate generator (110-2400 baud); 44-pin edge connector; requires +5, −12 V.
101/101A. Bare board/with parts .... $12/$35

RS-232/TTL INTERFACE
Interconverts TTL-level and RS-232 serial data; two separate conversion circuits; requires ±12 V; 20-pin edge connector.
232/232A. Board/with parts .... $5/$7

RS-232/TTY INTERFACE
Dual circuits convert RS-232 to 20 mA and vice versa; requires ±12 V.
600/600A. Board/with parts .... $5/$7
RS-232/20mA INTERFACE Similar, but with passive, opto-isolated circuits.
7901/7901A. Board/with parts .... $10/$15

MODEM
Type 103; full/half duplex; originate or answer; TTL serial I/O; connects to 8-ohm speaker, crystal mic; 300 baud; requires +5 V.
109/109A. Bare board/wtih parts .... $8/$28

TAPE INTERFACE
KC-standard, at up to 1200 baud; TTL-serial I/O to computer; audio I/O to recorder. Requires +5 V.
111/111A. Board/with parts .... $8/$28

TV TYPEWRITER
Stand-alone TVT, 16 li × 32 or 64 char; parallel ASCII (TTL) input, video output; 1K on-board memory; output for computer-controlled cursor; auto scroll; upper-case only; requires +5 V @ 1.5 A, −12 V @ 30 mA.
106/106A. Board/with parts .... $39/$145

TV INTERFACE
Converts video to modulated r-f, channels 2 or 3; on-board regulated power supply; requires 12 V ac (center-tapped) or +5 V dc.
107/107A. Board/with parts .... $8/$14

HEX ENCODED KEYBOARD
19 keys, 16 encoded, three user-definable; debounced; on-board LEDs indicate code generated; 44-pin edge connector; requires +5 V.
HEX-3/HEX-3A. Board/with parts .... $15/$50

ASCII-CORRESPONDENCE CODE CONVERTER
Provides RS-232 serial ASCII I/O for Trendata 1000 Selectric terminal; direct replacement for original Trendata board.
TA 1000C. Wired and tested $230

TIDMA (S1)
Tape Interface Direct Memory Access. FSK encode/decode for direct connections to audio recorder at 1200 baud, digital recorder at any baud rate; requires no bootstrap PROM.
112. S-100 boards only $35
112A. Board with parts $110

ACTIVE TERMINATOR (S1)
For S-100 bus.
900/900A. Bare board, board with parts .$15/$25

OTHER S-100 BOARDS (S1)
16K EPROM; 8K EPROM with programmer; 16x64 video terminal with keyboard input.

APPLE TRIAC BOARD (AP)
Holds 8 triacs, capable of switching 6-A, 110-V loads.
210/210A. Bare board/board with parts .... $15/$119

OTHER APPLE BOARDS (AP)
Serial I/O interface; parallel input, opto-isolated.

TRS-80 SERIAL I/O (RS)
RS-232 Serial I/O for TRS-80; usable with/without expansion bus; requires +5, −12 V.
8010/8010A.8010C. Bare board/with parts/wired .... $20/$60/$80

OTHER BOARDS.
For external connection to computers; see Peripherals section.

F & D ASSOCIATES

EPROM PROGRAMMER
For 2704/2708 EPROMs. Software timing and control; requires three ICs, six transistors plus power supply. Designed primarily for SWTPC 6800, but can be adapted to I/O ports of other MPUs. With software for SWTPC system with console. EPB-2. Bare board and documentation $29

GIMIX

GHOST POWER CONTROL SYSTEM
Allows remote device on/off control, manually or with any computer. Following modules may be used alone or together.

GHOST RELAY DRIVER BOARD
Controls up to 31 GE RR8 relays; scanning circuitry determines relay status; usable with any computer; up to four boards (124 relays) can operate from one 20 mA current-loop serial port; provision for manual control as normal low-voltage switching system, even without computer. System fits in 30×6×12-in. electrical cabinet.
Relay driver board $449
Transformer, 2 A, 24 V, to power boards and relays. $14
G.E. RR8 Relays. 24 V, mechanical-latching, can handle up to 20 A, 277 V ac U.L. approved $12
Relay bracket $38
Relay Driver Package. With 31 relays, bracket, transformer. Wired $848

GHOST OPTO-ISOLATED INPUT BOARD (S5)
For remote-control device monitoring via any 8-bit parallel input port with handshake lines. Detects up to 34 different switch closures. Input voltages from 5 to 24 V; FIFO buffer memory, switch debouncing; self-scanning. For remote-control device monitoring via any 8-bit parallel input port with handshake lines. Can mount to and draw power from SS-50 bus if available $349

16-BUTTON REMOTE 2-WIRE KEYBOARD (S5)
Allows remote control from any number of keyboards, using only one #24, twisted-pair phone line (up to 1 mile distance). When one keyboard is in use, others are locked out. Tone Receiver Board powers and controls the keyboards, and converts their signals into binary. For any computer with 8-bit parallel input port with handshake lines: can mount to and draw power from SS-50 bus, if available.
Tone Receiver Board (one required) $249
16-button keyboard (0-9, A-D, *, @) $99

35-KEY REMOTE KEYPAD SYSTEM
Keypad with 34 data keys plus shift; shift locks when pressed twice; keytop layout user-definable; RS-423 serial output (RS-232 compatible, but transmits up to 2500-ft on twisted pair); 75 baud standard, 300 baud optional; in 3½"×4½"×1½" case; modular (telephone-style) cord; requires 15-18 V ac @ 80 mA. Also available for Gimix relay driver board. Wired $119

HAZELTINE

HAZELTINE 1410
CRT terminal with typewriter keyboard plus numeric keypad; 5 × 7 dot matrix display, 64-char upper-case ASCII (transmits/receives all 128 ASCII codes); cursor addressing and sensing; EIA interface; eight transmission rates to 9600 baud; self test; 12-in screen; cursor controllable by computer, with home key for manual control; 80-char × 24-line display; block cursor with reverse video when positioned over car; RS-232, full or half duplex; export configurations optionally available $900

HAZELTINE 1420
Similar to 1410, but displays 94-char ASCII, including lower-case; 5 × 8 dot matrix; addition of "+", "−" and Enter to numeric pad; user-defined video intensity, blink and non-display; non-glare screen; keyboard control of backspace, clear field or screen, field and column tab $995

HAZELTINE 1500
Similar to 1420, but with EIA and 20-mA interface; baud rates to 19.2K; auxiliary EIA output; remote editing commands; standard or video. Uses 9 × 11 dot matrix display, switch selected normal/reverse video; improved monitor with 17-MHz bandwidth; low-audibility 18.4 kHz horizontal frequency; keyboard controls include clear foreground, clear to end of line or of screen; switchable lower-case disable $1225

HAZELTINE 1510
Similar to 1500, but with 95-char ASCII set, cursor control keys, protected/unprotected data; function keys; tab/back tab/auto tab; format mode with insert/delete-line keys; additional keyboard functions include local/remote, clear unprotected, clear-display, insert/delete line, set-/reset format mode $1395

HAZELTINE 1520
Similar to 1510, but with serial microprocessor-controlled parallel printer interface with 2K buffer; keyboard controls similar $1650

HAZELTINE 1552
Similar to 1520, but with 31 graphics symbols added to 95 ASCII; max baud rate 9600; programmable key switch audio feedback; hold-screen mode; alternate key pad mode; VT-52 compatibility; keyboard control of field and column tabs; 155-2 or VT-52 terminal ID select $1500

HAZELTINE MODULAR I
Two-piece, with detachable keyboard; 64 ASCII characters displayed, 128 ASCII codes recognized/send; 7 × 9 matrix; numeric pad and cursor control keys; dual intensity, reverse video, blink and non-display; cursor addressing and sensing; baud rates to 9600; alpha only or numeric-only fields; data compression; protected/unprotected data; unprotected-only batch transmit; tab, back tab, auto tab $1550

HEATHKIT

H9CRT TERMINAL
Displays 12 lines of 80 characters on 12-in screen, formattable to four columns of 12 lines × 20 char-

acters; cursor control; batch transmit; plot mode; 110-9600 baud; serial RS-232, 20 mA, and TTL interfaces. Kit $479
WH9-1. EIA-standard interface between H9 and other devices $15

SMART VIDEO TERMINAL
CRT terminal with Z80 intelligence; 25-line × 80-char display; full typewriter keyboard plus numeric keypad and 12 function keys (8 user-programmable); addressable blinking cursor; reserve video on any portion of screen; upper/lower case plus 33

graphics characters; RS-232 interface; tab; non-destructive underline, blinking cursor; 25th line software controlled for status display, etc.; auto scroll or line/page freeze; erase page, line remainder, page remainder; 110-19,200 baud.
H19/WH19. Kit/wired ....$675/$995

LINE PRINTER
Dot-matrix, impact printer; 96-character (upper/lower-case) ASCII, on 5 X 7 matrix; max. print speed 165 char/sec; line length selectable 80, 96 or 132 char; line spacing 6 or 8 lines/in, software selectable; 110-4800 baud; adjustable width sprocket, uses edge-punched fanfold paper 2.5"-9.5" wide, 0.006" max. thickness; RS-232 or 20-mA serial interface; 10 to 16.5 char/in hardware/software selectable, 12 char/in software-selectable only; standard typewriter ribbon with auto reverse; printhead temperature monitor light; controls for power, local/on-line, reverse and forward feed, top of form, wide characters; self test mode.
H14/WH14. Kit/wired ....$625/$895

FLOPPY-DISK SYSTEM (H8)
Mini-floppy disk system for Heath H8 computer. Controller circuit board plugs into H8 mainframe. Uses hard-sectored, 40-track, 5¼" diskette; Wangco 82 drive; capacity 102K/disk.
H17/WH17. Kit/wired ....$495/$550
H17-1. Second drive $295

H27 FLOPPY-DISK SYSTEM (LS)
For H11A; compatible with DEC floppy software; dual, 8-inch drives; reformattable for DEC or IBM 3740 format; built-in self-diagnostic on power-up; write-protect; uses one backplane slot.
H27/WH27. Kit/wired ....$1895/$2595

HEATH DATA SYSTEMS

Heath Data Systems products are identical to factory-wired Heathkit products, but available through computer stores, not directly from Heath. For product details, see Heathkit listing.
WH19. Smart Video Terminal $995
WH14. Dot-Matrix Impact Line Printer $895

IMAGE-21

TVM-90 MONITOR
Black-and-white, 9-in-diagonal video monitor; 600 lines resolution; front-panel controls; metal housing $194
Also available: 9-17-in B&W monitors, 500-800 line resolution; 12-in color monitor.

INNOTRONICS

INNOVEX 410/420 FLOPPY DRIVES
Full-size (8-in) floppy drives; mount two horizontally or four vertically in standard rack; single and double-density (3200 and 6400 BPI, inner track), unformatted capacity 400K/800K per diskette. Available in IBM-compatible, soft-sectored (410) and hard-sectored (420) versions; 220/240 V and 100/115 V 50 Hz versions also available.
410. Soft-sectored $495
420. Hard-sectored $505
400-2046. Triple-voltage power supply for two-drive system............................$110

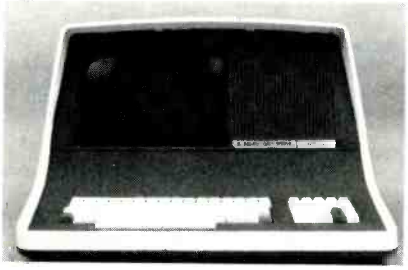
3400 DUAL DISKETTE SUBSYSTEM (LS)
Includes two Innovex 410 or 420 drives, power supply, rack-mount enclosure (10.5-in panel height) with forced cooling, ac line filter, mounting for controller or interface board $1555
3401. With Controller for LSI-11 ....$2955
3401-D. Double-density version....................$3155
3430. With general-purpose 8-bit interface ...$2250
3440. Double-density version $2590
400-2047. Solid wood table top cabinet for any of above 3400-series subsystems. (choice of wood available) $125

OPTIONS
Write Protect. Per spindle $25
Remote Eject. Per spindle $25
Dual Density. Per spindle $75
RS 232 Serial Interface $100

4400 THREE-DRIVE DEVELOPMENT SUBSYSTEM
Includes three, 400-series drives, enclosure, power supply and indicator panel; indicators for disk presence, drive select, read, write, ready and write protect $2500

INTERTEC

INTERTUBE II VIDEO DISPLAY TERMINAL
Displays 24 lines X 80 char, plus half-intensity status line; 8X10 dot matrix with descenders; ASCII



keyboard plus 18-key numeric pad; cursor addressing; automatic repeat on all keys; shiftlock, backspace; graphics mode; programmable white-on-black or reverse display; self-test mode; editing features include char and line insert/delete, full/partial block transmit, line-end terminators, protected fields; generates all 128 ASCII characters; blinking, reverse and half-intensity; 12-in CRT; RS-232 standard, 20 mA avail.; aux. printer port with local print mode; export models available $995

AMOEBA TERMINAL
Intelligent terminal; similar to above, but with Z80 processor; 16K RAM; high-level string editor; provision for second Z80 to handle I/O overhead; 1K PROM (2708); build-in digital mini-cassette drive, program-controlled $1495

SUPERBRAIN TERMINAL (S1) (RS)
Intelligent terminal; see under "Computers."

JADE

JP-80T DOT MATRIX PRINTER
Tractor-fed; 150 char/sec; 96-char ASCII set, upper/lower-case; RS-232 serial interface; built-in self-monitoring program; 80 chars/line.
PRM-27081 .... $749

JHM MARKETING

VOTRAX VOICE SYNTHESIZER
Produces continuous speech analog output from instructions representing phonemes; RS-232 input.
K232 ....$745
K001. Synthesizer module only............................$375

LEAR SIEGLER

ADM-3a "DUMB TERMINAL"
CRT terminal; 80 characters X 24 lines on built-in, 12-in-diagonal screen. Standard 64-character ASCII uppercase character set supplied; 90-character upper/lower-case set optional. Switch-selectable cursor modes. Underline cursor homing to lower left of screen, with automatic scrolling and page mode with reverse-character cursor homing to upper left. End-of-line tone. Full and half-duplex modes, 11 communication rates from 75 to 19,200 baud. Switch-selectable RS-232 and 20-mA interface to computer; extension RS-232C port for printer, recorder, or additional terminals (20 mA optional). Cursor can be directly addressed to any part of screen by keyboard or computer, in page mode.
Wired $895
Lowercase option $75
Arithmetic keypad, with cable and connector $80
Answerback $115

ADM-31 SMART TERMINAL
Similar to ADM-3a but with two-page memory (displays either page); 90-key keyboard with integral numeric pad, tab, upper-case lock, character and line edit keys, line and page erase keys; field protection with dual-intensity; optional RS-232 extension or printer interfaces; keyboard-selectable transmission mode (page, line or message); visible control chars; polling-addressing option. Wired $1450

ADM-42 SMART TERMINAL
Two-piece terminal (keypad detachable from CRT). Two-page memory (expandable to 8 pages) with independent protect, write/protect, program mode and cursor retention; 15" CRT display with dual-intensity, blinking, blanking and protected fields; 24-line display with 25th line for status indicators; multiple tab modes; numeric keypad, cursor keys and 16 shiftable function keys; programmable function keys optional. Other options include: alternate 128-character set; extension, printer and internal system bus interfaces; communications protocol; line drawing. Wired $1595

BALLISTIC PRINTER
180-char/sec matrix impact printer. Built-in microprocessor provides 15 switch-selectable form lengths, 15 perforation-skipover formats, complete vertical and horizontal tab control; print and font controls allow up to 2 sets of 128 characters alternatable line by line; auto space and blank character compression saves buffer space and speeds tabbing; standard buffer lengths 512 char (serial), 256 (parallel), both expandable to 2048 char; resident, non-volatile format-retention system with 96-hour battery backup. 9 X 7 matrix characters in 9 X 9 matrix, allows underlining and lower-case descenders. Wired. Serial/Parallel interface versions ....$2045/$1995

MECA

ALPHA-1 MASS STORAGE SYSTEM (S1)
Dual cassette system operating under computer control. S-100 interface supports up to four drives; 750K byte/drive; 780 byte/sec.; high-speed search at 100 in/sec.; will access any position on C-30 cassette in 20 sec.; independent motion control and read/write electronics for simplified tape copying, look-ahead tape queuing, and file management; additional track for audio recording; with 8080 assembler, editor, debugger, and operating system. Other software available, including BASIC and patches to 4.0-4.1 mits Extended BASIC. System with controller, power supply, enclosure, cabling and software.
Single drive. Wired $685
Dual drive. Wired $985
1702 Bootstrap Loader. (Does not include PROM board) $50
Audio play/record option. Wired $140
All components available separately.

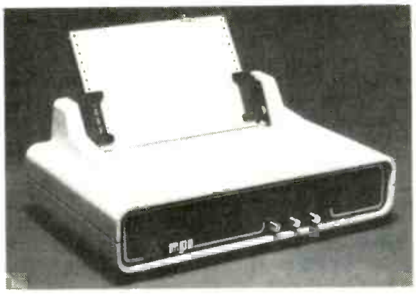
BETA-1 MASS STORAGE SYSTEM
Similar to Alpha-1 but interfaces to standard 8-bit parallel port, serial operation optional; runs at 100 ips (4000 bits per second), double density optional; internal 8035 processor; with 2K byte program; comes with single drive, slave drives optional.
Wired $399
Slave drive $270

DELTA-1 DISK/TAPE SYSTEM
Double-density minidisk storage system puts 200,000 bytes on one side of 5¼-in floppy, (400,000 bytes on double-sided drive); controller will support up to three 5¼-in drives, and interface with Alpha-1 or Delta-1 for fully integrated tape and disk system; CP/M compatible.
With single-sided drive $699
With double-sided drive $925
Controller alone $270

MICRO PERIPHERALS INC.

MPI PRINTER
40-column, impact dot matrix printer. 75 lines/min., line-length 3.33 in. on adding-machine roll paper to 3⅞" W. Available with serial, parallel ASCII, and parallel programmable interfaces, 64-character upper-case ASCII. Option "A" provides strappable data formats, double-wide characters under software control, and reverse-field printing on parity errors; option "B" provides the above, plus fast paper-feed option (5 line/sec line-feed). Interface boards and printer mechanism with interface available separately; prices shown are for assembled and tested printers with power supply and case. Interface options include parallel and buffered parallel (Centronics-compatible), RS-232/current loop serial, or IEEE-488.
Parallel I/O $435
Buffered parallel or IEEE-488 .... $585
Serial $575
With Option "A" (Serial only) $625
With Option "B" (Serial, buffered or IEEE-488) $650
Journal Take-up Option (exc. parallel version) .. $50
Rack mount version .... add $60
RFI/EMI Filter $25

MODEL 88T PRINTER
Serial dot matrix, impact; 100 chars/sec max; 60 lpm (80 cps) bidirectional 8" printing line, 80 cols



@ 10 char/in., 96 cols @ 12 char/in., or 132 @ 16.5 char/in.; 96-char ASCII upper/lower-case set; 6 li/in.; tractor feed; 5"-9.5" paper, roll or fan-fold; rear or bottom paper loading; power, paper feed and select/deselect; serial/parallel I/O $749

MICROPOLIS

MACROFLOPPY (S1)
Double-density (5162 BPI) system for 5½-in. hard-sectored diskettes. Records 143K bytes per diskette. System includes S-100 controller for up to four drives, cable, and diskettes with BASIC (requires 24K RAM) and DOS (16K required). Has built-in bootstrap and file project.
1041-I. Macrofloppy. Can be installed in S-100 chassis (with optional dc voltage-regulator kit). With one drive $695
1041-I. Two drives $1240
1042-I. Macrofloppy. Includes power supply and cabinet, for stand-alone mounting $795
1021-I. Add-on drive with enclosure; requires daisy-chair cable and regulator kit $445
1022-I. Add-on drive with enclosure, and power supply; requires daisy-chair cable $545
1091-01. Regulator kit for 1041 .... $20

METAFLOPPY (S1)
"Quad density" 5¼-in. floppy systems, using double-density (5162 BPI) recording on 77 (not 35) tracks. Capacity 315K per drive. Other features similar to MacroFloppy.
1043-II. One-disk system $1145
1053-II. Two-disk system $1895
1054-II. Four-disk system $3290
1023-II. Single add-on disk. Requires daisy chain cable $645
1033-II. Dual-disk add-on; requires cable ... $1395

NATIONAL MULTIPLEX

CC-9 DIGITAL COMPACT-CASSETTE RECORDER
Direct digital recorder (no audio-cassette interface required) using standard Philips-type Compact Cassettes. Handshake signals when motor is up to speed. RS-232 I/O standard, TTL optional (user changeable); speed adjustable for matching to other recorders; three speeds available: 75-1200 baud at 1.6 ips tape speed; 2400-4800 baud at 3 ips, 4800-9600 baud at 6 ips (slow recording allowable at higher speeds, with loss of tape economy); half-track format (flip cassette over for second track); adaptable for 12 V operation; motor start/stop by local or remote control, rewind/fast-forward manual only; three-digit counter.
Slow and medium speed versions $200
9600-baud, 110/220 V $220
220 V, 50 Hz. (Any speed) $220
Speed lock (± 0.3%), 110/220 V $250
12 V powering option $20
20 mA current-loop adapter $20

NESTAR SYSTEMS

CLUSTER ONE (AP)(PT)(RS)
Distributed computer system based on independent personal microcomputers; supports up to 30 user stations, running independently, but sharing such resources as disk systems, program libraries, printers and data files; supports Apple II, Commodore Pet or Radio Shack TRS-80 computers, in any combination; uses plug-in module board interfaces for Apple and Pet, mini-box for TRS-80. System includes following units: Cluster/One Storage Unit, dual 8-in floppies, 630K total formatted capacity; with disk and bus controllers, buffer memory (16K), power supplies, cooling and software $4995
Extended Storage Unit. As above, but double-sided, 1.2M total capacity $5005
Computer interfaces. For Pet/Apple/TRS-80 .... $75-$100/$150/$150

NORTH STAR

MDS-A MICRO-DISK SYSTEM (S1)
Uses Shugart Mini-Floppy drive, 100K bytes per diskette. Controller on one Altair-bus board, with bootstrap software in PROM. Supplied with DOS and disk BASIC software, all connectors and cables. Power requirements 0.9 A @ 5 V, 1.6 A @ 12 V, can be supplied by computer or optional power supply. Drive assembled, controller available. Kit/wired .... $699/$799
Power Supply Kit $39
Cabinet Kit $39
Additional drive. Kit/wired .... $400/$450
MDS-A-ND. System less drive, for use with previously purchased SA-400 drive .... $449/$549

DOUBLE-DENSITY MICRO DISK SYSTEM
Specifications same as above, but double-density, for 180K bytes/disk. Kit/wired .... $699/$799
Other Options: Quad capacity (double-density, dual-sided).

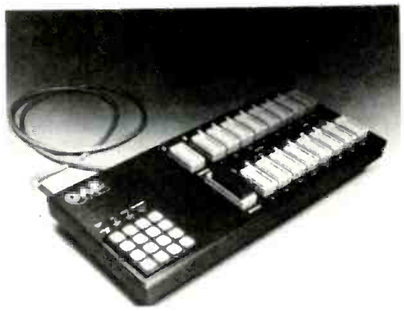
ADDITIONAL DRIVE CABINET
Holds two North Star drives; includes power supply, wood or metal cover.
ADC kit $129
With one/two drives, wired .... $599/$999

OAE (OLIVER)

OP-80A PAPER TAPE READER
High-speed optical tape reader; no moving parts. Reads punched paper tape up to 5000 char/sec. Includes optical sensor array, high-speed data buffers, handshake logic for interfacing with parallel I/O. Kit/wired .... $85/$100

PROM PROGRAMMER
Programmer interfaces to parallel port; requires very little software—data is dumped via lower eight address lines using patented technique; no wiring necessary, plugs into any ROM socket; requires 5 V @ 100 mA plus any other voltages required by PROM being programmed.
PP-2708. For 2707, 2704, and 27L08's $295
PP-T2716. For T.I. and Motorola TMS 2716's $295
PP-2708/216. For all of above EPROMs $325
PP-2716. For new 5-V-only 12716, 12758, TMS2516, and TMS 2558 .... $295
PP-2532. For T.I.'s TMS 2532 .... $295

EPROM TESTER/DUPLICATOR
Tests for incorrectly inserted or poorly erased EPROMs, evaluates static-damaged audible defect

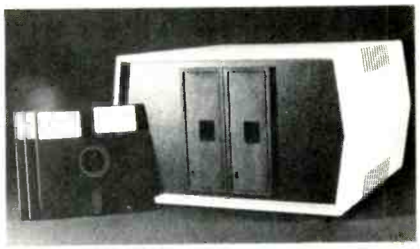


alarm, or poorly erased EPROMs, programs up to 16 PROMs at the same time, verifies all EPROMs in the matrix with the master, allows data to be added to pre-programmed parts (overprogramming). Using personality module for each generic family, the 8048 based programmer and hefty power supply will support a second duplicator for burning 32 PROMs at a time.
UPP-2700 Duplicator. Personality module and power supply $2450
Second Duplicator $1995

OTTO ELECTRONICS

OE 1000 TERMINAL
Video terminal with composite-video output; requires monitor. Screen format 16 li × 64 char; upper/lower-case and TTY modes; will display 96 ASCII characters and 32 special characters; full cursor control, automatic scroll, erase to end of line, erase to end of screen, and clear-screen. Interfaces to 300-baud full-duplex serial port, 20-mA or RS-232. Has 57-key keyboard, plastic case; requires 115 V ac power. Kit/wired .... $300/$375

ADD-A-DISK
Dual BASF 6106, 5¼" drives and power supply in cabinet that can hold up to four drives; increased



capacity from using available 40 tracks instead of customary 35; uses industry standard interface, power plugs, and mounting points $775
Interface cables and software for the 40-track operation available at extra cost.
Single bare BASF drives $299

PERCOM DATA

CIS-30 + CASSETTE INTERFACE
Self-clocking audio cassette interface, functioning at 120, 60 or 30 bytes/s. Usable with any computer having a serial port, but designed for SWTPC 6800; uses MIKBUG for all ordinary functions except 120 byte/s loading, plays unmodified SWTPC cassette software, and is finished in matching colors. Includes RS-232 data terminal interface, allowing both tape and terminal to use one serial port; user-

selectable 1200, 600 or 300 baud terminal interface. Independent record/play circuits permit dual cassette operation; uses phase-locked (bi-phase/M) data and clock recovery, optional kit allows program control of recorders; local/line switch for off-line sending of recorder programs to terminal only. Requires regulated +5 V @ 50 mA, ±12 V @ 10 mA, both available from SWTPC 6800.
Kit/wired .... $80/$100
IC sockets $5
Remote-control kit $15
Test cassette $5

CI-812 CASSETTE INTERFACE (S1)
Similar, but board for S-100 bus. Kit/wired .... $100/$130

LFD-400 MINIDISK SYSTEM (S5)
Mini-floppy system for SS-50 bus (does not use I/O slots), up to three drives. Consists of: SS-50 controller board with space for 3K PROM; Shugart SA-400 drive; power supply; cabinet; software and firmware. Controller turns drive motors off if system is inactive more than three seconds; has 1K miniDOS; allows use of existing software (patches provided), disk protection; also available are miniDOS+, supporting named files (miniDOS is sector-referenced) and FMS-6800 file-management system (requires 4-8K RAM support). Wired only.
One-drive system $600
Two-drive system $1000
Three-drive system $1400
MiniDOS+ Firmware (2708) $35
All system components also available separately.

TFD MINI-DISK SYSTEMS (RS)
For TRS-80. Choice of 40-track (102.4K bytes/side) and 77-track (197.12K bytes/side). Require TRSDOS or MICRODOS, Level II BASIC, 16K RAM; PATCH PAK 1 software to extend TRSDOS for 40/77-track use included.
TFD-100 (40-track). With 1/2/3 drives .... $399/$795/$1195
TRD-200 (77-track). With 1/2/3 drives .... $675/$1350/$2025
MICRODOS operating system $30

TFD-1000 (RS)
800K dual-drive system for TRS-80. Includes power supply, cabinet, MICRODOS operating system, peripheral adapter module PC card, interconnect cable and support documentation $2495

ELECTRIC CRAYON
Color-graphics system with own microprocessor; for virtually any microcomputer with parallel I/O port. Displays animation graphics, charts, tables, text, etc. on color TV $185

PICKLES & TROUT

P&T-488 INTERFACE BOARD (S1)(EE)
For bi-directional communications between S-100 computer bus and IEEE-4888 instrumentation bus. Can function as controller, talker or listener, includes Bitwiggler tape interface, K.C. compatible; software on K.C. tape included. May be addressed as four consecutive I/O ports or memory locations with 488-compatible cable. Specify whether for North Star, CP/M, and (if custom software) on cassette. Wired $400

RADIO SHACK

QUICK PRINTER II (RS)
Prints 16- or 32-character lines on 2⅝-in aluminized paper; non-impact; upper/lower case; automatic "wrap-around" when text exceeds line length; switch-selectable input interfaces to RS-232 serial, Centronics parallel or TRS-80 Level II CPU (no expansion or printer interface accessories required); 120 lines/min; 9 or 18 chars/in, software-selectable $219

QUICK PRINTER (RS)
Non-impact; delivers 150 lines/min on 4¾-in aluminized paper; prints all keyboard characters except arrows, no graphics; software selectable character width (20, 40 or 80 chars/line), auto underline, audible signal; requires Level-II BASIC plus either printer or expansion interface $499

LINE PRINTER (RS)
Impact, dot matrix; 64-char ASCII (upper-case); continuous-loop cloth ribbon; character width variable 10-16.5 chars/in; maximum 132-char/line at 21 lines/min; requires expansion or printer interface.
Friction-feed. Includes holder for roll paper to 9.8-in wide; requires additional Interface Connecting Cable $1299
Interface Connecting Cable $39
Tractor-Feed. Similar to above, but allows multiple copies, exact placement of type on pre-printed forms; tractor width adjustable 3-12.1-in; Interface Connecting Cable not required $1559

PRINTER INTERFACE CABLE (RS)
Allows direct connection of Quick Printer II or Line Printer to CPU without expansion interface $79

LINE PRINTER II (RS)
Impact; prints 50 char/sec; 80-char./line (or expanded letters under software control); upper/lower case; dot-matrix; friction- and pin-feed modes; forms up to 9½-in wide; detachable rear bail for roll paper feed in friction-feed mode; for TRS-80 Model II, or TRS-80 with expansion interface $999

LINE PRINTER III (RS)
Impact, dot-matrix; 132-character lines; upper/lower case; 120 char/sec, bi-directional; line-feed controllable in increments to ⅛-in; expanded characters under software control; tractor feed; forms up to 15-in wide; drive motors run during printing only $1999

TRS-80 MINI-DISK SYSTEM (RS)
Holds 55K bytes/disk; includes TRS-80 DOS software; adds 15 additional features to Level-II BASIC. Requires 16K RAM, Level-II BASIC, Expansion Interface $499
Additional drives. (Up to three supported) $499

TRS-80 MODEL II DISK EXPANSION (RS)
For TRS-80 Model II; 8-in disk system; for one to three additional drives.
Expansion System with one drive $1150
Additional drives $600

TRS-80 EXPANSION INTERFACE (RS)
For TRS-80 system expansion (not required for Model II). Contains sockets for added 16K or 32K RAM; disk controller for up to four Mini-Disks; software-selectable dual cassettes; real-time clock; card-slot for interface options; parallel port for Centronics printer. Usually requires Level-II BASIC. Required for all peripherals above, except as noted.
Expansion Interface. With 0 RAM $299
16K RAM Increment $199

VOICE SYNTHESIZER (RS)
Generates synthesized speech under program control; built-in amplifier, speaker and volume control; 16K RAM recommended $399

TRS-80 VOXBOX (RS)
For computer voice-recognition experiments; includes microphone with coiled cord $169

TRS-80 TELEPHONE INTERFACE II (RS)
Telephone modem with acoustic coupler; Originate and answer modes; requires RS-232 interface $199
Communications Software. For use of above on TRS-80. Requires Level II BASIC $30

RS-232-C SERIAL INTERFACE (RS)
Mounts inside Expansion Interface; includes interactive-terminal program; 50-19, 200 baud $99

RCA

FULL ASCII ENCODED KEYBOARD
Typewriter-format, 58-pad keyboard with positive pressure light touch; two user-definable keys; +5 V operation.
VP-601 .... $65
VP-611. Same as above but includes 16-pad numeric-entry keyboard $80
Cables for above keyboards $20

COSMAC MICROTERMINAL
Hand-held, machine-language terminal with hex keypad input with 8-digit LED displays; control keys for reset, run utility, run program, start program, increment, clear address, data/address entry select, continuous/single-step select; utility firmware. Designed for 1802 systems, direct plug-in to COSMAC Evaluation Kit, EK/Design Kit, and Development System II.
CDP18S021. Wired $140

COSMAC MICROMONITOR
In-circuit debugger for 1802 systems. Connects between MPU and socket. Has built-in keyboard, display and status indicators; interfaces to external terminals; allows real-time run with breaks, plus operation for specified numbers of machine or instruction cycles; programmable break conditions, with register preservation and trace; control of memory, I/O and all registers and flags; inhibits or allows system-generated DMA and interrupt requests.
CDP18S030. Wired $1995

COSMAC FLOPPY-DISK SYSTEM II
Dual-drive system designed for direct plug-in to COSMAC Development System. Includes system diskette (IBM-compatible format) with editor, assembler, diagnostic, and utility programs.
CDP18S805V1. Wired $3600

SMOKE SIGNAL BROADCASTING

BFD-68 MINI-FLOPPY DISK SYSTEM (S5)
SS-50 controller supporting up to 3 drives, 3-drive cabinet with space and power supply for 3 drives, DOS-68 and Disk File Basic DFB-8 software; other software available.
BFD-68. Single-drive version $795
BFD-68-2. Dual-drive system $1139
BFD-68-3. Triple-drive system $1479
5 1/4-Inch Floppy Drive $355
8-Inch Floppy Drive $585
ABFD-68. Single-drive system less cabinet and power supply $649

LFD-68 (S5)
Similar to BFD-68, but with 8-inch floppies; supports up to 4 drives, for 1 megabyte max. storage.
LFD-68. One drive $1395
LFD-68-2. Two drives $1895
DGD-68-2. With two, double-sided 8-inch drives $2495

SOROC TECHNOLOGY

IQ-120 TERMINAL
Displays 24 lines, 80 char/line, on built-in 12-in CRT. Includes keyboard with cursor control, numeric keypad, tab, auto-repeat. ASCII 96-character upper/lower-case set. RS-232 interfaces to computer and extension port (optional) for printer, etc. Has protect mode; displays protected data in reduced intensity. Can erase to end of line, end of field, end of memory, all unprotected data, or complete screen. Switch-selectable baud rates, 75-19, 200.
Wired $995

IQ-125 TERMINAL
Similar to IQ-120, but with descenders on lower-case characters, block-mode transmit option, printer port with independently-selectable baud rates.
Wired $1095

IQ-240 TERMINAL
Similar to IQ-125, but with detachable, 117-key keyboard, including 16 function keys, separate numeric keypad; full screen edit capability and block mode transmit; reverse video, underline, blink, blank security fields; polling option. Wired $1495

SOUTHWEST TECH. PRODUCTS

CT-64 TERMINAL
CRT terminal, 16 lines of 32 or 64 characters per line; scrolling or page mode operation, upper and lower case characters, with switchable lower case defeat; reversed character printing; control character display, with defeat switch; cursor control; complete control character decoding. Usable with any eight-bit ASCII computer. With power supply, keyboard, serial interface, beeper, chassis, and cover.
Kit $325
CT-VM. Video monitor for above, in matching case. Requires CT-64's power supply. Wired $175
CT-EA Screen Read Board. Allows block transmission of screen contents after editing. Kit $18

CT-82 TERMINAL
CRT terminal with 9", green-phosphor screen; 82 char × 16 or 20 lines, software-selectable; dual-

intensity upper/lower-case characters, graphics optional; protected fields; cursor addressing with 12-key cursor control pad, page or block transmit; driver for Centronics PR-40 parallel printer; decodes reader and punch on/off control characters; socket for optional 2716-pinout custom character generator; optional light pen; 110-34,800 baud. Control functions include scrolling by screen or quadrants, up and down, left and right slide; erase to end or beginning of line or frame, or erase quadrant; line and character insert-delete. Operates on 100, 120, 220, 240 V ac, 50-60 Hz.
Wired $849

AC-30 AUDIO CASSETTE INTERFACE
Interfaces between computer and terminal (requires accessible, 16 × clock and 300 baud rate, RS-232 serial). Provides independent control for two recorders, including automatic start/stop; either cassette may record while the other plays back data. LED indicators display record/read status and data flow. Local/remote switch permits using recorder with terminal alone. Kansas-City standard.
Kit $80

GT-6144 GRAPHICS TERMINAL
Cell array is 64 wide by 96 high; each cell addressable by computer; programming allows fixed or moving images. Data can be loaded in less than 2 μ sec. Image reversal for white or black or reverse; standard 525-line format; 6144-bit static RAM. Operates with any computer whose parallel interface outputs an eight-bit word and data-ready strobe; this includes any 8080 or 6800 machine. Does not include chassis or video monitor. Programming allows display of graphics, CT-1024 alphanumerics or combination of both. Kit $99
CT-P. Power supply. Kit $16
Joystick potentiometer digitizer $40

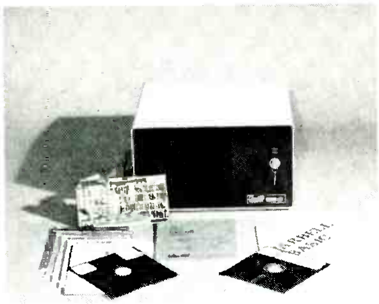
PR-40 ALPHANUMERIC PRINTER
Alphanumeric printer with 64 upper case characters, 40 characters per line, 75 lines per minute. Uses standard 3⅞-in adding-machine paper. Has internal 40-character line-buffer memory; printing takes place at carriage return or when line-buffer memory is filled; 5 × 7 dot-matrix impact printing. Accepts data up to one character per microsecond or slower; seven parallel data lines are TTL-compatible and enabled by data-ready signal. Used with any computer having eight-bit parallel interface, including 8080 and 6800 machines. Internal power supply.
Size 8¾"H × 10½"D × 9⅝"W. Kit $250

MF-68 DISK SYSTEM (S3)
Dual minifloppy (5¼") disk system for SWTPC 6800 and similar computers. Controller plugs into I/O slot 6, support up to 4 drives; includes SWTPC 8K BASIC ver. 2, modified for disk save/load, plus FDOS; stores up to 85K bytes/disk; requires 16K memory in computer; with chassis, cover; power supply. Kit, with 2 assembled Shugart SA-400 drives $995
MF-6X Expansion Kit. With power supply, enclosure, 2 drives $850

DMAF1 FLOPPY (S5)
Full-size (8") floppy-disk system with DMA controller for up to 4 drives; 600K bytes/disk; with two Cal-Comp 143M double-density-rated disk drives; other features similar to MF-68 system. Kit/wired .... $2000/$2095
DMFXA Drive Expansion. Kit/wired .... $1800/$1850

TARBELL

VDS-II VERTICAL DISK SUBSYSTEM (S1)
Includes wired, tested Tarbell Floppy Disk Interface (see Module Boards), 2 Siemens 8" disk drives'



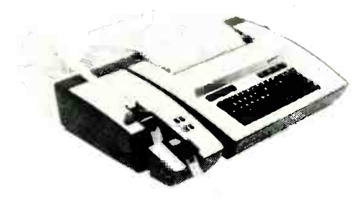
cabinet with fan and power supply, CP/M DOS and Tarbell BASIC disks $1888

TECHNICO

POWER SUPPLIES
For Technico and other systems. Wired.
T99SAD-A. 5 V @ 6 A $75
T99PSLP-A. +5 V @ 1.5 A; −5, +12 V @ 0.5 A $115
T99PSLP-A. −5 V @ 6 A; −5 V, +12 V @ 0.5 A; 28 V @ 100 mA $175

TELETYPE

MODEL 43 TELEPRINTER
Dot-matrix, impact; 110 or 300 baud; typewriter keyboard with back-space, N-key rollover, eight-



character burst buffer, caps lock, control keys; friction feed prints to 72 or 80 char/line at 10 char/in, six li/in, on std. 8½-in roll paper; pin feed also prints to 132 char/line at 13 char/in, on 12-in paper, with up to five carbons; nine-wired matrix printhead; prints full 94-char. ASCII upper/lower-case set, plus parity error symbol; paper alarm; last character visible.
4320 KSR. Keyboard send/receive. RS-232/current-loop serial $1442
4310 RO. Receive only, no keyboard; serial .$1275
Pin feed option $22
Other options: Pedestals; 13 to 10 char/in conversions; programmable answer-back; built-in modem; paper-tape ASR (Automatic Send-Receive) option.

TERMINAL DATA CORP. OF MARYLAND

CRT TERMINAL
High-speed TTY-replacement terminal with separate, 9" CRT monitor. RS-232 interface; 64 char ×

16-line display; 110-9600 baud; half or full duplex; auto carriage return/line feed; automatic rollup; available with built-in acoustic coupler.
675 .... $695
675-1. With acoustic coupler $925
675-2. With coupler and stand $1050

DATA SPLITTER
Diode network providing dual-output interface from RS-232 port; allows printer and modem, printer and plotter, etc. to share a port, and isolates the two output lines from each other. Can be daisy chained.
1200K. Kit/wired .... $59/$119
1204K. Similar, but 4 in, 1 out .... $99/$169
2204. Similar, but 4 in, 2 out .... $149/$229

BIDIRECTIONAL DATA INTERFACE
Converts TTL 20 or 60 mA signals to RS-232 levels and vice versa; both sides opto-isolated; baud rates to 9600; includes power supply, DB-25 connectors and cabinets; all options switch-selectable.
1250. Kit/wired .... $119/$149
1254. Similar, but contains 4 separate circuits .... $199/$249

PRINTER
1200-baud electrostatic printer, 64/80 cols; with controller and interface; option for 675, 700 and 725 CRT terminals $1295

PORTABLE TERMINAL
132-column, 30-CPS portable terminal, with coupler and carrying case.
680. .... $1595

INTELLIGENT CRT TERMINAL
Intelligent B&W terminal; 24 li × 80 char; u/l case; line insert/delete, read cursor address, display control chars; w/separate 9" monitor and stand $995

THINKER TOYS

DISCUSI (S1)
Full-size, 8-in single-density floppy-disk system. IBM-compatible, soft-sectored format, 256K bytes/disk. Software initialized to use on-board, memory-mapped serial I/O port can be reinitialized to other ports. Controller can accommodate up to eight drives, occupies 1K starting at 340:000 octal/E000 hex (other addresses on special order). Complete with Shugart 800R drive, power supply, cabinet. BASIC-V, DISK/ATE DOS/ Assembler/Text Editor,

For more product information write directly to the manufacturer. See address list on page 127.

and patches for CP/M.
Single-drive system. Wired $995

DISCUS 2D (S1)
Same as above except dual density $1149

Additional drive. With power supply, line cord cabinet $795
Dual drive cable $35
Additional connectors on cable for multiple drives. Add each $15
Software (with purchase):
CP/MDOS single/dual density .... $125/$150
Microsoft Extended Disk BASIC $299
Microsoft FORTRAN $450
Controllers available separately. See Module Boards.

U.S. ROBOTICS

USR-310 ORIGINATE ACOUSTIC COUPLER
Asynchronous, half/full-duplex, originate-only acoustic coupler for terminal communication to computer; data rates 0-300 baud; RS-232 computer interface; acoustic connection via standard telephones; with case and power supply $139

USR-330 ORIGINATE/AUTO-ANSWER MODEM
Permits computer to access other computers equipped with answer modems as well as answer incoming calls from other computers. Connections to voice grade phone lines are via RJ11C "modular" jack. No DAA is required. Available for RS232C or 20 mA current loop interfaces or both at rates up to 300 baud.
USR-330. .... $324

VECTOR GRAPHIC

MINDLESS TERMINAL
Terminal housing with keyboard and video screen; accepts TTL video and sync from most alphanumeric video display boards; 12-in screen, 750-line min. resolution 60-key keyboard plus 12-key numeric pad; special-function, directional and control keys $805

MICRO-STOR (S1)
Includes two Micropolis Mod II disk drives, power supply, cabinet, software. For use with Vector Graphic disk controller board $1395
KEYBOARD $225

VOLKER-CRAIG

VC303A TERMINAL
TTY-compatible computer terminal; stand-alone unit with 1920-char screen; upper/lower-case; 12" CRT; RS-232 interface; 24 li × 80 char; cursor control keys and direct X-Y cursor addressing; composite video output for slave monitor. Auxiliary serial and parallel interfaces optional $1195

VC404 STANDARD TERMINAL
Similar to VC-303A, but with detachable keyboard; clear to end-of-line and end-of-screen; transparent/tape mode; switch-reversible video. Options listed below.
VC404. .... $1195
VC404/RO. Same, less detachable keyboard; receive-only $1050

VC414 EDITOR
Similar to VC404, but with block mode. Allows formatted data entry and complete local editing before transmitting all or variable data; multi-level display; blinking/reverse video; horizontal tabs; character/line insert and delete; character highlighting; protected/unprotected data; line-drawing capability $1395

VC424 TERMULATOR
Similar to VC414. Complete editing terminal with polling and independent printer port $1595

VC415APL APL/ASCII TERMINAL
Features APL overstrike; APL/ASCII character underscoring; character rubout in APL interactive

mode; buffered line edit mode; character/line insert and delete; independent window for host responses; cursor memory with auto restore; remote APL/ASCII mode select; direct X-Y cursor addressing; transparent (tape) mode; detachable keyboard; clear to "end of line" and "end of screen" $1275

VC4152 TERMINAL
VT52 compatible data terminal; upper/lower case detachable keyboard; full cursor control; 12" nonglare screen; auto character repeat; auxiliary dual-mode keypad; up/down scrolling; horizontal tabs; hold screen mode; XON/XOFF data control; character highlighting; clear to "end of line" and "end of screen"; transparent mode $1275

OPTIONS FOR 400 SERIES
SPI. Switches serial peripheral interface $75
KB1. Numeric pad and function keys $75
APL. Front-panel switch-selectable ASCII and APL character sets, typewriter-paired (no overstrikes) $250
PIP. Auxiliary parallel input $75
CDS. Colored anti-glare display screen (specify green or amber) $50
MTI. Multiple Terminal Interface. Switching box, connects up to 5 VC-series terminals to serial printer $250
BRI. Bar code reader interface for Monarch 2243 scanner $315
GRA-4152. Graphics option; 33 special characters. (VC4152 only) $125
SSO. Split speed option. Transmit and receive speed may differ $55
CCS. Custom character set $140

COMPUTER MODULE BOARDS

MODULE BOARDS
Due to limited space, and the vast number of RAM, ROM, I/O and alphanumeric video boards of similar characteristics, such boards are only summarized briefly here. For further information, write the manufacturers concerned.

ALPHA MICRO SYSTEMS

AM-100 16-BIT CPU (S1)
16-bit MPU board for S-100 bus. Includes software. See "Computers" section for details $1495

AM-210 FLOPPY-DISK CONTROLLER (S1)
DMA floppy-disk controller for AM-100 16-bit and 8-bit MPU's. Includes disk formatting; full and partial sector reading from drive; multiple drive control; multi-level interrupt capabilities. Supports Per-Sci 277 disk drive and Wango 80 disk drive subsystem $695
CP/M operating system for 8080, with manuals .$85
CP/M PROM $30
2708 PROM for IBM, AMS or CP/M formats $30

AM-400 HARD-DISK CONTROLLER (S1)
Interfaces S-100 bus to Calcomp Trident series of hard-surfaced (3330 type) disk drives; drives available in 25, 50, 80, 200 and 300 Mbyte configurations; four drives can be intermixed on-line-average access time, 28 ms. Can be used with AM-100 or 8080 MPU's; CP/M to be available for 8080.
AM-400 controller $2000

AM-500 HARD-DISK SUBSYSTEM (S1)
Interface formatter/controller from S-100 bus to 10-MB hard-disk drive; can support up to 40 MB. Compatible with AM-100 or 8080; CP/M available for 8080; rack mount $7995

APPLE COMPUTER

INTERFACE CARDS (AP)
Parallel Printer Interface Card. ROM firmware answers BASIC commands; allows up to 255 char/line, upper/lower case, special symbols; prints up to 5K char/sec; interfaces to most printers through parallel port $180
Communications Interface Card. RS-232 port with PROM firmware on card; for use with serial peripherals and modems; passes lower-case or converts to upper-case at user's option; 110 or 300 baud; half-duplex $225
High-speed Interface Card. Similar to C.I. card, but 75-19.2k baud; switch-selectable speed, line length, auto line feed, carriage return delay $195
Centronics Printer Interface Card $225

LANGUAGE CARD (AP)
16K RAM electronically replaces Apple ROM firmware; language of user's choice automatically loaded from disk on start-up by Auto-Start ROM on card; system includes PASCAL, Applesoft and Integer BASICs. Requires 48K RAM and Disk II $495

CLOCK/CALENDAR CARD (AP)
Provides 388-day calendar and clock with 1/1000 sec resolution; four-day battery backup with automatic recharge; external batteries usable for longer periods; optional interrupt $199

OTHER CARDS (AP)
Prototyping/Hobby card; Applesoft II Firmware Card; 16K RAM; Modem interface firmware.

AUM IDEAS

HOBBYIST'S DUAL BUS BOARD (S1)/(S5) (AP)(RS)
Prototyping board with full S-100 bus compatibility,

plus uncommitted set of 50 contacts (0.156" spacing) with uncommitted connections adaptable to SWTP, Apple, TRS-80 buses (though not sized for those cabinets); boards can be stacked in vertical or horizontal plane, eliminating dependency on particular motherboards; provision for up to 100 DIP ICs (14-pin; accepts 20 40-pin ICs, or other combinations of 28-, 24-, 16-pin ICs); also provides for four voltage regulators with independent power and ground lines, space for up to 38 additional discrete components, two card ejectors, filter capacitors, etc. Ground and power planes on both sides of board. Kit, with heat sinks, layout sheets, and wire-guide wires.
HDBB (50/100) UD $30
HDBB-HMK. Horizontal mounting kit for HDBB; spacers and hardware for stacking two or more cards at 0.75" spacing; requires no motherboard $2

SWITCH & INDICATOR PANEL
Accommodates 16 LEDs in two rows of 8, plus eight SPDT switches; debounced and undebounced signals; board size 4½" × 2½", for custom front panels, etc.
SIP-BD. Bare board/complete kit .... $10/$30

AUTOMATED INDUSTRIAL MEASUREMENTS

AIM-1005 8-BIT FREQUENCY METER (S1)
Frequency-meter board for 8-bit computers; S-100 adapter available. Measures 13 bits plus overrange, accurate ±1 count, 0°-70° C. On-board 5-MHz clock. Measures frequencies from dc to 25 MHz; comparator input with up to ±15 V common mode, input down to 100 mV usable to 2 MHz. Uses memory-mapped I/O in any of 14 locations. Allows external reset for real-time measurements. On 4" × 4½" board. 250 mA @ 8 V.
AIM-1005. .... $178
(S1)S-100. Mounting board for AIM-1005 .... $30

AIM-1006 16-CHANNEL DIGITAL MULTIPLEXER (S1)
For use with AIM-1005. Allows 16 different frequencies to be measured; has memory to store data output from AIM-1005; jumper-programmable for use with fewer channels; may be interfaced with microcomputers directly as standard or memory-mapped I/O.
AIM-1006 .... $143
(S1)S-100. Mounting card with extra socket for AIM-1006 .... $35

CALIFORNIA COMPUTER SYSTEMS

HUH FROM CCS 8100 (S1/RS)
Interfaces Radio Shack TRS-80 to S-100 bus; includes six-slot motherboard with card guides; ribbon cable connects to TRS-80. Includes circuitry and socket for optional RAM and I/O (1 serial, 1 parallel); stop bits, parity and word-length software-selectable; baud rate software programmable; supplied with one S-100 connector and card-guide set; RAM addressable in four 4K blocks.
8100. Kit/wired .... $185/$245
RAM Support option. Less RAM chips. Kit/wired .... $45/$75
I/O option. Kit/wired .... $85/$115
Five extra connectors and card guides. Kit/wired .... $45/$75
(Option prices applicable only with initial purchase.)

HUH FROM CCS S-100 MPA (S1/PT)
Interfaces Commodore Pet to S-100 bus; allows full DMA in accord with S-100 bus protocol; emulates read but not write wait states; emulates 8080 I/O addressing. Kit/wired .... $200/$280
Stand-Alone Option. Allows use as 6502 processor for S-100 bus. $50

HUH FROM CCS VIDEO BUFFER (PT)
Allows video monitors or TV sets to be used with Commodore PET for larger screen displays or remote viewing. Plugs into PET user port, and provides standard 75-ohm composite-video output (PET has separated sync and video). For use with unmodified TV sets, space is provided for M&R SUP'R'MOD II r-f modulator. Wired $30
With SUP'R'MOD II option and 60-dB antenna isolation switch. Wired $60
(Note: Use of modulator may not meet FCC requirements.)

HUH FROM CCS PETUNIA (PT)
8-bit digital-to-analog board for PET. Can be used as music generator (up to four notes at once), or for graphics, control and other applications. Plugs into PET user port. Requires external amplifier and speaker; phono jack connection. Wired $30

COMBO (PT)
Combines Video Buffer and Petunia on one board, wired and tested $50
With SUP'R'MOD II modulator $80

BEEPER (PT)
Automatically beeps at file headers and program endings when reading or writing PET tapes; audible warning when computer is ready after save or load; can also beep under program control. Plugs into PET; has volume control. Wired $25

PROM MODULE (AP)
For Apple II; allows addition, replacement or bytewise patching of Apple II firmware without physical removal of Apple II ROMs; powers down PROMs when not in use; 14K PROM space (2716); supports DMA and interrupt daisy chains.
7114A. Kit/wired .... $70/$80

ARITHMETIC PROCESSOR (AP)
For Apple II; allows 16/32-bit fixed-point, 32-bit floating-point operation; arithmetic, trigonometric and inverse trig functions; square roots, logs, exponentiation; 256 ROM or RAM space on board.
7811A. Wired $400

PROGRAMMABLE TIMER MODULE (AP)
For Apple II; programmable interrupts; count-down; selectable frequency or pulsewidth gating; three maskable outputs.
7440A. Kit/wired .... $150/$160

GPIB INTERFACE (AP/IEE)
Implements Controller/Talker/Listener functions. Allows Apple II to act as controller or peripheral to GPIB (IEEE-488) bus systems, instruments and controllers.
7490A. Kit/wired .... $250/$300

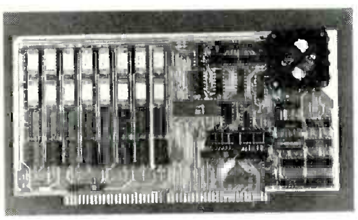
3-3/4-DIGIT BCD A/D CONVERTER (AP)
Converts dc voltages to BCD numbers for computer monitoring and analysis; ±4 V dc full-scale; selectable interrupt at conversion end; 200 µs/conversion; adjustable offset error, temperature coefficient, calibration; overrange and sign indicators.
7470A. Kit/wired .... $130/$150

OTHER APPLE II BOARDS (AP)
Serial synchronous and asynchronous I/O; parallel I/O; prototyping boards (wire-wrap, solder & etch); extender board; 16K RAM.

OTHER BOARDS (S1)
16K RAM; wire-wrap and solder prototyping boards; extender; extender/terminator.

CENTRAL DATA

RAM (S-100)



Dynamic RAM, 16K to 64K .... $249 to $625

CGRS MICROTECH

FRONT PANEL (S1) (EX)
Address, data, reset, memory protect, single-step and run switches; status LED's and 7-segment hex displays. For CGRS System 6000, (S-100), but also plug-compatible with Motorola EXORcisor boards.
Bare board/kit/wired .... $40/$140/$200
6502 MPU Boards. See Computer Section.

PETREX S-100 ADAPTOR (S1/PT)
Adapts S-100 bus to PET computer with cable provided; can be adapted to KIM, Motorola EVII and other 6502 or 6800 computers with appropriate connector cables. Board fits S-100 card slot, generates all required S-100 control signals, such as psync, I/O address, wait states. Cable fits PET memory expansion connector. Wired $196

MPU BOARDS (S1)
6502-MPU boards for S-100 systems.
Level I. MPU with 1-MHz crystal clock; power-up restart circuitry; 50-pin front-panel connector; slow-memory and S-100 interface logic.
Bare board/kit/wired .... $50/$150/$180
Level II. Similar, plus 2K RAM, 4K 2708 EPROM.
Kit/wired .... $240/$280
2-MHz option. For above boards and computers, ... $50

VB1-B VIDEO OUTPUT CARD (S1)
Displays 16 lines of 64 characters and graphics can simultaneously be displayed as a 128 by 48 block; memory mapped; occupies 1K of space
VB1-B. Kit/Wired .... $130/$170

FLOPPY DISK I/O CARD (S1)
Persci 1070 disk controller card adapter; 4 parallel I/O ports; 2 serial I/O ports; dual 16-bit counter/timer; 4K bytes of PROM space (2708).
Floppy I/O Card. Bare board/Kit/Wired .... $50/$190/$250

TIM II I/O BOARD (S1)
Fully decoded memory-mapped I/O with 3 parallel ports and 1 serial port; 6530-004 "T.I.M." I/O circuit; 6820 P.I.A. I/O circuit; 320 bytes RAM and 1024 bytes of ROM for T.I.M. monitor; bread board area.
TIM II I/O Board. Bare board/Kit/Wired .... $40/$140/$170

Note. Compatibility listings for other S-100 boards are available from CGRS Microtech.

CHRISLIN

RAM BOARDS (S1) (EX) (LS) (MB)
RAM boards in 16-64K configurations for S-100, EXORciser, Multibus; 8-32K for LSI-II (Heath H11) bus. Write manufacturer for details.

COMPUTALKER

SPEECH SYNTHESIZER (S1) (RS) (AP)
Voice generator, available in versions for S-100 bus, Apple, TRS-80. Produces speech output from

acoustic-phonetic parameters transmitted at 900 bytes/second. Two operating modes: precoded vocabulary for higher speech quality and optional CSR1 phoneme-conversion software for simpler operation. Data tapes and CTEDIT parameter editor included.

CT-1. (S1). S-100 board version; requires +8 V @ 250 mA, ± 16 V @ 100 mA $425
CT-1A. (AP). Apple version, in cabinet with 110 V power supply, cable and Apple controller card; includes 2-W audio amplifier and Software Package 1 on cassette or disk; requires speaker, hi-fi amp; for 16K systems minimum, 32K recommended $595
CT-1T. (RS). Similar, but for TRS-80, plugs into bus jack of main cabinet or expansion interface $595
Software: Available for CP/M, Micropolis, North Star, CUTS, Tarbell, MITS ACR, Intel hex-format paper tape.

CROMEMCO

CGI TV DAZZLER (S1)
Graphics interface, 128 X 128, 64 X 64, or 32 X 32 element resolution, software selectable; output in color (eight colors available) or black and white (16 gray-scale intensities). Alphanumeric output also available. Requires r-f converter or direct video input. Uses two bus slots, draws 1.4 A @ +8 V, 50 mA @ -18 V. Kit/wired .... $215/$350
Dazzler Programs. Dazzler games on 5-in or 8-in diskette $95
Dazzler Graphics on 5- or 8-in diskette $95

D+7A ANALOG INTERFACE (S1)
I/O board wtih seven channels of 8-bit analog-to-digital conversion for input, seven channels D/A for output, plus one 8-bit parallel digital I/O port. For process control, digital filtering, games, oscilloscope graphics, speech and music uses. Analog signal range, −2.56 to +2.54 V. Takes 0.4 A @ +8 V, 30 mA @ +16 V, 60 mA @ +18 V. Kit/wired .... $145/$245

4-MHz Z-80 CPU CARD (S1)
Extra-high-speed Z-80 microprocessor card, using Z-80. Specially selected for 4-MHz clock-rate operation. Clock switchable, 2 or 4 MHz. Automatically jumps to any desired 4K memory boundary when turned on; no front panel required. Monitor program supplied in paper tape, available in ROM for $50 more. Kit/wired .... $295/$395

SCC. SINGLE-CARD COMPUTER (S1)
Z-80 with ROM, RAM and I/O. See Computer Section. Kit/wired .... $395/$495

DISK CONTROLLER (S1)
Interfaces three mini-floppy (5") or four floppy (8") drives to S-100 bus. Built-in 1K bootstrap monitor; serial port (RS-232/20 mA); five interval timers. Requires +8 V @ 1 A, ± 18 V @ 100 mA ea.
4 FDC. Kit/wired .... $395/$495
PerSci 8" dual drive. Wired $2495

PRINTER INTERFACE (S1)
Dual interfaces for dot-matrix or daisy-wheel printers. Includes one Centronics-compatible parallel interface for dot-matrix, plus interface for Cromemco 3355 daisy-wheel printer. Daisy-wheel interface includes ribbon-lift and ribbon-lowering circuitry to free software overhead. Requires +8 V @ 0.7A.
PRI. Wired $195
Cables for PRI interface:
CBL-2. 62 cm long, for Z-2 computer $15
CBL-3. 110 cm long, for System Three $15

WIRE WRAP CARD (S1)
Holds over 70 integrated circuits; includes 5-V power supply on board; gold-plated contacts.
WWB-2. Kit/wired .... $35/$45

EXTENDER CARD (S1)
S-100 extender with female top connector; gold-plated contacts.
EXC-2. Kit/wired .... $35/$45
Others: Company also makes 8K-32K PROM boards, 4K-64K RAM, serial, parallel and combination I/O.

DELTA PRODUCTS

Complete line of Z-80 compatible boards and industry standard 4½ X 6½-in boards on 44 pin bus.
DP-Z80A. 4 MHz CPU. Kit/Wired .... $135/$185
DP-16KA. 16K static RAM. Kit/Wired ..... $250/$315
DP-VIDA. 64 X 16 video monitor driver, separate video and sync, non-composite. Kit/wired .... $135/$195
DP-CASA. Tarbell and Kansas City interface. Kit/wired .... $98/$165
Many other boards include serial and parallel interfaces, single and double density disk controllers, etc. Write company for details.

ELECTRONIC CONTROL TECHNOLOGY

8080 CPU (S1)
8080 CPU card with jump on reset. Kit/wired .... $120/$175

PB-1 PROTOTYPING BOARD (S1)
With heat sink and 5-V regulator. Kit $28

XT-100 EXTENDER CARD (S1)
Kit/wired .... $24/$34

R_2 I/O ROM, RAM & I/O BOARD (S1)
Includes 3 serial and 1 parallel I/O port, 4 status ports, 2K ROM, 2K RAM. Normally addressed F000-F7FF ROM, F800-FFFF RAM, but addresses jumperable; for 2708 ROM, but adaptable to 2716; baud rates individually selectable (75-9600); RS-232 serial. Wired $295

OTHER BOARDS (S1)
16K static RAM.

EVENTIDE CLOCKWORKS

REAL-TIME AUDIO ANALYZER (PT)(RS)(AP)
Displays levels for ⅓-octave audio-frequency bands, 20-20 kHz, on ISO centers, plus overall signal level. Mode 1s for Pet, Radio Shack TRS-80, and Apple II; vertical resolution varies with computer (e.g., 144 vertical elements for PET, for 7-mV resolution with 1 V input signal); input impedance 10k, unbal.; programmable in BASIC; modifiable to display 32 channels of absolute level indication, for multi-channel audio use; accommodates 2K ROM $595

OTHER BOARDS (PT)
16K/24K/32K RAM for PET .... $420-$615

F&D ASSOCIATES

CPU-1 CENTRAL PROCESSOR (S5)
6502 MPU board for SWTPC 6800 or SS-50 bus. Includes TIM monitor ROM, 1 MHz crystal, 1 serial interface (RS-232 or TTY), 8-bit bi-directional parallel port with two handshake lines (TIM can use this port for high-speed input); provision for 2704/2708 or 2716 PROM; jump on restart, if desired. Bare board with documentation $29

CPU-2 CENTRAL PROCESSOR (S5)
6802 MPU board for SS-50 bus. Similar to above, but with dual crystals, two 8-bit I/O parallel ports, 128-byte RAM at F400-F47F for stack and registers, plus 128-byte RAM at 000-007F; provision for 2708 or 2716 PROM. Optional FADBUG monitor supports serial port, ASCII keyboard, and video display, plus cassette routines in MIKBUG format. Bare board wtih documentation $35
FAD-1E. EPROM with FADBUG monitor $18

KBT-1 KEY/TIM MONITOR
For combining CPU-1 with ASCII keyboard, motherboard (see below) and VDB-1 video board (see Video Board chart) into a system; can also operate as standard TIM system with terminal.
KBT-1. Documentation and program listing $5
KBT-1E. KBT-programmed EPROM $15

FDT-1 FANCY DATA TERMINAL
Similar to above, to form serial video terminal. EPROM resides on CPU-1. Power may be taken from SWTPC 6800 or power supply providing ± 13 V and +8 V. Displays 32 char X 16 lines, with auto scrolling.
FDT-1. Documentation and EPROM listing $5
FDT-1E. FDT-programmed EPROM $15

MOTHERBOARDS (S5)
MB-1-6. Six-slot SS-50 motherboard $19
MB-1-3. Three-slot $12

NCU-1 NUMBER-CRUNCHING UNIT
Scientific and floating-point calculator interface using National MM57109 number-crunching IC. Handles all common math and trig functions in hardware. Plugs into one I/O slot of SWTPC 6800 for power, connects to MP-L or MP-LA board for communication; adaptable to general-purpose ports of other micros. Includes 6800 control subroutines, and exerciser program allowing use of terminal as calculator. Bare board/wired .... $19/$49

STM-1 SIMULATOR, TIM MONITOR
6502-MPU board, usable as stand-alone 6502 computer using TIM monitor, or as simulator for development work on single-board 6502 systems. In stand-alone mode, has 2K RAM, 2K EPROM space (2708), serial and parallel I/O, built-in 2708 programmer, provision for on-board regulation. In simulator mode, connects between 6502 and system under test, controls I/O and memory on tested board, RAM debugging space at address program will occupy in EPROM. Uses 44-pin edge connector. Bare board and documentation $33
STM-1E. 2708 EPROM with programmer functions $18

PIC-1 PROGRAMMABLE INTELLIGENT CONTROLLER
For control and interface applications with 6802 or 6502 microprocessors; can drive devices up to 300 mA and up to 80 V; 16 I/O and four handshake lines; provision for serial/parallel conversion, interval timers; holds 1 EPROM (1K 2708 or 2K 2716), 256-384 bytes RAM; 44-pin connector.
Bare board with documentation $29
EPROM for 6502 or 6802 use $15
OTHER BOARDS:
SS-50 video boards, parallel interface board. Supplied bare, with documentation. Write for details.

GIMIX

GIMIX CPU BOARD (S5)
6800 MPU board; 110-9600 baud-rate generator; 128-byte RAM, switch-addressable; fully buffered; 4K (2708) EPROM sockets, switch-addressable; one EPROM switch-addressable to both E000 and FC00 for MIKBUG compatibility; optional hardware timer for interrupt or output generation.
CPU $224
CPU with Timers $288

OTHER BOARDS (S5) (S3)
Serial and parallel I/O; 4K PROM burner; 8K PROM; 16K RAM w/wo software control; 64 X 16, 32 X 16, 80 X 24 video boards; power-control boards (see Peripherals); Motherboard (see Accessories).

GODBOUT

ECONORAM VI (H8)
12K static RAM for Heathkit H8 computer; 450-ns;

addressable and write-protectable in independent 4K and 8K blocks; board deselect switch. Requires 2.25A power. Kit. $200

TRS-80 CONVERSION KIT (RS)
Set of chips and DIP shunts to upgrade TRS-80 from 4K to 16K. With instructions. $87

HEATHKIT

MODULE BOARDS (H8)
Boards for H8 computer; include 8K and 16K RAM boards, 3-port parallel and 4-port serial interfaces; serial/cassette interface; breadboard card.

INNOVATIVE TECHNOLOGY

AD-68A ANALOG-TO-DIGITAL CONVERTER (S3)
Analog-to-digital converter for SWTPC 6800 and similar computers; occupies one I/O slot. Eight analog input channels; input range 0-2.5 V dc; requires +8 V @ 82 mA max., +13 V @ 3 mA max, −13 V @ 26 mA max. Wired $40

ITHACA INTERSYSTEMS

Z-80 CPU (S1)
Z-80 MPU with on-board 2708 EPROM, power-on jump to any 4K boundary above 32K; MWRITE for operation without front-panel; selectable wait states on M1, memory request, on-board ROM, input and output cycles, selectable 8080 or Z-80 I/O addressing modes; clock-generator provides 8080-like signals for S-100 bus. Requires +8 V @ 1.0 A; with optional 2708, requires +16 V @ 100 mA and −16 V @ 50 mA also.
CPZ80. Bare board $35
With 2-MHz/4-MHz Z-80 .... $175/$205

FRONT PANEL (S1)
Binary-format, for S-100 bus; supports any 8-bit MPU, including 6800, 6502, etc. as well as 8080/Z80 types. Externally accessible functions include: read, write, jump to address, single-step, slow-step, run, stop, reset, and set breakpoint. Cover removes to expose controls for: slow-step rate (10-100 instructions/sec); break on Fetch, on I/O, on Interrupt Acknowledge or Hold Acknowledge; breakpoint oscilloscope trigger; continuous NOP for Signature Analysis. Binary LED indicators for address and data busses, status byte, programmed output byte and command status. Wired. $375

FLOPPY DISK CONTROLLER (S1)
For hard or soft sectoring; 330K bytes/surface (hard); compatible with all Shugart or similar single- and double-sided drives; supports up to four drives, with independent-head-load and enable circuitry; write gate protects against data loss during power-down; compatible with IEEE S-100 bus standard; for two or four MHz systems; uses no RAM addresses; generates −5 V on board for up to 2 disk drives; optional on-board 2704 or 2708 PROM bootstrap; uses 8 port addresses, swtich-selectable.
Bare board/wired .... $35/$195
K2 Operating System. Soft Sector $75
K3 Operating System. Hard Sector $75
(Pascal and BASIC also available)

OTHER BOARDS (S1)
Also available: S-100 2708/2716 EPROM 16K/32K; 8K RAM; 16X64 video board; wire-wrap prototyping board. All available as bare boards or wired and tested.

JADE

DOUBLE-D CONTROLLER (S1)
Double-density, floppy-disk controller; supports 5½- or 8-in floppies, single or double density, IBM 3740 or System 34 soft-sector formats; meets IEEE S-100 standards; CP/M compatible; has own Z80, 2708 EPROM and 1K RAM on board.
IOD-1200. Kit/wired .... $285/$350

BIG Z Z-80 CPU (S1)
Z80 MPU board with on-board EPROM (2708, 2716, 2516, 2532), power-on jump; shadow mode disables EPROM, allowing full 64K RAM use; MWRITE generation; on-board baud-rate generator; accepts handshake signals.
CPU-30200B. Bare board $40
CPU-30200K/A. 2-MHz kit/wired .... $150/$200
CPU-30201K/A. 4-MHz kit/wired .... $160/$210

I/A Z80 CPU (S1)
Z80 MPU board with on-board 2708 EPROM, power-on jump; selectable wait states; usable at 2 or 4 MHz; 8080 or Z80 I/O modes, selectable; mirrored I/O addressing; DMA request/grant utilized; clock-generator duplicates 8080 timing signals.
CPU-30100B. Bare board $35
CPU-30100. 2-MHz. Kit/wired .... $135/$190
CPU-30101. 4-MHz. Kit/wired .... $150/$200

8080A CPU (S1)
8080-MPU board; with vectored-interrupt circuitry (need not be built up till needed), for up to 8 levels of priority interrupt (with real-time clock board).
CPU-10010B/K/A. Bare board/kit/wired ....$35/$90/$150

MODEM BOARD KIT
Allows computer to generate and receive Type 103 modem frequencies via crystal microphone and 8-ohm speakers; can be configured as originate or answer mode; TTL digital I/O; requires +5 V.
IOM-5011B/K. Bare board/kit .... $8/$28

CASSETTE TAPE INTERFACE.
FSK interface for mass storage on audio recorders; logic frequencies 1200 and 2400 Hz, adjustable; requires +5 V.
IOT-5016B/K. Bare board/kit .... $8/$28

UNIVERSAL LEVEL TRANSLATOR KIT
Converts TTL to RS-232 or current loop, or vice versa. Requires ±5 V, ±12 V.
IOL-5010B/K. Bare board/kit .... $7/$13

OTHER BOARDS (S1)
Also available: 64X16 video board; 8K, 32K RAM; 16K/32K EPROM (2708/2716); parallel/serial I/O.

JHM MARKETING

VOTRAX VOICE SYNTHESIZER (S1)
Produces continuous speech analog output from phoneme instructions. On S-100 board.
K100. ....$495

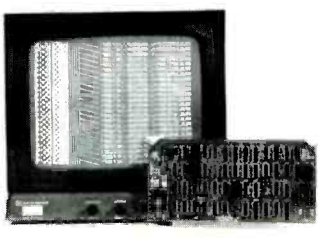
LARKS ELECTRONICS & DATA

ACCELEWRITER
Module to modify DECwriter LA36 from 110/150/300 baud to 110/300/600. Plug-in installation $115

MATROX

VIDEO RAMS
Video controller modules addressed as RAM memory, each on-screen character equivalent to a one-byte memory location. Controllers available as plastic-packaged modules, or as complete module boards.

ALT-2480 ALPHANUMERIC DISPLAY INTERFACE (S1)
4K video RAM providing 24 lines X 80 characters,



strappable for two pages of 40 char/line (recommended mode for use with ordinary TV, or other monitors with less than 10 kHz bandwidth); compatible with ALT-256 for combined alpha/graphic display; built-in refresh; available as 128-char upper/lower-case ASCII 7 X 9 matrix, or uppercase only in 5 X 7 matrix; inverse and blinking under software control; available in American or European standards interlaced or noninterlaced; interlaced display requires long-persistence phosphor CRT; can drive up to 10 monitors, up to 500-ft cable run. Wired $295

MLSI-2480 (LS)
Similar, but for LSI-11 (and Heath H-11) bus ... $495
Other Versions: Available for Prolog, STD, EXORciser, SBC-80 and PDP-11 buses.

ALT-256 GRAPHICS DISPLAY (S1)
256 X 256 graphic card, addressed as four output ports and one input port (port addresses strappable); ports control dot coordinates, intensity, color and screen-clear; multiple ALT-256 cards may be combined for grey scale or color capability; may be used with ALT-2480 for combined alpha/graphic display. Other specifications similar to ALT-2480. Wired $395

ALT-512. (S1)
Similar to ALT-256, but 512 X 256 .... $595
Other Versions: 256 X 256 available for STD, SBC-80, LSI-11, PDP-11 buses; 512X256 avail for EXORciser, LS-11, SBC-80, PDP-11; 512X512 for SBC-80, LS-11, PDP-11; 256X1024 SBC-80, LSI-11, PDP-11.

MODULES
MTX-816. Video RAM for eight lines, 16 characters, upper-case ASCII (128 bytes) $179
MTX-6132. 512-byte VRAM, 16 lines X 32 characters, upper/lower-case ASCII. Drives up to 25 TV monitors $225
MTX-1632SL. Externally synchronized version, allows output to be mixed with or superimposed on other images $225
MTX-2480. 24 lines X 80 characters, upper- and lower-case, half-intensity, blink, inverse video (lower-case requires long-persistence CRT phosphor) $395
MTX-256"2. Graphics board; 256 X 256, individually addressable dots. Color or grey-scale available. Light pen, cursor plot, point plot, alphanumerics, and ROM screen patterns may be implemented. On pc board, with 44-pin edge connector $630
Character fonts. 1632 and 2480 may be supplied wtih upper-/lower case ASCII, upper case ASCII/Greek, General European, and French character fonts at no extra charge. Japanese (Kata-Kana), British, German, math symbols, etc., available for $150 per order. Custom-designed character fonts available.

MICRODASYS

6809 CPU CARD (S1)
6809, 16-bit processor card for S-100 bus; integrated I/O, RAM, PROM, cassette interface; 1K RAM, 10K PROM space, RS-232 level shifters, interrupt-driven keyboard input, 20 I/O lines, power-on reset, real-time clock; cassette @ 2400 baud (Manchester) or 300 baud (K.C.). Choice of MONBUG II for memory-mapped video I/O or RSBUG II for RS-232 serial I/O
MD-690b. Kit/wired ....$239/$299

6802 CPU CARD (S1)
Same as above, but with 6802 processor, 8-bit.
MD-690a. Kit/wired ....$198/$258

MULTI-PURPOSE PARALLEL/SERIAL I/O WITH MODEM (S1)
Provides 8 bi-directional parallel ports (64 lines) with full handshake and interrupt handling; 2 serial I/O ports, one configurable RS-232, other as full-duplex answer or originate modem or as Byte-standard cassette interface.
8P2SM-C. Kit/Wired ....$149/$199

MICROPRODUCTS

APPLE II/PR-40 PRINTER INTERFACE (AP)
Interfaces Apple II computer to SWTP PR-40 printer. Plugs into Apple II slot 3, prints one line for each Return command, will list BASIC as screen scrolls; includes cable and cassette software $50

APPLE II EPROM BURNER (AP)
EPROM programmer for 2716 EPROM. Plugs into Apple II; zero-insertion-force EPROM socket; on-board, 25-V power supply $100

INTERFACE BRAIN (AP)
Provides firmware drivers for Centronics 779, PR-40 and Okidata printers and for Microproducts EPROM burner. EPROM in adapter socket for insertion into APPLE II D8 ROM slot $60

EPROM SOCKET ADAPTER (AP)
Adapts 2716 EPROMS to Apple ROM sockets ... $15

PARALLEL OUTPUT (AP)
8-bit parallel output board for Apple II; TTL or CMOS compatible; 15-mA output can drive LEDs directly; interfaces with SWTP PR-40 or Centronics 779 printer; wiring diagrams supplied for use as power controller $45

THE MICRO WORKS

DIGISECTOR (S3)
Random-access video digitizer for SWTP 6800 and similar computers; stores video signals in computer memory. Resolves 256 × 256 picture scan; 64 levels of gray scale; conversion times as low as 3 µs/pixel; accepts interlaced (NTSC) or non-interlaced (industrial) video input; requires one I/O slot; can superimpose cursor on picture. Software supplied digitizes one pixel every other horizontal scan line, fills 16K with 6-bit gray-scale value in under 4 sec, providing 128 × 128 resolution; drives Malibu 160 graphics line printer, commented for interfacing to others. Wired
DS-68 .... $170
DS-68R. Regulated +12 V $180

DS-80 (S1)
Same, but for 8080; S-100 board; minimum conversion time 4 µs/pixel; with software. Wired $350

DM-85 DISK MIXER
Add-on board for Smoke Signal Broadcasting BFD-78A disk controller, to permit intermixed operation of 8-in and 5¼-in drives. Kit $40

PROM SYSTEM BOARD (S5)
PROM/RAM combination. 1K 350ns RAM, space for up to 8K 1708 EPROM, both addressable to any 8K boundary; provision to move I/O locations to any unused 1K block in EPROM space, permitting memory expansions to 56K contiguous; +12 V regulator optional, for systems using Smoke Signal PS-1 or equivalent power supplies. Wired.
PSB-08. .... $120
PSB-08R. Regulated +12 V $125

EPROM PROGRAMMER (S3)
Programs 2708 EPROMs; fits SWTPC 6800 I/O slot. Safety switch and LED indicator for programming voltage; zero-insertion-force socket, extended board for easier PROM insertion/retrieval; 12 V regulator optional.
B-08. .... $100
B-08R. (+12 V regulated) $105
U2708. EPROM-burning firmware; specify C000 or FC00 address $30
U2708/1000. KC-standard, 300-baud cassette .. $10

UNIVERSAL INTERFACE BOARD (S3)
For custom interfaces. Space for 40-pin wire-wrap socket for Motorola 40- or 24-pin interface chips; data and control lines at appropriate edge-connector pins; other bus connections to 16-pin socket pad; includes Molex connector, +5 V regulator; space and bussing for up to 35 14-pin ICs. **UIO** .$25

EXTENDER BOARDS (S3) (S5)
Double-sided extender boards, wtih bus extensions on bottom, ground plane on top; silkscreened bus pin designations and ground-clip attachment points.
X-50. (SS-50 bus) $30
X-30. (SS-30, I/O bus) $23

MK ENTERPRISES

DTMF TRANSCEIVER (S1)
Interfaces S-100 computer to Touch-Tone phone system, via DAA. Converts Bell System Dual-Tone Multi-Frequency (DTMF) signalling to binary and vice versa; when used with interrupt controller (such as IMSAI PIC 8), can perform ring detection and DTMF signalling without CPU looping; allows remote data entry from Touch-Tone phones; 4-bit input port allows additional data transfer on DTMF detection or servicing up to eight incoming lines; 4-bit output port for supervision of DAA or other equipment; DAA not provided. Wired $425

MOUNTAIN HARDWARE

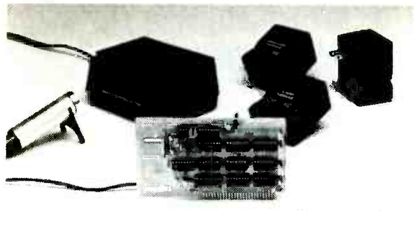
100,000 DAY CLOCK (SI)
S-100 clock board; times in 100 µs increments for periods up to 100,000 days (273 years); allows reading of time and programming of time-dependent functions; on-board battery backup. Uses 15 I/O ports for time, plus one I/O port to set interrupt function; user-addressable to any 16 consecutive 8080-Z-80 ports; time set by entering BCD digits through ports; write protect switch prevents accidental clock stop or reset; can interrupt computer at pre-programmed intervals; crystal control, 0.001% accuracy. Can be used with most BASICs: software documentation includes calendar, interrupt-handling, time-reading and setting routines $259

APPLE CLOCK (AP)
Similar to above, but for Apple II. Keeps time and date in 1-ms increments for one year; on-board battery backup; software controlled, clock-generated interrupts; accessible from BASIC using routines in on-board ROM $199
External Charger. Fits on-board recharge socket on both clocks above $10

SUPERTALKER (AP)
Allows Apple II to output speech through loudspeaker (supplied) or external sound system; digitizes words spoken into microphone supplied, stores them in RAM for manipulation $279

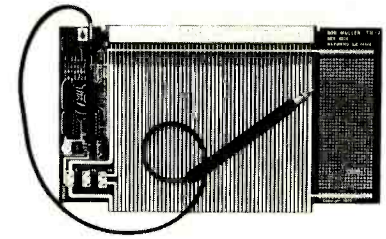
ROMPLUS+ (AP)
Adds upper/lower-case, plus five, individually-addressable 2K (2716) PROM sockets. Firmware provided adds upper/lower case, multiple user-defined character sets, colored or inverse-colored letters, two-key entry of user-defined words or phrases including BASIC and DOS commands, improved cursor control; 255-byte on-board scratchpad RAM $169
Without firmware (holds 6 PROMs) $149
Firmware retrofit $50

INTROL/Z-10 (AP)
Controls 110-V devices by commands sent through building wiring to BSR System X-10 control modules; uses ultrasonic commands to BSR X-10 command console; controls up to 16 remote modules or module groups; software provided for daily or weekly timed controls, time intervals, power-consumption control.
With BSR X-10 console and three remote modules $279
Controller card separately $189



MULLEN

EXTENDER BOARDS (H8) (S1)
Raise module boards above chassis for easier in-circuit testing; jumper links in power lines for current-measurement and for fusing of board under test; edge-connectors with formed leads for easy scope probe attachment; all connector lines labelled. S-100 version also has TTL logic probe indicating low- and high-level logic and pulses on seven-segment LED display; pulse-catcher LED whose brightness corresponds to pulse-stream duty cycle; "kluge board" section with holes on 0.1-in grid for user circuits.
H8-Extender Kit $39
TB-2. S-100 Extender. Kit/wired .... $49/$52



OPTO-ISOLATOR/RELAY CONTROL BOARD (S1)
Interface board for device control. Has eight reed relays (rated 10 VA, 20-200 V) controllable by 8-bit computer command, eight opto-isolators for feedback handshake. I/O port address switch-selectable; ac relay modules (500 W) available; see Accessory section.
CB-1. Kit/wired .... $129/$179

NATIONAL INSTRUMENTS

LSI-11/IEEE-488 INTERFACE (LS/IEE)
Interfaces LSI-11 bus to IEEE-488 bus. Includes 4-meter cable with connector; allows user to connect as many as 14 instruments on a single interface; with software
GPIB11V-1 .... $695

NATIONAL MULTIPLEX

DOUBLE DENSITY DISK SYSTEM (S1)
Reads and writes single or double density on 5¼-in or 8-in disks, single and double sided; density and disk size selection user manual or software control, using CP/M disk from National Multiplex; on-board EPROM bootstrap, relocatable to any 2K boundary.
D3S. Specify ROM address. Wired. $320
CP/M and proprietary software (for Z80 only) ..$70

Z80 BOARD (S5)
Replaces MPU board in SWTP 6800 or similar SS-50 bus computer; includes on-board ROM monitor; 2-MHz; on-board baud-rate generator, to 9600 baud; uses 8080/Z80 I/O ports or memory-mapped I/O; tape read/write routine; software-controlled tape start/stop. Wired. $190

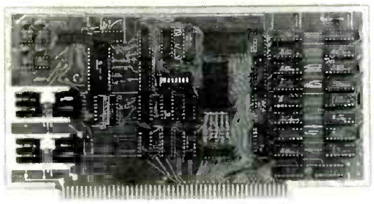
NORTH STAR

HARDWARE FLOATING-POINT BOARD (S1)
Hardware arithmetic board performing floating-point add, subtract, multiply and divide with up to 14 digits of precision; approximately 50 times faster than 8080 software or firmware; uses BCD number representation; precision under software control. In versions for S-100 and SBC (Multibus) buses. Includes North Star BASIC modified for hardware calculations; specify whether disk or paper-tape version desired.
FPB-A. S-100 version; requires +8 V @ 1.8 A. Kit/wired .... $259/$359

OTHER S-100 BOARDS (S1)
Z80 processor; 16K and 32 K RAM.

OBJECTIVE DESIGN

PROGRAMMABLE CHARACTER GENERATOR (S1)
Adds software-created characters to existing video display boards such as VDM-1, Polymorphic VTI,



etc. Works with video boards using Motorola 9 X 7 matrix character-generator ROMs. Board includes parallel keyboard interface, two-dimensional joystick interface provisions, and 2K onboard character memory; can produce graphic images up to 512 X 256 (not bit-mapping—suggested where basic image sets are repeated on screen); requires no external system memory or DMA; requires +8 for board, −16 if interfaced to keyboard requiring −12 V; list of bus-control signals used is available; specify video display in use when ordering. Kit/wired .... $150/$200
High-speed option for 4-MHz systems $16

DATABANK (S1)
PROM programming and storage card with onboard RAM. Holds up to eight 2716 or 2708 PROMs (16K or 8K bytes), plus separate socket for programming; computer can read programmed PROM in place of any other on board, under software control, for testing and verification; on-board static RAM (1K on 2708 boards, 2K on 2716) can be software-substituted for any PROM, to test program patches, or can be independently addressed; 2nd programming socket may be connected to external socket on computer front panel or housed separately; size of address space occupied is switch-selectable; jump-on-reset to lowest-addressed PROM; phantom (bus-line 67) defeats any memory at 0000 during jump.
Without RAM. Kit/wired .... $200/$225
With 1K RAM. Kit/wired .... $220/$245
With 2K RAM. Kit/wired .... $240/$265

DOUBLE-X EXTENDER CARD (S1)
Double-X pattern of interleaved ground and signal lines for reduced noise and crosstalk; 5 V regulator for logic probes. Kit/wired .... $35/$45

CONSOLE INTERFACE (S1)
Special-function interface; includes 8279 programmable keyboard/display interface for switches, keypads and up to 32 seven-segment displays; 8259 programmable interrupt controller generating interrupts to any location in memory; up to 6K PROM; 256 bytes RAM, real-time clock with selectable interrupt intervals from 100 μsec to 100 ms; power-on jump; optional on-board generation of MWRITE. Available in several configurations, with firmware including interrupt service routines, time-of-year and general timed alarms, console functions, etc. $200
Others: Video: 80 X 24/64 X 16 (S1)

PARATRONICS

MODEL 150 "BUS GRABBER" LOGIC ANALYZER (S1)
One-board logic analyzer for S-1 bus. Automatically monitors address and data busses, MPU status, interrupts and controls signals, performs automatic clock qualification and clock polarity selection; also offers 8 user-defined signals interfacing via optional, plug-in, flat ribbon probe assembly, providing independent 8-channel logic-analyzer functions, triggering, display formatting and operational modes controlled from hand-held pod connected to main pc board by cable; trigger word can be up to 24 bits; analyzer data memory 16 bits by 16 words, can capture over 8 million 16-bit words/sec for use with future, faster S-100 systems. Data words displayed as ones and zeros on ordinary oscilloscope; connecting cables included; displays signals as series of eight, 8-bit, 16-word truth tables, selectable from control pod. Pod also formats data in hex or octal groupings, stores or updates individual truth tables, chooses post- or pre-trigger data acquisition; trigger-indicator LED on pod and trigger output signal.
Kit/wired .... $369/$499
8-bit data probe set $10

PERCOM DATA

CI-812 CASSETTE/TERMINAL INTERFACE (S1)
Dual-function interface board for S-100 bus. Cassette interface is KC-standard, with independent record and playback circuits, optional relay kit for programmed control of two recorder/players. Also includes RS-232 terminal interface. Tape data transfer at 30, 60, 120 or 240 bytes/sec; RS-232 @ 300-9600 baud. Kit/wired .... $100/$130
Remote-Control Kit $15
IC socket kit $15
Test cassette with operating software $5
Operating system firmware (2708) $45

LFD-400 MINI-DISK CONTROLLER (S5)
SS-50 controller board for up to three Mini-Floppy drives (See "Peripherals" sections for system details). Wired $115

TRS-80 PRINTER INTERFACE (RS)
Connects any serial RS-232 printer to TRS-80 .. $60

6809 ADAPTER (S5)
6809 MPU adapter for SWTP MP-A2 6800 processor card, may also be used to upgrade most other 6800/6802 systems to 6809. Kit may be removed and original components restored when desired $70
PYSMON 6809 Monitor. On 2716 EPROM/diskette .... $70/$30

OTHER BOARDS (S5)
For SS-50 bus. SS-50/SS-30 prototyping cards; 24 X 80 video display board.

SD SYSTEMS

VDB-8024 VIDEO DISPLAY BOARD (S1)
Full 80 character by 24 line display; keyboard power and interface; composite video out, plus TTL level sync and video out; 2K bytes RAM and Z-80 on board. Kit/wired .... $319/$469

VERSAFLOPPY SINGLE-DENSITY DISK CONTROLLER (S1)
IBM 3740 compatible format; for both 8-in and 5-in drives; operates with Z-80, 8080 and 8085; control and diagnostic software in PROM; CP/M compatible. Kit/wired .... $159/$259

VERSAFLOPPY II (S1)
Same as above but operates with single or dual density, single or double sided drives. Kit/wired .... $309/$399
Many other boards available including ExpandoRAM 8K-64K; PROM-1000, PROM blaster; MPB-100, Z-80 CPU and others.

SILVER SPUR

RAM; PROM; I/O; A/D; PROTOTYPING (S-44)
RAM boards in 4-32K configurations; 4K PROM; 8K EPROM; EPROM Programmer; parallel I/O; 32-channel A/D; CRT controller; audio cassette controller; serial I/O; KIM/S-44 interface, all for S-44 bus. Available as bare boards or as kits. Write manufacturer for details.

SMOKE SIGNAL BROADCASTING

SCB-68 MPU (S5)
6800-MPU board; features 1K scratch-pad RAM; 2K EPROM monitor; addresses up to 1MB memory, in 16, 64K-byte pages; space for up to 20K EPROM; options include: floating-point processor, RS-232 I/O, real-time clock; port and EPROM addresses customizable by replacing FLPA controller $250

OTHER BOARDS (S5)
80X24 video board; 16K RAM.

SOLID STATE MUSIC

MUSIC SYNTHESIZER BOARD (S1)
Waveform synthesizer card for S-100 computers; polyphonic capability available through use of multiple cards; frequency software controllable over 9-octave range; volume software-controlled at 15 levels; waveform user-definable in 32 bytes of memory; envelope user-definable; note durations controllable from 64th-note to whole note. High-level music software available. Board is memory-mapped device, addressable from 8000 to FF00; output 1 V rms, low-impedance; requires +7 to +9 V @ 1.3 A, ± 12 to ± 18 V @ 25 mA.
SB-1. Bare board/kit/wired .... $45/$179/$249

CB1A 8080 CPU BOARD (S1)
Includes 1K scratchpad RAM, sockets for 2K EPROM (2708) addressable to any 2K boundary, 8-bit parallel input port; optional power-on jump to on-board ROM; generates MWRITE; requires +8 V @ 0.95 A, +16 V @ 50 mA, −16 V @ 25 mA (more, when EPROMs installed).
C81A. Bare board/kit/wired .... $39/$159/$224

CB2 Z-80 BOARD (S1)
Similar, but with Z80; switch-selected 2 or 4 MHz; sockets for two 2716 or 2732 EPROMs (total 4K or 8K), and for 2K TMS-4016 RAM, both switch-disabled; run/stop and single-step switches for systems without front panel; extended memory addressing with eight additional address lines, controlled by output port FE; power-on/reset firmware jump; MWRITE; jumpers generate new IEEE S-100 signals. Requires +8 V @ 0.75 A (less EPROMs).
CB2. Available 10/79.

OTHER S-100 BOARDS (S1)
Video boards: 64/32 X 16 plus 128 X 48 graphics, 64 X 16 with keyboard input, 80 X 24/51 plus 160 X 204 graphics and keyboard port. I/O boards: 1+1 parallel, 2 parallel + 2 serial. Memory board: Dual 4K and 16K static RAMs, 1-16K and 2K/4K EPROM and 4K/8K with 2708/2716 programmer. Active terminator. Extender board. 2K Monitor firmware (1702 or 2708).

SERIAL & PARALLEL APPLE INTERFACE (AP)
1 serial, 2 parallel ports, with on-board firmware. Serial port has nine baud rates, 110-19,200, including 134.5 baud (Selectric), additional baud rates via external input; 256-byte on-board PROM; includes interface cables; PROMs and data buffer power-down when not addressed.
AIO. Kit/wired .... $135/$175

SOUTHWEST TECH. PRODUCTS

MP-N CALCULATOR INTERFACE (S3)
Hardware arithmetic calculations, to simplify machine-language programs and conserve memory; features Reverse Polish Notation, floating-point or scientific operation (to 8-digit mantissa, 2-digit exponent); four-register stack; memory register; trig functions; base-10 and natural logs; overflow indicator. Kit $47

MP-T INTERRUPT TIMER (S3)
Provides software-selectable interrupts of 1 μsec, 10 μsec, 100 μsec, 1 msec, 10 msec, 20 msec, 100 msec, 1 sec, 10 sec, 100 sec, 1 min, 10 min or 1 hour; also includes fully-buffered 8-bit input port with handshaking. Requires +8 V @ 0.3 A, −12 V @ 15mA. Kit $40

RAM BOARDS (S5)
8K to 32K .... $225 to $650

SPACE TIME PRODUCTIONS

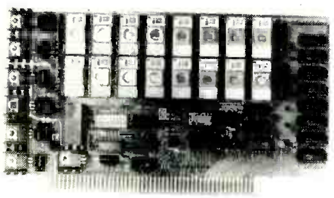
MASTER I/O-ROM-RAM BOARD (S1)
Combines serial and parallel I/O plus RAM and ROM, allowing minimal two-board system in con-

junction with a CPU board. 1K RAM; 3K ROM, six parallel, one serial port; three 16-bit counter/timers, programmable as binary or BCD counters; programmable one-shots, digital delay, pulse or square-wave rate generator, software- or hardware-triggered strobe. Synchronous serial I/O (TTL levels) to 56K baud, software programmable; parallel interface with total of 24 possible I/O lines, programmable as input, output, bidirectional data or handshaking; two I/O lines have bit/reset. Bare board/kit .... $40/$139

SZERLIP

PROM SETTER (S1)
EPROM programmer board with external programming socket and three parallel ports (2 out, 1 in). Programs and reads all 24-pin EPROMs, including 1702A, 2704, 2708, 2716 TI, S5204, 6834; supplied for 1702A and 2704/2708, but can be configured for any combination. Single read/write EPROM socket can be externally mounted for easy accessibility; has write-enable/disable switch. Requires four consecutive I/O port addresses, +8 V @ 0.7 A, ±16 V @ 0.2 A. Kit/wired .... $210/$375

RAM'N'ROM (S1)
Holds up to 64K of any 24-pin EPROM (16 sockets); can accept two different EPROM types, in two



groups of eight. Has power-on-jump and run for computers with front panel, jump-on-reset and MWRITE logic for computers without. Kit/wired .... $117/$168

TARBELL

1001 CASSETTE INTERFACE (S1)
Saves and reads data on audio cassette machines. Data transfer rates up to 540 bytes per second with high-quality cassette recorder, 187 bytes/sec suggested for medium-quality recorders (both Tarbell format), modifiable for Kansas-City format @ 27 bytes/sec. With Triple-I Phi-Deck, 1000 bytes/sec @ 10 in/sec. Extra status and control lines available for use with computer-controlled drives such as Phi-Deck, or multiple tape recorders with Ro-Che controller (see Peripherals). Includes software, room for user-developed circuits. Kit/wired .... $120/$175
8K EMPL. Cassette $15
P.T. Editor. Cassette $5

1011 FLOPPY DISK-INTERFACE (S1)
Interfaces single-density, full-size (8-in) floppy drives; for up to four drives (or two double-sided). CP/M-compatible. Includes 32-byte bootstrap ROM with jump-on-reset; ROM switches out of address space once run; uses programmed data transfer (not DMA); connector pins come out to jumper pads, for easy adaptability to different drives; user-circuit area can be used to increase capacity to eight drives. Bare board/kit/wired..$40/$190/$265
CP/M disk $70
CBASIC disk $85
TARBELL BASIC disk $36

OTHER BOARDS (S1)
32K RAM, kit or wired.

TELESENSORY SYSTEMS

SPEECH SYNTHESIZER MODULE
Converts digital speech data in on-board ROM to analog voice output (external filtering and amplification required). Requires 6-bit parallel address and start signal; +15 V and −5 V power; on 3.10-in

square board with 22-pin connector; can be made TTL compatible. Available with choice of one 24-word, two 64-word vocabularies; custom vocabularies available on special order.
S2A. With 24-word Calculator vocabulary $95
S2B. With 64-word "Standard" vocabulary $179
S2C. With 64-word "ASCII" vocabulary $179

CALCULATOR SPEECH SYNTHESIS MODULE
With 24-word Calculator vocabulary only; specify English, German or Arabic. On 4 × 7-in circuit board with 16-pin DIP connector, audio filter circuit, 200-mW amplifier, volume control, 2-in speaker $150

TELETEK

DAJEN UCRI (S1)
Universal cassette recorder interface. Switch selectable baud rates from 520 to 41,000 baud (maximum usable typically 5000 baud on cassette, 12,000 baud on 7½ ips tape); switch-selectable Tarbell, Kansas-City or other format. Independent switch selection of transmit and receive data inversion for use with different recorders. Level indicator light. Relay option for independent control of two recorders; independent latched input port for keyboard or other use. Kit/wired .... $165/$210

DAJEN SYSTEM CENTRAL INTERFACE (S1)
Combines ROM reader/programmer, RAM, serial, parallel and cassette I/O, with reset-jump. Can program 2708 EPROM, read up to 3K; software included in 2K firmware monitor. Has 3 parallel ports, RS-232/20mA/60mA serial port. Cassette I/O compatible with Tarbell; bi-phase recording at programmable speeds from 800 to 100k baud; 2 on-board relays control 2 recorders; status lines can control automatic decks; sync and level indicator LEDs. Firmware monitor includes I/O, EPROM programming, video-board drivers, hex arithmetic, memory examine/move/verify/clear/search, tape verify. With all output connectors. Wired $385

FLOPPY DISK CONTROLLER-I (S-1)
Can be configured as a central processor in an S-100 system or as a smart floppy disk controller; 4 MHz Z-80A microprocessor; EPROM/ROM/RAM up to 8K, two RS232C ports, two parallel ports, cassette port; reset-jump; 2K monitor; up to three mini or four maxi drives, single or double density, single- or double- sided, e.g. Shugart or PerSci; CP/M-compatible.
FDC-I $995

FLOPPY DISK CONTROLLER- II (S-1)
Can control up to three mini or four maxi drives, single or double density, single or double sided, e.g. Shugart or PerSci or any ANSI-compatible; on-board Z-80 boot; simultaneous seek on multiple drives
FDC-II $395

THINKER TOYS

DISC JOCKEY 1 CONTROLLER (S1)
Single density controller board for full-size, 8-in floppy disks. IBM-compatible soft-sectored format; 256K bytes/disk. Can accommodate up to eight drives; on-board ROM with bootstrap and other functions; 256-byte RAM buffer; board occupies 1K starting at 340:000 octal or E000 hex (other 1K-boundary addresses on special order). Software is initialized to use on-board, memory-mapped serial I/O port, allowing easy use or access to reinitialize to any other port desired. Supplied with DISK/ATE (DOS/Assembler/Text Editor) and BASIC-V. CP/M compatible; patches supplied for those with CP/M; disk available.
Kit .... $179/$214
Cable for disk drive $20
Additional connectors for multiple drives $15
Software options: see under Peripherals.

DISC JOCKEY 2D CONTROLLER (S1)
Same as above except double/single density capability, requires 2K of address space starting at 340:000 octal or E000 hex consisting of 1K PROM and 1K RAM.
Kit/Wired .... $379/$429

KEYED-UP 8080 (S1)
Combination 8080 MPU/front-panel board, with octal keypad and display, two on-board I/O ports (for keyboard), 256-byte RAM and 256-byte ROM. Facilities to start, stop, or step any program, processor remains active after HALT command. Kit/wired .... $250/$325

SWITCHBOARD I/O BOARD (S1)
Eight I/O ports switch selectable for location on any boundary in address space divisible by eight; two serial ports, one serial status port, four independent parallel ports, separate status port, separate strobe port; 4K RAM option; 4K EPROM option; dip-switch selectable phantom disable.
Kit/wired .... $199/$259
Optional 2114 RAM $70
SWITCHBOARD connector kit $12

SPEAKEASY CASSETTE/GEN. PURPOSE I/O BOARD (S1)
Kansas City Standard cassette interface can read from or write up to three recorders, verify tape against memory contents including checksum, will read or write Intel hex format too; software UART RS-232/TTY serial port with software control of baud rate, self measures baud rate of device talking to it; bi-directional parallel port will accept inverted or positive logic; 512 bytes RAM; 512 bytes PROM committed to COPE software; built-in bootstrap.
Kit/wired .... $130/$175
26-conductor cable assembly $6

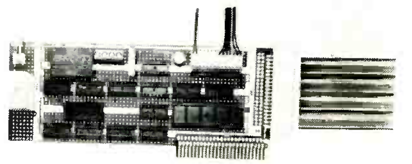
RAM BOARDS (S1)
RAM boards 8K to 32K .... $149/$699

VECTOR ELECTRONIC

Microcomputer prototyping boards with bus lines, DIP-spaced holes, and appropriate edge connectors for the following microcomputer systems:

S-100 Boards (S1)
8800 V. Power & ground planes for wire-wrap; for 52 16-pin DIPs or equivalent $22
8800V-B. 8800V with sockets and wrap-posts in place and ready to wire, for 2 40-pin, 8 24-pin, 36 16-pin DIPs $89
8801-1. Bare board with edge contacts, for 88 16 pin DIPs, or equivalent in any size DIPs and components $15
8802-1. With 2-hole pads, power & ground buses for 42 16-pin DIPs or equivalent $24
8804. With power and ground planes for wire-wrap; for 70 16-pins or equivalent $22
8801. With 1 pad per hole, plus power & ground buses; for 16-pin DIPs or equivalent $21

APPLE/SUPERKIM/PET BOARDS (AP)
4609. Peripheral interface board for Apple II, Superkim or Pet with Expandamem (Expandapet).



Provision for peripheral connectors $22

SBC MULTIBUS BOARDS (MB)
4608. With 3-hole pads, power & ground buses; for 54 16-pin DIPs or equivalents $45
4608-1. Bare board with edge contacts for 144 16-pin DIPs or equivalent $34

H11 BOARD (LS)
4607. For Heathkit H11, DEC LSI-11, PDP-8, PDP-11. Bare board with edge contacts; for 89 16 pin DIPs or equivalent $20

VECTOR GRAPHIC

Z80 CPU (S1)
Z80 MPU board; 2/4 MHz, jumper-selectable; jumper-selectable—automatic wait state; all signals buffered; jumper-selectable MWRITE $215

8080 CPU (S1)
Includes real-time clock generator, eight-level priority interrupts $195

HIGH RESOLUTION GRAPHICS (S1)
Composite video output for faster-scan monitor; digital output 256×240; 128×120 with 16-level gray scale; circuitry for glitch-free update; includes software for alphanumeric, X-Y plot, pattern-drawing, demonstration images; requires Vector 8K Static RAM board; RAM available for general use when graphics not in use; requires +8 V @ 750 mA $235
8K RAM for above $245

VIDEO DIGITIZER BOARD (S1)
Fast-scan video digitizer; converts TV-camera or other composite video signal into eight-bit, gray-scale digital information; input resolution 700 points/line horizontal; vertical input resolution depends on camera, typically 480 li.; requires three ports, +8 V @ 500 mA, −16 V @ low amperage $175

ANALOG INTERFACE (S1)
Single-slope analog/digital converter; four A/D channels, one parallel port; occupies two I/O addresses, user-selectable; 480 μs conversion time for 16-count resolution; 16 to 1025-count resolution, software controlled; 450 and 800 Hz tone generators $115

PRECISION ANALOG INTERFACE (S1)
Analog input and output; two 12-bit converters; two output, eight input channels; resolution 1 in 4096; monopolar and bi-polar analog output; requires six control ports; one parallel output port on board; patch area $390

PROM/RAM I (S1)
Holds 2K PROM (1702), 1K RAM; occupies 4K address block; on-board MWRITE generation; selectable wait states; requires +8 V @ 450 mA, ±16 V (current varies with PROM quantity) $129

PROM/RAM II (S1)
Holds up to 12K PROM/EPROM (2708), 1K RAM; addressable as 8K PROM and 8K PROM/RAM blocks, RAM independently addressable within block; MWRITE and jump-on reset; power required, as above $175

PROM/RAM III (S1)
Same, but also programs PROMs; programming time approximately two minutes $215

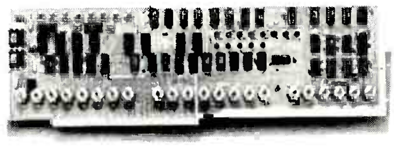
OTHER BOARDS (S1)
Also available: 8K, 16K static, 48K dynamic RAM, parallel/serial I/O, 64×16 and 80×24 video boards.

WAMECO

WMC 8080A CPU WITH 8-LEVEL INTERRUPT (S1)
8080A MPU board for S-100 bus, with eight-level vector interrupt; interrupt circuitry need not be built up until system has real-time clock board.
CPU-1. Bare board/kit/wired ....$30/$185/$220

WMC REAL-TIME CLOCK BOARD (S1)
Includes eight-page software source listing and three-page flowchart for Time-of-Day and Day-of-Week display; addressable to any of 128 port-address pairs; includes 16-bit (10-65K μ sec) and decade (100 μsec-100 sec) interrupts.
RTC-1. Bare board/kit/wired ....$30/$199/$229

FPB-1 FRONT PANEL BOARD (S1)
For control of 8080A microcomputer with features like memory examine, memory deposit, run, reset;



hex display of address, data and I/O port FF; M1 status on discrete LEDs; will fit into IMSAI. Bare board $55

FDC-1 FLOPPY DISC CONTROLLER (S1)
Will operate with Shugart, Pertec or Remex standard or mini drives; CPM compatible; control of up to eight drives; on-board PROM for cold boot; vector selection of interrupt; for 8080A or Z-80 at 2 MHz or 4 MHz. Bare board $45

EPM-1 FOUR KILOBYTE EPROM MEMORY BOARD (S1)
For 1702A. Can be used as 2K or 4K on any 4K boundary. Bare board $30

EPM-2 16 OR 32 K BYTE EPROM MEMORY BOARD (S1)
For 2708 or +5 V 2716. Addressable in 4K byte increments. Bank addressing and phantom disable. Bare board $30
MEM-1A. 8K RAM for 2102. Bare board $32
MEM-2. 16K RAM for 2114. Bare board $32

COMPUTER ACCESSORIES

AUM-IDEAS

BB-50 MOTHERBOARD (S5)
22-slot motherboard designed to mate with SS-50 card edge of AUM HDBB board (see Module Board section); for SS-50 bus fans preferring card-edge connectors; ¾-in card spacing; up to four power and ground lines, selectable on same or opposite board edges; terminated.
BB-50 board $50
MC-50 edge connectors $6

BB-100 MOTHERBOARD (S1)
Four-slot, S-100 motherboard with IMSAI-type connectors. Board $15

CGRS MICROTECH

S-100 CARD RACK (S1)
For rack-mount or table-top use; has room for motherboard and power supply; with end plates, side rails, card guides and mounting hardware. Kit/Assembled ....$50/$60

CABINET (S1)
Room for 11 cards, front panel, power supply and 4½" fan. Kit/Assembled ....$150/$165

POWER SUPPLY (S1)
S-100 power supply: +8 V @ 10 A, +16 V @ 1 A, and −16 V @ 1 A. Kit/Wired ....$55/$65

CROMEMCO

CARD CAGES (S1)
Steel cages with card retaining bar; Blitz-Bus low-noise motherboards with connectors wave-soldered in place. Height 6⅝", width 10⅞", length as follows:
CC-8. 8-slot cage, 7" L $195
CC-12. 12-slot cage, 10 ¼" L $245
CC-21. S21-slot cage, 16 ¾" L $395

DYMA ENGINEERING

LINE SURGE PROTECTORS
Protect 120-V electronic equipment against power-line surges. 20-A capacity. Available with barrier-strip connections (#1AC), 2-pin ac connector and plug (#2AC), 3-wire U-ground connector and plug (#3AC) $19

ELECTRONIC CONTROL TECHNOLOGY

ECT-100 CARD CAGE (S1)
Card cage for S-100 boards, mounts in 19" rack.
ECT-100-F. With 20-slot motherboard, connectors and guides. Kit/wired ....$200/$250
ECT-100. With motherboard only. Kit $100
POWER SUPPLY. 30 A. Mounts on back of ECT-100. Kit/wired ....$115/$175
Also available: 10-slot card cage; 15 A power supply; door for rack-mount card cages; table-top 10-slot mainframe.

F&D ASSOCIATES

MOTHERBOARDS (S5)
Bare boards for SS-50 bus.
MBI-6. 6-slot $19
MBI-3. 3-slot $12

GIMIX

MAINFRAME (S5)(S3)
Includes chassis with 15 SS-50, eight switch-addressable SS-30 slots; punched for 16 D-type data connectors, four video connectors; slotted for ribbon cables; space for dual mini-floppy drives; key-switch; reset switch with lockout; power supply; fan; mother board $748

GIMIX MOTHERBOARD (S5)
Fifteen 50-pin slots, plus eight switch-addressable 30-pin I/O slots configurable to four or eight decoded addresses. Barrier-block power connections $224

POWER SUPPLY COMPONENTS KIT
Includes 550-VA ferro-resonant constant-voltage transformer, other components including individual output fuses, terminal block; supplies 8 V @ 25 A, ± 15 V @ 5 A, for 90-140 V ac input voltage $249

HEATHKIT

COMPUTER WORK STATION
Computer desk with 60" × 30" walnut formica top, under-top shelves 15¼" W X 20" D, 1 each 8¼" H and 7" H. Dockable casters.
PD-11. ....$295

ITHACA INTERSYSTEMS

DPS/PS POWER SUPPLY
Supplies +8 V @ 25 A, ±16 V @ 5 A; all three outputs individually fused; large barrier-strip connections; 12⅝" X 4 ½" W X 4 ¾" H. Wired.
DPS/PSD. For 117 V ac, 50/60 Hz $175
DPS/PSF. For 240 V ac, 50 Hz $175

JADE

ISO-BUS MOTHER BOARDS (S1)
Shielded, S-100 mother board; mirrored ground cur-

rents for 100 dB crosstalk rejection without termination; LED indicates active power on bus; fits Jade, Integrand, Imsai-type mainframes.

MBS-061B/K/A. 6-slot. Bare board/kit/wired .... $25/$50/$60

MBS-121B/K/A. 12-slot. Bare board/kit/wired .... $40/$90/$100

MBS-181B/K/A. 18-slot. Bare board/kit/wired .... $60/$130/$150

JADE MAINFRAME (S1)

Accommodates most S-100 mother boards; lighted reset switch; keyed power switch; rear cutouts for 10 DB-25, 3 BNC connectors; Whisper Fan; switched ac outlet; +8 V @ 30 A, ± 16 V @ 4 A, all outputs fused; −8 may be added.

ENS-000101 .... $389

ENS-000321. Same, with mini-floppy cutouts ... $389

PIGGY MAIN FRAME (S1)

Includes Iso-Bus mother board; high-impact plastic case; space for dual mini-floppies; choice of colors; power supply with ± 16 V @ 3 A; 12 V, 3 A regulated mini-floppy drive supply.

ENS-106320 .... $475

MULLEN

AC RELAY CONTROL MODULE

Interfaces control boards such as Mullen CB-1 (see Module Boards) with ac power loads up to 500 W; fully-enclosed; plug-in connections; dual isolated control lines for operation by computer or remote switch; has both normally-open and normally-closed contacts $10

NNC ELECTRONICS

NO NAME MAINFRAME (S1)

To accommodate S-100 and other motherboards; lighted reset button; keyed power switch; 60-Hz line for real-time clock; accessory receptacle; rear-panel slots for up to 10 DB25 and 3 BNC connectors; power supply with 95-130 V ac input, output ± 16 V @ 4 A ea., +8 V @ 30 A, −8 V available; card cage with 12 pairs guides installed $255

MOTHERBOARDS (S1)

S-100 motherboard with resistor networks and interlaced ground lines for low noise; data lines actively terminated with provision for pull-up or pull-down; board silk screened for circuit identification; populated with edge connectors.

100-08/100-19. Wired, 8/19 slot .... $145/$225

OPTIMAL TECHNOLOGY

EP-2A EPROM PROGRAMMERS

For 2704, 2708, TMS-2708, 2758, and 2716 EPROMs and others where specified. Require 12-bit parallel I/O. Configured to match various MPUs (see below); replace "-x-" in model number with appropriate MPU code when ordering.

EP-2A SERIES

On 4.3 × 2.2-in circuit card, with 44-pin edge connector. Requires +5 V @ 150 mA +28 V @ 50 mA (all PROMs), +12 V @ 100 mA and −5 V @ 100 mA (2704/08, TMS-2708/16 only).

EP-2A-X-01. With low-insertion-force socket. Kit/wired .... $50/$60

EP-2A-X-02. With lower-force socket. Wired $64

EP-2A-X-03. With off-board, zero-force socket. Wired $70

EP-2A-G-05. General software instructions only. Kit $33

EP-2A-X-04. General software instructions only. Wired $43

EP-2A-78 SERIES

Similar to EP-2A, but also programs TMS2532, TMS2716, and 2732 PROMs; card size 4.3" × 2.4", PROM type selected with jumpers at card edge connector.

EP-2A-78-x-01. With zero-force socket. Wired $80

EP-2A-78-x-02. With same socket as EP-2A-x-02 .... $74

EP-2A-79

Similar to EP-2A-78, but stand-alone type, with power supply and enclosure; PROM type selected by plug-in personality module (one supplied, others $15/$30 each).

EP-2A-79-x. Wired $155

MPU Code. For letter "-x-" substitute: K for 6502; M for 6800; 18 for 8080, 8085, Z-80; R for 1802; F for F-8. Also available for use with: KIM-1, SYM-1, Cosmac II, VIP, RCA 18SO20, TRS-80, AET, Apple, EXORCISER, INTELLEC, and Ohio Scientific machines.

ANALOG I/O CARD

Eight-channel, A/D and two-channel D/A converter; ± 5 V full scale; requires 50 mA @ ± 12-15 V; interfaces via two I/O ports; 8-bit accuracy; 10-meg input impedance; on 4.25 × 3.75-in card.

I/O 802. Wired $115

I/O 802-A. Eight-channel A/D only. Wired $79

RADIO SHACK

TRS-80 SPACE-SAVER DESK

For TRS-80 or similar-sized systems; 37¾" W × 23¾" D; raised rear platform to hold video monitor, etc $50

TRS-80 SYSTEM DESK

Larger (27" H × 48" W × 27" D), with keyboard and monitor/expansion-interface recesses on top, shelf below desk to house Mini Disk drive units; conceals interconnection wiring $199

MODEL II SYSTEM DESK

Modular desk, with drawer mountable above or below desk top; allows mounting TRS-80 Model II Disk Expansions above or below desk-top $350

PRINTER STAND

Designed for TRS-80 Line Printers, which screw directly to stand cross-members $99

SILVER SPUR

S-44 MOTHERBOARDS (S-44)

Motherboards in 8-, 12-, 16-, 20-, and 24-slot configurations for the S-44E (extended Atwood) bus. Connectors on half-inch centers. Connectors and card guides available. Write manufacturer for details.

SOUTHWEST TECH. PRODUCTS

MP-B MOTHERBOARD (S3) (S5)

Provides 7 SS-50 slots (for processor, memory, etc.), 8 SS-30 I/O-board slots. Bus may be paralleled onto another MP-B with power supply. Bare board/kit .... $30/$40

MP-P POWER SUPPLY

Supplies all power required for MP-B motherboard with full complement of plug-in boards. Kit $43

TERMINAL DATA CORP. OF MARYLAND

WORKSTATIONS

Fixed and mobile workstations for variety of terminals. Write for details .... $85-$269

CARRYING CASES

Carrying cases with foam insulation, reinforced web fabric straps. Available for Teletype 43, ADM-3/3A, Sanyo 9" monitor, and similar. Write for details. .... $149-$179

SOUND ENCLOSURES

Noise-reducing enclosures for printers and printing terminals, including various models of Teletype, Centronics, DEC, IBM and Xerox .... $189-$750

THINKER TOYS

WUNDERBUSS MOTHERBOARD (S1)

S-100 motherboards, with Noiseguard ground-line interlacing and active termination circuitry. Includes on-board power supplies for small peripherals like paper tape readers and keyboards (+5 V, ± 12 V); used in Parasitic Equinox, mounting holes compatible with IMSAI.

20-slot. Kit/wired .... $76/$226

12-slot. Kit/wired .... $65/$175

8-slot. Kit/wired .... $54/$144

TRINEX

PANELOGIC KIT

Kit of plastic materials for prototyping backlighted display panels, including digital and CRT displays. Includes black dead-front plastic and transparent colors, plus cutters and mounting adhesive. For panels to 11" × 19" $60

ULTRA-VIOLET PRODUCTS

UVS-11E EPROM ERASING LAMP

Erases up to four UV-erasable EPROMs at a time, in as little as 20 minutes; has safety interlock to protect eyes. EPROM holding tray holds up to four chips at constant 1-in exposure distance, has conductive foam liner to prevent electrostatic buildup, transmits visibly while blocking UV light. Lamp shuts off when lifted from tray. Provides 1 watt-sec/cm^2 in 200 secs. (Larger systems available.)

UVS-11E. 115V/220V versions .... $71/$77

34-0003-01. Replacement tube $13

VECTOR ELECTRONIC

8803 MOTHERBOARD (S1)

11-slot S-100 motherboard, with etched circuit for active or passive termination $30

VECTOR GRAPHIC

MOTHERBOARD (S1)

18-slot, shielded, S-100 motherboard, with connectors $175

RACK MOUNT CARD CAGE (S1)

For 19-in EIA rack; boards accessible from front; includes motherboard above $225

POWER SUPPLY

Delivers 8 V @ 18 A, ± 16 V @ 2.5 A; transformer tapped for 110/120/130 V input $125

WAMECO

QMB-12 QUIET MOTHER (S1)

13-slot motherboard with breadboard area (passive termination). Bare board $40

QMB-9 LITTLE MOTHER

Nine-slot version of above. Bare board $35

WESCORP

PORTABLE WORK STATION

Static-free work station consists of 18 × 24-in conductive felt mat, wrist grounding strap and mat grounding strap; will fold to fit in briefcase.

W-9010 .... $20

Industrial versions available.

WESTAT FLOOR MATS

Electrically conductive, ⅛-in thick, polyethylene floor mats to prevent data loss or equipment damage caused by static electricity.

W-5052. 24 × 32-in $35

W-5053. 5 × 4-ft incl. lip $129

W-5054. 4 × 8-ft $136

Anti-static floor runners, parts bins, shipping protectors, measuring devices and other anti-static supplies available. Write manufacturer for details.

Directory of Microcomputer Products Manufacturers

ALF PRODUCTS, INC.
1448 Estes, Denver, CO 80215

ALLIED COMPUTERS
48th St., 9th Ave., 11, Ashok Nagar, Madras-600 083, India

ALPHA MICRO
17881 Sky Park North, Irvine, CA 92714

APF ELECTRONICS, INC.
444 Madison Ave., New York, NY 10022

APPLE COMPUTER INC.
10260 Bandley Dr., Cupertino, CA 95014

ATARI, INC.
1265 Borregas Ave., PO Box 9027, Sunnyvale, CA 94086

ATV RESEARCH
13th and Broadway, Dakota City, NE 68731

AUM-IDEAS
P.O. Box 2582, Richardson, TX 75080

AUTOMATED INDUSTRIAL MEASUREMENTS, INC.
P.O. Box 125, Wayland, MA 01778

CALIFORNIA COMPUTER SYSTEMS
309 Laurelwood Road, Unit # 18, Santa Clara, CA 95050

CENTRAL DATA CORPORATION
P.O. Box 2530, Station A, Champaign, IL 61820

CENTRONICS DATA COMPUTER CORPORATION
Hudson, NH 03051

CGRS MICROTECH
P.O. Box 368, Southampton, PA 18966

CHRISLIN INDUSTRIES, INC.,
31352 Via Colinas, #102, Westlake Village, CA 91361

COMMODORE BUSINESS MACHINES LTD.
901 California Ave., Palo Alto, CA 94304

COMPRINT, Computer Printers International, Inc.
340 East Middlefield Rd., Mt. View, CA 94043

COMPUCOLOR CORPORATION
5965 Peachtree Corners East, P.O. Box 569, Norcross, GA 30091

COMPUTALKER CONSULTANTS
P.O. Box 1951, Santa Monica, CA 90406

CROMEMCO, INC.
280 Bernardo Ave., Mountain View, CA 94040

D.C. HAYES ASSOCIATES, INC.
10 Perimeter Park Dr., Atlanta, GA 30341

DELTA PRODUCTS, INC.
1653 East 28th St., Signal Hill, CA 90806

DIGITAL SPORT SYSTEMS
Seventh and Elm Sts., West Liberty, IA 52776

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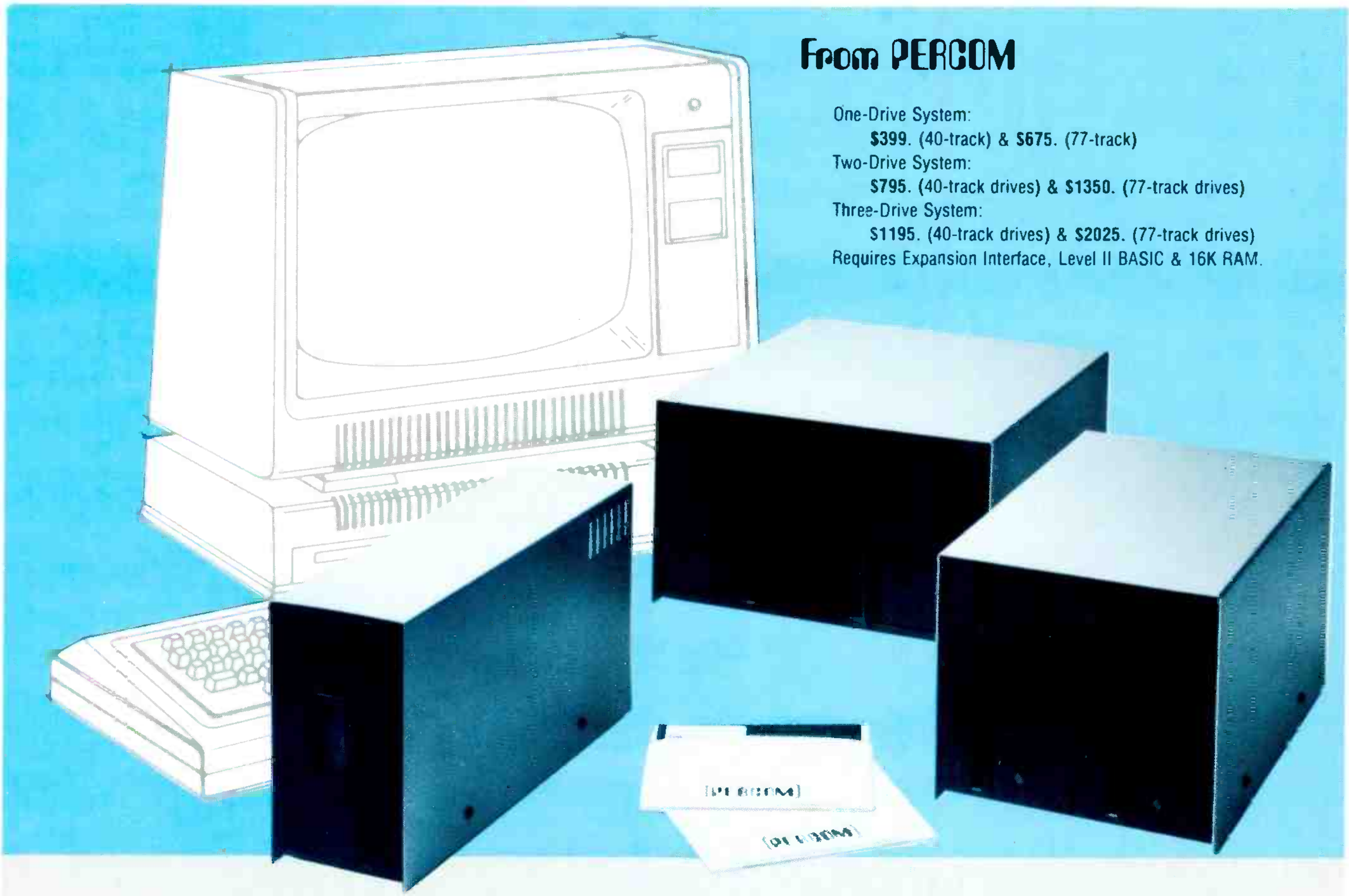

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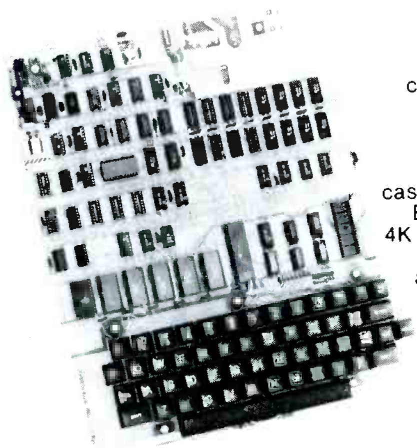

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