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September 1990 Radio Electronics

Vol. 61 No. 9

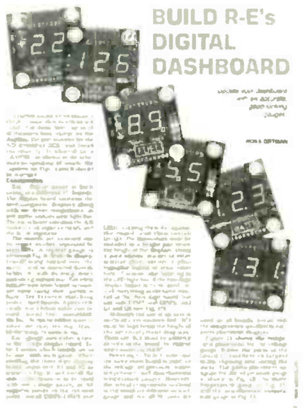
BUILD THIS

TECHNOLOGY

COMPUTERS

DEPARTMENTS

PAGE 47



PAGE 61

AND MORE

ON THE COVER

If there's a common thread that runs through the three seemingly disparate stories highlighted on this month's cover, it would have to be the notion of control—whether at home, at work, or at play. Our Telephone Line Controller (see page 37) is an obvious example, allowing you to block out any calls, either incoming or outgoing, that you deem undesirable. If your work (or your hobby) involves electronic design, the article on data disks that replace bulky, inconvenient cross-reference books will show you how to take better control of your valuable time. Turn to page 47 to find out how to speed up the device-selection process. And, just for fun, our Lead-Vocal Zapper (see page 33) gives you some control over your stereo records, by letting you replace the lead vocal with your own voice.

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SOME TV SETS CROSS THE BENCH
Case histories in TV service have some lessons to teach.

MICROWAVES: PART III
A look at magnetron tubes.

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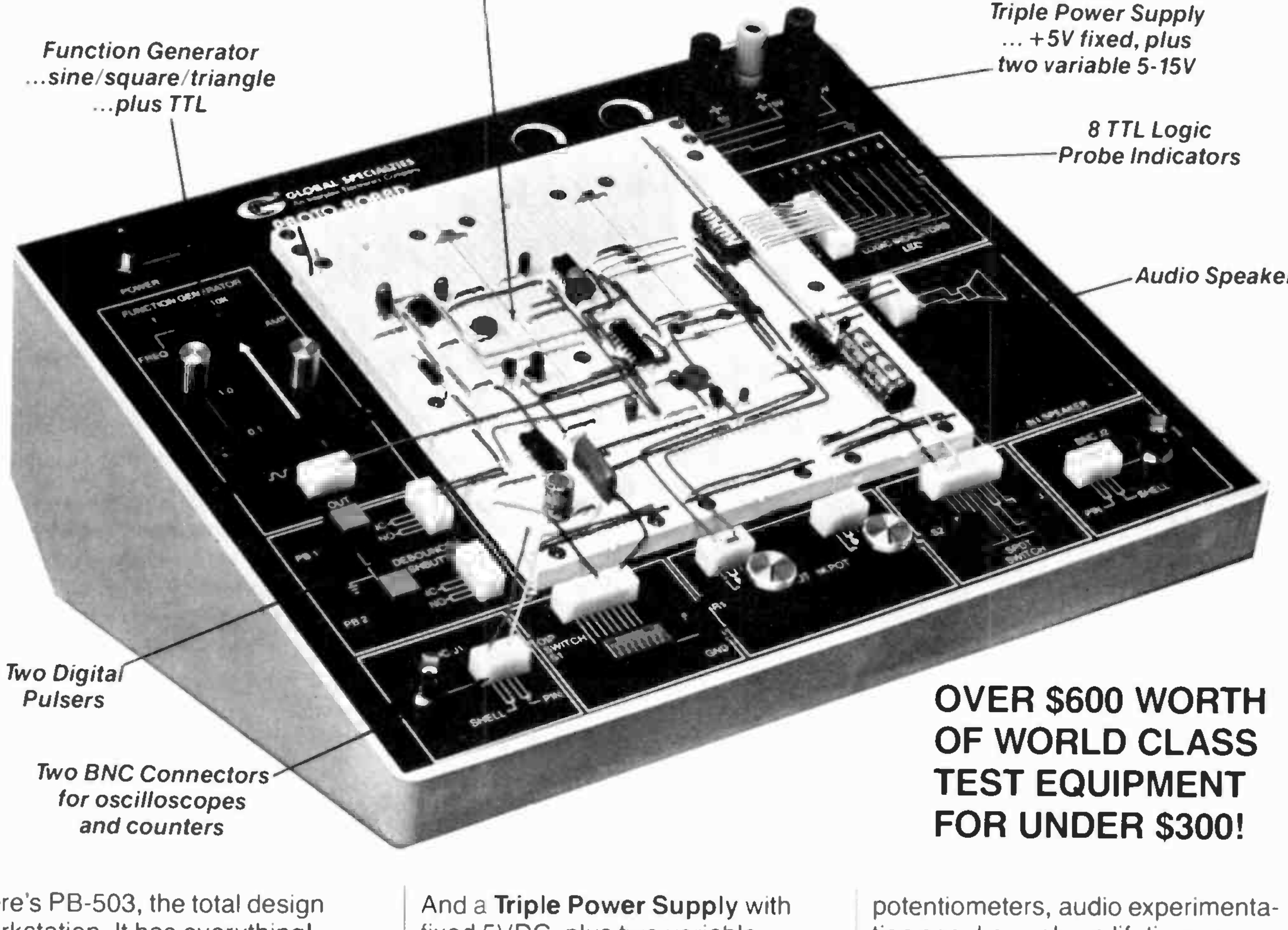

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CIRCLE 189 ON FREE INFORMATION CARD

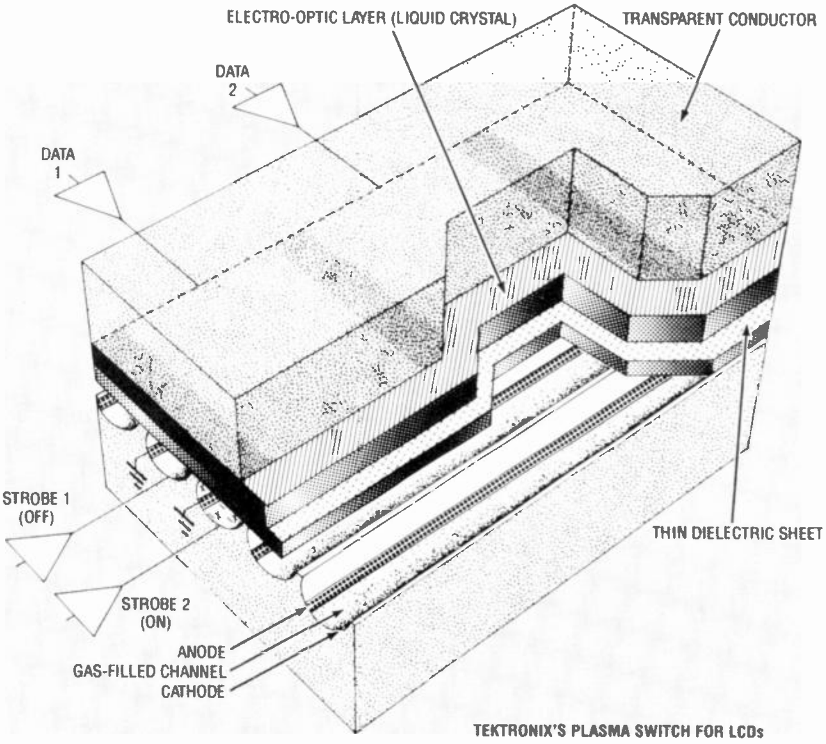
WHAT'S NEWS

A review of the latest happenings in electronics.

Ultra-pure silicon crystal

Scientists at the Westinghouse Science & Technology Center (Pittsburgh, PA) have produced a silicon crystal that is four times purer and significantly larger than any previously reported silicon material. Impurities comprise only a few parts in 100 trillion, compared to more than 10 parts in 100 trillion previously reported for one-inch diameter silicon crystals. The 22-pound cylindrical structure—called a boule—is more than a yard long and has a diameter of just over 3 inches. Its larger size makes it more practical for use in microelectronics circuits and devices. Crystal boules are sliced into wafers on which microelectronic circuits and power semiconductor devices are fabricated. The Westinghouse crystal, which its developers believe to be the purest silicon crystal ever made, is expected to play an important role in the manufacture of infrared detectors for space, defense, and environmental applications. The ultrapure silicon crystal was grown in Westinghouse's float-zone crystal-growth facility, the largest float-zone furnace in the U.S., which can be adapted to produce boules up to four feet long and five inches in diameter.

WESTINGHOUSE TECHNICIAN Don Nebel holds a single-crystal boule of silicon, believed to be the purist and largest ever produced.



IN TEKTRONIX'S PLASMA-ADDRESSING PROCESS, the liquid-crystal material and a protective dielectric layer are sandwiched between two sheets of glass; the upper sheet contains the data electrodes patterned from the transparent indium-tin-oxide conductors and the bottom sheet provides channels that contain the plasma gas with two electrodes per channel.

Plasma-addressing approach for high-resolution LCD's

Tektronix researchers in Beaverton, Oregon, are developing a new plasma technique using a plasma switch to address the active matrix of a liquid-crystal display. Intended as an alternative to silicon thin-film transistors (TFT's), which are successful in small, full-color displays but are difficult to manufacture in a large array to address more than a million elements, the new technique could significantly reduce the number of row drivers and make the displays easier to manufacture.

The plasma technique uses gas-filled channels to address a variety of twisted-nematic and polymer-dispersed liquid crystals. Confined ionized gas acts as an electrical switch: It conducts in an ionized state and becomes nonconductive when de-ionized. The degree of conductivity is determined by the number and mobility of the carriers in the gas. Tektronix says that the conductivity range of the gas (between conducting and nonconducting states) can be ten orders of magnitude. They have developed a plasma switch to take advantage of that property.

The plasma switch is a three-terminal structure that uses a probe electrode on one terminal to alter the conductivity between the other two. A single switch can replace a whole row of silicon-based TFT's.

Results of the initial demonstrations have been promising. R-E

VIDEO NEWS

What's new in the fast-changing video industry.

DAVID LACHENBRUCH

• **More 8mm converts.** The 8-millimeter camcorder format is gaining adherents in the United States at the expense of the full-size VHS and VHS-C (for compact) versions. Last month I reported the addition of an 8mm camcorder to Zenith's line (**Radio-Electronics**, August 1990). The latest brands to add 8mm are even more significant. RCA, owned by France's Thomson Consumer Electronics, has added four 8mm camcorders to its line, and—perhaps even more telling—Hitachi entered the 8mm field with three camcorders. Hitachi's entry is particularly significant since it is a member of the original Japanese VHS group and the first to break ranks and market an 8mm product under its own name. In addition to fielding 8mm camcorders under its own brand name, Hitachi is manufacturing the camcorders for RCA's line.

The VHS-C camp is replying with significant artillery. JVC has introduced several VHS-C recorders that rival 8mm in compactness and light weight with excellent picture quality. Panasonic, Quasar, and Magnavox have added tiny, palm-size VHS-C models built by Matsushita. The VHS-C group says it will mount a major promotion campaign for the VHS-C format.

Neither Zenith, Hitachi, nor Thomson is abandoning VHS-C. All three will also have the compact semi-compatible format as well. Zenith introduced several VHS-C models made by JVC, while Hitachi added a fold-up VHS-C camcorder for easy storage, and Thomson said its GE brand will have a model similar to Panasonic's Palmcorder. Although VHS-C is fighting back, 8mm is definitely gaining ground in the camcorder wars.

• **TVRO's climbing again.** After a major setback when signal scrambling started, home satellite dishes are on the upswing, according to the Satellite Broadcasting & Communications Association (SCBA). It puts the home-dish population at 3,000,000 and estimates that sales are now running at 30,000 monthly, with total new installations expected to hit 400,000 this year, up from 240,000 when the scrambling-induces slump began.

• **CDTV.** That stands for "Commodore Dynamic Total Vision," a new interactive system combining audio and video scheduled for introduction this fall. Developed by Nolan Bushnell, who originated the video game when he headed Atari, CDTV can play standard compact discs, the new Compact Discs + Graphics, or special CD-ROM interactive audio-visual programs. Included in the initial 100 programs, to be sold for $30 to $100, will be a world atlas, a cookbook, encyclopedias, and games for both adults and children. The system uses the basic chips of the Commodore Amiga computer—in fact, it's convertible to a computer with the addition of a keyboard.

The basic system, to be priced at "less than $1,000" initially, is operated by a wireless remote control, which lets users pan, zoom, and control a cursor, among other things. It permits full motion on half the screen, or 15 frames per second for full-screen scenes, but Commodore says it is an "open architecture" system that can be converted to a full-screen, full-motion medium when a standard is approved by the International Standards Organization.

Philips and American Interactive Media previously announced that they will market their full-screen Compact Disc-Interactive (CD-I) system in 1991. A Philips official expressed disappointment that the CDTV system was introduced before a standard was set. Consumer confusion could be the result.

• **Laserdiscs grow up.** More than a decade after its introduction, the laserdisc is beginning to approach mass-market status. Sales of discs exceeded 3,500,000 last year, and by midyear at least 16 brands were offering combination CD-laserdisc players or had announced their intentions to do so. Players are now, or will soon be, available under these brands: Denon, Fisher, Funai, Kenwood, Magnavox, Marantz, Mitsubishi, NEC, Panasonic, Philips, Pioneer, Quasar, RCA, Sharp, Sony, and Yamaha.

• **Video vignettes.** After lagging for three years, sales of projection-TV receivers in the first quarter of 1990 were up 25% from the same period in 1989, and there were forecasts that 1990 would be the first record year for projection TV since 1986.

The picture-tube shortage that plagued the TV industry for the last few years seems to have ended, and an overcapacity of 3,000,000 to 4,000,000 tubes is being forecast for 1992. Companies that have expanded, built, or announced new color-tube plants in the United States since 1988 include Hitachi, Matsushita (Panasonic), Philips, Sony, Thomson (RCA and GE), and Toshiba.

• **Digital VHS audio.** JVC, the leader of Japan's VHS group, has developed a compatible digital soundtrack for VHS recordings. Although the system is at least a year from the market, the company has released specifications, presumably to encourage other VHS manufacturers to go along. The system uses "depth multiplex" recording, which permits video and audio signals to be recorded on different layers of the tape's magnetic coating.

The recorded digital signal doesn't disturb the other soundtracks on the VHS tape—longitudinal mono and AFM stereo. The PCM audio signal uses a 48-kHz sampling frequency and 16-bit quantization, according to JVC. It will be used only on Super VHS recordings; if the technique were used on standard VHS it would overlap the luminance signal and cause interference, said JVC. The signal may be split into four channels for multilingual recording or other purposes. **R-E**

ASK R-E

Write to Ask-RE, Radio-Electonics, 500-B Bi-County Blvd., Farmingdale, NY 11735

XT TO AT UPGRADE

I recently upgraded my computer from an XT to an AT clone, and there seems to be some sort of problem with the disk drives. Whenever I try to read a disk from the AT on my XT, I get one of two kinds of errors. The most common one is that lots of read errors show up, but occasionally I can't read the disk at all. I can't even get a directory to show up on the screen. What's going on?—F. Scher, Amsterdam, NJ

You haven't given me all the particulars of your computers, but I can make a good guess as to the source of the problem. The chances are that you got your AT with a 1.2-MB 5¼ inch drive and your XT has a 360K drive. The two drives look very much alike on the outside, but there's a big difference internally. In order to understand what's causing your first problem, let's talk a bit about the basic difference between the drives.

The original 360K floppies have two sides with 40 tracks each, and each track has nine sectors. The 1.2-MB disks were organized a bit differently to get the increased amount of storage. The high-density disks have 80 tracks on two sides, and each track is divided into 15 sectors. Since you've got twice as many tracks and 60% more sectors, you can store more data on the disk. If you do the arithmetic, you'll see that the numbers work out correctly.

It makes sense that something had to be done to the original drives to allow them to hold so much more information. And it's what was done to the drives that's causing both of your problems.

Disk drives are essentially the same as tape recorders. They have a read/write head, and they record information on magnetic media (the disk surface). When the number of tracks was doubled, the distance between tracks was halved (makes sense), and doing that increased the chances of crosstalk between the tracks.

The problem was solved by reducing the write current on high-density drives. Since the signal was much lower, the unwanted noise from nearby tracks was reduced. In order to read the desired tracks, however, the read gain was also increased. The system worked well (and still does), but it was necessary to change the composition of the recording medium in order to make the system reliable. There's a real, physical difference between 360K and 1.2-MB disks, and each can only be used for its intended purpose.

If you want to use a 1.2-MB drive to write to a 360K disk, you have to use a disk made for 360K operation. Both the number of tracks and the number of sectors can be changed in software. When you issue the command FORMAT A:/4, you're telling the software to make the head put forty tracks and nine sectors on the disk—you'll be formatting a 360K floppy disk.

What's causing your problem is that while the software can force the drive to do the correct number of tracks and sectors, it can't do anything abcut the write current—that's an internal adjustment on the drive and the software can't do a thing about it.

When you write a 360K disk on a high-density drive, the information is going to be correctly organized on the disk but the recorded level will be very low. Since the 360K drive has its read gain set for a higher recorded level, the drive often has trouble reading the disk and that's the first problem you're having.

The second problem you're having—not being able to read the disk at all—is probably because you're trying to read a 1.2-MB floppy in the 360K drive. That can't be done at all.

The solution to your problems is through hardware, and the cheapest way to do it is to add a 360K drive to the AT. Adding a 1.2-MB to your XT will undoubtedly mean you'd need a new disk controller as well, and there's no reason to spend the extra cash.

COMMON-CATHODE DRIVERS

I'm building a circuit that uses a 4511 to drive a seven-segment LED display. Everything is fine but the chip is designed to drive only common-cathode displays and I have a box of common-anode displays. Is there any way I can use these instead of having to go out and buy a bunch of common-cathode displays? I asked the person in the store about this and he said there was no way it could be done. You're my last hope.—N. Rofe, New Brunswick, NJ

Although you're not *supposed* to do it, there's *always* a way to do that kind of thing. The person in the store who told you that it was impossible has, in kind words, a very limited imagination.

The 4511 is designed to directly drive a common-cathode display, but using it to drive a common-anode display means that you'll have to add a transistor as shown in Fig. 1. The transistor is working as a simple inverter, and just about any small signal PNP transistor should be able to handle the amount of current you'll need. Remember the rule: Better to underrate parts than to overrate them.

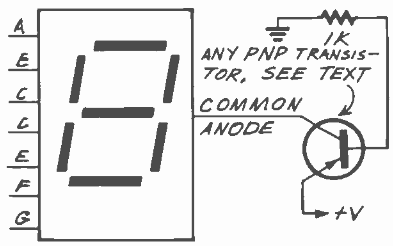


FIG 1—THE 4511 IS DESIGNED to directly drive a common-cathode display but, by adding a transistor as shown here, you can use it to drive a common-anode display.

You may find the schematic shown in Fig. 2 to be useful as well. Even though the 4511 can directly drive a common-cathode display, it has (as do all display drivers) a maximum current that it can deliver at the outputs.

That causes a problem when you try to drive really big displays or even incandescent bulbs.

Putting a transistor at the output switches the burden of powering the display from the chip to the transistor. If you need more current just add a chunkier transistor. The solution is really that simple.

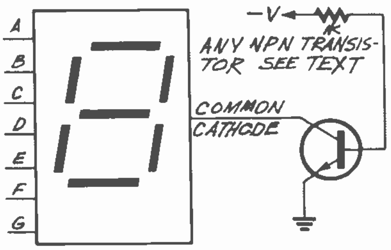


FIG. 2—EVEN THOUGH THE 4511 can directly drive a common-cathode display, you may have to add a transistor to the output. That allows you to drive really big displays or even incandescent bulbs.

Of course you have to keep in mind that the 4511 is a CMOS part and it can't be expected to deliver enough current to trigger heavy-duty transistors. If you ever want to do something like that, you'll have to build an intermediate transistor stage to bring the output of the 4511 up to the level of the output transistor. But, for driving standard common-anode displays that typically want a maximum of about 20 mA per segment, that circuit should solve the problem without any difficulty.

DIGITAL AMPLIFICATION

I've built a circuit to accept data from a temperature sensor but the input signal is a bit too low to go through my A-to-D converter. I don't want to have to add analog circuitry to the design so is there any easy way to amplify the incoming signal with digital IC's?—A. Dolan, Belmar, NJ

Once upon a time there was no way to do that, but your problem can be solved with the addition of a couple of CMOS inverters. You may have to add an IC to the board but, if you've got three spare inverters around, you can use them.

The 4049 is a good choice for this application since it can handle higher power levels and is perfect to use if you've got to do any sort of voltage translation. As shown in Fig. 3, the amplifier will give you a gain of 10 with an input impedance of over a megohm. It doesn't require any kind of special layouts and should work without a problem. If you add a 4049 remember to do something with the unused inverter inputs.

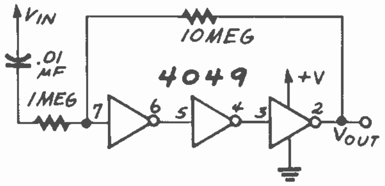


FIG. 3—The 4049 CAN HANDLE high power levels and is perfect for any sort of voltage translation. The amplifier will give you a gain of 10 with an input impedance of over a megohm.

Although you can easily build the circuit, and it will do the job, I don't understand why you don't build a small single-transistor amp to do the same job. I don't know what the characteristics of your input signal are but I'm sure you could easily design a simple transistor amp to provide the gain you need. **R-E**

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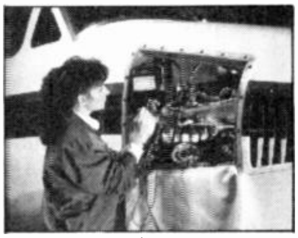

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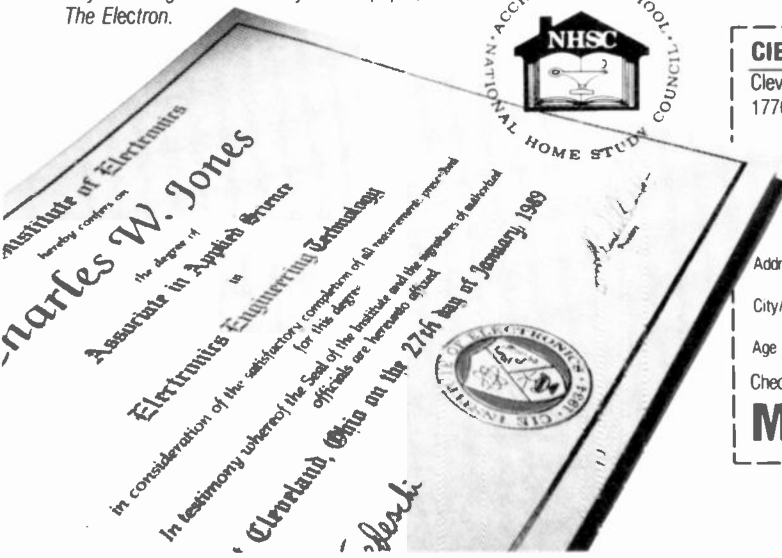

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DESOLDERING DEVICES

I'm writing in response to Mr. Perdue's letter that appeared in the May 1990 issue of **Radio-Electronics**. (He was responding to a previously published letter that concerned IC removal.) I take extreme exception to his general statement that the use of desoldering braid is "the only one approved by government organizations." I work for a government organization that regards the use of desoldering braid as a last resort! As a matter of fact, the U.S. government approves several methods of both soldering and desoldering components on printed-circuit boards.

One of the approved methods of desoldering IC's is to use a motorized vacuum device, such as a "Pace Kit." Of course, that method requires specialized training, and the cost of such a device would be prohibitive to the average home technician. Next on the list is the mechanical vacuum device, commonly known as the "solder sucker." That item is available at most electronics parts stores. To use it, simply cock it and then heat the joint to be desoldered with a low-wattage iron. As soon as the solder begins to flow, place the tip of the solder-sucker vacuum over, and in physical contact with, the joint, and press the trigger button. When the solder sucker has tripped, remove both the iron and the vacuum immediately. Check the joint to make sure that all the solder was removed. If not, simply repeat the procedure.

A few words of caution: First, use a low-wattage (10-25 watts) soldering iron at all times, to prevent overheating the IC and causing internal damage. A temperature-controlled iron is even better. Next, when working with IC's—particularly CMOS types—always use a ground strap (a metal wrist strap with a detachable ground wire) and connect its wire to ground. That will prevent the dreaded static discharge from destroying your IC or other components on the circuit board. If you don't have a ground strap, discharge yourself on a cold-water pipe or some other type of ground before starting work. Finally, use a small-diameter pointed or wedge tip on your soldering iron. That helps to heat only the area intended to be heated, and will prevent circuit-board runs from being lifted.

As a last resort, Mr. Perdue's desoldering braid method, as described in his letter, will work. Using either the solder-sucker or the solder-wick method will take some practice, and I, too, would recommend that the novice practice on a junk circuit board to get a feel for either method. That lessens the chance of accidentally destroying a good circuit board or its components.

STEVEN E. SWENTON
Glen Burnie, MD

I/O CARD INPUT

I was intrigued by Mark Hanslip's article, "Build This Experimenter's I/O Card" (**Radio-Electronics**, June 1990). I find it amazing that the 8255 PPI, an LSI IC introduced about a decade and a half ago for 8080 systems, is still being used in new designs.

I disagree with the author's statement about Port B when Port A is initialized for mode 2 operation: "Port B is not used at all." Although Port B cannot be initialized for mode 2 operation, it is far from useless. Port B, independent of Port A's mode of operation, can still be used in either mode 0 or 1.

One last thing: The pins of Port C that are not commandeered for use by Ports A and B (when operating in modes 1 and/or 2 for handshaking) are available for use as input or output lines.

JAMES KOVAR
Lincoln, NE

Fig. 1 goes here

Mr. Kovar has a point. The chart that he provided (Fig. 1) leaves a blank where Port B would be located in relation to mode 2. As I have never needed to use mode 2, the situation has never come up. Thanks, Mr. Kovar, for clearing up that anomoly.

Mode Definition Summary

	MODE 0		MODE 1		MODE 2
	IN	OUT	IN	OUT	GROUP A ONLY
PA_0	IN	OUT	IN	OUT	↔
PA_1	IN	OUT	IN	OUT	↔
PA_2	IN	OUT	IN	OUT	↔
PA_3	IN	OUT	IN	OUT	↔
PA_4	IN	OUT	IN	OUT	↔
PA_5	IN	OUT	IN	OUT	↔
PA_6	IN	OUT	IN	OUT	↔
PA_7	IN	OUT	IN	OUT	↔
PB_0	IN	OUT	IN	OUT	
PB_1	IN	OUT	IN	OUT	—
PB_2	IN	OUT	IN	OUT	
PB_3	IN	OUT	IN	OUT	MODE 0
PB_4	IN	OUT	IN	OUT	OR MODE 1
PB_5	IN	OUT	IN	OUT	ONLY
PB_6	IN	OUT	IN	OUT	
PB_7	IN	OUT	IN	OUT	—
PC_0	IN	OUT	$INTR_B$	$INTR_B$	I/O
PC_1	IN	OUT	IBF_B	$\overline{OBF}_B$	I/O
PC_2	IN	OUT	$\overline{STB}_B$	$\overline{ACK}_B$	I/O
PC_3	IN	OUT	$INTR_A$	$INTR_A$	$INTR_A$
PC_4	IN	OUT	$\overline{STB}_A$	I/O	$\overline{STB}_A$
PC_5	IN	OUT	IBF_A	I/O	IBF_A
PC_6	IN	OUT	I/O	$\overline{ACK}_A$	$\overline{ACK}_A$
PC_7	IN	OUT	I/O	$\overline{OBF}_A$	$\overline{OBF}_A$

CAN ALSO BE USED WHEN PA IS MODE 2

OR

The 8255 is truly a great device. It allows for software-configurable hardware. In the past, I have designed interfaces using the 8255 for Apple, Radio Shack, Timex, Decision Mate V, and S-100 computers.
MARK HANSLIP

TUBE TALK

While browsing through some old issues of **Radio-Electronics** I came across several letters in the December 1988 issue that dealt with tubes from Russia being imported into this country, and it brought to mind an experience I once had.

At a government auction (where I purchased a couple of pallets of test gear), a well-dressed fellow was bidding on items that I considered to be just so much junk. (After all, they were all full of tubes.) He was picking the stuff up by the ton, while hardly anyone else there showed any interest in it.

When I asked him about his purchases, he told me that he and two other ex-Air-Force pilots had formed their own business. He went around the country to all the government auctions and routed his purchases to a port, where they were loaded onto a ship and sent to Taiwan. One of his partners headed a group there that dismantled all the gear, "even salvaging the pan-head screws." The tubes, considered "choice" items, were re-routed to Europe where they commanded a very high price. (The third ex-pilot handled the European end.)

When I saw those letters about Russian tubes, I couldn't help but wonder: "Does it seem likely that a lot of our own tubes are coming back at us—re-labeled?"
RUSSELL RIESBERG
Weimar, CA

ALL ABOUT THX SOUND

In Josef Bernard's June 1990 article, "All About Surround Sound," he gives the mistaken impression that "THX" is ".. just quality control for movie sound ..." The THX Sound System was developed by Tom Holman for the main sound-mixing theater at Lucasfilm. It consisted of particular speakers mounted in a special construction behind the screen along with a crossover designed with those elements in mind. Its sound was amazing. Since the vast majority of sound systems in cinemas were outdated, and few could handle the dynamics of a Lucasfilm movie, the THX system was licensed to theaters. As a former "THX engineer," I was involved in some of the first installations. The theater had to meet certain acoustical criteria concerning the overall noise level, reverberation time, and more. If a theater couldn't meet those criteria, it could not get a THX system. If it could, the theater was shut down while the screen was removed so that the THX wall could be built and the speakers installed. The THX crossover was put in along with amplifiers that also had to meet certain standards.

Thus, if a movie patron went to a THX theater, they would be listening to the same system that the sound was mixed on. The "quality control" consisted of periodic checks of alignment. As for the letters "THX," I remember that *T*om *H*olman designed the crossover or *X*-over.

ROBERT HUGHES
San Francisco, CA

Since Mr. Hughes was there, and I merely got my information second-hand, I will have to bow to his expertise—and thank him for the additional background on THX. My original point is still valid, however: THX is just a special case of Dolby Stereo, and one should not expect to be able to rent or purchase videotapes or laser discs recorded using a "THX process."
JOSEF BERNARD

CHAOS vs. CLASSICAL PHYSICS

While sitting in my den the other day, reading James Gleick's fascinating book called *Chaos*, I took a break to thumb through the new issue of **Radio-Electronics**. In the "Letters" column, I read with astonishment the letter from Jon Rolph criticizing Don Lancaster's ideas about the size of the brain's computer and its relationship to other computers. I'm astonished because of its parallel to one of the main themes in *Chaos*. The painful, "feet-of-clay" conservatism that has hampered the emerging super science of chaos for nearly a decade appears from Mr. Rolph's letter to have infected computer science as well. Chaos's pioneer physicists and mathematicians, men like Mandelbrot and Feigenbaum, literally risked their careers by publishing the new and radical ideas embodied in chaos and fractal geometry. Still considered a renegade science by many, those new ideas have rattled the rusty old cages of many disciplines. Mr. Rolph's suggestion that any radical departure from the classical understanding of a science might "set us all back a few paces" is the very kind of thinking that has plagued the advancement of chaos as a scientific discipline. The only way we progress in our thinking is to make those conceptual leaps that go beyond proven classical knowledge to provide the theory and hypothesis for the next generation to prove or disprove. Condemning Don Lancaster and *Hardware Hacker* for allowing to appear in print aberrations such as the idea of computer systems "waking up" or four-gigabit brains is not an argument against the fear of new technology, as Mr. Rolph suggests, but a demonstration of that very fear.

I am writing this letter on a desktop computer that itself has nearly four gigabits of memory. It is my personal workstation, and I consider it to be quite "awake" in many respects. It clearly has a personality of sorts. It expects my interaction with it to follow certain behavior patterns and complains if I deviate from them. It has a strong instinct toward self-preservation. It stops and asks me if I'm sure before it allows me to reformat its disk memory. Other computers, those that do real-world control applications, are aware of at least some of their surroundings and are able to interact with them. That all suggests a form of awareness that has obviously escaped Mr. Rolph. While he waits for his network to wake up and assault him, Heinlein style, he is sleeping through a revolution in computers.

I applaud Don Lancaster for his imaginative thinking; I have been a follower since the days of the "TV Typewriter." I also applaud **Radio-Electronics**, for providing a forum for him and other innovative thinkers.

PETER A. BARNES
Cincinnati, OH

SHARING FREEWARE

I have thoroughly enjoyed each of the articles in **Radio-Electronics**; it is one of the few publications that I actually read cover-to-cover. It is also one of the few magazines in my field that contains something I can share with everyone on at work, at any level of expertise. I'm not saying that I agree with everything in its pages, but that it promotes discussion on the art of electronics.

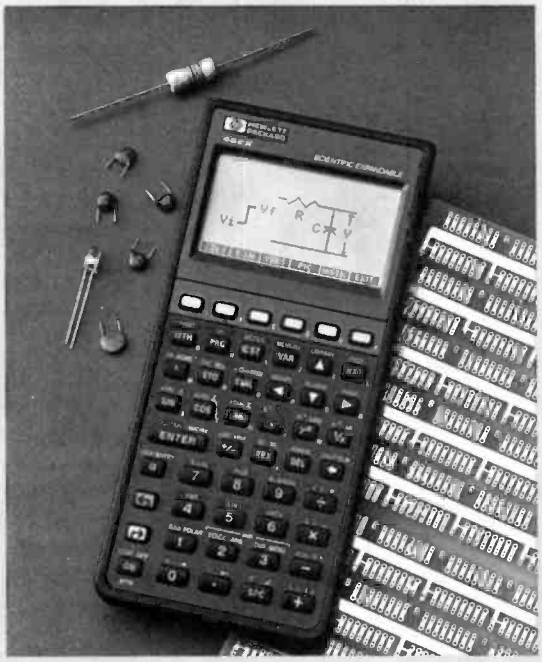
One thing I'd like to share with other **Radio-Electronics** readers is that Linear Technology Corporation is supplying—for free—an improved freeware PSPICE version from Microsim. It provides 28 op-amp models, which model benched data. I don't like to keep lots of inventory in my lab at work or my home workshop. This excellent simulator lets me be certain a circuit does what it should, and if a circuit doesn't work (i.e., an amp oscillates), I can quickly work out the bugs. Impedance matching, feedback, and other work becomes play, because parts values can be swept to cover a range. The freeware simulates a digital storage scope and a digital signal processor.

ROBERT KESSERLING
Plano, TX

R-E

EQUIPMENT REPORTS

Hewlett-Packard 48SX Scientific Expandable Calculator



HP's latest scientific calculator is at the head of its class.

CIRCLE 13 ON FREE INFORMATION CARD

September is back-to-school time for many of tomorrow's engineers. It's the time that many students—along with those of us who haven't been students for some time—start looking for the perfect scientific calculator. We may have found that perfect calculator, the HP *48SX* from Hewlett Packard (Inquiries manager, Hewlett-Packard Company, 1000 N.E. Circle Blvd., Corvallis, OR 97330).

The calculator, introduced earlier this year, boasts more than 2100 functions. It allows equations to be entered the same way they would be written, and an impressive array of graphics functions lets you plot the equations. An RS-232 interface is available as an option, and an infrared interface is also offered. The standard built-in memory consists of 256K of ROM and 32K of RAM, but plug-in cards allow you to expand memory to 512K of ROM and 288K of RAM.

Using the 48SX

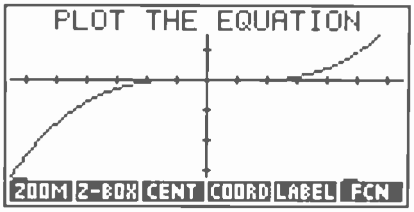
Without question, the *48SX* is the most powerful and advanced handheld calculator available. Getting access to all of that power is not always easy because some functions don't work the way you would intuitively expect. Also, the larger than 800-page (!) manual, while excellent on specifics and details, does not give a good overview of what the calculator has to offer. (We would recommend stopping by an HP dealer, who should have a demo disk or RAM card that *does* provide a good overview.)

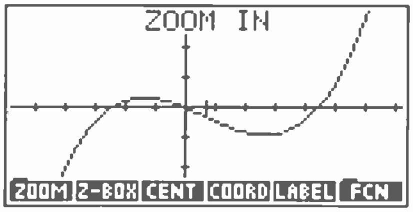
The HP *48SX* offers several impressive and important features. Its *EquationWriter* application allows equations to be entered as you would write them. Its graphics capabilities integrate calculus and graphics functions to find roots, minima and maxima, slopes, area under a curve, etc. A unique *automatic unit management* feature converts unlike units of measurements (148 different units in 16 categories such as force and energy) automatically. An equation-solver function allows you to find the numerical solution to an equation without isolating the dependent variable. For example, if Ohm's law was entered as an equation, you could enter the numerical values of the known variables, and the calculator would solve for the missing one.

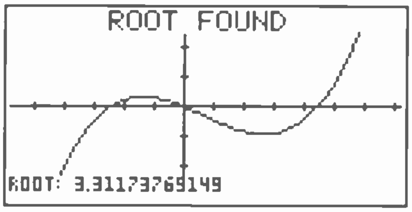
The calculator's keyboard contains 49 keys, most of which perform three or four different functions. Each key's primary function is on the keyface, while its secondary functions are shown in orange, blue, and white legends around the key, and are accessed by using the appropriate shift key. Some secondary functions (lower-case letters, Greek letters, and special characters), which are not shown on the calculator's face, are also available. The top row of keys are "soft" keys—they take on the function shown on the bottom, menu line of the display.

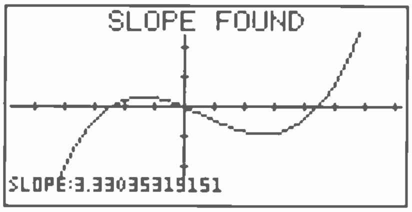
Most mathematical operations are performed by entering arguments on to the *stack* (which is a last-in, first-out sequence of storage locations) and then executing commands to manipulate the stack contents. Although the display can show the contents of up to four stack locations, the actual stack size can be much larger, and is

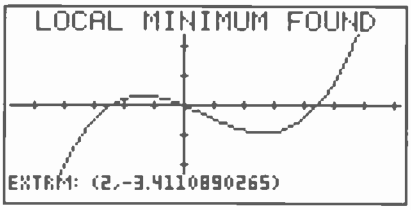
A SERIAL INTERFACE KIT is available as an option to allow you to link the calculator to a PC or Macintosh so you can take advantage of the computer's storage, printing, and display capablilties.











THE HP 48SX INTEGRATES GRAPHICS AND CALCULUS functions to automatically find roots, intersections, minima and maxima, derivatives, and the like.

limited only by available RAM.

As you might guess, the calculator uses *reverse Polish notation* to solve equations. For example, to find the sum of 2 + 2, you would enter both addends on the stack, and then perform the addition. The keystrokes would be: "2 <enter> 2 <enter> +." The number 4 would appear at the top of the stack.

Understanding the stack is the key to understanding how to use the calculator. Even when you enter an equation "as you would write it," you cannot solve it, plot it, or do anything else with it until you put it on the stack. Unfortunately, when you do move the equation onto the stack, it loses its "textbook appearance" and takes on a form more common to computers. That can be disconcerting and confusing until you get used to it—and the learning curve can be a steep one if you've never had any similar experience.

You can name an equation that is stored on the stack. That's helpful because the name can be used to identify an equation that might otherwise be very difficult to recognize once it's moved to the stack—especially if the equation contains integrals.

While the *48SX*'s built-in functions are impressive, it's important to remember that the calculator can be custom programmed through its built-in programming language. And we've barely mentioned the calculator's built-in functions! The *48SX* can handle all sorts of operations with arrays and matrices, statistics, algebra, calculus, logical operations, vectors, complex numbers, and more. It can also produce eight different types of plots from function plots to histograms, and from scatter plots to polar and parametric plots.

Equation Library

Hewlett-Packard calls the *48SX* an expandable calculator. One way it can be expanded is with plug-in cards, such as the *HP Solve Equation Library Applications Card*, which contains more than 300 science and engineering equations. The library's main menu contains such entries as ELECTRICITY, FLUIDS, HEAT TRANSFER, OPTICS, OSCILLATIONS, and SOLID STATE DEVICES. Each main entry contains sub-entries and equations, and in some cases, pictorial representations.

The equation library also contains a library of constants. Avogadro's number, Planck's constant, and the rest mass of an electron are among the 40 physical constants in the library (in both SI and English units).

A periodic table is available, as are various financial applications. And of course, things wouldn't be complete without a game of some sort. *Minehunt* should provide a pleasant diversion for both the bored and the frazzled engineer.

Although the equation library is the only currently available ROM card, HP does plan to introduce special cards to customize the HP *48SX* for specialized applications.

Serial interface kit

For those more comfortable working with a large monitor and standard QWERTY keyboard, an RS-232 interface allows you to take full control of the calculator from your PC or Macintosh. Programs, plots, and data can be stored on disks—a convenient way to swap them with other users. The interface kit gives your PC as much or greater power (although not the speed) of many comparable math software packages. But try putting one of those packages in your pocket and using it without a computer attached!

Of course, the power of the HP *48SX* doesn't come for free. The calculator itself costs $350. The serial interface carries a list price of $99.95, as does the *HP Solve Equation Library Application* card. RAM cards cost $79.95 (32K) or $250 (128K).

With the *48SX*, Hewlett-Packard maintains its leadership position in the scientific-calculator business. While we're inclined to say that the *48SX* is the last calculator you'll ever need, we won't—HP is probably already hard at work to make its successor even more impressive. **R-E**

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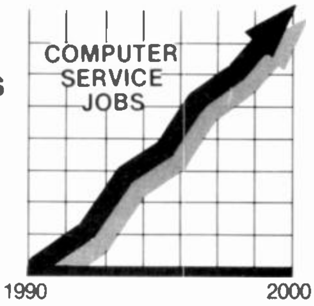

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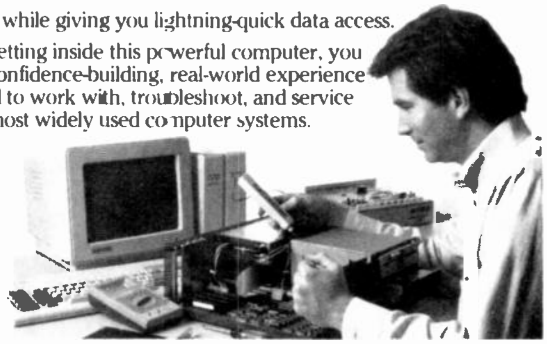

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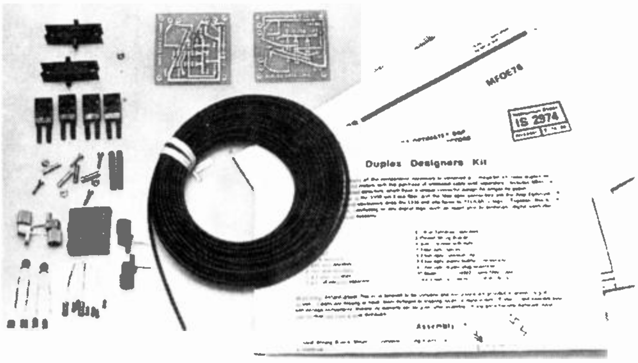


CIRCLE 15 ON FREE INFORMATION CARD

Prices for the fiber-optics designer's kits range from $59.95 to $89.95, depending on the version and the length.—**Sintec Company**, 28 8th Street, P.O. Box 410, Frenchtown, NJ 08825; Tel. 201-996-4095; Fax 201-996-3891.

DIGITAL/ANALOG MULTIMETER. Sporting both 3¼-digit and linear bar-graph readouts for measurement display to 4,000 counts, *B&K-Precision's* model *2919* handheld digital/analog multimeter is designed for situations where the accuracy of a digital readout and the responsiveness of an analog display are needed. The 41-segment bar graph, which is updated 20 times per second to follow changing values, simplifies peaking or level adjustments. "Data hold" immediately freezes the displayed digital reading, and "peak hold" holds the highest digital value obtained during a measurement, while "min/max" memory stores the lowest and highest reading observed.


CIRCLE 16 ON FREE INFORMATION CARD

The model *2912* also offers selectable auto- or manual ranging; measurement of voltage, current, and resistance; diode check; and an audible continuity check. Additional functions include capacitance measurement up to 40 mF and frequency to 400 kHz. The meter is rated at 0.3% accuracy on DC volts, and spans 40 ranges, including the frequency counter and capacitance functions. It is well-protected against reverse polarity and overloads, and features high-energy fusing to protect the μA/mA current ranges.

The *2912* handheld analog/digital multimeter costs $149.00.—**B&K-Precision**, Division of Maxtec Internat onal Corporation, 6470 West Cortland Street, Chicago, IL 60635; Tel. 312-89-9087.

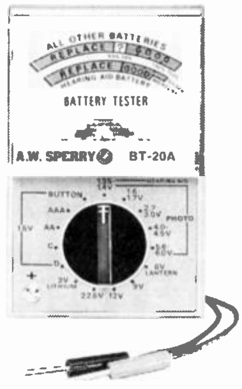
COAXIAL ADAPTER KIT. *Pomona's* Model *5698 Universal Adapter Kit* allows lab workers, field-service/installation technicians, and designers to quickly "mix and match" almost any combination of coaxial end termination styles, including banana plugs. The specially assembled kit allows users to make their own adapter combinations, such as SMA to BNC, or BNC to double banana plugs for connecting coax to instruments. The kit includes two male and two female of each the following: BNC, TNC, SMA, and "N" adapters. Four intermediate coupling nuts, one double banana plug, and one double banana jack/binding post round out the assortment.

Each of the double-banana jack/plug adapters are fitted with an integral coupler to accept any threaded coaxial connector. Individual connectors can be joined with a coupling nut to any other


CIRCLE 17 ON FREE INFORMATION CARD

to make the required coaxial assembly. The high-quality adapters, which come equipped with gold-plated center pins and silver-plated bodies, are packaged in a convenient reusable plastic case.

The model *5698 Universal Adapter Kit* costs $99.00.—**ITT Pomona Electronics**, 1500 East Ninth Street, P.O. Box 2767, Pomona, CA 91769; Tel. 714-623-3463, Fax 714-629-3317.



CIRCLE 18 ON FREE INFORMATION CARD

BATTERY TESTER. A quick, inexpensive means to determine the condition of a wide variety of batteries is provided by the *BT-20A Battery Tester* from *A.W. Sperry*. The compact, handheld instrument can be used to test all popular batteries from 1.25- to 22.5-volts DC—including hearing-aid batteries; "AAA," "AA," "C," and "D" cells; 6-volt lanterns; 3-volt lithium batteries; and 5.6- to 6-volt photo cells. The rugged tester is reliable and easy to use, and comes with a one-year warranty.

The model *BT-20A* battery tester costs $15.95.—**A.W. Sperry Instruments Inc.**, 245 Marcus Boulevard, Hauppauge, NY 11788; Tel. 516-231-7050.

HANDHELD LOGIC ANALYZER. Intended as an affordable alternative to multiple logic probes, *Global Specialties'* model *LM-8* TTL logic analyzer has trigger word recognition that allows to it be used in place of more complex logic analyzers for troubleshooting 8-, 16-, and 32-bit microprocessor circuits. The *LM-8* has eight input channels, an external clock input, and an oscilloscope trigger output. The number of channels can be expanded to as many as 32 by linking four pods together and triggering from a 32-bit trigger word. The captured data can be displayed by the built-in LED's or on an oscilloscope. Each channel's trigger can be set to 0, 1, or "don't care." The logic status of each channel is continuously displayed on the LED's. Pulse stretching allows high-frequency or short-duration pulses to be viewed. The maximum clock frequency is 25 MHz, with pulses as narrow as 10-ns wide being captured and displayed.

CIRCLE 19 ON FREE INFORMATION CARD

The *LM-8* provides two operating modes: RUN and TRIGGERED. In the RUN mode, the data is continuously updated every time the trigger word is recognized. In the TRIGGER mode, the data is captured and displayed until the trigger word is recognized, at which time the analyzer is halted and the last data held.

The *LM-8* handheld logic analyzer, complete with grabber leads for each data channel, costs $249.95.—**Global Specialties**, 70 Fulton Terrace, New Haven, CT 06512; Tel. 1-800-572-1028.

MULTIMETER LEADS. Silicon-rubber multimeter leads from *Test Probes, Inc.* remain soft and flexible even under conditions of

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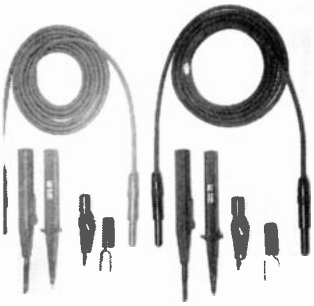

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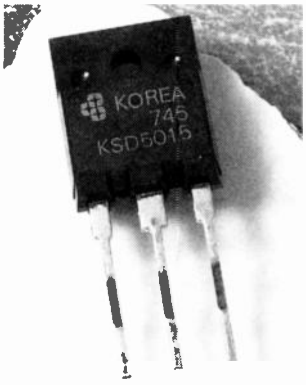
extreme cold. The *TLS200* owes its flexibility to the fine silicon wires in the cable. It fits all makes of analog and digital multimeters that are equipped with standard 4-mm input jacks. Offered in straight or right-angle plug versions, with an array of interchangeable accessories available, the leads are suitable for a wide variety of measurement applications. Their low contact resistance facilitates accurate measurements of low voltages and resistances.

The *TLS2000* multimeter leads cost $30.00.—**Test Probes, Inc.,** 9178 Brown Deer Road, San Diego, CA 92121; Tel. 619-535-9292.

PRE-ISOLATED POWER TRANSISTORS For use in color monitors, power supplies, and high-voltage switching applications, *Samsung* is offering pre-



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isolated bipolar power transistors in TO-3PF packages that simplify mounting procedures. The isolated packages offer better EMI control for ungrounded heat sinks, require less mounting hardware, and are cost effective. The power transistors can handle 1500-volt collector-base voltage. The devices have a 5,000-volt isolation rating, eliminate bushings and isolation pads, and have no exposed metal surfaces other thai the leads.

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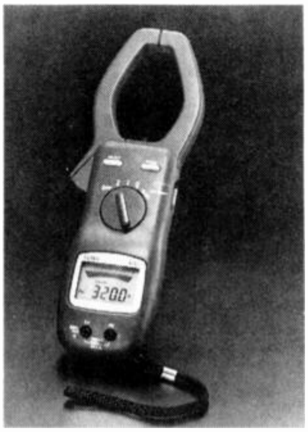
Eight devices—*KSD5010-KSD5017*—are available. When ordered in quantities between 100 and 999, the prices range from $1.55 to $2.10 each.—**Samsung Semiconductor**, 3725 North First Street, San Jose, CA 95134-1708; Tel. 408-434-5400.

DIGITAL CLAMP METER. Four advanced digital clamp meters introduced by *C.G. Instruments* have 3¾-digit displays and offer up to 4,000 counts. All four meters are UL listed and have rugged, drop-proof enclosures. They feature large clamping jaw openings to allow easy measurements of cables and bus bars up to 2.95 inches in diameter.

The *Soar 632 AC Clamp Meter* (shown in photo) has a basic accuracy of ±1%, provides 3200 counts, and has an analog bar-graph indicator. Its features include auto and man-



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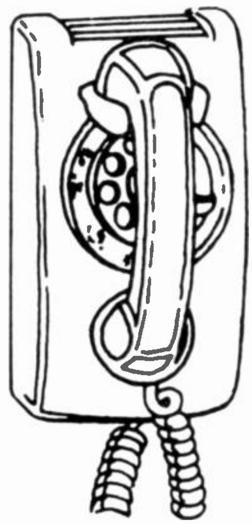
ual range select, data-hold function, audible continuity test, and low power consumption. The *632* measures AC current to 1000 amps in two ranges, AC volts to 630 volts in two ranges, AC/DC volts up to 630 volts, and ohms to 3.2 Kohms in two ranges. The *Soar 641* and *Soar 642* each provide 4000 counts and feature an analog bar-graph indicator, data hold, peak hold, max hold, averaging functions, and diode-audible continuity test capabilities.

The meters measure AC to 1000 amps in three ranges, AC/DC volts to 630 volts in three ranges, ohms to 4 Kohm in two ranges, frequency from 20 Hz to 999.9 Hz with 0.1 Hz resolution, and temperature from −50° to +130°C. The model *641* has an average-type sensing mode; the *642* offers true RMS. The fourth instrument in the group is the *Soar 643*, a true RMS, multifunction, AC/DC current clamp meter with 4000 count that measures AC/DC current to 1000 amps as well as all the features of the models *641* and *642*.

List prices for the digital clamp meters start at $124.95.—**C.G. Instruments Corp.,** 434 Windsor Park Drive, Dayton, OH 45459; Tel. 513-434-6952; Fax 513-434-7643. **R-E**



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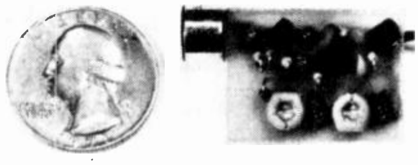

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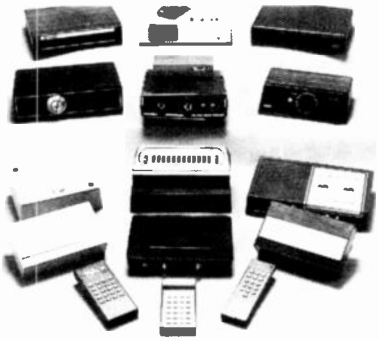

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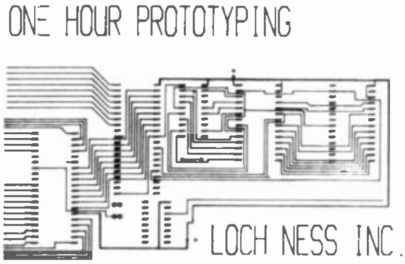

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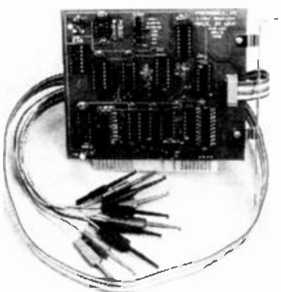

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CORDLESS TELEPHONE BATTERIES. Power Pak, Inc., 6216 Oakton Street, Morton Grove, IL 60053; Tel. 1-800-637-2212; free.

This guide to replacement batteries for cordless telephones is written to help the user make an intelligent, well-informed selection. The brochure is filled with specifications and complete cross-reference material, along with other information about replacement batteries.

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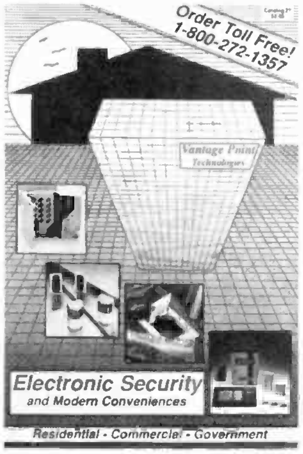

CIRCLE 25 ON FREE INFORMATION CARD

ELECTRONIC SECURITY AND MODERN CONVENIENCES. Vantage Point Technologies, 630 Nordahl Road, Suite P9, San

Marcos, CA 92069; Tel. 800-272-1375 or 619-565-1863; free.

Electronic security systems and accessories designed for do-it-yourself installations are described in a clear, easy-to-understand style in this 32-page catalog. The brochure covers a broad range of high-tech systems for residential, commercial, and government needs— ranging from no-wire home alarms to state-of-the art computer-based building-management system. Some of the products described include burglar-alarm systems, motion detectors, glass protection, switches, fire detectors, sirens, vehicle alarms, notification systems, CCTV, and building-access systems, along with special tools and books. Helpful installation and product tips are provided throughout the catalog. R-E

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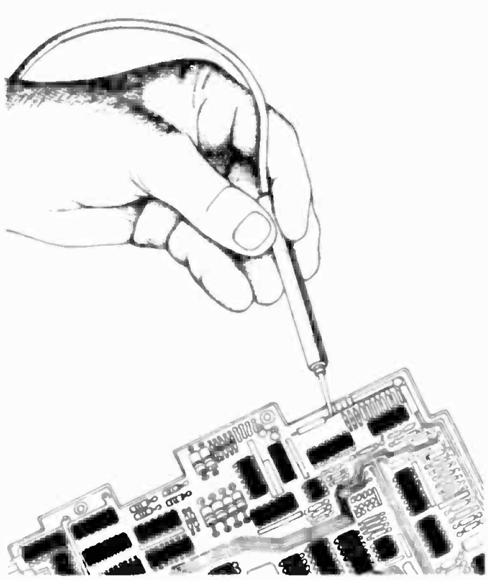

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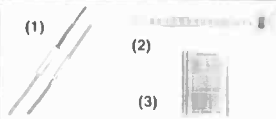

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0.47	35	272-1433	.59
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2.2	35	272-1435	.69
10	16	272-1436	.79
22	16	272-1437	1.19

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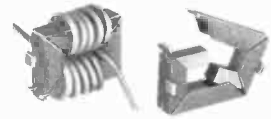

Snap-Together Toroid Cores. Effective "roadblock" to radio-frequency interference. Just wind on AC, phone, computer, coax or audio cable, then snap choke together. #273-104 ..... **Set of 2/7.95**

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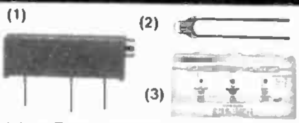

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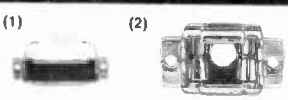

Fig.	Description	Cat. No.	Each
1	9-Position Metal	276-1508	2.19
	25-Position Metal	276-1510	2.79
2	9-Pos. Metalized	276-1513	1.49
	25-Pos. Metalized	276-1536	1.99

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Great Entry Alerter

This IC and mini-speaker combo has a pleasant chime output and it's ideal for a customer-entry alert, doorbell or event indicator. Operates from 6 to 18 VDC. Produces 80 dB sound pressure at 12 VDC. 5" leads. #273-071 .... 8.99

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Sections	Extended	Cat. No.	Each
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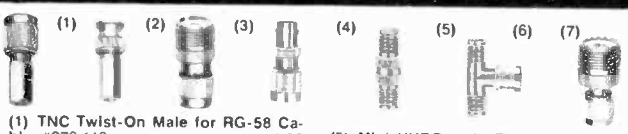

(1) TNC Twist-On Male for RG-58 Cable. #278-140 ..... 1.99

(2) TNC Double-Female. #278-142. 1.99

Fig.	Accepts	Fits TNC	Cat. No.	Each
3	PL-259	Female	278-118	3.49
4	BNC Male	Female	278-145	4.99

(5) Mini-UHF Double-Female. Joins two male mini-UHFs. #278-172 ..... 2.49

(6) Mini-UHF T Adapter. Female-male-female power divider. #278-173 ... 3.99

(7) UHF Adapter. Accepts PL-259. Fits female Mini-UHF. #278-174 ...... 3.99

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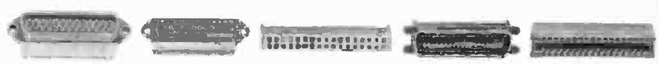

Fig.	Description	Cat. No.	Each
1	25-Position D-Sub Male	276-1559	3.99
2	25-Position D-Sub Female	276-1565	3.99
3	34-Position Header	276-1525	2.49
4	36-Position Male Printer Connector	276-1533	4.99
5	34-Position Card-Edge Connector	276-1564	1.99

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Replacement Tip. #64-2065 .... 1.19

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CIRCLE 78 ON FREE INFORMATION CARD

BUILD R-E's VOCAL STRIPPER

Build this lead vocal filter and test your singing ability.

TERRY J. WEEDER

ALMOST EVERYONE ENJOYS LISTENING TO music, and just about as many people enjoy singing along to their favorite songs. If you're one of the many people who loves to sing, you may be interested in a clever audio device that filters out lead vocals from a stereo recording, leaving just the background music. For under $50.00, you can build this unique audio filtering device. Impress your friends with this *Karaoke*-like audio system and enjoy hours of singing pleasure.

Filtering out the vocal tracks from a recording is not as simple as merely eliminating the midrange frequencies. Along with the vocals, the midrange frequencies contain a large portion of the music. Vocal filtering is quite easy, however, if you take advantage of the way stereo recordings are mixed.

Stereo mixing

When mixing is done in a studio, each instrument or voice is assigned a position relative to left (L) and right (R) channels. Some instruments are recorded at higher levels on the right channel so that their sounds seem to come from the right side of the stage. Others are recorded on the left channel for the opposite effect. Lead vocals and instruments such as the bass drum and bass guitar are usually recorded at the same level on both channels so they seem to come from center stage. That is what makes lead vocal filtering possible.

Vocal signals, which consist primarily of mid-high range frequencies, can be filtered out by a series of filtering stages shown in Fig. 1. Bass instruments, corresponding to a lower frequency range, can be diverted to a final mixing stage so that the music is not filtered out along with the vocals.

A signal from one channel is inverted and subtracted from the

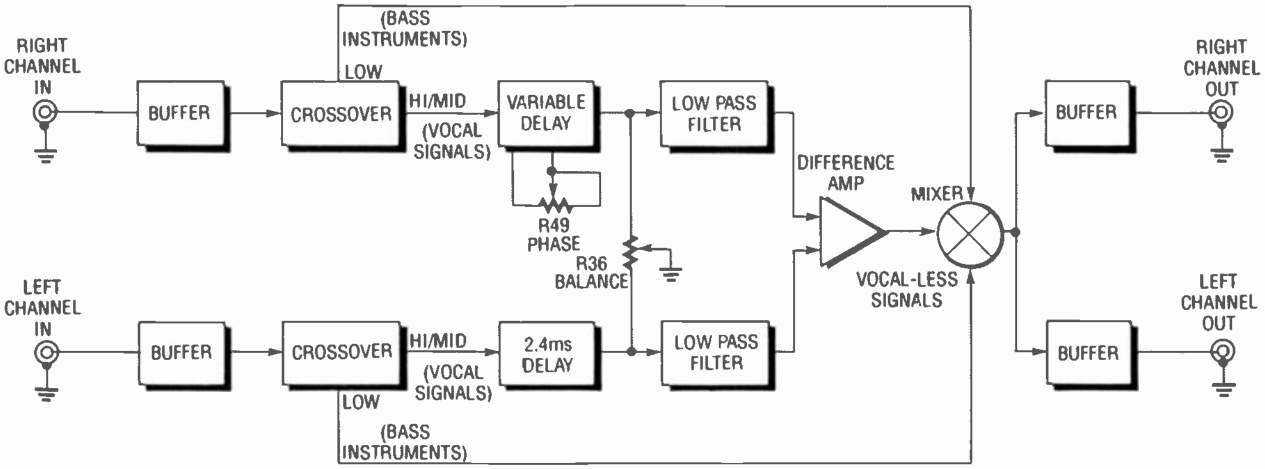


FIG 1—BLOCK DIAGRAM OF FILTER NETWORK. Right channel signal is inverted and subtracted from the left channel, cancelling the lead vocals. Low frequencies are bypassed by an active crossover and remixed with the difference signal, without the vocals.

other (L – R), which causes the lead vocals that are common to both channels to cancel out. The music common to the left and right channel remains unchanged. Unfortunately, along with the lead vocals, all low frequencies are common to both channels and must bypass the cancellation circuit. A simple active crossover removes the low frequencies so that they can be remixed with the vocal-less signal at a later stage.

From the active crossover stage, all midrange and high frequencies pass through a variable delay stage, which is used to align the left and right channel signals so that they are exactly 180° out of phase with each other. Proper signal cancellation is achieved only when both signals are 180° out of phase. The low-pass filter stage filters out unwanted high frequencies from the variable delay stage. The output of the low-pass filter enters a difference amp, where the lead vocal signals cancel, and is then remixed with the low frequencies at the final mixing stage.

Here's how it works

The schematic of the lead vocal filter is shown in Fig. 2. The left and right channel signals are coupled through C1 and C2 to buffer amps IC4-a and IC4-b. From the buffer amps, the left and right channel signals pass through active crossovers IC5-a and IC5-b, sending all low frequencies to a final mixer IC6-c, and all middle and high frequencies to analog delay lines IC1 and IC2, RD5106 256-sample bucket-brigades. Integrated circuit IC2 delays the left channel signal by

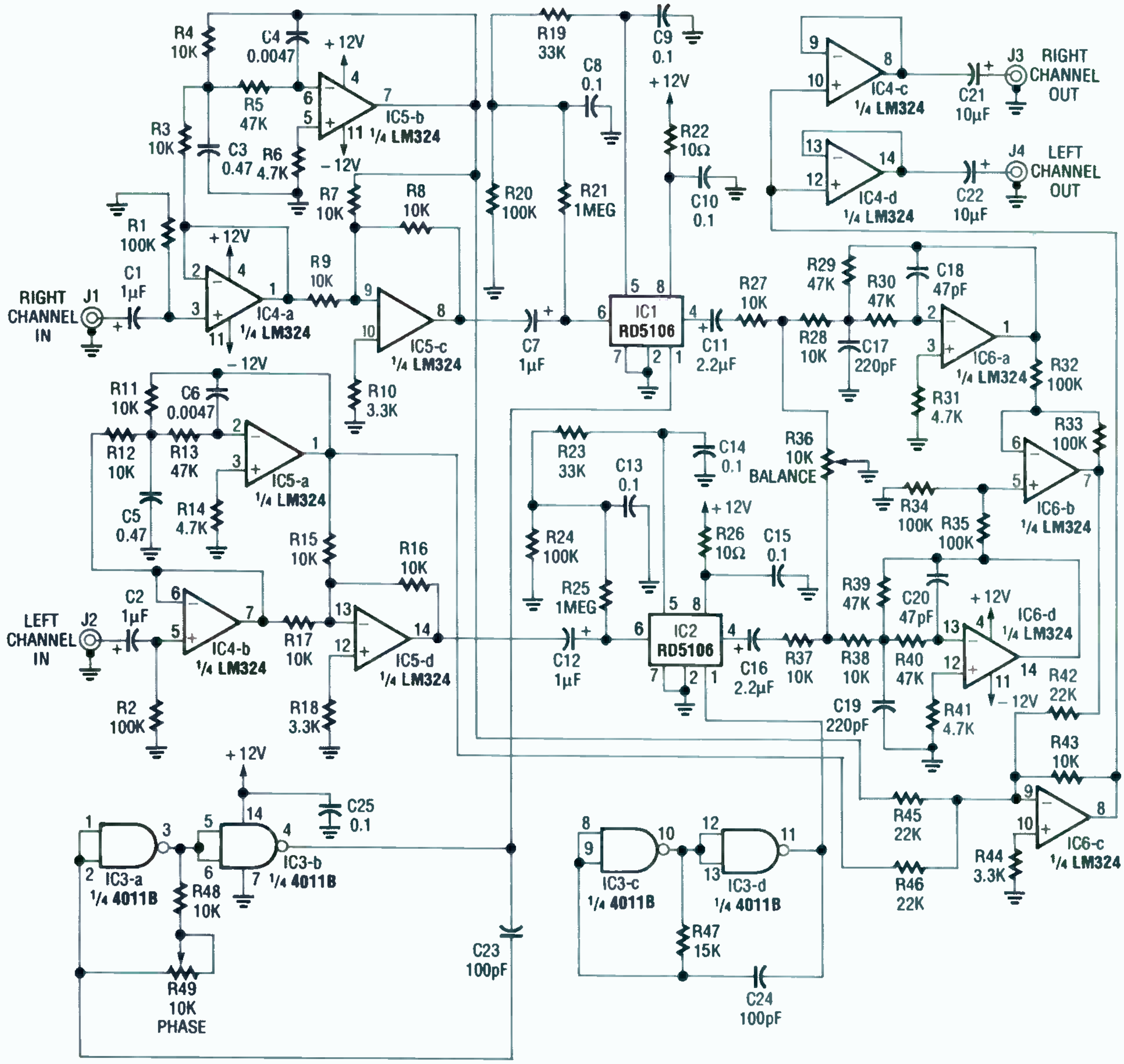


FIG. 2—SCHEMATIC OF LEAD VOCAL FILTER. Right and left channel signals pass through IC4-a and -b buffer amps into active crossover IC5; low frequencies are sent to IC6-c mixer, middle and high frequencies are sent to analog delay lines of IC1 and IC2. That output passes through IC6-a and -d to filter high frequency sample steps. IC6-b signals are remixed with low frequencies by IC6-c and are sent to final output via IC4-c and -d buffers.

2.4 ms, set by the fixed-frequency clock generated by ½-IC3, R47, and C24. The right channel signal is delayed by IC1 with a variable-frequency clock generated by ½-IC3, R48, R49, and C23. Potentiometer R49 is used for phase adjustment.

The output of each delay line from IC1 and IC2 passes through low-pass-filters IC6-a and -d, and their associated parts, to filter out high-frequency sample-steps produced by IC1 and IC2. Balance control R36 is adjusted for equal amplitude of the left and right channels. IC6-b is a difference amplifier which cancels all lead vocals that are common to both channels. The resulting signal from IC6-b is remixed with low frequencies by IC6-c and is then sent to the output via buffers IC4-c and IC4-d.

Construction

The easiest way to go about constructing the vocal filter circuit is to use a PC board. An etched and drilled PC board is available from the source in the Parts List or you can make your own from the foil pattern provided here. Mount the vocal filter components as shown in the parts placement diagram, Fig. 3. Use shielded wire to connect the RCA jacks, and ground them properly, either by mounting them to a grounded chassis or by soldering ground wires to their cases. The DC power supply leads from the power-supply board should be twisted to reduce noise transmission.

If you don't use PC mounted potentiometers for R49 and R36, be sure to keep their connecting leads short and twist them to re-

All resistors are ¼-watt, 5%, unless otherwise indicated.
R1, R2, R20, R24, R32, R33–R35—100,000 ohms
R3, R4, R7–R9, R11, R12, R15, R16, R17, R27, R28, R37, R38, R43, R48—10,000 ohms
R5, R13, R29, R30, R39, R40—47,000 ohms
R6, R14, R31, R41—4700 ohms
R10, R18, R44—3300 ohms
R19, R23—33,000 ohms
R21, R25—1 megohm
R22, R26—10 ohms
R36, R49—10,000 ohms, potentiometer
R42, R45, R46—22,000 ohms
R47—15,000 ohms
Capacitors
C1, C2, C7, C12—1 µF tantalum
C3,C5—0.47 µF tantalum
C4, C6—0.0047 µF Mylar
C8, C9, C10, C13, C14, C15, C25—0.1 µF Mylar
C11, C16—2.2 µF tantalum
C17, C19—220 pF ceramic disc
C18, C20—47 pF ceramic disc
C21, C22—10 µF electrolytic
C23, C24—100 pF ceramic disc
Semiconductors
IC1, IC2—RD5106 256-sample bucket-brigade analog delay line, EG & G-Reticon
IC3—4011 quad two-input NAND gate
IC4–IC6—LM324 quad op-amp
Miscellaneous: Perforated circuit board, standoffs, mounting hardware, hookup wire, shielded cable, 18-AWG power supply cord, strain relief, and four RCA jacks for J1–J4.
Power supply parts
F1—0.5 amp fuse and fuseholder
T1—24 VAC center-tapped transformer
BR1—1.5-amp bridge rectifier, 100 PIV
C1, C2—1000 µF, 25 volts, electrolytic
C3, C4—10 µF, 16 volts, electrolytic
C5, C6— 0.1 µF, ceramic disc
D1, D2—12-volt Zener diode
R1, R2—220 ohms
R3—1000 ohms
S1—SPST switch, 1 amp
LED1—light emitting diode, any color
Note: The following are available from Weeder Technologies, 14773 Lindsey Rd., Mt. Orab, Ohio 45154: An etched, drilled, and plated PC board, $15.00; a basic parts kit including all resistors, capacitors and semiconductors (not including power-supply components), $29.00. Please include $2.00 for shipping and handling in the U.S., $3.00 in Canada. Ohio residents add 5.5% sales tax. Allow 4 to 6 weeks for delivery.

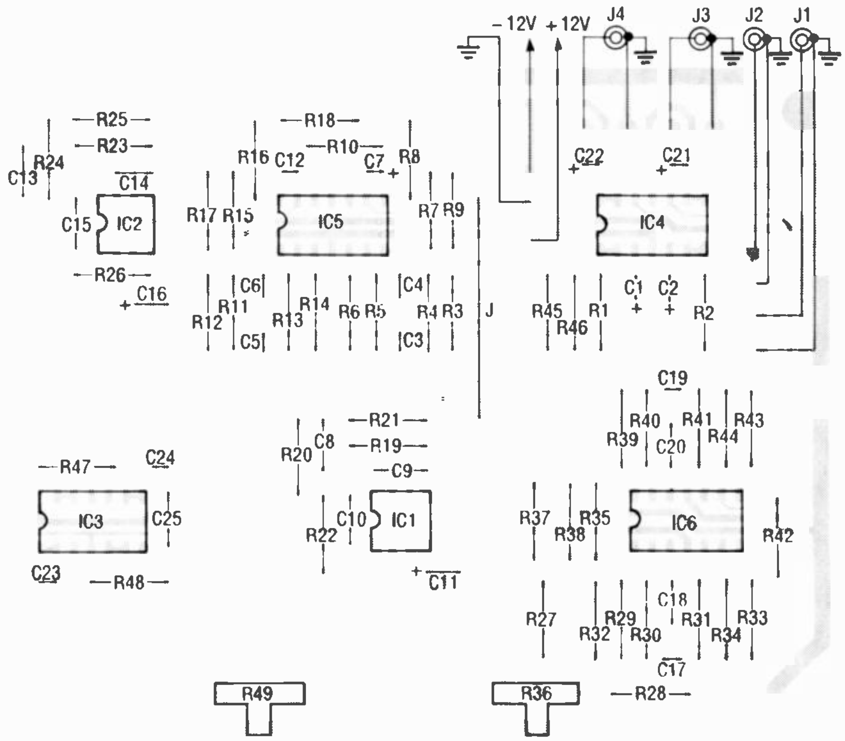


FIG. 3—PARTS PLACEMENT DIAGRAM. Remember to connect the jumper lead, use shielded cables for the RCA jacks and twist the supply leads before soldering to the LED and main PC board.

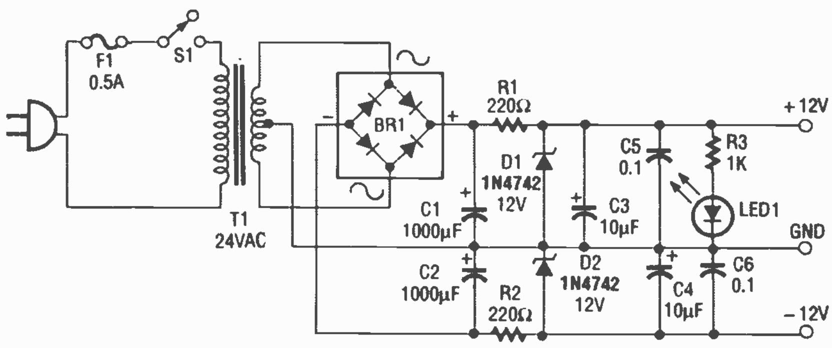


FIG. 4—POWER SUPPLY SCHEMATIC for the lead vocal filter circuit.

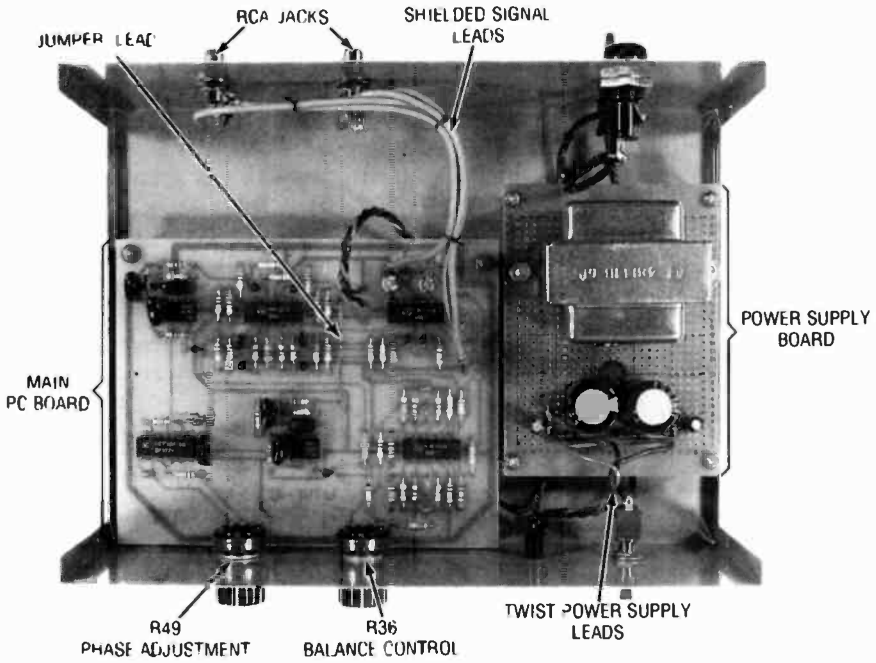
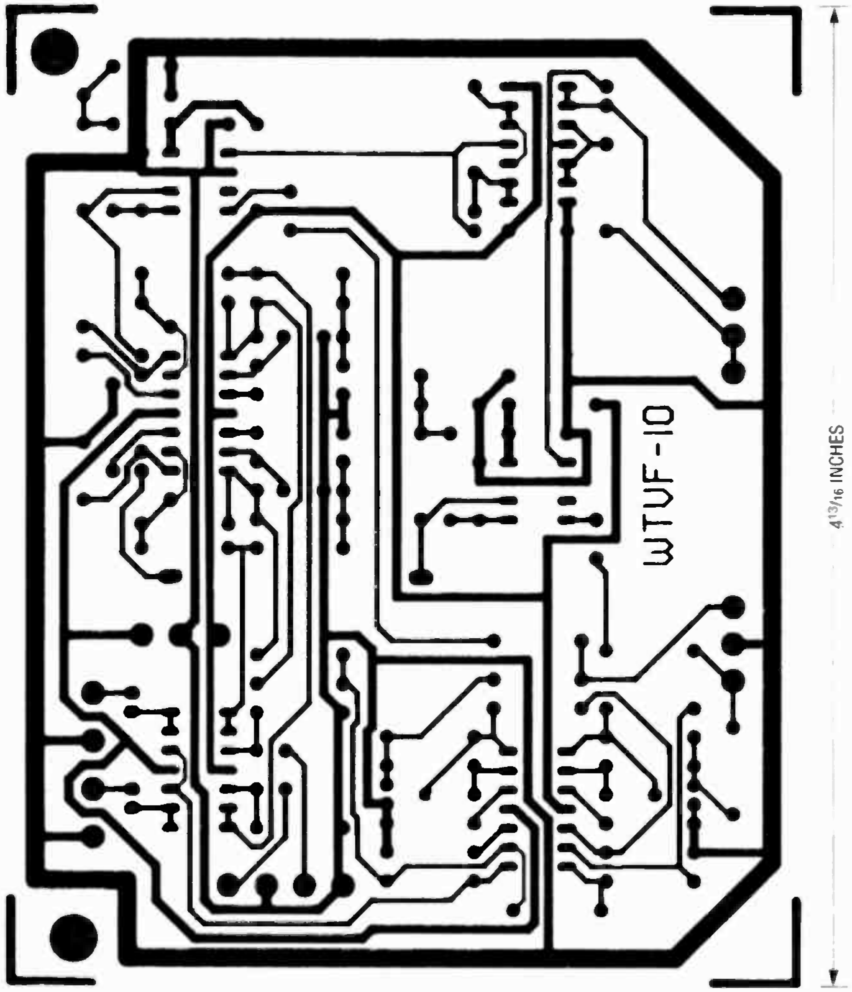


FIG. 5—AN INTERNAL VIEW OF THE LEAD VOCAL FILTER



duce noise and hum pickup. It is preferable, though, to use shielded leads for these connections. These potentiometers should be grounded by mounting to a grounded chassis.

A simple power supply, like the one shown in Fig. 4, may be used for this device. The power supply can be mounted on a perforated circuit board, as long as you closely follow the component connections shown on the schematic. Although optimum performance is obtained with a ±12 volt supply, the vocal filter gives good results using two 9-volt batteries connected in series.

The power supply and main PC board should be adequately enclosed before operating the vocal filter. A metal enclosure is recommended, as a 120-volt line potential is exposed in the power supply circuit (see Fig. 5).

Hook up and operation

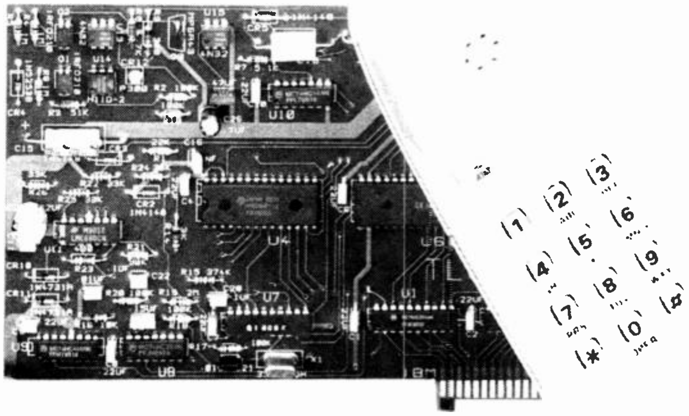
The vocal filter should be connected into the tape loop of your stereo system. Use shielded cables with phono connectors to connect inputs J1 and J2 to the "record" tape monitor jacks on your stereo, and outputs J3 and J4 to the "play" side. To use the vocal filter with a tape deck that normally uses tape monitor jacks, plug the output "play" jacks of the tape deck into J1 and J2 of the vocal filter. Plug J3 and J4 into the input or "play" jacks of the stereo. Make sure you apply power to the vocal filter before turning on the stereo; sensitive components in the vocal filter may be damaged if a signal is applied before power is turned on.

Set R36 to its middle position, play a stereo sound track or tune in an FM stereo broadcast, and switch in the tape monitor. Adjust R49 for minimum lead vocals, then adjust R36. Repeat that process until the lead vocals are suppressed.

If you think the vocal filter is not working, tune in to a mono FM broadcast. If you can't find one, tune to a stereo station, and adjust the tuning knob either way, just enough so the stereo light goes off. If the vocal filter operates properly, you should be able to adjust R36 and R49 to filter out all music except low frequencies.

With a little help from **Radio Electronics**, you now have the know-how to build a fairly simple audio filtering device in just a few short evenings. Once completed, you can use this system to practice singing alone, or be creative and have all your friends over for a *Karaoke* party! **R-E**

Build R-E's TELEPHONE-LINE CONTROLLER



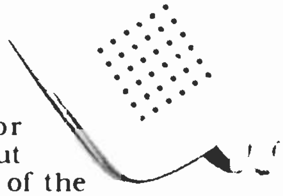
Take full control of incoming and outgoing telephone calls.

MORDECHAI SAAD

WITH THE EVER INCREASING VARIETY of pay telephone services such as Dial-A-Sex, Dial-A-Party, and Dial-A-Friend, the telephone abuses at home and in the office are reaching alarming proportions. For many years, only large corporations were able to afford PBX (private branch extension) systems with facilities to restrict the use of certain numbers. However, now you can build an inexpensive, microprocessor-controlled, integrated telephone line controller that can selectively restrict outgoing calls, selectively restrict incoming calls, selectively dial an array of numbers for promotions, and record all activities on the telephone line, including the time, date, and duration of each call.

The controller uses an IBM PC or clone as a host. However, the card is almost a stand-alone device. It includes its own microprocessor and runs its own operating program. The computer is needed to load the operating program into the controller's static RAM, to initialize operations, and to let the user interact with the controller. The host computer may access the SRAM for reloading firmware, sending and retrieving data, and alternating modes and functions. An internal power supply allows the line controller to operate even when the host computer is turned off.

The line controller does not have to be installed on the phone line at the point of entry to restrict outgoing calls and screen unwanted incoming calls. The card can be plugged into a modular telephone outlet at any point along the indoor phone line, without any modification of the existing installation (see Fig. 1).



How it works

The controller is fully programmable and can perform a wide variety of functions. Using the software provided on the RE BBS, the controller can prevent a number from being dialed if the prefix matches a number on your "list to restrict" (see Fig. 2). If, for example, the list contains the number 9311, then dialing 931-1882 (or 931-1xxx) will be prevented. A list containing 0–9 will prevent all outside calls, and a list containing 0, 1, 20, 21, 30, 31, 40, 41...90, 91 will prevent the use of all area codes, operator, and international. The list can consist of up to 128 prefixes, up to 6 digits each.

The user may choose to have the controller automatically list all outgoing calls made on the computer screen. The list will consist of the destination telephone number, date, time, and duration of each call.

The user can screen incoming calls and limit them to as many as 32 relatives and friends. In that case, the card would have to be used in conjunction with a telephone answering machine. The answering machine would prompt the caller to enter his own number. Then, only the numbers that match one on the list will be allowed to go through. Any matching number, along with time and date, will be stored in memory for later use. The user can then make a list of the incoming calls appear on the screen.

The card can be used to automatically dial a number from the keyboard, a number selected from a menu, or a pre-selected range of numbers. The redial function is not limited to the last dialed number, as the user may select a number from a list of previously dialed numbers.

Circuitry

The line controller contains a microprocessor, memory to hold the software and data, interface circuitry for the host computer, a telephone line interface, and a wall transformer to maintain power when the host computer is off.

A schematic of the circuit is shown in Fig. 3. In the center of the diagram is the microprocessor (IC6, a 65SC02), which is an 8-bit CMOS version of the 6502 used in Apple, Atari, Commodor, and other computers. The static memory, IC4, is an 8K×8 SRAM. The host computer is used to write the program to IC4. The bi-directional tri-state buffer (IC5) is enabled by the pro-

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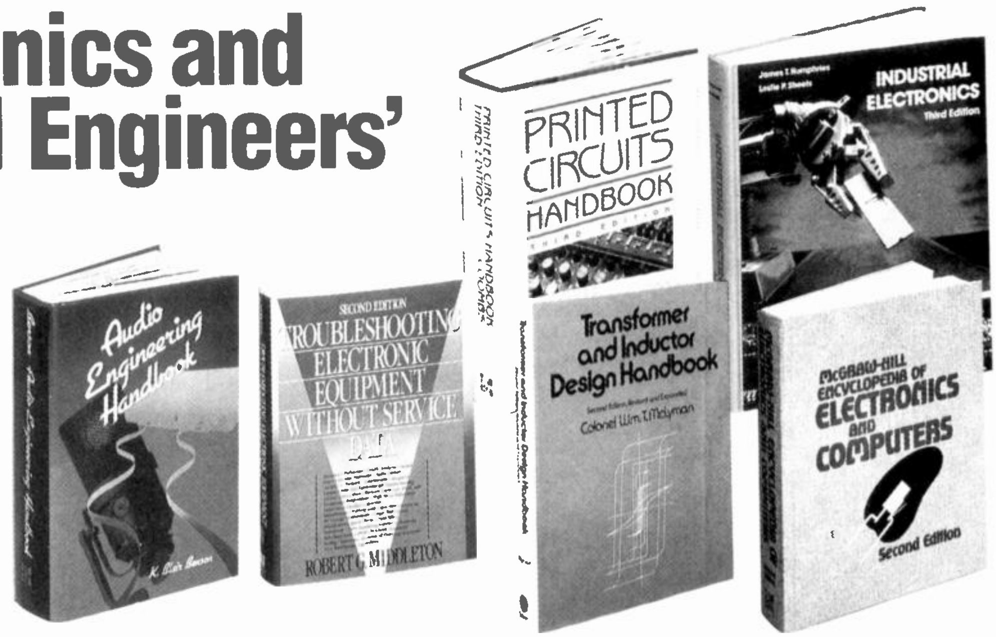

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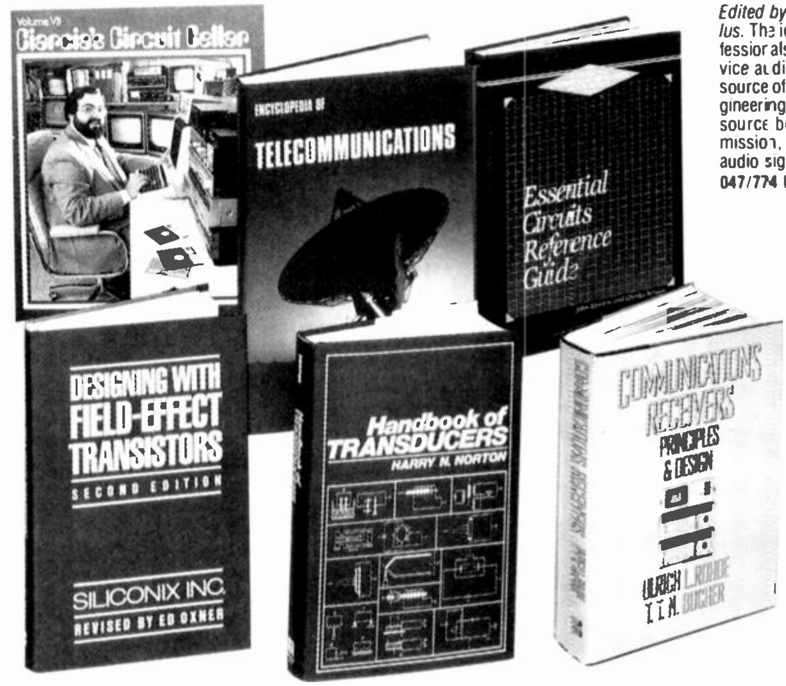
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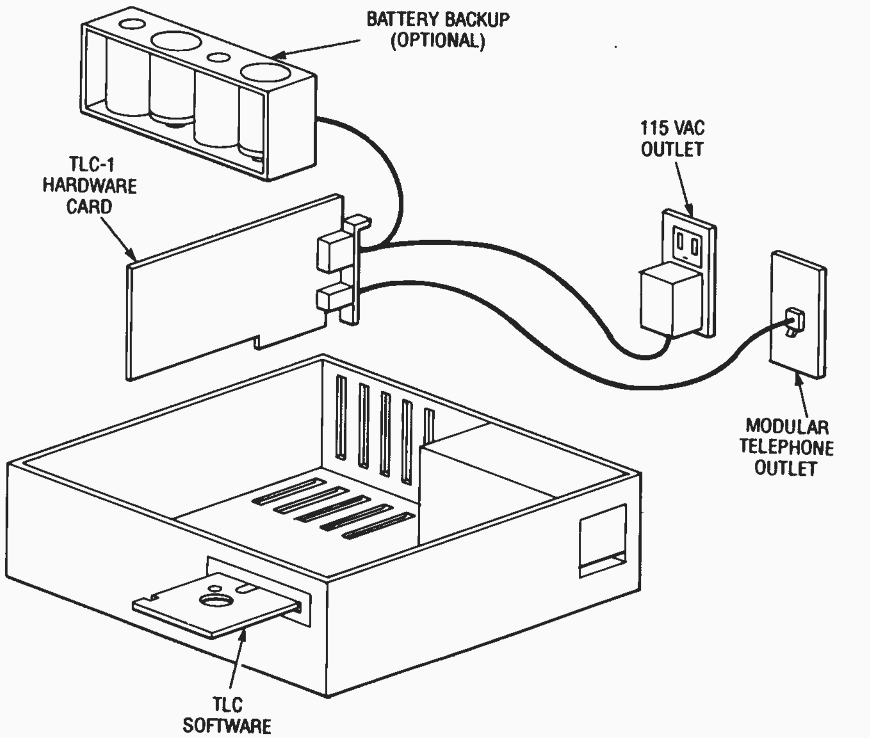


FIG. 1—THE ADD-ON-CARD can be plugged into a modular telephone outlet at any point along the indoor phone line, without any modification to the existing installation.

1/ 25 Records	Tel. No.	Description
1.	0	Operator
2.	1	Long Distance
3.	20	Long Distance
4.	21	Long Distance
5.	30	Long Distance
6.	31	Long Distance
7.	40	Long Distance
8.	41	Long Distance
9.	50	Long Distance
10.	51	Long Distance
11.	540	General Information
12.	550	Group Talk Line

ACCESS BLOCKED

Home PgUp ↑ ↓ PgDn End Ins Del Esc F9=More F10=Help

FIG. 2—THE CONTROLLER CAN PREVENT a number from being dialed if the prefix matches a number on your "list to restrict."

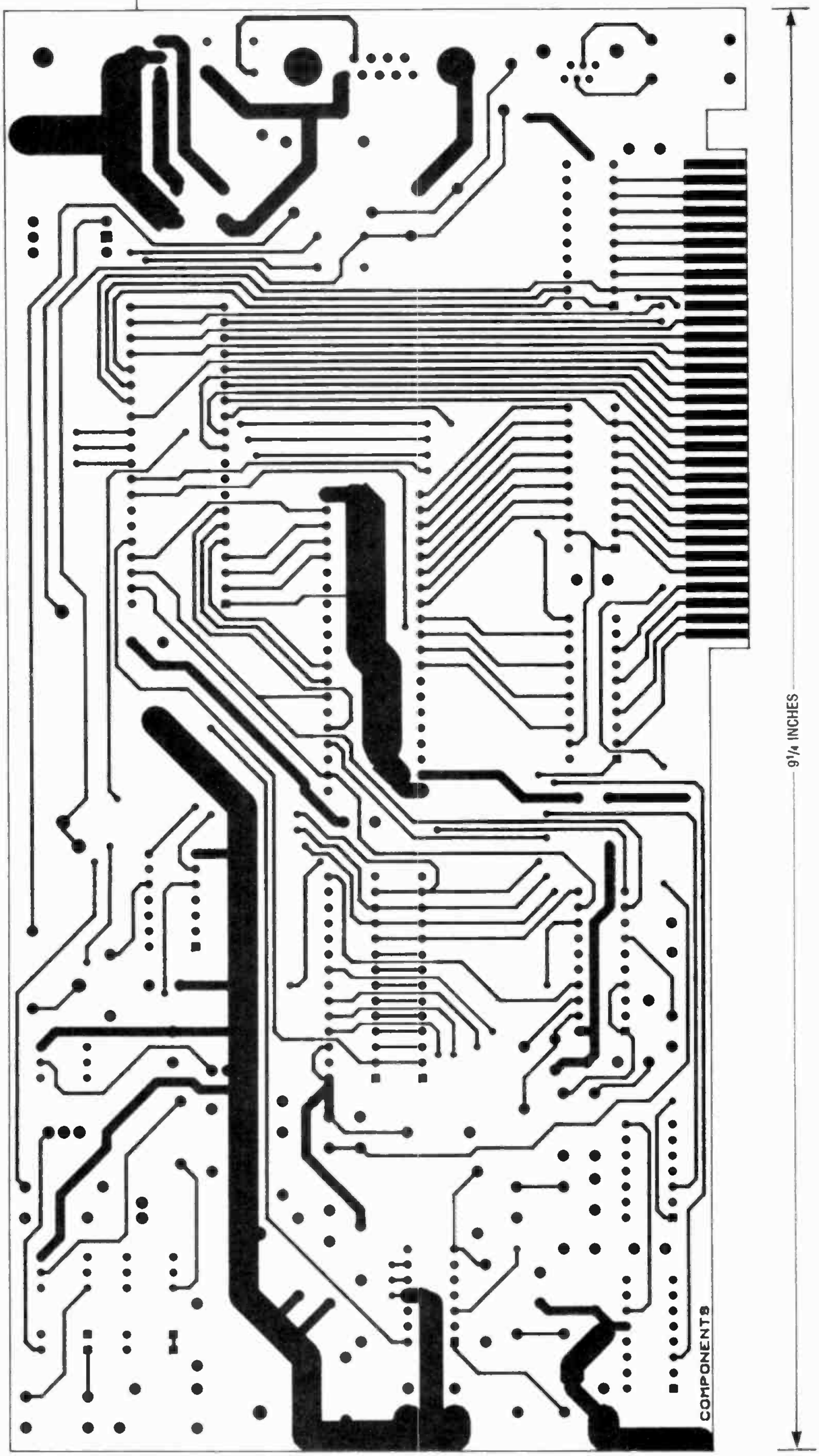
cessor on pin 1 (the direction pin) according to whether the host computer wants to read from or write to the SRAM. Components C16, R1, and D3 provide the processor with a power-on reset.

The peripheral interface adapter (PIA) IC3 is responsible for synchronizing the control of the buses between the host processor (80xx) and the controller's 6502. The DTMF (dual-tone multi-frequency) transceiver, IC7, is constantly monitoring the telephone line for DTMF activities, as well as for incoming calls. When dialing, the transceiver generates DTMF signals. Resistors R17 and R18 set the gain of IC7 to 1, C24 provides AC coupling for the incoming signals, and D10 and D11 are 4.3 volt-Zener diodes; when connected back to back they limit the voltage swing on the secondary of T1 to 5 volts (4.3 + 0.7), thereby protecting IC7 and IC11 from voltage transients. The transmitter output of the DTMF transceiver is buffered by IC11-b to drive the 600-ohm line transformer T1. IC11-b is configured as an inverting amplifier with a gain of 1. By connecting the non-inverting input to a reference voltage of 2.5 volts, the output swing can extend to both rails, centered around 2.5 volts.

The other side of T1's secondary is connected to the output of IC11-a which is configured as a voltage follower to buffer the voltage reference of IC7, and is also used as a return for the line transformer T1. The on-chip clock oscillator of IC7 uses a 3.58-MHz crystal, and the output is coupled to the input of 4-bit binary counter IC8-a via C21. The first-stage output of the counter is the source of the 1.79-MHz clock for the processor. The fourth bit of IC8-a outputs 224 kHz, which IC8-b divides down to 14 kHz. The 14-state counter, IC9, divides the 14 kHz by 1024 down to 13.65 Hz, which is the real-time clock. The 13.65-Hz clock signal is used to tag events such as outgoing calls, incoming calls, and duration of calls, with a relative time and date. The host computer converts it to absolute time and date.

Varistors R27–R29 are used as surge suppressors, preventing the tip and ring terminals from exceeding a differential potential of 150 volts with respect to chassis ground and to each other. Bridge-rectifier BR2 is used to correctly polarize the telephone line on its way to the line-status and -control circuitry. The ring-detector circuitry is connected directly to tip and ring. It detects an AC signal greater than 100 volts p-p. Capacitor C18 blocks the 48-volts DC from opto-coupler IC15's LED, and R11 limits the LED's current.

When a ring signal is present, the opto-coupler's output transistor is on, which causes C26 to



YOU CAN MAKE YOUR OWN PC BOARD for the telephone line controller. This pattern is for the component side of the board.

discharge, pulling the input of IC10-d to ground. The processor reads the output of IC10-d (high when ringing) into data line DO by enabling IC1. Resistor R10 charges C26 at a rate where the brief pauses between rings will not reach the threshold of IC10-d, thereby maintaining IC10-d's output high.

Schmitt trigger IC10-e and IC14 allow the controller to "pick-up," or get on line. The processor sets the input of IC10-e. The output of IC10-e then drives the LED part of opto-coupler IC14 to ground via R7. The transistor part of IC14 then turns on, driving Q3. At this point, the following components are conducting the loop current in a clockwise order: R13, ¼ of BR2, Q3, LED1, R9, ¼ of BR2, and R12. LED1 is there only to indicate that the controller has "picked-up."

A circuit made up of transistors Q1 and Q2, IC13, and IC10-c continually monitors the telephone line. When any telephone on the line is picked up, the voltage between the tip and ring drops from 48- to 7-volts DC and, as a result, Q2 turns off. Transistor Q1 then turns on, turning on the transistor in the opto-coupler IC13, causing the output of IC10-c to go high. That tells the processor that somebody is on the line. The processor reads that signal on data line D1 via IC1. IC10-a and -b provide the internal microprocessor with a reset pulse on power up, and on bus-transfer command.

The card can get its power from the host computer via D2, at least while the host computer is in operation, and the external wall transformer is not connected. The existence of external power

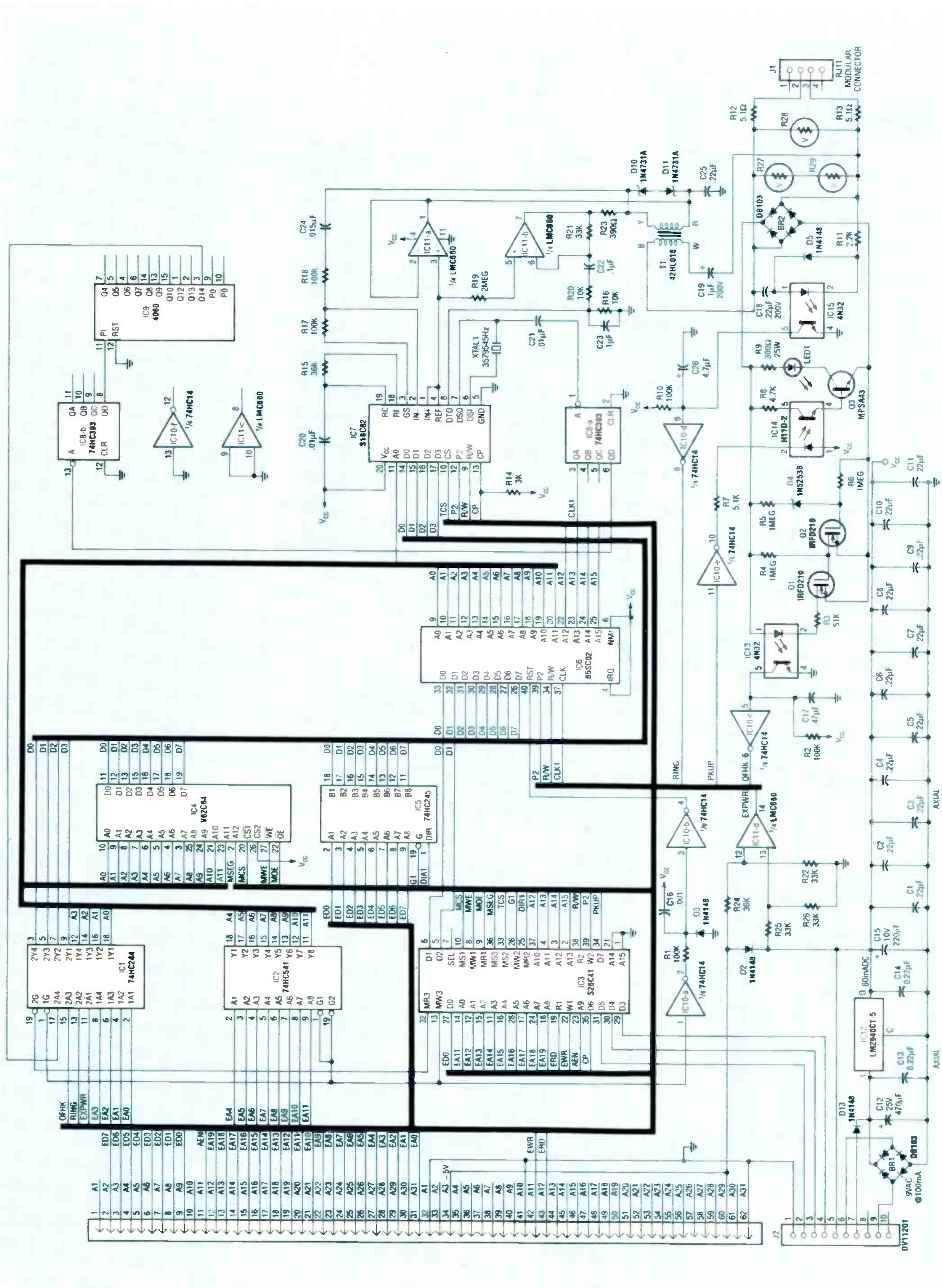


FIG. 3—SCHEMATIC OF THE LINE CONTROLLER. The 8-bit CMOS microprocessor (IC6) is used to coordinate everything.

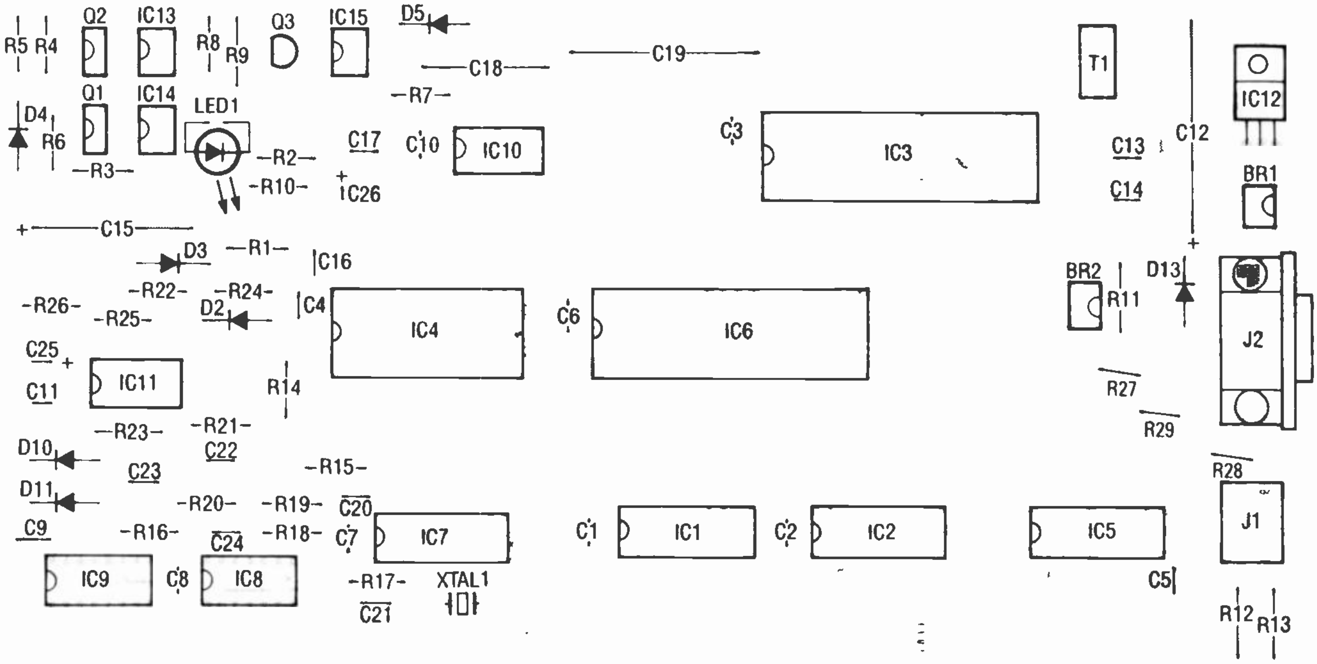


FIG. 4—PARTS-PLACEMENT DIAGRAM. The card is assembled on a double-sided PC board that fits in an expansion slot on your motherboard.

PARTS LIST

All resistors are ⅛-watt, 2%, unless otherwise indicated.

R1, R2, R10, R17, R18—100,000 ohms
R3—51,000 ohms
R4–R6—1 megohm
R7—5100 ohms
R8—4700 ohms
R9—300 ohms, ½-watt
R11—2200 ohms
R12, R13—5100 ohms
R14—3000 ohms
R15, R24—36,000 ohms
R16, R20—10,000 ohms
R19—2 megohms
R21, R22, R25, R26—33,000 ohms
R23—390 ohms
R27–R29—P7056 125-volt surge suppressor

Capacitors
C1–C11, C13, C14, C25—0.22 µF, 50 volts, ceramic
C12—470 µF, 25 volts, electrolytic
C15—220 µF, 10 volts, electrolytic
C16—1000 pF, 100 volts, ceramic
C17—0.47 µF, 50 volts, ceramic
C18—0.22 µF, 250 volts
C19—1 µF, 250 volts
C20, C21—0.01 µF, 100 volts, ceramic
C22, C23—0.1 µF, 50 volts, ceramic
C24—0.015 µF, 100 volts, ceramic
C26—4.7 µF, 25 volts, electrolytic

Semiconductors
IC1—74HC244 octal tri-state buffer
IC2—74HC541 octal tri-state buffer
IC3—S26C41 interface adapter
IC4—V62C64 8K × 8 SRAM
IC5—74HC245 octal transceiver
IC6—65SC02 8-bit microprocessor
IC7—S18C62 DTMF processor
IC8—74HC393 dual 4-stage counter
IC9—74HC4060 14-state counter
IC10—74HC14 hex Schmitt trigger
IC11—LMC660 quad op-amp
IC12—LM2940CT-5 +5-volt regulator
IC13, IC15—4N32 optoisolator
IC14—H11D-2 optoisolator
BR1, BR2—DB103 bridge rectifier
D2. D3. D5, D13—1N4148 switching diode
D4—1N5253B 25-volt Zener diode
D1, D6–D9, D12—not used
D10, D11—1N4731A 4.3-volt Zener diode
LED1—P300 light-emitting diode (any color)
Q1, Q2—IRFD210 N-channel hex DIP
Q3—MPSA43 H.V. NPN transistor

Other components
J1—H9032 modular connector
J2—8926 747844-1 female D-subminiature connector
T1—42HL016 600/600-ohm transformer
XTAL1—3.579545-MHz crystal

Miscellaneous: PC board, 9-volt 200-mA AC wall adapter, E09P male D-subminiature connector, battery holder, PC bracket, hardware, solder, etc.

Note: The following items are available from AC&C, 717 E. Jericho Tpk., Suite 101, Huntington Station, N.Y. 11746: A PC board (TLC-1) and OGC Restrainer software (on 5¼-inch floppy disk), $55.00; A wall transformer, modular phone cord, three connectors, and a metal PC mounting bracket $36.00; all the above mentioned items, and all components including semiconductors, resistors, capacitors, and optoelectronics devices; $198.00. Be sure to add $5.50 to any order for shipping and handling. For technical information, write to AC&C, and please include a self-addressed stamped envelope. AC&C is constantly adding software functions for the entire product line, and for those with unique applications, AC&C is ready to work on your custom software requirements.

(AC line transformer, and or battery backup) is detected by IC11-d, in order to alert the user before shutting off power on the host computer. Resistors R24 and R22 are set to provide the non-inverting input of IC11-d with 2.39 volts.

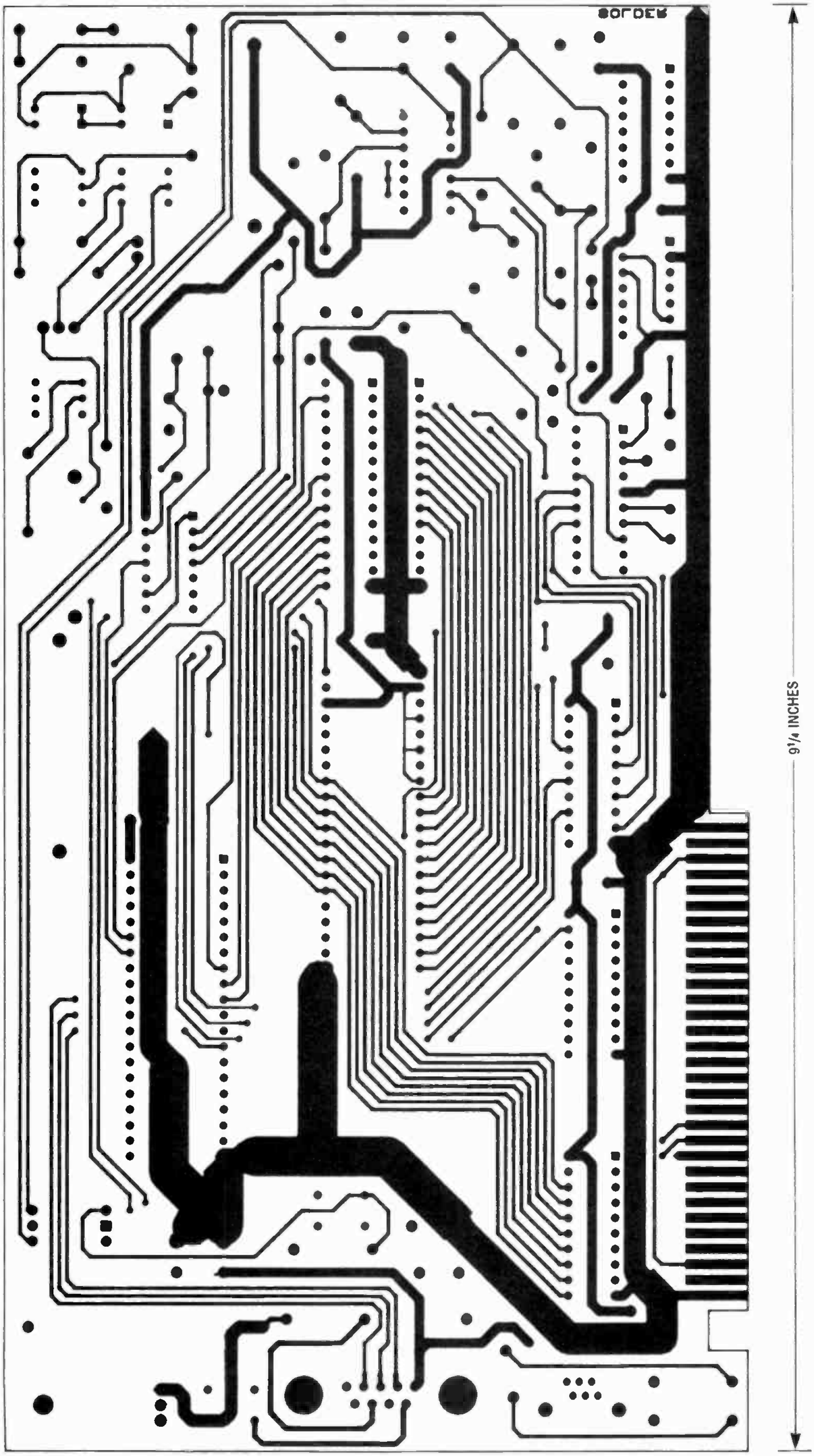
When external power exists, the cathode of D2 is at 5 volts. When external power does not exist, the voltage drops to 4.3 volts; resistors R25 and R26 divide the voltage by 2, to 2.5 and 2.15 respectively, to drive the inverting input of IC11-d. The output, therefore, will go high when the external power does not exist and vice-versa. The 5-volt regulator IC12 provides the circuits with power as long as it is supplied with at least 6.5-volts DC or 7 volts AC RMS.

A provision has been made for future interface with external hardware on a three-line serial communication; see pins 2–4 of connector J2. Also, ground and V_{CC} is brought to pins 1 and 5 respectively. The connection of a battery to pin 7 is optional; when used, it ensures proper operation during power interruptions.

Construction

Construction of the card is straightforward. Figure 4 shows a parts-placement diagram. The PC board can be made from the foil patterns provided, or you can purchase one from the source mentioned in the parts list. When building the board, just be sure to install the IC's last, as they are more susceptible to damage than the other components. The only other thing that needs explaining is the bracket that holds the card down in the computer. You must take a "blank" IBM-

(Continued on page 82)



THIS IS THE FOIL PATTERN for the solder side of the telephone line controller PC board.

DATA DISKS: HIGH SPEED DEVICE SELECTION FOR THE 90'S

ED PRESTWOOD*

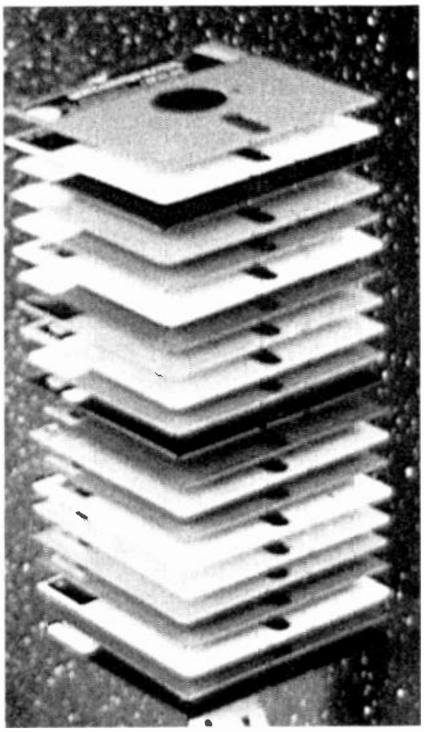
Finding the right component for a particular application is easier than ever, with the help of today's data disks.

TRADITIONALLY, DEVICE SELECTION involved paging through hard copy selection guides and data books until a suitable device was located. Now, with the revolution in electronic data processing, the technical community is quickly moving toward high-speed computer-assisted software for selecting semiconductors and other electrical components. The process is not only faster and simpler, it also results in better device selections.

What began as a simple foray into PC-assisted device selection is rapidly becoming the preferred method of device selection by today's engineers. For one thing, data disks routinely save users hours in the device-selection process. Second, and perhaps even more important, there's a tremendous cost advantage for engineers to design in components that not only perform well, but are cost-effective as well. Selecting the ideal device at the best price often results in the savings of thousands of dollars for companies that take the time to optimize their designs. Some companies are even using data disks to find better, less expensive replacements for components in existing designs.

What are data disks?

Data disks are selection guides on floppy disks. Manufacturers are now providing data disk's to customers as a supplement to conventional literature to speed up and simplify the device selection process. Data disks are not intended or designed to replace data sheets; instead, they are computer-assisted selection guides that recommend several suitable devices for the user's application. They run on popular PC's and help users select the ideal device or product for their application in seconds rather than minutes or even hours. Some data disks integrate cross reference support for as many as 27,000 competitive devices.



After the data disk recommends several suitable candidates, it's up to the user to obtain the appropriate data sheet to make a final intelligent selection. To make it easier to order the proper literature, some disks even contain listings of technical literature for the devices on the disk. The Motorola data disk, for instance, lists every application note, article reprint, engineering bulletin, training course, data sheet, and data book available for over 13,000 integrated circuits and discrete semiconductors.

What do data disks do?

One of the simplest functions provided by these electronic selection guides is the part number search. Users enter the device number they are interested in, press the Enter key, and the program conducts the search. When the part is found, all information concerning it is displayed. The more sophisticated disks automatically search every product category on the disk for a spec-

*Ed Prestwood is president of Cybersoft, Inc., a Tempe, AZ company specializing in the production of data disks.

ified part number. A useful variation of the part number search is the partial part number search. In a partial device number search (also called a substring search), the user enters a portion of a device number—"6800," for instance. The program then locates every device that contains "6800" somewhere in its part number and displays the list in a tabular format on the screen. One similar feature is called the complementary device number search. This option will locate the electrical complement for any discrete device specified by the user.

A few of the currently available data disks provide a useful cross-referencing feature. If the specified part number isn't on the disk, the program automatically looks for it in a special cross-reference file. If it's listed, the software automatically looks up the manufacturer's equivalent device and displays the information for that device. Some data disks tell users if the cross-reference device is a "similar replacement" or a "direct replacement." The Harris Op Amps data disk even tells users about the pin-to-pin compatibility and the degree of electrical equivalency. The Harris disk also provides comments regarding the suitability of the device as a substitute for the requested device number.

For most users, the most valuable capability of data disks is the parametric search function. After this function is selected, the program displays a menu of parameters for the devices in the selected product category. Users then select the parameters for their application from a menu and enter minimum or maximum values appropriate for their application. Some data search disks provide pop-up menus that list choices for parameters such as package, temperature range, Zener voltage, etc. After entering the values, pressing a single key will display all the devices that meet or exceed the specified requirements.

Like any good spreadsheet, the better data disks allow users to conduct "what if?" sessions. High-end data disks, such as those developed by CyberSoft, actually remember the previous parametric search and permit users to conduct the search over and over, "tweaking" just one or two parameters with each pass. That permits users to make whatever compromises are necessary to optimize the cost-performance tradeoffs.

Data disks also provide a host of other features, such as the ability to limit searches to military components, surface mount components, or military surface mount components. Many data disks include a printable "Information Request Form" so that users can order technical literature and sample devices. Most data disks also contain sales office and/or distributor contact lists. Help files, screen-color utilities, and printer utilities (including network and spooler support) are also available on some disks. The Burr-Brown data disk even has a provision for displaying new product information that users can download from the Burr-Brown BBS in Tucson, Arizona. Thoughtful manufacturers also include a phone number for users to call to obtain the latest versions of their data disks. Many offer free subscription services.

Are all disks created equal?

By no means. Several of the data disks available today are highly polished, professional software packages. A few, however, carry the mark of the novice. The differences matter little, however, when a manufacturer

SOME AVAILABLE DATA DISKS

Analog Devices
Two Technology Way
Norwood, MA 02062
Bill Schweber (617) 329-4700
CIRCLE 225 ON FREE INFORMATION CARD

Best Power Technology
P.O. Box 280
Necedah, WI 54646
Literature Center (800) 356-5794
CIRCLE 226 ON FREE INFORMATION CARD

Bourns
1200 Columbia Avenue
Riverside, CA 92507
Customer Service (714) 781-5500
CIRCLE 227 ON FREE INFORMATION CARD

Burr-Brown
P.O. Box 11400
Tucson, AZ 85734
Customer Support (800) 548-6132
CIRCLE 228 ON FREE INFORMATION CARD

Cuttler-Hammer
Dept H293
4201 N. 27th Street
Milwaukee WI 53216
Diane Nuesslein (800) 833-3927
CIRCLE 229 ON FREE INFORMATION CARD

Equipto
351 Woodlawn Avenue
Aurora IL 60506
Customer Service (708) 897-4691
CIRCLE 230 ON FREE INFORMATION CARD

Harris Semiconductors
P.O. Box 883, M/S CB-1-25
Melbourne, FL 32901
Literature Center (407) 724-3739
CIRCLE 231 ON FREE INFORMATION CARD

Lambda
515 Broad Hollow Road
Melville, NY 11747
Customer Service (800) 526-2324
CIRCLE 232 ON FREE INFORMATION CARD

Motorola
P.O. Box 20924
Phoenix, AZ 85036
Literature Center (800) 521-6274
CIRCLE 233 ON FREE INFORMATION CARD

Newport
P.O. Box 8020
Fountain Valley, CA 92728
Technical Hotline (714) 965-5406
CIRCLE 234 ON FREE INFORMATION CARD

Philips Components
George Washington Hwy.
Smithfield, RI 02917
Cindy Taylor (401) 232-0500
CIRCLE 235 ON FREE INFORMATION CARD

Precision Monolithics
1500 Space Park Drive
Santa Clara, CA 95052
Literature Center (800) 843-1515
CIRCLE 236 ON FREE INFORMATION CARD

Titan Severe Environments
20151 Nordhoff Street
Cathsworth, CA 91311
John Van Putten (818)709-7117
CIRCLE 237 ON FREE INFORMATION CARD

Western Digital
17900 Von Karman Ave.
Irvine, CA 92714
Literature Center (800)832-4778
CIRCLE 238 ON FREE INFORMATION CARD

Xentek
P.O. Box 1987
Vista, CA 92083
Larry Merchell (619)727-0940
CIRCLE 239 ON FREE INFORMATION CARD

has the only data disk for their given product line. But with new disks becoming available every few weeks, the competition to provide the most convenient and powerful user interface is intensifying. All the manufacturers mentioned here have improved their disks with each new revision. It may seem ironic, but today and throughout the 90's, the battle for share-of-mind will be fought and won on the basis of

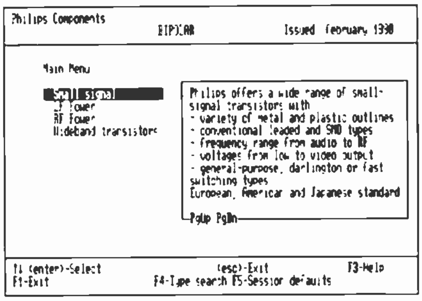


FIG. 1—THE MAIN MENU from Philips Components' Discrete Semiconductors Transistors data disk.

the ease of selection rather than solely on the reputation of the manufacturer.

A few of the data disks available today provide automatic multi-level sort capability, which is a definite advantage in today's competitive market. CyberSoft, Inc. introduced the multi-level sort feature when it developed the first Motorola data disk in 1987. The multi-level sorting algorithm sorts each and every column selected by the user. It sorts on the first selected parameter, the second parameter, the third, and so on across all the parameters selected by the user. The procedure takes place in milliseconds and assures users that the absolute best device in the database for the specified application is always listed first, and so on.

The automatic multi-level sort is arguably the very best way to display data. A less useful compromise to the automatic multi-level sort is the manual column-by-column sort that users can conduct after the search has been completed.

One feature users should be aware of is called the "early-abort" search algorithm. Some data disks search their databases and abort the search after a specified number of devices are located (10 and 15 are common numbers). That's an awful approach to searching a database, since the 16th device—or the 2,016th, for that matter—may be the ideal device for the specified application. Look for disks that search the entire database for parameters selected by the user, then report back the total number of "hits." The best way for the software to "know" how many devices meet the user's requirements is by searching the entire database.

Another very useful feature that separates the men from the boys is called parameter queuing. That is, the program automatically displays the parameters in the same sequence that the user selected them in. If a user selects $r_{DS(on)}$ as his or her

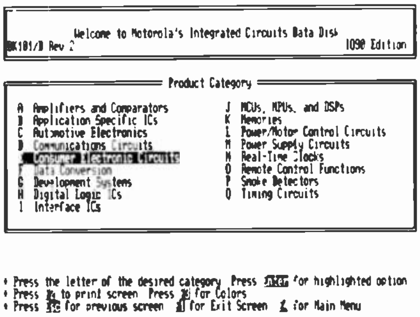


FIG. 2—MOTOROLA'S IC data disk gives access to a wide variety of product categories.

most important parameter, it is displayed in the first column. Likewise, if the user specifies breakdown voltage as the second most important parameter, it will be displayed in the second column. Automatic parameter queuing, coupled with automatic multi-level sorting, provide users with the most useful and convenient display sequence possible. Burr-Brown, Harris, and Motorola support both of these important features in their data disks.

Data disks also vary greatly in the amount of data they store. The number of devices is not a reliable indicator of the amount of information contained on the disk because there may be only five or six columns of information available for each device. CyberSoft, who developed the Burr-Brown, Harris, Motorola, Titan, and Western Digital data disks, supports up to 64 columns of data for every device, which can add up to a lot of data. A final consideration when gauging the amount of information on a disk is the number of cross references supported. Motorola's data search disk contains well over 25,000 cross-references, which can be a great convenience for designers and technicians alike.

Some data disks include pricing information. Most engineers insist on seeing price information, even if it's only "ball park" pricing. Relative pricing greatly simplifies designing to a budget. If two devices will work in a specified application and one costs half as much as the other, it generally pays to take a good look at the less expensive component. Some disks, like the Titan Data disk, provide users with volume pricing based on the quantities ordered.

One other feature that appears only on high-end data disks is footnote support. All too often, a device that looks ideal may be inappropriate because of some subtle characteristic that isn't obvious by looking at the tabular

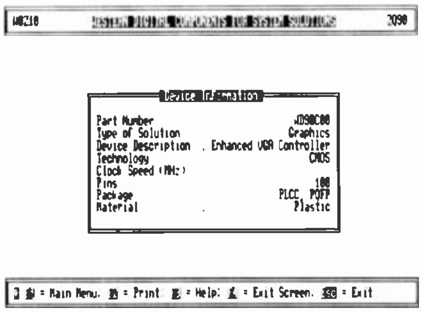


FIG.3—A SAMPLE DEVICE INFORMATION screen from Western Digital's data disk.

data itself. All data disks developed by CyberSoft provide extensive footnoting capabilities.

Another important thing to look for in a data disk is good customer support. Some companies, like Burr-Brown, Motorola, and Western Digital, are placing their data disks onto corporate Bulletin Boards so users can download their latest data disk (and/or new product updates) in minutes. Others, like Equipto, provide a dedicated customer service number that users can call. Within minutes, Equipto sends FAX information on any component covered in their data disk to their customers. Equipto's disk, coupled with their dedicated support line, has not only dramatically increased sales leads, it's also propelled them into a record sales year.

Who's offering data disks?

Over the past four years, a number of companies have provided data disks to their customers. Disks are distributed at trade shows, technical colleges and universities, and through "shareware" catalogs. More and more of the 6,000+ bulletin board services across the United States have data disks waiting to be downloaded at no charge. The following list shows a sampling of the data disks that are free for the asking.

- Analog Devices—This disk provides pricing information and covers Analog Devices' line of op amps and data conversion circuits. Disks containing SPICE emulation models for Analog Devices op amps are under development and will soon be available.
- Best Power Technology—This disk, available in English, French, German, or Spanish, is a "brochure-on-a-floppy" for their broad line of computer-grade uninterruptible power supplies.
- Bourns—Bourns "Selectrim" data disk provides coverage for Bourns' complete line of trimmer potentiometers.
- Burr-Brown—This data disk covers Burr-Brown's entire line of op amps, instrumentation amplifiers, isolation amplifiers, analog circuit functions, D/A and A/D converters, analog circuit multiplexers, sample/hold amplifiers, voltage-to-frequency converters, and data-acquisition components.
- Cuttler-Hammer—Billed by the company as an "Expert System" program, this data search disk leads specifiers through a series of pertinent questions that results ultimately in the recommendation of the appropriate photoelectric or proximity transducer for a given specified application.
- Equipto—The Equipto disk incorporates more graphics than most data disks. It helps users specify the optimal modular enclosure (including vertical racks and slope front consoles) for electronic equipment. Also includes computer furniture, instrument cabinets, and EMI/RFI shielded enclosures.
- Harris—Harris' first entry in the data disk arena covers their broad line of operational amplifiers, including devices from the recent merger of GE, RCA, and Intersil. Look for additional Harris product lines to be added soon. A disk containing SPICE macro models for several Harris op amps is also available.
- Lambda—Lambda offers a disk covering their broad line of AC-DC switching and linear power supplies, DC-DC power supplies and converters, supplies for laboratory and test equipment, power semiconductors and power systems. It also includes pricing information.
- Motorola—Motorola offers two IBM disks containing all the selection guide information for both IC's and discretes. These disks operate stand-alone or in concert when copied onto a hard drive. This disk is also available on a single microfloppy for Macintosh PC's. It features 124 product categories, 13,000 device numbers, 27,000 competitive cross references, and half a million parameters. Motorola also offers SPICE models for their power MOSFET's and scatter parameters for selected small signal RF devices.
- Newport—The Newport Optics Catalog on a floppy features their line of optical lenses. Includes over 2,100 cross reference products for several of Newport's major competitors products.
- Philips Components—This company is offering four data disks, covering diodes, FET's, hybrid amplifiers, optocouplers, power MOSFET's, small-signal transistors, and trigger devices. Competitive cross references and pricing are supported.
- Precision Monolithics—The "Precision Decisions" data disk provides data for PMI's IC product line, including op amps, data conversion circuits, and sample and hold circuits. Includes prices and industry cross references. A disk containing SPICE emulation models is also available.
- Titan Severe Environment Systems—The Titan disk features the company's full line of SECS militarized and ruggedized board-level and system products, including microcomputers, memory, parallel and serial interface, bus interface, analog, and peripheral controller modules. The data disk also includes product overviews and general pricing information.
- Western Digital (WD)—Provides extensive coverage for WD's line of VLSI chip set solutions for XT, AT, 386 and 486 PC architectures, including their Microchannel products. Prints product overviews and provides a useful "Related Solutions" section. WD also offers a two-disk set of utilities and schematics captured using the ORCAD/STD III v3.22 software. This data search disk set facilitates the development of design solutions based on the AT-compatible WD286-LPM16 motherboard.
- Xentek—This disk provides pricing information and major parameters for Xentek's line of standard linear power supplies. Extreme isolation transformers and switching power supplies will be added in the near future.

Gimmick or trend?

Data disks have come a long way from the first ones that appeared in the mid 1980's. What may have begun as a marketing gimmick is now evolving into a useful engineering trend. Today's data disks cover virtually every discrete and IC product category. New disks are also covering power supplies, sensors, resistors, VLSI chip sets, plastics, and even optics and lasers.

The major force driving the data disk market is that companies are motivated to make it as easy as possible for customers to select and purchase their products. The thrust and cut of competition has helped create a healthy win-win situation: manufacturers view their data disks as marketing tools; users view data disks as time-saving engineering tools. Since introducing their first data disk, Equipto reports an increase in sales leads from 12,000 per year to approximately 75,000 better qualified sales leads per year! That kind of result, coupled with increasing customer demand for faster, easier, and better device-selection tools will continue to assure the proliferation of data disks. For more information, contact CyberSoft, Inc., at 1820 W. Drake Drive, Suite 108, Tempe, AZ 85283, (602)491-0022. R-E

LAST MONTH WE FINISHED BUILDING THE MOTHERBOARD AND THE motor-controller board. Then we covered the operating theory of the power board. So, now let's get to building whatever we haven't covered yet, including the control panel, power board, and mechanical assembly.

Let's mow the lawn already—rather, let's watch the lawn get mowed!

Build the Lawn Ranger

RAYMOND RAFAELS

Construction

Fabricate an aluminum sheet-metal enclosure to house the control-panel electronics; we showed you how to wire everything last month.

As for the manual controller, drill holes in a plastic box to accommodate the components; we showed you a schematic of the controller last month. Feed the ribbon cable through a hole on the side of the plastic box and put a knot on the inside of the box so that the wire can't be pulled through. Fasten the top cover to the box and attach the knob to the potentiometer (P1).

Power-board construction

Following Fig. 1, mount the following components on the solder side (back side) of the PC board: R42, R52, R54, D7–D9, D20–D29, and all E-terminals (they are basically solder posts that allow you to solder heavy-gauge wire to the PC board). Those components are mounted on the solder side in order to create more space for the other components. It is probably a good idea to add a ⅛-inch piece of sleeving insulation to the leads of those components before assembly (with the exception of the E-terminals). That will prevent any accidental shorting of the exposed component leads. After they are installed, trim the component leads. Now install the remaining parts on the component side with the exception of the power MOSFET's.

The MOSFET's require the installation of heat sinks and insulators before assembly. For each MOSFET, place an insulator on the PC board and then cover with a heat sink. Carefully clip off the center lead (drain) of the MOSFET as close to the device body as possible. The lead is not used because the drain connection is also provided by the metal tab on the MOSFET. Bend the MOSFET leads at a 90° angle and insert into the PC board so the device lies flush with the heat sink. Secure the device and heat sink to the PC board with 4-40 hardware.

The high-current jumpers should now be installed on the solder side of the PC board; solder them to the E-terminals. The jumpers are required because the etched traces on the PC board can not handle 15–30 amperes. The jumpers should be made of solid insulated 18-gauge wire. Figure 2 illustrates the three types of jumpers. Install the jumpers on the solder side

Lawn Ranger is a registered trademark of Technical Solutions, Inc.

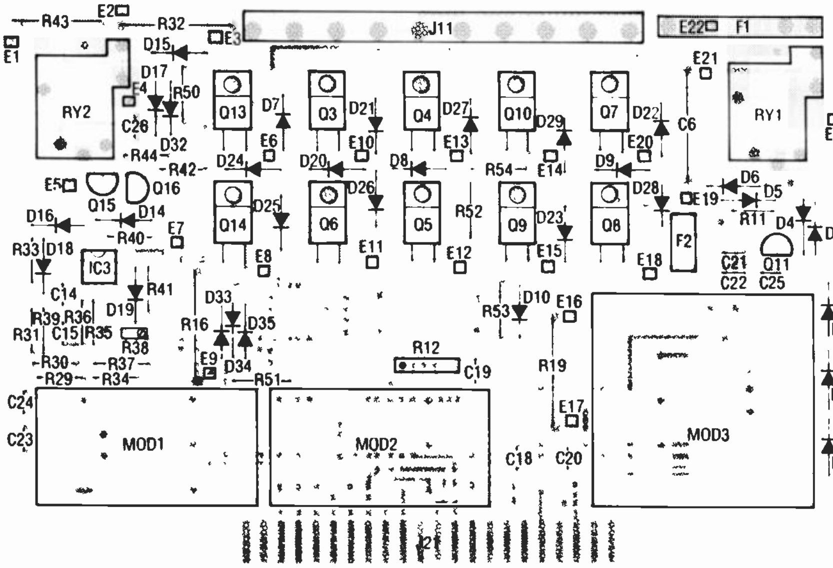


FIG. 1—PARTS PLACEMENT DIAGRAM for the power board. Remember that several components must be mounted on the solder side of the board to leave room for the other components (see text).

of the board as follows:

TYPE-A JUMPERS
E-23 to drain of Q8
E-18 to drain of Q9
E-20 to drain of Q10
E-13 to drain of Q5
E-10 to drain of Q6

TYPE-B JUMPERS
Drain of Q4 to Drain of Q7
Drain of Q3 to Drain of Q4
Drain of Q8 to Drain of Q14
Drain of Q7 to Drain of Q18 (mount on component side)
Drain of Q13 to Drain of Q14 (mount on component side)

TYPE-C JUMPERS
E-23 to E-21
E-18 to J11-10
E-19 to J11-8
E-20 to J11-9
E-17 to J11-8
E-14 to E-15
E-15 to E-16
E-13 to J11-7
E-10 to J11-6
E-12 to E-11
E-11 to E-7
J21-23 to J11-3
E-6 to E-8
E-2 to E-6
E-5 to J11-2
E-1 to E-17
E-1 to E-9
E-3 to E-4
E-22 to J11-4
E-22 to J11-5

Grass-sensor assembly

Build the mechanical portion

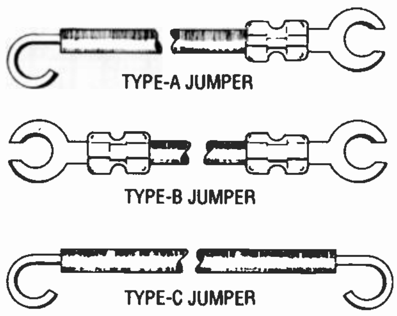


FIG. 2—HERE ARE THE THREE TYPES OF JUMPERS. They are used to handle the high currents that exist on the power board.

of the sensor assembly as shown in Fig. 3, and wire the grass sensors themselves as shown in Fig. 4. The length of the ribbon cable that connects the sensor assembly to J1 on the motor-controller board should be approximately 3½ feet long. Crimp J1 onto the end of the ribbon cable using an IDC crimping tool or vise.

Power-board testing

Inspect all solder joints and jumper connections to ensure that everything is properly assembled. Place the power board on a flat surface (not plugged into the motherboard) and temporarily jumper J11-3, J11-8, and J21-44 with clip leads. Now connect the +24-volt input to the PC board through J11-4 (+) and J11-3 (ground). You should hear the relay "click" on. Measure the DC voltages at J21-32, J21-18, J21-30, J21-31, and J21-19. The voltage readings should match the values listed on the schematic diagram that we showed you last month. If all the voltages read correctly, the DC/DC converters are working properly. Remove the test clip leads from the PC board.

Mechanical assembly

Figure 3 shows the mechanical assembly of the Lawn Ranger. Although it does not include all of the details, detailed mechanical drawings can be purchased from Technical Solutions. However, the chances are that you won't follow the original plans exactly—just as long as you follow the general layout. Also, make sure that the cutting section is safely constructed, and that the blade shield protects the cutting deck a full 360 degrees. WARNING—The cutting blades should not be connected until it has been proven that the Lawn Ranger has been properly constructed, is fully functional, and safe.

Many of the mechanical parts are available from various manufacturers listed in Table 1. The rest of the mechanical components shown in Fig. 3 are not available from TSI; you must either fabricate them yourself or have a local machine shop make them for you.

WHAT'S BEEN COVERED

This series on the Lawn Ranger began in the June issue. In that issue, we covered the general operation of the unit, the software, and we discussed and built the CPU board.

In the July issue, we went over the electronic control system, the motor controller board, D/A converter circuitry, grass-sensor circuitry, motherboard, and velocity-feedback loops. We gave you the parts lists for the motor-controller board and the motherboard, although we didn't get to build them that month.

In August, we began with the construction of the motherboard and the motor-controller board. Then we covered the operation of the power board, drive motors, cutting motors, hand-held controller, and the Lawn Ranger's electronic control panel.

In this issue we have finished up the series. We hope you have found it to be an interesting and worthwhile project. R-E

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VOL. 1 NO. 1

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Issue	Reservations in N.Y.	Final Film in N.Y.
Sept. 1990	June 11, 1990	June 18, 1990
Nov.	Aug. 13	Aug. 20
Jan. 1991	Oct. 15	Oct. 22
Mar.	Dec. 13	Dec. 20
May	Feb. 13, 1991	Feb. 20, 1991

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NEW! NEC 10 Mil HeNe LASER Plus Power Supply $200.00

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By Oriental Motor, Model #PH566-A-Q5, high precision, 500 steps per revolution, 0.72° per step.

HITACHI LCD DOT MATRIX LM215B $29.00
Graphic and Alphanumeric, 480 Dot(W) x 128 Dot(H) High quality device easily Interfaced with microprocessor. Bit map graphics and text. Other applications possible. Driving voltages available at microprocessor port, CMOS/TTL compatible signal level, built-in RAM for display data storage, built-in CMOS LCD driver and controller, supports full ASCII and extended character set, character size 5x7 or 7x9, dimensions 10.6" L x 4.3" W x 4/100" D

HITACHI DIGITIZING TABLET HICOMSCAN HDG-111
Input device through which graphic data is input to a computer.
11" x 10" Dimension **$199.00**
4-Button CURSOR for Digitizing Tablet **$29.95**
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22/44 Connector, .156 spacing **10pcs/$7.50**
25/50 Connector, for Apple **10pcs/$10.00**

COAX CONNECTOR Part #CP-N1 **$1.50**

MONITOR BOARD WITH POWER SUPPLY/HI VOLTAGE $7.95
Video, brightness, focus, vertical, and horizontal with flyback transformer and high voltage parts, Model 99-0493-001 rev D

Replacement CABLES for IBM-like keyboards $2.99

APPLE MANUAL (LaserWriter and LaserWriter Plus) **$5.00**

WATERTIGHT ALARM BELL $19.95
By Henschel Corp., Type IC/BID3, size 3", 24V DC

5 LB. SOLDER $25.00
Wire, Rosin Core, Tin/Lead 60/40, Flux 2.2%, Dia. .036 (20Ga)

HARD DRIVE CONTROLLERS:
Western Digital ST-506 (10-200 Mb)
XT-WD1002A-WX1 **$29** AT-WD1003WAH **$39**

HP NUMERIC DISPLAY 5082-7300 $4.95

DATA LINK CONNECTOR $7.75
(AMP Part #501107-2) Fiber optic field mountable connector used with 125 NM fiber clad OD. This connector mates with AT&T 40 MB/s and 1 MB/s data link products. AT&T F. Eq. Ref. No. 1005B.

AMP OPTIMATE FIBER OPTIC CABLE ASSEMBLY $49
with Biconic Connectors (AMP Part #501450-2) 5 meters long.

SYMBOL LASERSCAN 2000
VISIBLE LASER DIODE SCANNER $899
Hand-held point-of-sale bar code scanner manufactured by Symbol Technologies, Inc.

ORIGINAL IBM MODEL 1130700
COMPUTER PC POWER SUPPLY $19.95
63W 115VAC.

ORIGINAL IBM MODEL 154001438
COMPUTER PC-XT POWER SUPPLY $29.95
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Laser Platform Array Kit Price $499

Can be used for research, design, and engineering in the medical, industrial, and educational sectors. An experimenter's dream in the fields of holography, interferometry, graphic arts, light shows, and projection. The Laser Deck Consists of:

- ❑ A *10 milliwatt* (maximum output) *Helium-Neon laser* tube (NEC Part #GLG 5261) which emits a red beam. The tube is hard seal and 15.5" long by 1.75" in diameter. It is mounted by two transverse mounting fixtures.
- ❑ The *laser power supply* (NEC Part #GLS5281A) powers the laser tube and has an input voltage of 115 to 120 VAC. Output sustaining voltage is 2800 to 3300 VDC.
- ❑ This unit sits on an 18.5 lb precision cast aluminum plate.
- ❑ The *acoustic-optic modulator* (NEC Part #OD8813A) is a 140 Mhz broad band amplifier and will take TTL and video signals. The A-O driver is on the deck also and requires 24 volts to operate.
- ❑ The *polygon motor unit* (Mfr: Japan Electronics) is a ten-sided first surface mirror mounted on an electric motor that spins at approx. 26,000 rpm. The driver for the polygon unit is on the deck and requires 24 volts to operate.
- ❑ In addition to the main items above, there are (5) *special surface mirrors*, (2) *beam splitters* and (3) *special lenses* all attached by optical mounts which guide the laser beam to various sensors and places to give the desired result, a reproduced copy of information.
- ❑ We have available an excellent 24 volt LAMBDA™ power supply at 49.95 that will power both the Acoustic-optic modulator and driver and polygon motor unit and driver.

Laser Beam Modulator $398
(Acoustic-Optic Modulator and Driver)

MC14016 tube of 25 **$5.00**
Tri-state switch, CMOS

Argon-Ion Laser (Air Cooled) $2995

These lasers emit visible blue and green lines. Power output is 110mW. They are re-built with brand new tubes and power supplies. Manufactured by a major laser company, they are excellent for laser shows and holography. These lasers are guaranteed for one year.

NINTENDO GAME CONNECTOR **$9.95**
The black connector inside game unit that game cartridge fits into. Often needs replacing when cartridge makes intermittent contact. Almost impossible to get.

POWER SUPPLY **$9.95**
Bikor Corp. LBA 5-6, Input 115/230VAC, 47-440Hz, Output 5V DC at 6.o AMPS.

HALOGEN LAMP **$2.85**
Toshiba JH115V930WK1A, 17" long, 120V.

HP 10-ELEMENT BAR GRAPH ARRAY **$2.00**
HDSP-4820 (red)

HITACHI DIGITIZER **$99.00**
Comscan HDG-111, grid board/mother board, no plastic case, you build the case. Standard serial interface (15" X 15-1/2"), works on a PC.

IC SOCKETS **$1.00**
40 pin, Robinson-Nugent, tube of 10

MICRO-CONTROLLER—8048 **$1.50**
ROM is already programmed--you find a use, we've got 40K of these!

HITACHI DIGITIZER **$199.00**
HDG-1515BN-C, grid board/mother board, no plastic case, you build the case. Standard serial interface. Runs all versions of autocad. Cannot be used with mouse emulation.

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COMPUTER POWER SUPPLY

130W 115 VAC
IBM-XT
Model 1501438

(+5V, +12V, -5V, 12V)

These are brand new supplies. They make an excellent workbench power supply for experimenting. They can also be used in XT computers and other electronic equipment.

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Model 1130700

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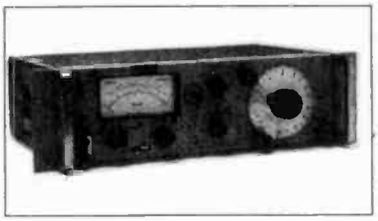
A.C. POWER SUPPLY
STACO MODEL E1010VA

This unit has been designed and constructed for rigorous industrial, classroom or laboratory applications. These power supplies are brand new. Current list price $750.00. Specifications: Input: 120 VAC 50/60 HZ. Output: 0-120 VAC 10 amps. Includes manual with schematics. Features: Ammeter, voltmeter, convenience outlet, power indicator and circuit breaker. Dimension: 10" × 15" × 6". Weight: 22 lbs.

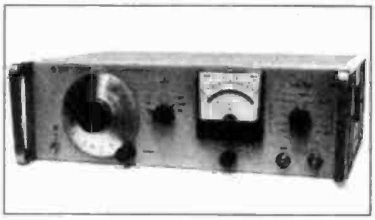
Price: $165



HP 333A DISTORTION ANALYZER

Covers 5 Hz to 600 kHz range. Measures down to 0.1% fullscale distortion. Includes auto nulling feature to speed up time consuming portion of measurements. Also includes switchable high-pass filter to attenuate frequencies below components.

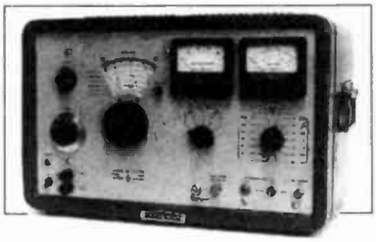
Price: $695.00



HP 651A TEST OSCILLATOR

Frequency range is 10 Hz to 10 MHz in six bands. Dial calibration, 1 to 10. Dial accuracy is ±2%, 100 Hz to 1 MHz, ±3%, 10 Hz to 10 MHz. Output of 200 mW (3.16 V input 50 Ω); 16 mW (3.16 V input 600 Ω); 6.32 V open circuit. Output monitor voltmeter monitors level at input of attenuator in volts or dB; accuracy is ±2% at full scale; frequency response is flat within ±2%, 100 Hz to 1 MHz; ±3%, 10 Hz to 100 Hz; ±4%, 4 MHz to 10 MHz. Attenuation range is 90 dB in 10 dB steps; overall accuracy is ±0.1 dB.

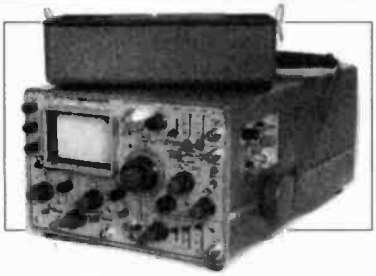
Price: $295.00



HEWLITT PACKARD
MODEL 606A SIGNAL GENERATOR

Signal Generator: Freq. 50kHz to 65 mHz in 6 bands ± 1%, freq. call 100kHz and 1 mHz, RF output 0.1 uV to 3.0V at 50 ohms ± 1dB over freq. range, output VWXR—30 DBC leverage 0.10V, modulation 0 to 100% +0.5DB over freq. range. Internal: 400 Hz/1000Hz ± 5%; External: DC to KHz. Power 115/230V, 50 to 1000 Hz, 135 watts. Size: 20¾" (W) × 12½" (H) × 14¾" (L). Wt. 46 lbs.

Price: $250.00



TEKTRONIX MODEL 453
OSCILLOSCOPE

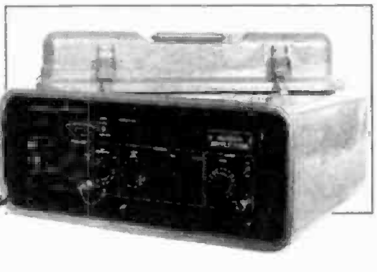
Vertical, 2 Channels. Bandwidth and risetime: 10 mV/div to 20 mV/div: DC to 50 MHz, 7 ns. 10 mV/div: DC to 45 MHz, 7.8 ns. 5 mV/div: DC to 40 MHz, 8.75 ns. Calibrated Deflection: 5 mV to 10 V/div in 11 calibrated steps (1-2-5 sequence). Input RC: 1 megohm ± 2%, 20 pf ± 3%. Modes: Channel 1, Channel 2 (normal or inverted), added alternate and chopped. Has vertical delay line. Horizontal: Time Base A: 0.1 us/div to 55/div in 24 steps. Length continuously variable from 4 div to 11.0 ± 0.5 div. Time Base B: 0.1 us/div to 0.5 sec/div in 21 calibrated steps (1-2-5 sequence). X 10 Magnifier: Increases sweep rate to 10 n sec/div. Triggers after delay time or starts after delay. Time Base A Trigger Modes: DC internal/external: AC, ACLF reject, AC HF reject. X-Y operation Ch 1 horizontal, Ch 2 vertical, 5 mV/div to 10 V/div in 11 calibrated steps. B.W. is DC to ≥ 5 MHz (−3dB). Horizontal Amplifier (ext in) 270 mV/div or 2.75 V/div in external ÷ 10 position. Calibrated sweep delay: 0.2 us to 50 sec. General: Power Requirements: 90 to 272 V @ 48 to 440 hz. Size: 7¼" (H) × 12½" (W) × 20½" (D) > Wt. 27¼ lbs. Includes manual.

Price: $400.00

I.R. TANK PERISCOPE

Type M-24. Rugged military construction. Contains two independent infrared image converter tubes plus correction lenses, prisms, and eyepieces. The binocular viewing system is directly connected to a prism-type periscope. The image tubes have dynamic focus provided by a built-in adjustable voltage divider. This unit requires 10 to 15 KV at low current for operation. Unable to supply power supply. (Dimensions: 18" high × 9" wide × 4½" thick. Weight 17 lbs.) Stock #OP 9001

Price: $200.00



HEWLETT PACKARD 8640B-OPT 323
SOLID STATE SIGNAL GENERATOR

(w/o synchronizer) Frequency range: 450 KHz to 512 MHz, to 1100 Mhz with external frequency doubler option (not supplied). Ten Frequency bands in octave increments from 500 KHz; band 11 for doubler use. Accuracy: 6 digit LED read out. Stability: < 1000 ppm. Output power: −145 dBm to +10 dBm (0.013 V to 2 V) into 50 Ω. Level flatness is < +0.5 dB from 0.5 to 512 MHz. Impedance is 50 Ω, VSWR < 2.0 on 2 V and 1 V range < 1.3 on other ranges >. Spectral Purity: Harmonics at 1 V outpt > 35 dB below fundamental of 0.5 to 128 Mhz; > 30 dB below fundamental of 128 to 512 MHz. Modulation: Internal AM, FM and PM, external AM, FM, and PM. Pulse frequency: 0.05 to 5 KHz. General: Power Requirements: 100, 120, 220, 240 V, 48 hz to 420 hz, 2 amps. Note: OPT 323 built to military specifications. Ruggedized performance for better operation under severe environment. Size: 6" (H) × 19" (W) × 13¾" (D). Wt. 60 lbs. Includes ruggedized case and manual.

Price: $1850.00

Current Hewlett Packard Price $12,050.00

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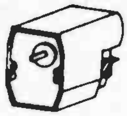
MINIATURE GEAR MOTORS

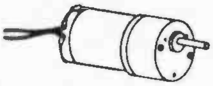


Buehler series 61.13 Miniature DC gearhead motors. Reversible. Motor and gearhead enclosed in rugged die-cast housing. 1.55" X 1.122" X 1.475". Long-life bronze bearings. 0.115" diameter flatted shaft. Two types available:

18 volts dc (nominal) @ 50 ma.
10 rpm @ 14 Vdc (no load)
17 rpm @ 24 Vdc (no load)
CAT# MOTG-18 $5.50 each

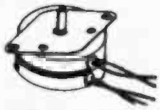
38 volts dc (nominal) @ 70 ma.
274 rpm @ 24 Vdc (no load)
451 rpm @ 38 Vdc (no load)
CAT# MOTG-38 $5.50 each

12 VDC GEARHEAD MOTOR



Soho# GBL 35-DH-21080-10Y Powerful little gearhead motor. 40 RPM @ 12 Vdc. 0.5 amps (no load). 32 RPM with load. Operates at lower voltages with reduced speed and torque. 6.3 pound inches torque. Stall: 27 pound inches. 3.1" long X 1.375" diameter. Shaft: 0.187" dia. X 0.75" long. **CAT# MOTG-14** $11.50 each
10 for $100.00

STEPPING MOTORS

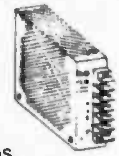


Airpax# C82711-M1
17 Vdc 23.25 ohm dual coil, permanent magnet stepper motor. 7.5 degrees per step. 2.25" dia. X .91" thick. 0.25" dia. shaft is 0.6" long. Two hole mounting flange, 2.625" centers. 6 wire leads.
CAT# SMT-6 $6.00 each • 10 for $50.00

Airpax# C 82710
12 Vdc, 36 ohm dual coil permanent magnet stepper motor. 7.5 degrees per step. 2.25" dia. body X 0.93" high. Mounts on 2.675" centers. 6 wire leads.
CAT# SMT-7 $7.00 each • 10 for $65.00

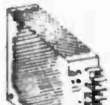
POWER SUPPLIES

5 VOLT, 5 AMP



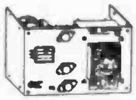
Lambda# LUS-9A-5
Switching power supply.
Input: 85-132 Vac 47-440Hz or 110-165 Vdc 37 watts
Output: 5 Vdc ± 5% @ 5 amps.
Overvoltage and overcurrent protection. 120 mV ripple. 5.2" X 3.8" X 1.375". Grey, vented metal case. UL and CSA listed.
CAT# PS-55 $14.00 each

12 VDC 2.1 AMP



Lambda# LUS-9A-12
Fully enclosed switching power supply with screw terminal connections.
Input: 120 Vac 60 Hz.
Output: 12 Vdc ± 5% @2.1A overvoltage and overcurrent protection.Compact ventilated case measures 5.24" X 3.81" X 1.38" overall. Includes instruction sheet.
CAT# PS-122 $23.50 each

24 VOLT DC - 2.4 AMP



Power-One Inc.# HC24-2.4
Input: 115/230 Vac (wired for 115Vac)
Output: 24 Vdc @ 2.4 amp. Brand new open frame power supply with line and load regulation, remote sensing, overload and short circuit protection. 5.62" X 4.87" X 2.50". CSA rated.
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6 mhz **CAT# CRY-618S**
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MINIMUM ORDER 100 PIECES

100 of either VALUE $75.00
500 of either VALUE $300.00
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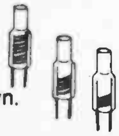
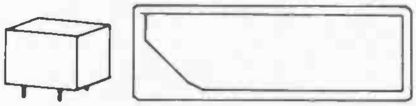
CHOKE GRAB BAG



8 pieces, 2 each of 4 different tunable chokes. Actual values unknown.
CAT# GRCK $1.00 each

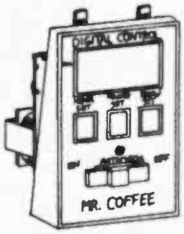
ELECTROLUMINESCENT STRIP(GLOW STRIP) AND INVERTER



Electroluminescent strips used for back-lighting control panels or as decorative or emergency prime lighting source. They are thin, tough and flexible and operate on low current. They operate on AC voltage, and the preferred power source is a miniature DC to AC inverter. We received a supply of glow strips that have a bit of an odd shape. The strips are 2.15" wide X 5.88" long and are 0.035" thick. The luminescent area is 5.3" long X 1.72" wide and has one corner cut off, leaving a useful area of fairly good proportions. We are selling the strips and inverters as a package.
Inverter operates on 6 Vdc.
Glow strip, inverter and hook-up diagram
CAT# GS-500 $5.00 per set

EXTRA INVERTERS
Input: 6 Vdc Output: 225 Vac
CAT# INV-1 $2.00 each

DIGITAL CLOCK AND APPLIANCE TIMER



Turn on lights, radio, VCR automatically. Digital clock and appliance timer removed from automatic electric coffee makers due to design changes. Operates on 120 Vac and is capable of turning on appliances drawing up to 10 amps. Because of the application they were designed for they automatically turn off after two hours. Guaranteed to work but some have surface blemishes. 4.2" X 2.45" X 1.1" deep. Beige or ivory with brown trim. **CAT# MCT** $6.50 each

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STEPPER MOTOR $3.95
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4 windings. 7V @ 350 mA
1.8° (200 steps per rev.)
DC. res. 20 ohm ea. 25 oz. in.
torque. Works great on 5vdc. W/Data
FOR ROBOTICS

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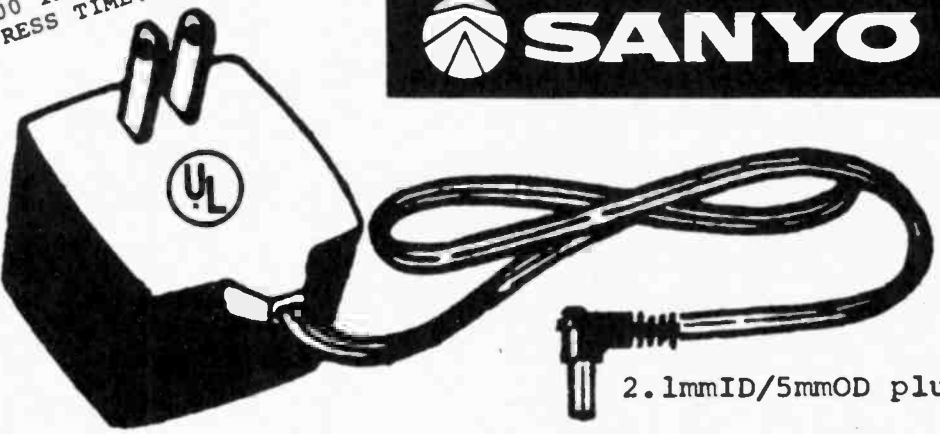

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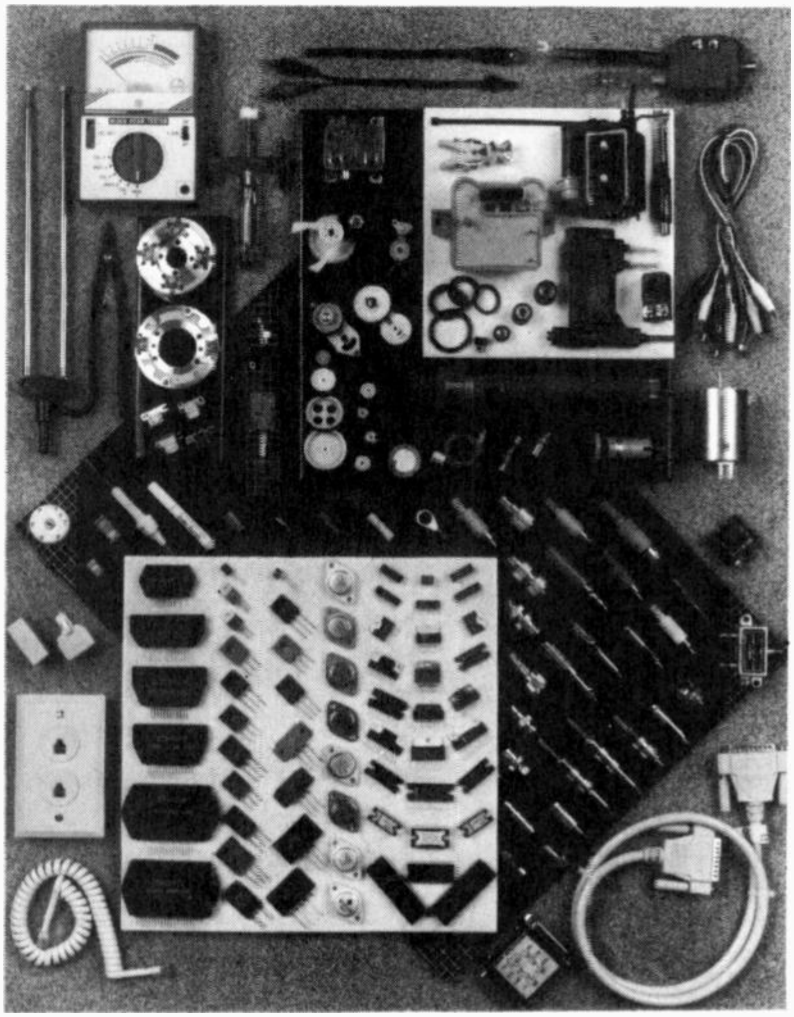

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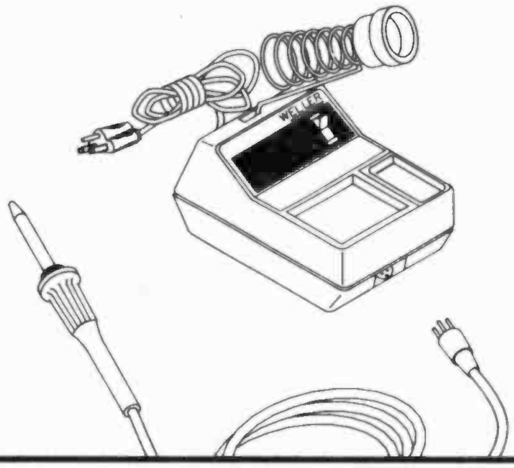

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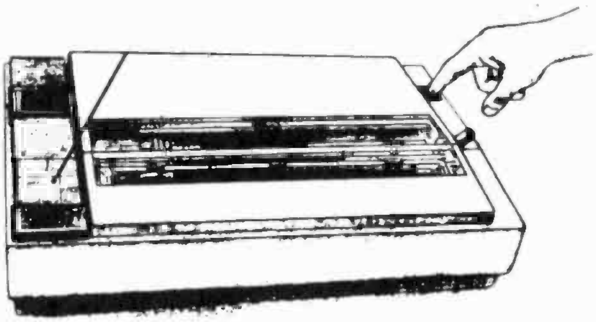

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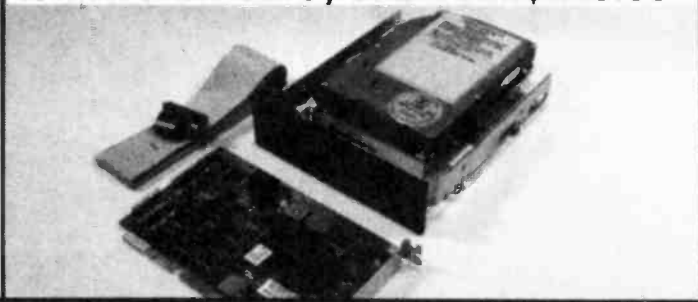

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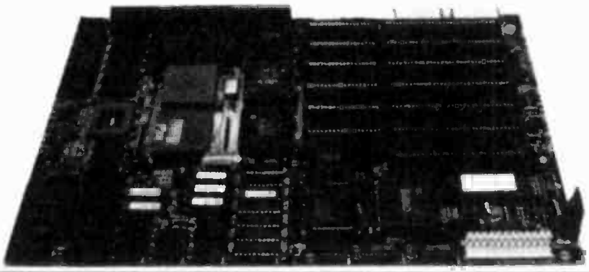

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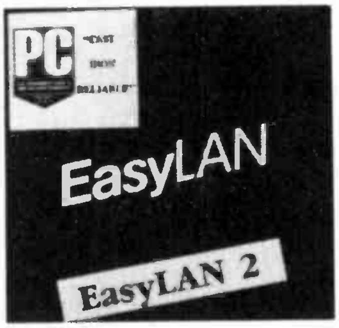

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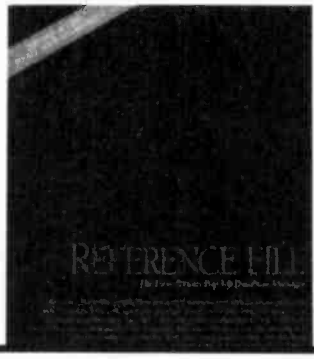

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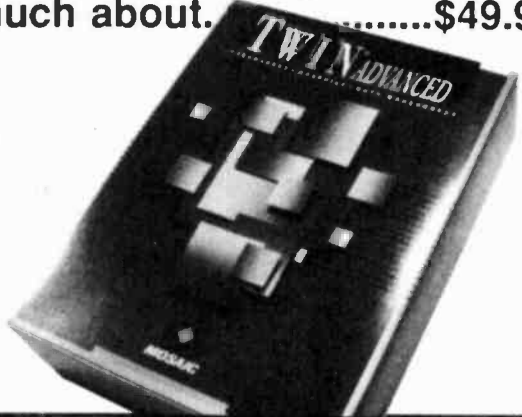

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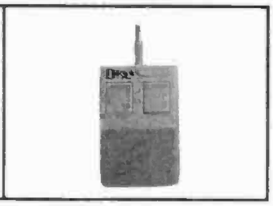

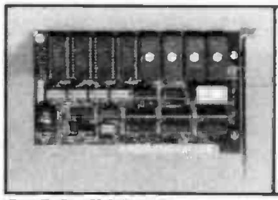

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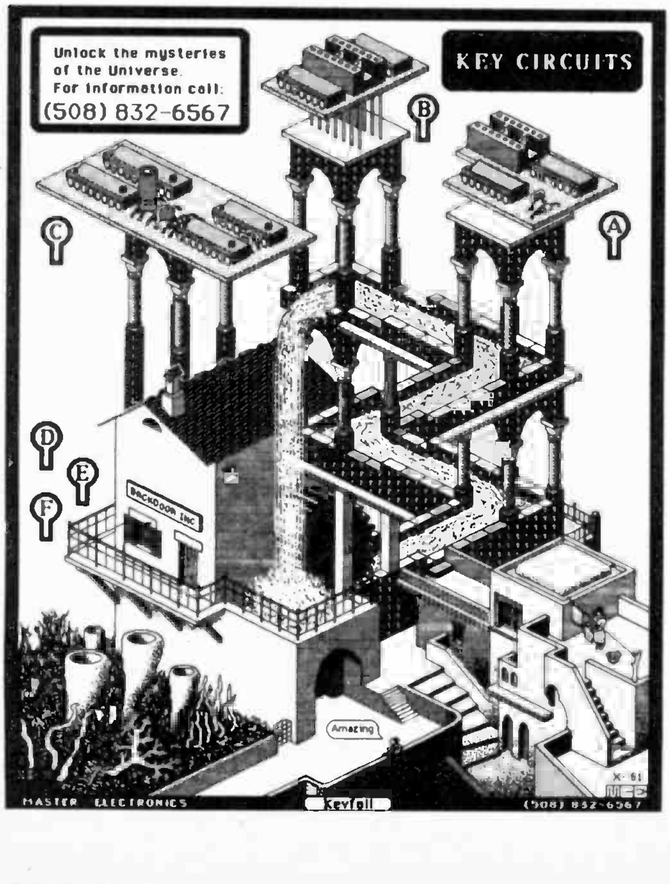

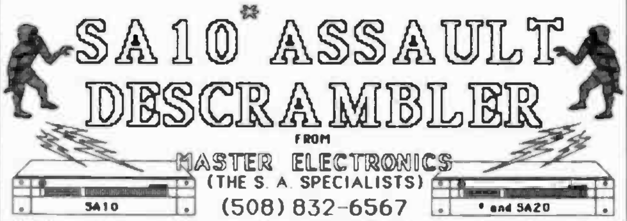

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C6356 $13.95

INFRARED DETECTOR KIT
* Detects ALL Types of Infrared (TV/VCR Remotes, LEDs)
* Produces Sound and Bright Red LED Output
* Operates from 9V Battery (not incl.)

C6441 $5.95

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$1.00 Each

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☐	20	Plastic Transistor PC Leads	G706
☐	30	Capacitors-Disc & Electrolytic*	G707
☐	2	CDS Cells	G708
☐	2	Solar Sensors	G709
☐	40	Tiny 1/8W Resistors*	G710
☐	10	1N4004 Diodes	G711
☐	12	LEDs-Different Colors, Sizes*	G712
☐	4	Circuit Board with Bubble Readout	G713
☐	20	Surface Mtg. Chip Capacitors*	G714
☐	20	Surface Mtg. Chip Resistors*	G715
☐	20	Silver Mica Capacitors*	G716
☐	20	Micro Red LEDs on Strip	G717
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☐	20	9V Mini Zeners	G719
☐	10	3MM Ultrabright Green LEDs	G720
☐	10	Small Single Turn Trim Resistors*	G721

Items marked with * are assortments and will contain several different values.

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Small diameter unjacketed fiber optic strand. Perfect for 1000's of applications. Fun to use and experiment with.

G722
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HIGH QUALITY!
2 mil bags with white block to write on. Sold in packages of 100 only.

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Unique game timer features 4 LEDs that extinguish one at a time over a ONE minute period as the unit increases its beeping. Great timer for games. Operates from 9V battery (not incl.).

G723 $2.95

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Great Bargain!

Perfect for almost all 9V battery powered items. Has 9V snap, filtered output. For 120VAC.

G724 $1.69

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Thin flexible PC material can be cut with scissors. Double sided 4" x 6".

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Tungten carbide.
Most popular size for PC boards.

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MAGIC SOUND SWITCH
Triggers with clap of hand. Turn on low voltage lamps, motors. With Schematic. Operates on 3VDC.

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Perfect for building our kits. Operates from 120VAC.

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SPECIAL PC SOLDER
Perfect solder for our kits. Low melting, excellent conductivity, micro thin solder, SN60 .031 Dia. made by Kester.

H1201 — 6Ft Coil — $1.50
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Great combo of mini straight xenon tube & trigger coil

A1039 $1.75

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SPDT type with mounting hardware

L1806 $1.00

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Small 4 lead transformer for use with 555 IC to convert 12VDC to 250V for strobe/fluorescent tubes with schematic.

N1703 $2.00 Each
1,000 for $1,500

4KV TRIGGER COIL
For strobe tube

3 Lead N1700 **1.25 Each** **1,000 for $650**
4 Lead N1701 **1.45 Each** **1,000 for $700**

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FLASHING RED LED
Flashes when 5VDC is applied. Red diffused case.

G301 79¢

CIRCLE 346 ON FREE INFORMATION CARD

PORTABLE DATA LOGGERS. A line of full-featured, rugged, data-gathering products that tie directly to thermocouples or voltage- or current-output devices has been introduced by *MetraByte*. The *DDL-400 Series* data loggers, and the variety of available hardware and software accessories, allow the user to configure a system to meet specific application requirements in the lab, factory, or field. The IBM-compatible, programmable, menu-driven data loggers offer 16 analog input channels, four digital inputs, and 16 alarm outputs. A sealed-membrane keyboard on the front panel controls functions such as data-logging interval, Hi/Lo alarm limits, channel select/skip, and time/date settings. The LCD readout shows channel data, alarm limits and status, time, and date.

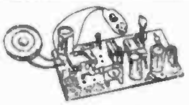
Each data logger requires a *TCV-16* I/O panel, a slide-in module that has 16 single-ended inputs for thermocouple, voltage, or current signals as well as 16 logic-level alarm outputs and four digital input channels for contact closures or logic levels. Each channel is independently configured by a 10-position range switch. Optional *Applications Software* allows remote control of one or more data loggers.

CIRCLE 321 ON FREE INFORMATION CARD

Every alarm in the system is independently and continuously checked at full speed at least every four seconds. Limit values are stored in non-volatile memory.

continued on page 28

RAINBOW KITS



RADAR SIGNAL DETECTOR

If you think that a sensitive radar detector is a complicated piece of equipment, take a look at this new kit. This simple, yet effective, detector circuit can be built in less than an hour and can be tuned to respond to signals between 50MHz to 500GHz. It's a fun kit to build and play with. A cigarette lighter plug is included. 1"x¾" operates on 9 to 15v DC.

KIT RSD-1 **$12.95**

STROBE LIGHT

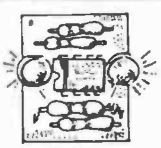
If you need an attention getter, or warning light, you need the strobe light kit. Use it for emergency light for autos, for model planes or radio towers. Even use it on your bicycle. Operates on 6 or 12v DC and has a variable strobe rate.

KIT ST-1 **$8.95**

DIGITAL THERMOMETER

Have you ever wanted to tell temperature changes fast & accurately? The DT-1 kit will turn your digital volt meter into an accurate digital thermometer with .1 degree resolution. It gives you a 250 degree window with a range from -40F to 300F degrees. It has a remote sensor .25" sq. that can be mounted many feet from the meter if need be.

KIT DT-1 **$8.95**



BLINKEY LIGHTS

Want to attract attention? These kits are perfect for decorating name tags, lighting up your hat, or flashing lights for your model trains. Some people use them to simulate a burglar alarm for autos. Put it in a box, set it on your dash and it looks like the real thing. Each kit contains two LEDs that alternates flashing. Operates on a 9v battery. Size .5"x.5"

KIT RB-2 **$3.45**

CAPACITANCE METER

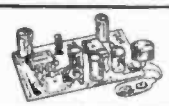
This easy to build kit will turn your digital volt meter into a CAPACITOR METER. Turn that junk box of unmarked capacitors into a fortune. Measures capacitors from (2pF to 2.2uF. Operates on a 9v battery. Size 1.75"x2"

KIT CA-2 **$12.95**

WIRELESS FM MIKE

Small but mighty .8"x1" PCB, will really stomp out a signal well over 400 yds. This is a buffered wireless mike that operates on 80 to 120 MHz FM. Comes complete with a microphone, and 9V battery connector. Operates on 6 to 12v DC.

KIT WM-1 **$12.95**



SUPER SNOOPER-BIG EAR

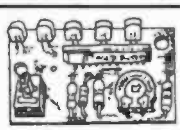
Use this BIG EAR amplifier to listen through walls, hear conversations across the room. Beef up the sensitivity with a parabolic reflector and hear blocks away. Due to the size, the BIG EAR can be hidden about anywhere. Use the earphones from a pocket transistor radio to listen. Makes an ultra-sensitive intercom. Can also be used as a general purpose 1.5W amp. We supply a mini-microphone in the kit. You can also use any 8 to 45 ohm speaker. Operates on 6 to 12v DC. Size 1"x1.75"

KIT AA-1 **$10.95**

AC LINE MONITOR

This is something every computer user, photographer, or anyone that must maintain a safe usable AC line voltage should have handy. Monitor the voltage of your motor home's 110v AC generator inside the motor home. Every technician's bench needs this item. The AC line monitor will indicate, with multi-color LEDs, what voltage is being distributed to your equipment at that particular outlet.

KIT LM-110 **$10.95**



12V BATTERY MONITOR

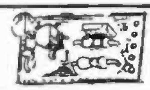
Have you ever been in your car, boat, or camper — you try to start your motor but the battery is dead? The BATTERY MONITOR kit uses the cigarette lighter plug outlet to monitor the true battery voltage. Multi-color LEDs indicate the voltage in 1v steps from 11v to 15v, green means great, yellow is good, and red — call the tow truck or get out the oars. Size 1.2"x1.75"

KIT LM-12 **$5.95**

PHONE BUG

Small but mighty, so small it fits anywhere. Telephone line powered, never needs batteries. Transmits both sides of a phone conversation loud and clear, wireless, to any FM radio at great distances away. Variable tunes 70MHz to 130MHz. It can also be used to make any phone a speaker phone. Size .55"x1".

KIT TEL-B1 **$10.95**



PHONE RECORDING SWITCH

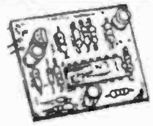
This telephone line powered switch is small enough to install anywhere only .9"x.6". Every time someone picks up the phone the tape recorder will record both sides of the conversation automatically. Use it in your office to record all phone conversations so you don't lose that important address you wrote on the back of an envelope.

KIT TEL-SW 1 **$10.95**

BUSY PHONE LIGHT

Add this little kit to any or all of your phones. When any extensions are in use the LED will light. Uses a 9v battery. P.C. Board 1"x½". Complete with etched & drilled PCB, all parts and schematics.

KIT TEL-LIT-1 **$9.95**



VOICE ACTIVATED SWITCH

This vox can be used to operate a tape recorder, ham radio, CB radio. Use it to turn on an alarm. The output can operate a load up to 100ma. It will operate a relay, lights, motor, or LEDs. What could you do with a sound activiated switch? Size 1.5"x1.25"

KIT VOX-1 **$6.95**

LIE DETECTOR

This kit can be great fun at parties. Lie and an audible tone will change, the more you lie the more the tone changes. When you lie your palms & forehead sweat. This kit allows you to measure these changes. Only a very slight amount of change will cause the tone to increase in frequency. Operates on 6 to 12v DC. Size

KIT LD-1 **$9.95**

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- X WE HAVE THE BEST UNIT YOU CAN BUY AT ANY PRICE
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- X USE ON ANY VCR
- X THE ONLY UNIT WITH THE ENHANCING SWITCH
- X 100% MONEY BACK GUARANTEE

VIDEO STABILIZER

If you rent movies you need THE STRIPPER

When watching rental movies you will notice annoying picture flashing from dark to light, color shifts, unwanted lines, & picture jitters. This is caused by the copy protection installed in the video tape by the manufacturer. **THE STRIPPER** completely eliminates all copy protection and gives you crystal clear copies.

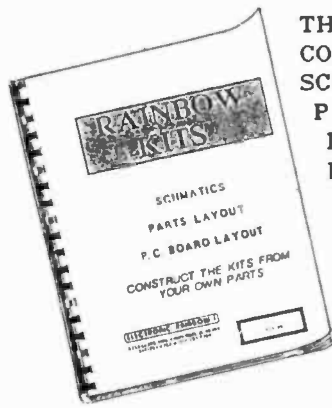
WE HAVE THE ENHANCING SWITCH

SOME NEW COPYGUARD SCHEMES REQUIRE ADDITIONAL CIRCUITRY TO CLEAR THE PICTURE COMPLETELY OF UNWANTED LINES AND PICTURE INTERRUPTION. THIS IS THE PURPOSE OF THE ENHANCING SWITCH. *NO OTHER UNIT ON THE MARKET HAS THIS FEATURE!*

THE STRIPPER'S intended use is to stabilize and restore crystal-clear pictures to prerecorded video tapes for your plersonal viewing enjoyment. Electronic Rainbow doesn't recommend using The Stripper to duplicate perfect copies from rental tapes in your own home for your personal use.

COMPLETELY BUILT **$49.95**

WARNING: Use of this device to duplicate copyright material may be against certain federal & state laws.



THIS MANUAL CONTAINS ALL SCHEMATICS, PARTS & P.C. BOARD LAYOUTS FOR ALL OF THE RAINBOW KITS. USE YOUR OWN PARTS TO CONSTRUCT ANY OF OUR KITS.

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Optimum survival and security radio equipment, methods, frequency allocations, voice/data scrambling/encoding. Includes small receivers and xmitters; telemetry, antenna optimizations; remote monitoring, control; security; surveillance; and ultrasonic, fiberoptic, infrared commo. 70+ Circuits. **$29.**

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Plans for undetectable (ultra-hi input impedance), indestructible **TELECORDER** to record phone conversations. Also monitors for bugs, taps. Plus simple FM Xmitter plans. Plus ear-piercing **SHRIEK CIRCUIT** plans. **$14.** Module **$195. SHRIEK MODULE $95.**

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How electric energy meters work; calibration; many error modes; ANSI Standards. **Demand Meters**, Pole Meters, Polyphase Meters; meter creep, overload droop. **$19.**

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Plans for neat devices to change voice frequencies. Effective against snoops using voice analyzers; to conceal gender for women living alone; for electronic games; for anti-intrusion systems; for musical accompaniment; for seances; as a gag; as a doorbell substitute; etc. **$19.** Module **$95.**

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Heat/cool with simple, amazing 3-Port Device. Uses no moving parts, electricity, fossil fuel, liquid or freon. Guaranteed Scientifically Sound. Plans. **$14.**

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Powerful, versatile menu-driven program allows you to dial any number (up to 10,000) or mix of local and long distance phone numbers in any order, over any length of time, whether busy or answered (your choice) and log the times, commands and results to monitor, printer and-or disk. Quick-dial directory of up to 600 numbers! BUSY redial options. Direct modem command and control! All Result Codes, including VOICE and RINGING. Optional shell to terminal program upon CONNECT. Exit to Menu or DOS (for batching). Ideal as a "**Wargames**" dialer, phone call logger and telemarketing dialer. **Disk* + Manual $29.** With **LABELS** and **LETTERS** programs **$49.** Optional **TeleMark. Interface $295.**

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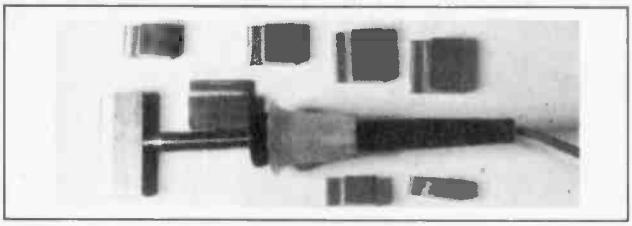
*Software supports **PCDOS, MSDOS, PS/2;** Mono, Herc., CGA, EGA, VGA, 5.25", 3.5", hard (specify your floppy drive size).

REMOVE IC'S *FASTER*



with this simple invention than any other method, including $6,000 vacuum desoldering stations. Salvages hundreds of good IC's per hour from junk boards, and also speeds up repairs. Won't damage IC's or circuit board. Removes 6 thru 40 pin IC's. This is a money making labor saving tool. Order now. We pay shipping on prepaid orders.

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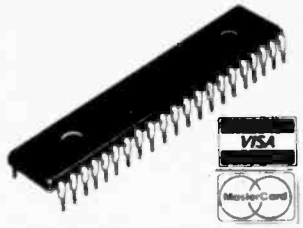

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LA1201	0.95
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LA1222	1.65
LA1231	1.55
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LA1260	1.60
LA1365	0.65
LA3115	1.35
LA3155	1.25
LA3160	0.80
LA3201	0.95
LA3220	0.90
LA3301	1.45
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LA3350	1.75
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LM340T-12	0.30
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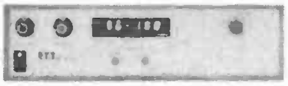

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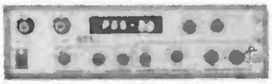

PGS-33
$1355
.100000 Hz. - 33 MHz.

PGS-33

Provides digital pulse train synthesis with six digit resolution. Control of single and dual pulse delay and duration. Multi-modes including burst pulse train and variable duty cyle. Output to 20 Vp-p with 50 ohm impedance. D.C. offset with TTL.

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PM-100 $855

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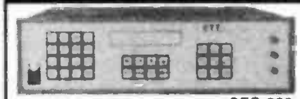

SFG-33
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.100000 Hz. - 32.9999 MHz.

SFG-330

SFG-33

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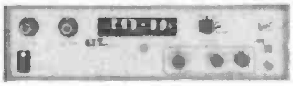

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$1095
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CSS-33

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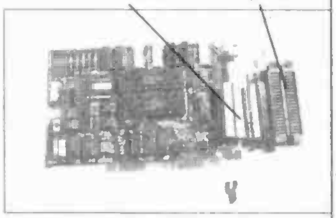

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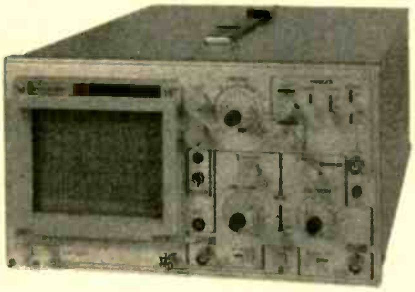

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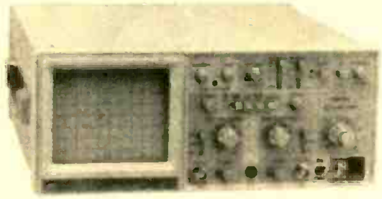

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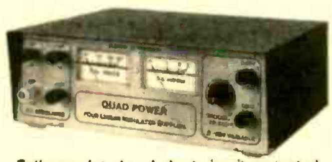

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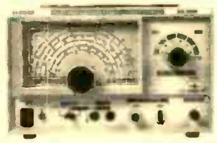

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continued from page 22

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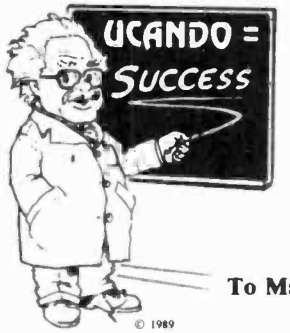

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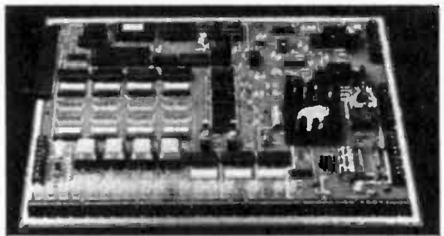

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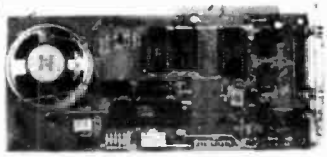

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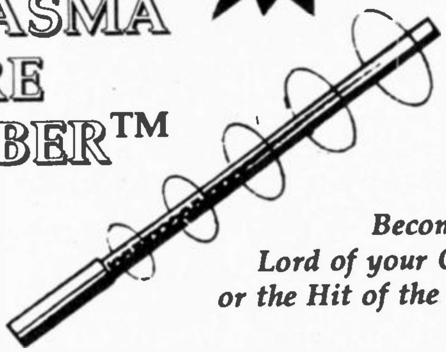

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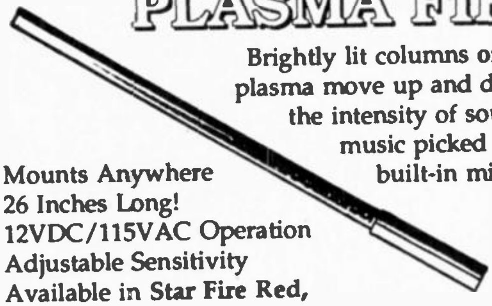

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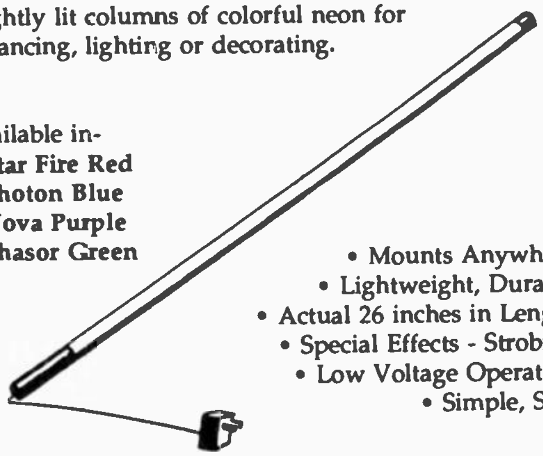

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Ads received by our closing date will run in the next issue. For example, ads received by June 11 will appear in the September, 1990 issue that is mailed on July 10. No cancellations permitted after the closing date. No copy changes can be made after we have typeset your ad. NO REFUNDS, advertising credit only. No phone orders.

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190 — Cable TV	360 — Education	540 — Music & Accessories	710 — Telephone
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Scientific Atlanta Combo
Model 8536. Works on all SA systems Channel 3 output Original equipment
Lots of: 1 $260 5 $225 $215 Lots of 10
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With new remote, 61 channel manual fine tuning Original equipment
Lots of: 1 $134 5 $115 $95 Lots of 10
Hamlin Tag-Alone Descrambler
MLD-1200 Available channel 2 or 3 output Original equipment
Lots of: 1 $64 5 $55 $45 Lots of 10
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Add-on descrambler with power supply Original equipment
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Non vari-sync (Vari-sync available) Original equipment
Lots of: 1 $79 5 $60 $50 Lots of 10
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Jerrold Tri-bi
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Lots of: 1 $95 5 $75 $65 Lots of 10
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Jerrold JRX 3 DIC Combo
With wire remote Channel 3 output 36 channels Original equipment
Lots of: 1 $84 5 $74 $55 Lots of 10
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Lots of: 1 $74 5 $65 $55 Lots of 10
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Available all channels
Lots of: 1 $24 5 $19 $14 Lots of 10
BRAND NEW
Panasonic Converter TZPZ145N
w/remote control, 83 channel Standard/Hrc switchable Favorite channel memory Channel scan, last channel recall Channel 2 or 3
Lots of: 1 $85 5 $76 $71 Lots of 10
MMDS Zenith
SSAV-1 Add-on Descrambler for wireless cable systems
Lots of: 1 $225 5 $200 $175 Lots of 10
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SA-3 Add-on descrambler
Lots of: 1 $109 5 $86 $70 Lots of 10
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Converter with remote 6 channel, Standard Automatic fine tuning Channel 3 output
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Oak N-12
Minicode descrambler Non vari-sync (Vari-sync available) Original equipment
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Signature Date

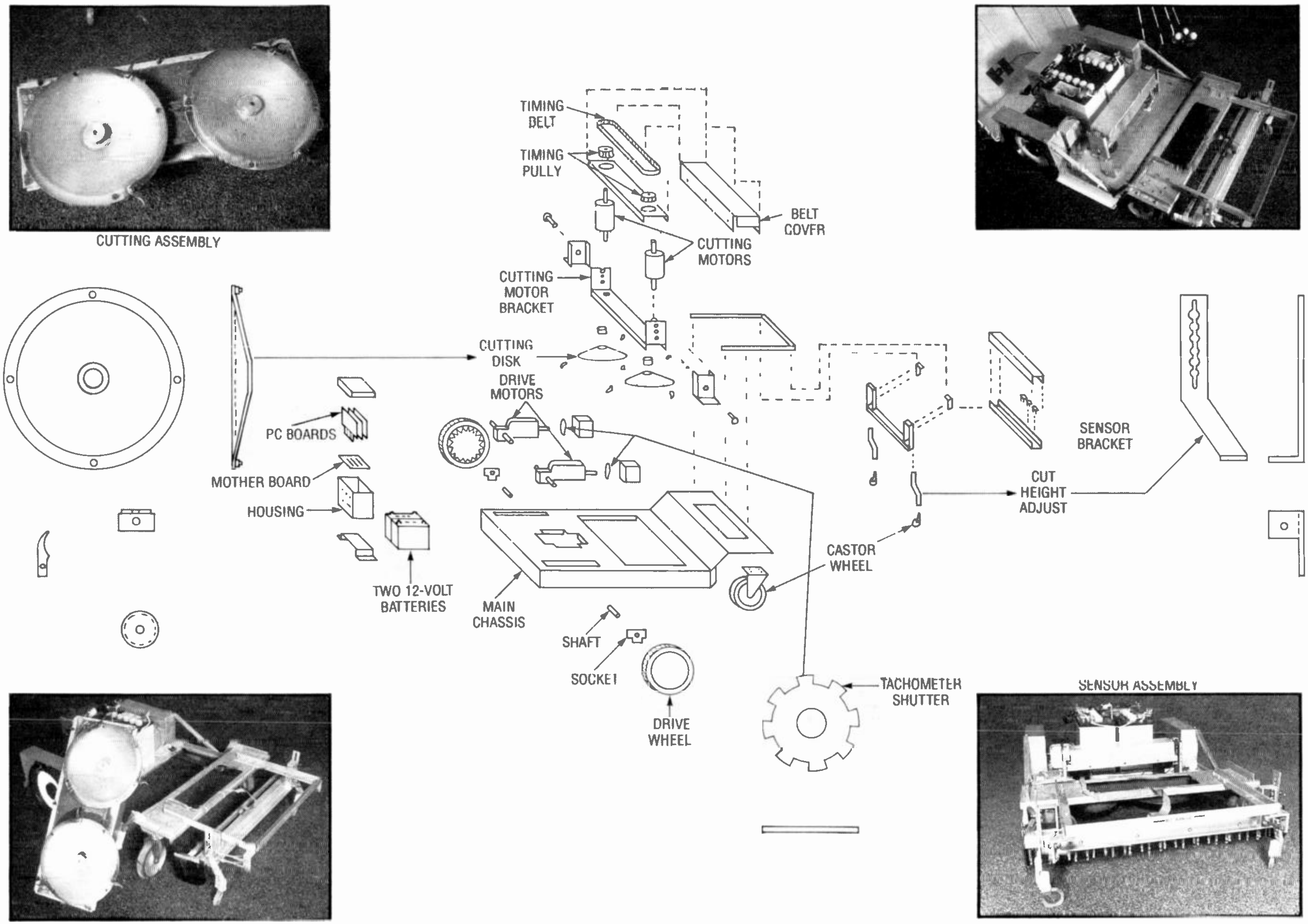


FIG. 3—THE MECHANICAL ASSEMBLY of the Lawn Ranger.

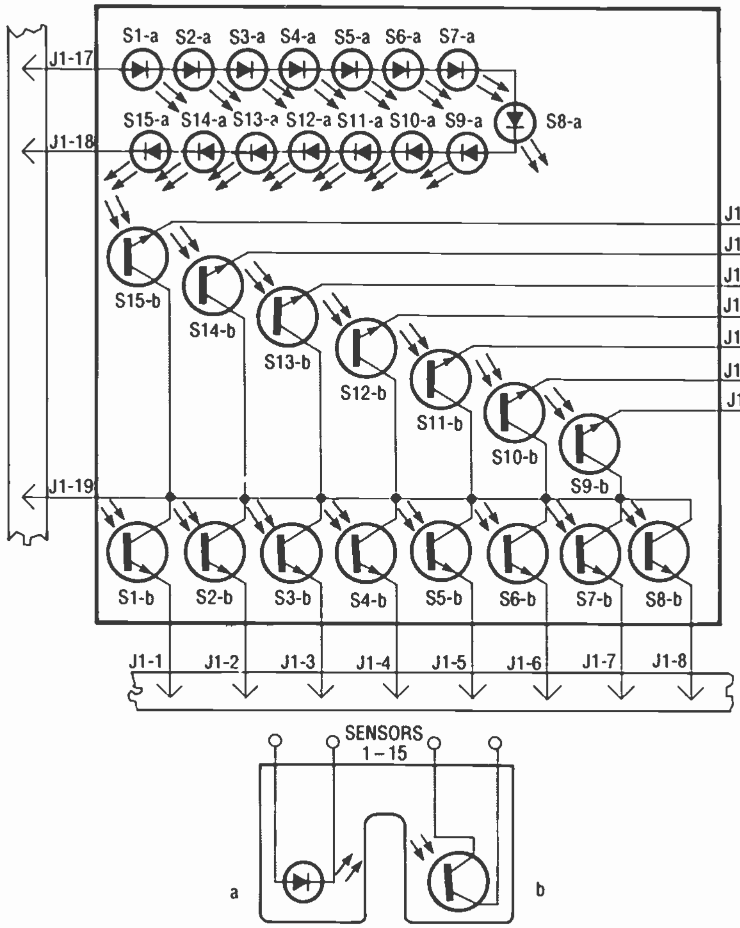


FIG. 4—WIRE THE GRASS SENSORS as shown here.

Chassis wiring

Wire the chassis as shown in Fig. 5. Use 18-gauge stranded wire for the high-current cutting- and drive-motor connections. Secure the cable harness with tie wraps and secure the cable harness to the Lawn Ranger's chassis. Make sure all external cables from the motors, electronic control panel, bumper switch, and grass sensors are connected properly.

Control-system test

Remove all input power and insert the power board into J21 on the motherboard. Repeat the test procedure that was just described, except measure the DC supply voltages at edge connector J23 and J22 on the motherboard. The supply voltages should agree with the values indicated on the CPU and motor-controller board schematics (refer to **Radio-Electronics**, June and July 1990). If the values are correct, remove the input power and plug the CPU board in edge-connector J23. Reapply the +24-volt input power and recheck the voltage levels. If all is well, perform the digital-board check-out procedure outlined in the June

PARTS LIST—POWER BOARD

All resistors are ⅛-watt, 5%, unless otherwise indicated.

R1–R10, R13–R15, R17, R18, R20–R28, R45–R49—not used
R11, R44, R50—3300 ohms
R12—680,000 ohms, 6-pin, ¼-watt, SIP resistor network
R16, R19, R32, R43—0.01 ohm, 5 watts
R29—150,000 ohms
R30, R31, R34, R35—270,000 ohms
R33, R36—1 megohm
R37—147,000 ohms, ¼-watt, 1%
R38—10,000 ohms, potentiometer
R39—82,000 ohms
R40—100,000 ohms
R41—27,000 ohms
R42—22,000 ohms
R51–R54—560,000 ohms

Capacitors

C1–C5, C7–C13, C16, C17—not used
C6—1000 µF, 35 volts, axial electrolytic
C14, C15, C23–C26—0.1 µF, 50 volts
C18, C21—100 µF, 50 volts, radial electrolytic
C19, C20—100 µF, 16 volts, radial electrolytic
C22—220 µF, 16 volts, radial electrolytic

Semiconductors

IC1, IC2—not used
IC3—LF412N op amp
D1, D2, D11–D13, D30, D31—not used
D3, D4, D16, D17, D20–D24, D33–D38—1N4001 diode
D5, D14, D18, D19, D32—1N4148 diode
D6, D15—1N5402 diode
D7–D10—1N5256B 30-volt Zener diode
D25–D29—1N4740 10-volt Zener diode
Q1, Q2, Q12—not used
Q3–Q10, Q13, Q14—IRFZ42 MOSFET
Q11, Q15, Q16—293904 NPN transistor

Other components

J11—terminal strip
RY1—T90N1D12-24 relay (Potter Brumfield)
RY2—68P-111P-US-DC24 relay (Omron)
F1—3AG 30-amp fast-blow fuse
F2—2AG 0.5-amp fast-blow fuse
MOD1—Model DC2-2-24/12, ± 12-volt DC converter (Power General)
MOD2—Model DC2-2-24/15, ± 15-volt DC converter (Power General)
MOD1—Model 710, 5-volt DC converter (Power General)

Miscellaneous: 3AG fuse holder, 2AG fuse holder, solder posts for the "E" terminals, 18-gauge solid insulated wire, 18-gauge stranded insulated wire, solder, etc.

Note: The following equipment can be purchased from Technical Solutions, Inc., P.O. Box 284, Damascus, MD 20872 (301-253-4933): etched and drilled PC boards for CPU Board, Motor Controller Board, Power Board, and Motherboard, $39 each; programmed EPROM, $39; grass sensors, $8.99 each; hand-held manual controller kit, $39; full kit for CPU Board, $129 (PC board, EPROM, all parts); full kit for Motor Controller Board, $169 (PC board and all parts); full kit for Motherboard, $69 (PC board and all parts); Power Board kit (PC board, and all parts except DC/DC converters), $149; Detailed drawing package, $79; Lawn Ranger demo videotape and information package, $19; complete electronic kit with everything mentioned above, $777. Please add $8.00 for S/H for all orders. Maryland residents add sales tax.

issue while the boards are plugged into the motherboard.

Now plug the motor-controller board into J22 on the motherboard. Also, plug the grass-sensor connector (J1) into the motor-controller board. Reapply the +24-volt input power to the power board.

If you have an oscilloscope, verify that a 5-volt 10-kHz square wave is found at the following points: J22-34, J1-1 through J1-15, and J22-2 through J22-16. The square wave is a gating pulse created by the CPU board which is used to turn the grass sensors on and off. The gating technique is used in order to conserve battery power and extend the life of the grass sensors. If you don't have a scope. Use an AC voltmeter to read the voltage levels at those points. The square wave should create a reading of approximately 4.5-volts AC. If the square wave is not there, you should read 0 volts on the AC voltmeter.

Now it is time to check the *P*ulse *W*idth *M*odulator (PWM) circuitry. Plug the hand-held controller into J4 on the motor-controller board. Temporarily jumper J22-40 to ground. Turn the steering control knob (the potentiometer on the hand-held controller) counterclockwise until you see a 30-volt square wave at J22-26 (L. REV), J11-7 (L. MOTOR –), J22-27 (R. FOR), and J11-9 (R. MOTOR +). If you don't have a scope, an AC voltmeter should give you a reading of 0 to 35.5 volts AC, depending upon the knob setting. Test points J22-25 (L. FOR) and J22-28 (R. REV) should read 0 volts.

The "left wheel reverse" (L. REV) and "right wheel forward" (R. FOR) signals become active since the Lawn Ranger has been commanded to turn to the left. If the steering knob is turned clockwise, the robot circuitry will be commanded to turn to the right. That causes J22-25, J11-6, J22-28, and J11-10 to become active with the 30-volt PWM square wave, and J22-26 and J22-27 to read 0-volts DC. If the steering knob is centered, J22-25, J11-6, J22-27, and J11-9 will be enabled and a voltmeter placed at J22-28 and J22-26 will read 0 volts since the robot has been commanded to steer straight.

TABLE 1—SUPPLIERS

Manufacturer	Description	Model #	Qty
Motor Products Owosso 201 S. Delany Rd. Owosso, MI 48867 (517) 725-5151	cutting motors, 3,000 RPM @ 80 oz-in torque, 24 volt DC	LES-25A	2
RAE Corporation 5801 West Elm St. McHenry, IL 60050-7480 (800) 323-7049	drive motors, 187 RPM @ 30 in-lb torque, 24 volt DC	P-20705	2
McMaster-Carr P.O. Box 440 New Brunswick, NJ 08903-0440 (201) 329-3200	slip joint hinge (for plastic top)	1606A41	1
	rubber sheet (for front of plastic top) 1/16"	8635K11	1
	yoke ends	6071K12	4
	ball joints	6072K35	4
Stock Drive Products 2101 Jericho Pike New Hyde Park, NY 11040 (516) 328-0200	timing pulley	6A4-14DF0	2
	timing belt	6R4-08005	1
General Battery P.O. Box 1425 Reading, PA 19612-4205 (215) 378-0500	lead-acid battery	22NF	2
Tape Switch 100 Schmitt Blvd. Farmingdale, NY 11735 (516) 694-6312	bumper switch, 8 oz	102-BPH	1
Agri-Fab 303 W. Raymond Sullivan, IL 61951 (217) 728-4334	drive wheels	3108-148	2
	drive gear	2692-006	2
Colson 3700 Airport Rd. Jonesboro, AR 72401 (800) 643-5515	Caster Wheels	2-6056-45	2
Power General P.O. Box 189 Canton, MA 02021 (617) 828-6216	+5 volt DC	710	1
	+ 30 volt DC	DC2-2-24/	1
	±12 volt DC	DC2-2-24/	1
Pioneer 9100 Gaither Rd. Gaithersburg, MD 20877 (301) 921-0660	E-terminals	160-2085-02-01	30
Techni-edge 389 Liberty St. Ferry, NJ 07643-1008 (201) 641-7776	hook blade	TE-28	6

Control panel test

Disconnect J11-2, J11-6, J11-7, J11-9, and J11-10 on the terminal block. Ensure that the cable from the electronic control panel is connected to J5 on the CPU board and that the batteries are connected to J11-4 and J11-5 on the power board. Turn the ignition key: the red power-on LED should begin to flash. This indicates that power has been switched on to all circuits. Push the STOP button. The Lawn Ranger should turn off. Check that the cutting-motor connection J11-2 is still disconnected. Turn the ignition key again and

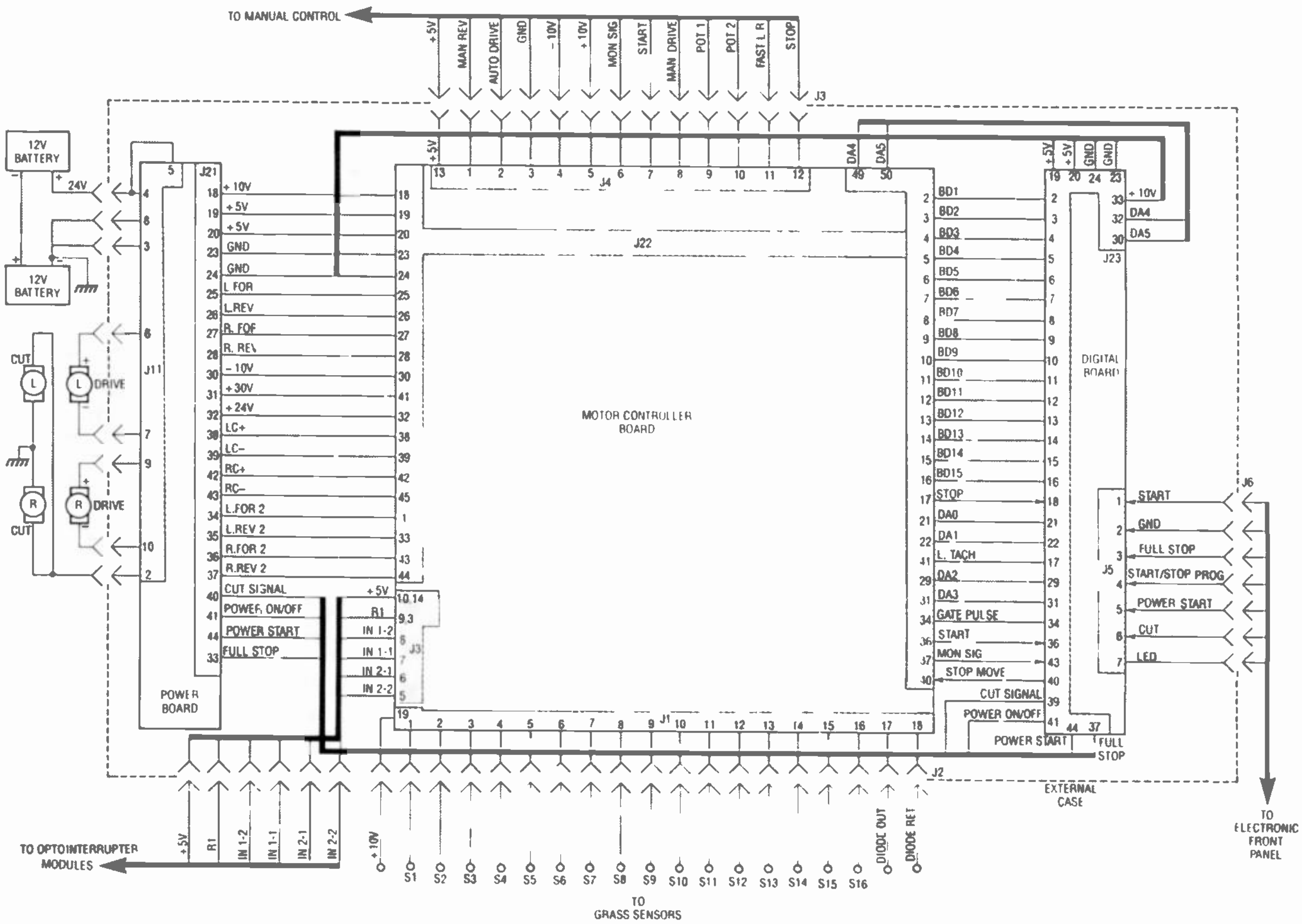


FIG. 5—WIRING DIAGRAM FOR THE CHASSIS. Use 18-gauge stranded wire for any high-current connections.

then push the CUT button. The voltage at J11-2 should now read +30-volts DC. Press the bumper switch and the Lawn Ranger should turn itself off. Turn the unit on again and push the RUN button. J23-40 (STOP MOVE) should now read +10-volts DC. Reconnect the motor wires to J11-6, J11-7, J11-9, and J11-10 on the terminal block.

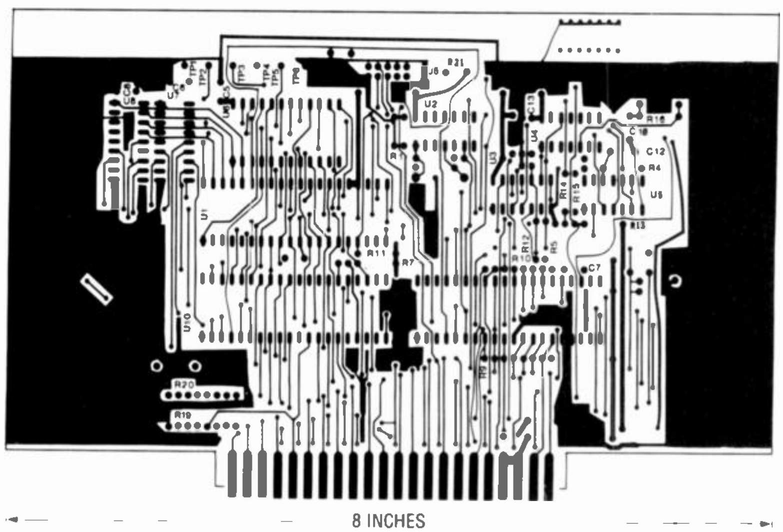
Drive-motor test

Make sure that the hand-held controller is connected to J4 on the motor-controller board, and that everything is connected on the terminal block J11 except for J11-2 (cutting motors). Turn the ignition key (the power LED should be flashing), and turn the steering knob to its centered position. Squeeze the hand switch on the manual controller. Both rear drive motors and wheels should be spinning forward. Push the REVERSE button. The wheels should slowly stop and then turn in reverse. Turn the steering knob and observe the drive wheels as they change speed for steering. Release the hand switch and the Lawn Ranger will turn itself off.

Cutting-motor test

WITHOUT THE CUTTING BLADES ATTACHED TO THE CUTTING DISKS, reconnect the cutting motor wire to J11-2. Put the Lawn Ranger on a flat level hard surface, and keep the cutting deck area free of obstructions. With your hands away from the cutting deck area, push the CUT button; the cutting disks will begin to spin. Push the STOP button; the cutting disks should stop within three seconds. If the

continued on page 70



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Update your dashboard with six accurate, good-looking gauges.

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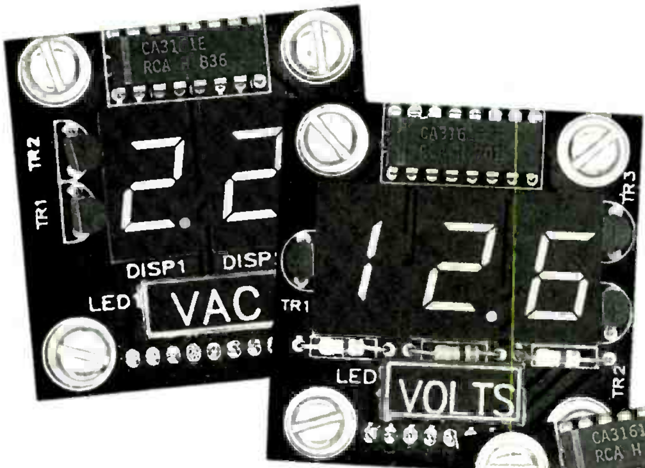
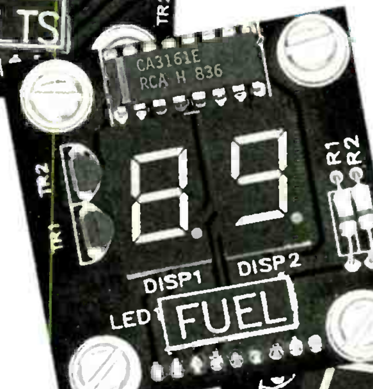
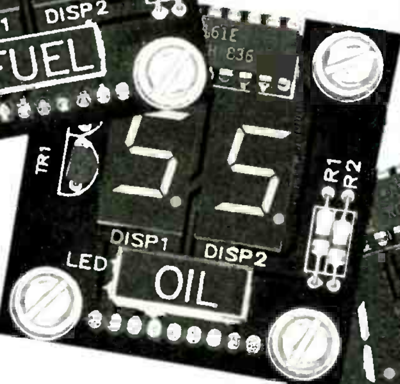






OUR DIGITAL GAUGE STORY BEGAN IN the July issue: this month we will build all of them. Note that in all of the parts lists, except for the displays, the part number for the A/D converter (IC2) was listed incorrectly. It should be a CA3162E, as shown in the schematics—speaking of which, the captions for Figs. 4 and 6 should be reversed.

Construction

Each digital gauge is built using two different PC boards. The display board contains the seven-segment displays along with the driver components, as well as the annunciator light bar. The main board contains the A/D converter, all input circuitry, and the 5-volt regulator.

The boards are mounted one on top of another, separated by standoffs. A typical gauge is shown in Fig. 8. With the display board facing toward you, the main board is mounted directly behind it, with its components also facing toward you. Electrical connections from board to board are made using short pieces of bare wire between matching pads on both boards. A piece of 9-conductor ribbon cable can be used instead. Once assembled, the boards can be folded apart to allow for easy testing, troubleshooting, or calibrating.

Each gauge uses either a two- or three-digit display board. Table 1 shows which boards are to be used with each gauge. When stuffing the three digit display board, begin with R1 and R2 as shown in Fig. 9, and install R3 only if the board is to be used with the voltage gauge, as R3 supplies power to the decimal point. Install DISP1–DISP3 and LED1, keeping them flat against the board, and then install Q1–Q3. The transistors must be installed to a height just below the height of the displays. Using a good silicone sealant or other similar glue, secure a photographic legend or some other form of annunciator lettering to the LED light bar. If the two-digit display board is to be used, install everything in the same manner as the three digit board, but use only DISP1 and DISP2, and Q1 and Q2 (see Fig. 10).

Although the use of sockets is normally recommended, IC1 must be kept below the height of the seven-segment displays. Therefore, IC1 must be soldered directly to the board. Be careful when soldering the IC.

Referring to Table 1, note that the same main board is used for the voltage, oil-pressure, water-temperature, and miscellaneous temperature gauges. However, the actual components soldered to the board are different for each gauge, and not all PC pads are used on all boards. Install only the components specified in each parts-placement diagram.

Figure 11 shows the component placement for the voltage gauge. Solder the parts to the board in smallest-to-largest order, clipping and saving the leads. The parts-placement diagram for the oil-pressure gauge is shown in Fig. 12, the water-temperature gauge in Fig. 13, and the miscellaneous temperature gauge in Fig. 14.

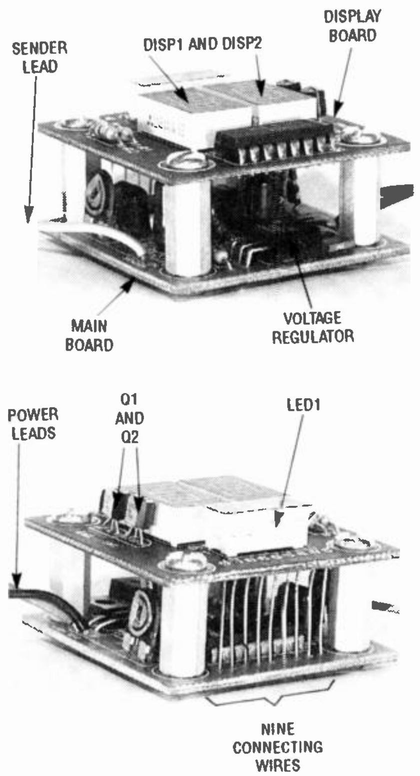


FIG. 8—THE BOARDS ARE MOUNTED one on top of another, separated with standoffs. A typical gauge is shown here.

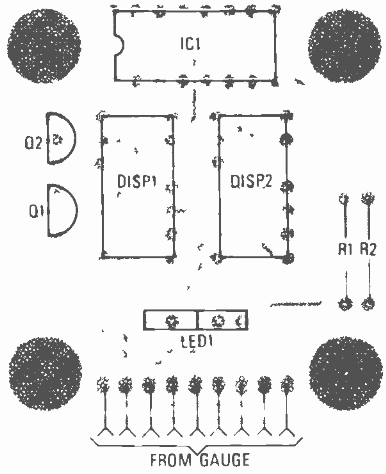


FIG. 10—THE TWO-DIGIT DISPLAY BOARD is the same as the three-digit board, but uses only DISP1 and DISP2.

The fuel gauge and vacuum gauge each has its own main board. Figure 15 shows the parts-placement diagram for the fuel gauge, and Fig. 16 for the vacuum gauge. Note that the resistors and diodes on the fuel- and vacuum-gauge main boards must be installed standing on

TABLE 1

Digital Gauge	Main Board	Display Board
Voltmeter	43B21	43B15 3-digit
Oil Pressure	43B21	43B16 2-digit
Water Temp	43B21	43B15 3-digit
Misc Temp	43B21	43B15 3-digit
Fuel	43B20	43B16 2-digit
Vacuum	43B17	43B16 2-digit

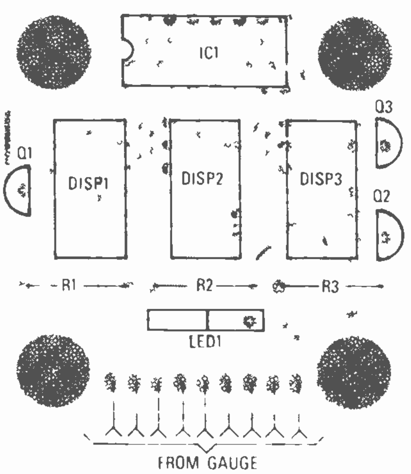


FIG. 9—WHEN STUFFING THE THREE-digit display board, install R3 only if the board is to be used with the voltage gauge. Otherwise it is not used.

end. Be sure to observe the polarity of the diodes.

After all of the components are installed on each board, solder a red wire containing a fuse holder and fuse into its respective hole. A black ground wire is soldered into the hole next to the power wire.

The oil-pressure, water-temperature, and fuel gauges all need one sender wire attached to the main board. Cut a 4-inch piece of wire and solder one end to the main-board location marked P2, "sender," and be sure to put it in the hole that is farthest from the upper-right-hand corner of the board. Next, crimp on a ¼-inch female solderless terminal to the other end of the wire. You will then need an appropriate length of wire that will run out to the actual sender, and you should crimp on a ¼-inch male solderless terminal to one end, and set it aside for now.

The miscellaneous temperature gauge will need both a sender wire and a ground return wire. Install the sender wire as previously described, and cut a 4" piece of black wire to be soldered into the hole just above the sender wire. A ¼-inch male solderless terminal goes on the end of the ground return wire.

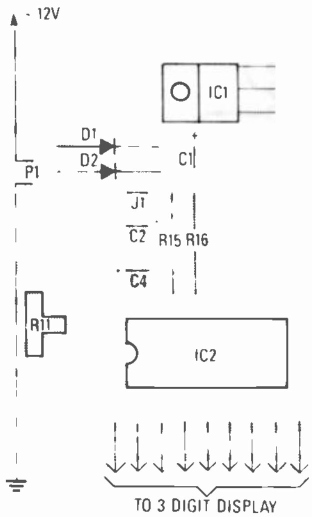


FIG. 11—VOLTAGE GAUGE parts placement. Solder the parts to the board in smallest-to-largest order, clipping and saving the leads.

VOLTAGE GAUGE

All resistors are ¼-watt, 5%, unless otherwise indicated.

R1–R10, R12–R14—not used
R11—10,000 ohms, PC-mounted trimmer potentiometer
R15—100,000 ohms
R16—1000 ohms
R17—50,000 ohms, PC-mounted trimmer potentiometer

Capacitors

C1—47 µF, 25 volts, electrolytic
C2, C5—10 µF, 35 volts, electrolytic
C3, C4—not used
C6—0.33 µF, 50 volts, stacked film

Semiconductors

IC1—LM340T-5, 5-volt regulator
IC2—CA3162E, A/D converter
D1, D2—1N4002 diode

Miscellaneous: 43B21 main PC board, 3-digit display board, in-line fuse holder, 1-amp fuse, four 6-32 × 0.625" standoffs, eight 5/16-inch #6 screws, bronze or red plexiglass, mounting hardware, hookup wire

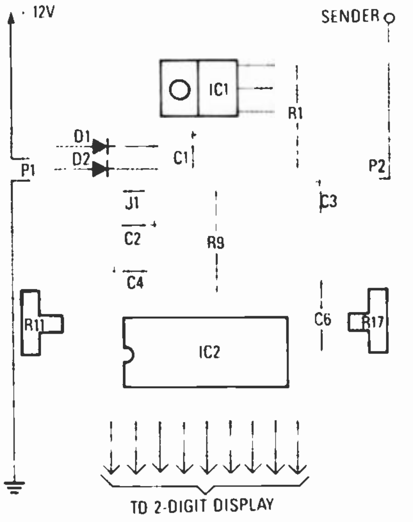


FIG. 12—OIL-PRESSURE GAUGE parts-placement.

OIL-PRESSURE GAUGE

All resistors are ¼-watt, 5%, unless otherwise indicated.

R1—470 ohms
R2–R8, R10, R12–R16—not used
R9—100,000 ohms
R11—10,000 ohms, PC-mounted trimmer potentiometer
R17—50,000 ohms, PC-mounted trimmer potentiometer

Capacitors

C1—47 µF, 25 volts, electrolytic
C2, C3, C4—10 µF, 35 volts, electrolytic
C5—not used
C6—0.33 µF, 50 volts, stacked film

Semiconductors

IC1—LM340T-5, 5-volt regulator
IC2—CA3136E, A/D converter
D1, D2—1N4002 diode

Miscellaneous: 43B21 main PC board, 15G5 oil-pressure sender, 2-digit display board, in-line fuse holder, 1-amp fuse, four 6-32 × 0.625" standoffs, eight 5/16-inch #6 screws, bronze or red plexiglass, mounting hardware, hookup wire

The main boards are now ready to be connected to the display boards. The first step is to place the four standoffs between the boards and secure them with eight 5/16-inch #6 screws. Assemble the boards with the foil side of the display board facing the component side of the main board. The holes for the board-to-board connecting wire should line up on the same edge. After the two boards are secured to each other, lay the assembly face down and begin inserting pieces of bare wire or scraps of component leads through the holes in the main board and down into the respective holes in the display board. After a few wires have been inserted, solder the connections. Continue until all nine wires have been installed.

The temperature probe for the miscellaneous temperature gauge is constructed from the 1N4148 diode, a 10-foot length of coax cable, and a male and female crimp-on connector. On one end

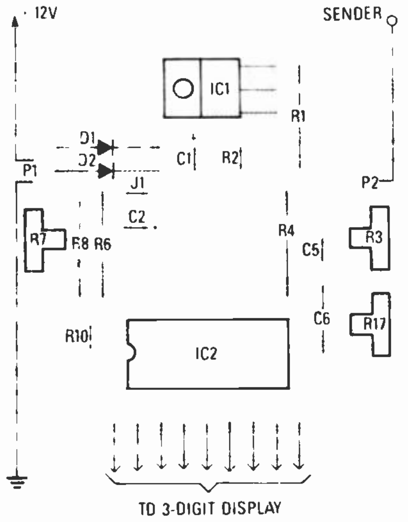


FIG. 13—WATER-TEMPERATURE gauge parts placement.

WATER-TEMPERATURE GAUGE

All resistors are ¼-watt, 5%, unless otherwise indicated.

R1—100 ohms, ½-watt
R2—430,000 ohms
R3, R7—10,000 ohms, PC-mounted trimmer potentiometer
R4, R8—22,000 ohms
R5, R9, R11–R16—not used
R6—470,000 ohms
R10—2200 ohms
R17—50,000 ohms, PC-mounted trimmer potentiometer

Capacitors

C1—47 µF, 25 volts, electrolytic
C2, C5—10 µF, 35 volts, electrolytic
C3, C4—not used
C6—0.33 µF, 50 volts, stacked film

Semiconductors

D1, D2—1N4002 diode
IC1—LM340T-5, 5-volt regulator
IC2—CA3136E, A/D converter

Miscellaneous: 43B21 main PC board, 14G11 water-temperature sender, 3-digit display board, in-line fuse holder, 1-amp fuse, four 6-32 × 0.625" standoffs, eight 5/16-inch #6 screws, bronze or red plexiglass, mounting hardware, hookup wire.

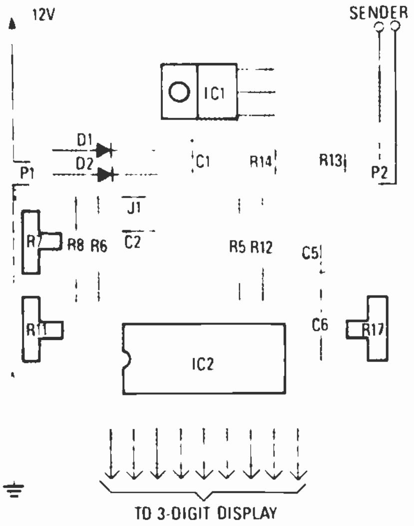


FIG. 14—MISCELLANEOUS temperature gauge parts placement.

MISCELLANEOUS TEMPERATURE GAUGE

All resistors are ¼-watt, 5%, unless otherwise indicated.

R1–R4, R9, R10, R15, R16—not used
R5—2200 ohms
R6—6800 ohms
R7—1000 ohms, PC-mounted trimmer potentiometer
R8—470 ohms
R11—10,000 ohms, PC-mounted trimmer potentiometer
R12—10,000 ohms
R13—1000 ohms
R14—220 ohms
R17—50,000 ohms, PC-mounted trimmer potentiometer

Capacitors

C1—47 µF, 25 volts, electrolytic
C2, C5—10 µF, 35 volts, electrolytic
C3, C4—not used
C6—0.33 µF, 50 volts, stacked film

Semiconductors

IC1—LM340T-5, 5-volt regulator
IC2—CA3162E, A/D converter
D1, D2—1N4002 diode

Miscellaneous: 43B21 main PC board, 1N4148 diode for temperature probe, 3-digit display board, coax cable, in-line fuse holder, 1-amp fuse, four 6-32 × 0.625" standoffs, eight 5/16-inch #6 screws, bronze or red plexiglass, mounting hardware, hookup wire.

of the coax cable, strip off about ¾-inch of the outer insulation, unbraid the outer conductor, and twist toward one side. Next, strip about ¼-inch of the cable's inner insulation.

Position the 1N4148 diode so that the band, or cathode, is touching the outer conductor of the coax cable. The diode will lay right against the inner-conductor insulation. Very carefully solder both sides of the diode, the cathode side to the outer conductor and the anode side to the inner conductor. After clipping the excess lead length, coat the diode and exposed wires with a good quality epoxy or sealer. Apply several coats to ensure a good seal. Only the end of the cable with the diode is coated. On the other end of the cable, strip and separate the inner and outer conductors. Crimp the male terminal to the center conductor and the female terminal to the shield.

The solid-state vacuum sensor is mounted to the vacuum gauge by first removing the two screws near IC3 that hold the main board to the standoffs. Place the sensor bracket on the back side of the main board and align the holes on the two tabs with the board mounting holes and reinsert the two screws (see Fig. 17). Next, insert the sensor leads into the main board with the lettering on the sensor body facing away from the bracket. Insert the remaining hardware and tighten the sensor to the bracket. Do not overtighten the mounting screws as you damage the sensor. It is a good idea to only hand tighten the screws and apply a small drop of glue to keep them from coming loose. Very carefully solder the leads of the sensor to the board, working from the back side of the board. Be careful not to melt the case of the sensor with the soldering iron.

Calibration

After the gauges are completely assembled, turn all the calibration potentiometers to the center of their rotation. Next, connect each gauge to a 12-volt DC power supply or battery. At this point, all the display digits should light as should the LED light bar.

The calibration process for all of the digital gauges begins with zeroing the A/D converter. To do that, pins 10 and 11 of the CA3162E A/D converter must be shorted together. Use a small screwdriver or jumper wire. Once connected, the display should now read zero or very close to it. Adjust the zero calibration potentiometer (see each schematic for exact potentiometer number) so that the display reads "000" or "00." Then remove the jumper.

The voltage gauge is calibrated by connecting a good quality bench voltmeter across the power supply that is used to power the gauge. Carefully adjust R11, the gain adjust potentiometer, so the reading is the same as the reading on your bench voltmeter.

The calibration process for the oil-pressure gauge requires connecting a precision 47-ohm resistor to the sensor lead and

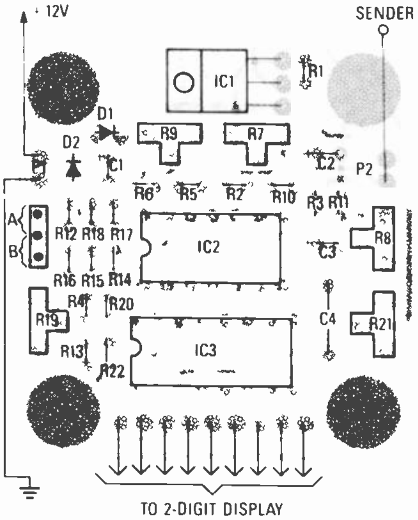


FIG. 15—PARTS-PLACEMENT DIAGRAM for the fuel gauge.

FUEL GAUGE

All resistors are ¼-watt, 5%, unless otherwise indicated.
R1—470 ohms
R2, R5, R10, R12, R14, R15, R16—100,000 ohms
R3—33,000 ohms
R4—47,000 ohms
R6—1.8 megohms
R7, R19—100,000 ohms, PC-mounted trimmer potentiometer
R8—10,000 ohms, PC-mounted trimmer potentiometer
R9—200,000 ohms, PC-mounted trimmer potentiometer
R11—2700 ohms
R13—8200 ohms
R17—22,000 ohms
R18—1000 ohms
R20—470,000 ohms
R21—50,000 ohms, PC-mounted trimmer potentiometer
R22—2200 ohms
Capacitors
C1—47 µF, 25 volts, electrolytic
C2, C3—10 µF, 35 volts, electrolytic
C4—0.33 µF, 50 volts, stacked film
Semiconductors
IC1—LM340T-5, 5-volt regulator
IC2—LM324, quad op-amp
IC3—CA3162E, A/D converter
D1, D2—1N4002 diode
Miscellaneous: 43B20 main PC board, 2-digit display board, 0.1" 3-conductor header, 2-conductor jumper, in-line fuse holder, 1-amp fuse, four 6-32 × 0.625" standoffs, eight 5/16-inch #6 screws, bronze or red plexiglass, mounting hardware, hookup wire.

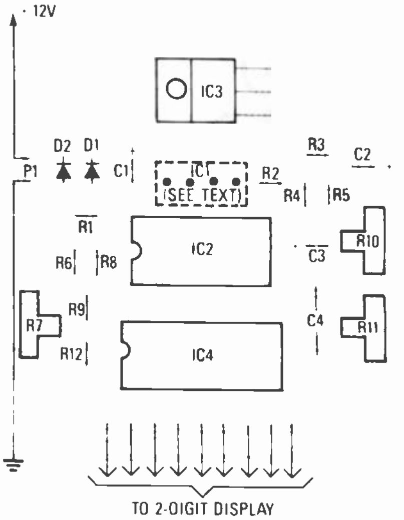


FIG. 16—PARTS-PLACEMENT DIAGRAM FOR THE vacuum gauge.

VACUUM GAUGE

All resistors are ¼-watt, 5%, unless otherwise indicated.
R1, R2—10,000 ohms
R3, R8—100,000 ohms
R4—22,000 ohms
R5—1000 ohms
R6—680,000 ohms
R7, R10—200,000 ohms PC mounted trimmer potentiometer
R9—82,000 ohms
R11—50,000 ohms PC mounted trimmer potentiometer
R12—2200 ohms
Capacitors
C1—47 µF, 25 volts, electrolytic
C2, C3—10 µF, 35 volts, electrolytic
C4—0.33 µF, 50 volts, stacked film
Semiconductors
IC1—Sensym SX30DN vacuum sensor (Dakota Digital #69G18 includes mounting bracket)
IC2—LM324, quad op-amp
IC3—LM340T-5, 5-volt regulator
IC4—CA3162E, A/D converter
D1, D2—1N4002 diode
Miscellaneous: 43B17 main PC board, 2-digit display board, in-line fuse holder, 1-amp fuse, four 6-32 × 0.625" standoffs, eight 5/16-inch #6 screws, bronze or red plexiglass, mounting hardware, hookup wire.

carefully adjusting R11 so the reading is at "47." Actually, any resistor between 33 and 91 ohms can be used to calibrate the unit. Just set the display to coincide with the value of the resistor.

The water-temperature gauge is calibrated by connecting the sending unit and adjusting for freezing and boiling temperatures. First, prepare a bowl of water with several ice cubes in it, and a pot of boiling water. Place the sending unit in the boiling water with its base submerged in the water and the terminal above the water line. After waiting about a minute for the sending unit to stabilize, adjust the "high adjust" potentiometer (R7) for a reading of "212" on the display. Next, place the sending unit in the ice water using the same precautions not to let the center terminal come in contact with the water. Wait a minute for the sending unit to stabilize and adjust the "low adjust" potentiometer (R3) for a reading of "032" on the display. Repeat the high- and low-adjustment procedures until a good balance has been reached.

To calibrate the fuel gauge, you must determine the empty and full resistance of your vehicle's sender. For most Fords, it's 73 ohms empty to 10 ohms full. GM vehicles run from 0 ohms empty to 90 ohms full, and AMC, marine, and most aftermarket senders use the scale of 244 ohms full to 33 ohms empty. The calibration range of our fuel gauge will easily accept the input from virtually any brand of sending unit.

Obtain two resistor values that are very close to the empty and full resistances of the sending unit that will be used. If your system requires you to use the "A" circuit, you will begin calibrating the fuel gauge by first turning R9 fully counterclockwise. Be sure the jumper is in the "A" position. With the "empty" resistance connected to the lead wire, adjust R7 for a reading between "00" and "05." Because the gauge has a large RC circuit for averaging, allow plenty of time for the reading to settle. Next, connect the "full" resistance and adjust R9 for a reading between "95" and "99." It is usually better to have some headroom to avoid over-range and under-range conditions due to sending-unit tolerance. After

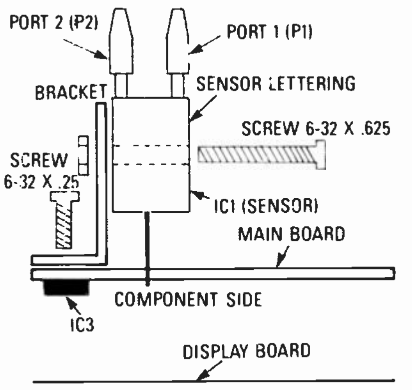


FIG. 17—PLACE THE SENSOR BRACKET on the back side of the main board and align the holes on the two tabs with the board mounting holes.

the empty and full settings are adjusted, repeat the two steps until a good balance has been reached.

If the "B" circuit is being used, begin the procedure by turning R19 fully clockwise. Connect the "empty" resistance and adjust R8 for a reading of "00" to "05" on the display. Reconnect to the "full" resistance and adjust R19 for a reading between "95" and "99." Repeat the two steps until a good balance has be obtained.

The calibration procedures for the miscellaneous temperature gauge are almost identical to the water-temperature gauge. Prepare a bowl of water with several ice cubes and a pot of boiling water. Place the temperature probe in the boiling water, wait 30 seconds for it to stabilize, and adjust R11 for a reading of "212" on the display. Next, place the sending unit in the ice water. Wait another 30 seconds for the sending unit to stabilize, and adjust the "low adjust" potentiometer (R7) for a reading of "032" on the display. Repeat the high- and low-adjustment procedures until a good balance has been reached.

The calibration process for the vacuum gauge begins by turning R10 fully clockwise and adjusting R7 for a reading of "00" on the display. That zeros the offset of the pressure/vacuum sending unit. Next, connect a piece of 7/64-inch vacuum line to P2 (port 2) on the sending unit. The other end must go to an accurate vacuum source that you will use as a standard for full-scale calibration of the vacuum gauge. The vacuum source can be a hand-held

3-DIGIT DISPLAY BOARD

All resistors are ¼-watt, 5%, unless otherwise indicated.

R1, R2—220 ohms
R3—220 ohms (voltmeter only)

Semiconductors

IC1—CA3161E, Display driver
DISP1–DISP3—0.43" 7-segment C.A. LED display (Panasonic LN514RA)
Q1–Q3—2N3906 PNP transistor
LED1—5- × 15-mm LED, (Panasonic LN0202RP)

2-DIGIT DISPLAY BOARD

All resistors are ¼-watt, 5%, unless otherwise indicated.

R1, R2—220 ohms

Semiconductors

IC1—CA3161E, display driver
DISP1, DISP2—0.43" 7-segment C.A. LED display (Panasonic LN514RA)
Q1, Q2—2N3906 PNP transistor
LED1—5- × 15-mm LED, (Panasonic LN0202RP)

Note: The following items are available from Dakota Digital, 11301 Kuhle Drive, Sioux Falls, SD 57107 (605) 332-6513: a PC-board set for each gauge (includes main PC board and display board) is $6.95. A parts kit for each gauge (includes PC boards, components, and manual) is $29.95. Each gauge assembled and tested is $39.95. Stock numbers are as follows: voltage-gauge kit #2005-KIT, assembled and tested #3005-UNIT; oil-pressure gauge kit #2006-KIT, assembled and tested #3006-UNIT (order oil-pressure sender separately); water-temperature gauge kit #2007-KIT, assembled and tested #3007-UNIT (order water-temperature sender separately); miscellaneous temperature gauge kit #2008-KIT, assembled and tested #3008-UNIT; fuel-gauge kit #2009-KIT, assembled and tested #3009-UNIT; vacuum-gauge kit #2010-KIT, assembled and tested #3010-UNIT (order vacuum sensor separately). Oil-pressure sender (#15G5), $15.50; water-temperature sender (#14G11), $5.50; vacuum sensor (#69G18), $19.95; RCA CA3161E driver (#69G16), $1.95; RCA CA3162 A/D converter (#69G15), $7.95. All orders add 4% shipping and handling ($1.50 minimum), Visa and Mastercard accepted.

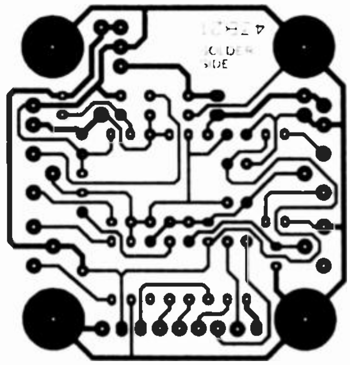
vacuum pump that has an accurate dial gauge, or you can connect the vacuum gauge and an automotive tune-up vacuum gauge to a running engine and use its reading as your standard. Once a known amount of vacuum is connected to the vacuum gauge, adjust R10 for a full-scale reading.

Installation

A good enclosure will protect the units from shock, dirt, and shorting. The enclosure must also have a front panel that will enhance the viewing of the displays. That is especially important for bright days, where bare LED displays can be very difficult to read.

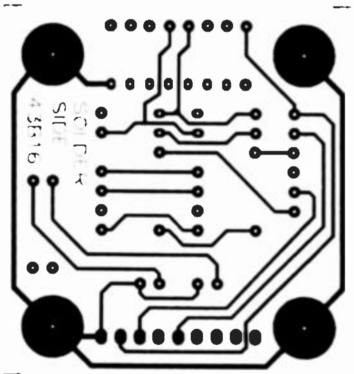
The digital gauges can be mounted by the same bolts that hold the two boards together. That allows the point of mounting to be from the front or back of the unit. For rear mounting, the screws that hold the main board to the spacers are removed. From here, additional spacers are used to mount the unit to a panel located behind the digital gauge. The length of the spacers will depend on how far the mounting panel is from the front panel. The unit can also be mounted directly to the front panel by removing the screws holding the display board to the spacers. Here again, additional spacers will be used to keep the unit away from the front panel and provide a secure mounting. If mounted from the front panel, use an attractive screw that will enhance the look of the front panel. Hex-head screws, Allen screws, or Torx screws can be used. As with any type of enclosure, you will also need to drill or cut vent holes to allow heat to escape.

For the front panel, bronze or smoked plexiglass is recommended. That material is not only durable, but it will also keep outside light from shining into the display area and allow the LED's to shine through, thus creating a more visible and readable display. Red filter plexiglass will also work well as long as only red LED's are used. The front panel should be masked to allow only the LED's and annunciator to show, thus hiding the rest of the display board. Masking can be done by taping over the area



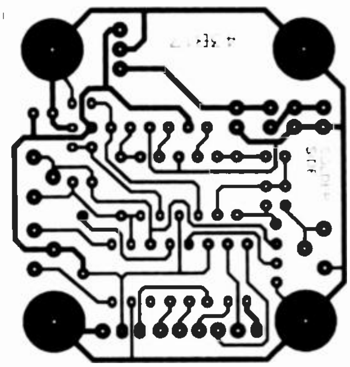
1 13/16 INCHES

VOLTS, OIL, WATER, AND MISC. TEMP.



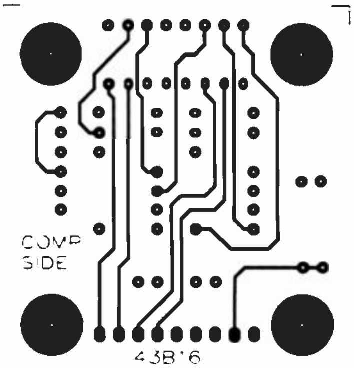
1 13/16 INCHES

2-DIGIT DISPLAY SOLDER SIDE.



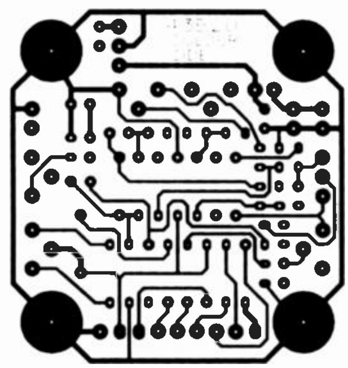
1 13/16 INCHES

VACUUM GAUGE FOIL PATTERN.



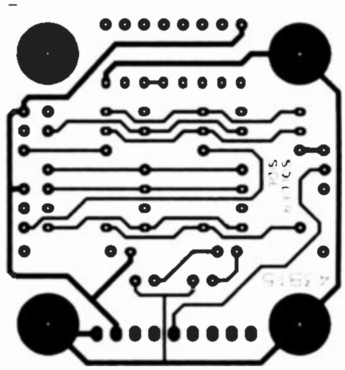
1 13/16 INCHES

2-DIGIT DISPLAY COMPONENT SIDE.



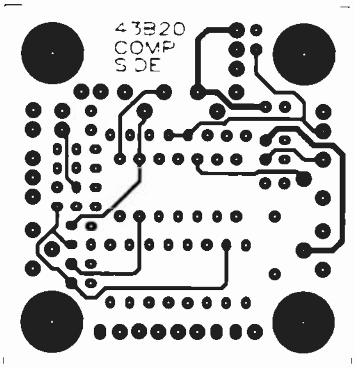
1 13/16 INCHES

SOLDER SIDE OF THE FUEL GAUGE.



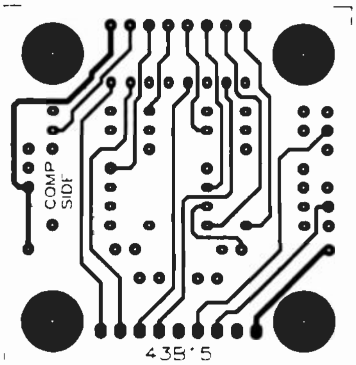
1 13/16 INCHES

3-DIGIT DISPLAY SOLDER SIDE.



1 13/16 INCHES

COMPONENT SIDE OF THE FUEL GAUGE.



1 13/16 INCHES

3-DIGIT DISPLAY COMPONENT SIDE.

where the displays will be located and painting the uncovered area black on the back side.

Both the oil-pressure gauge and the water-temperature gauge require sending units to be mounted to the engine. The oil-pressure sending unit mounts directly to the block of the engine. Its 1/8-inch pipe thread fits GM motors directly while Ford motors, along with some other manufacturers using 1/4-inch thread, will require a 1/4- to 1/8-inch adapter. The water-temperature sending unit is made to mount directly to the block or water pump of a Ford motor using standard 3/8-inch pipe thread. GM motors will require a 1/2- to 3/8-inch adapter. Should your application be somewhat different, adapters and fittings can be obtained from your local hardware or automotive store.

You may also wish to keep your original gauge or idiot light that came factory with your car. That can be done in one of two ways. A "T" fitting can be used to mount both the original sender and the new sender. Otherwise you have to find another location that is occupied by a plug that can be replaced with the sending unit. That lets you keep the factory dashboard functions intact.

When connecting the fuel gauge to the fuel sender, the easiest method is to find the factory wiring harness connection that runs back to the fuel tank. A second option is to run a new wire. The original fuel gauge cannot be connected to the same sender that the new digital fuel gauge is using. The two will interfere with each others readings.

When connecting any of the gauges to the motor or fuel tank, be sure that the sender has a good connection to chassis ground. Failure to properly ground the gauge or the sender will result in erratic or incorrect readings.

The temperature probe for the miscellaneous temperature gauge can be mounted in one of several ways. When monitoring air temperature, inside or out, the probe should be placed in an area where a good average temperature exists. Inside, that may be under the dash, away from any heating or cooling vents and out of any sunlight. Outside, under the front grill area of the car will provide the most accurate point as it is out of the sun and not affected too much by engine heat.

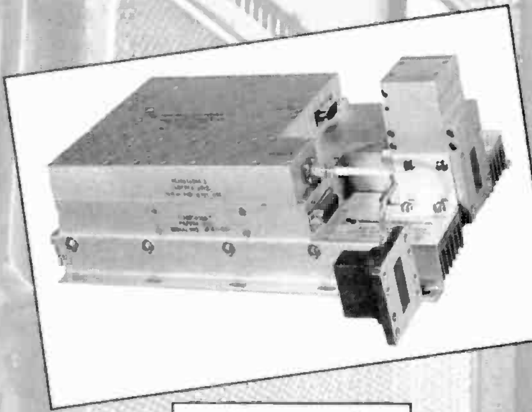
If the goal is to measure the temperature of the transmission fluid, engine oil, differential, or coolant, mount the sensor in a manner that maintains good thermal contact to the outer plate of the item being monitored. Heat sink compound should also be used to ensure good thermal contact. For example, when monitoring oil temperature, mount the sensor to the bottom, back side of the oil pan, where there will be very little air movement to cool the sensor.

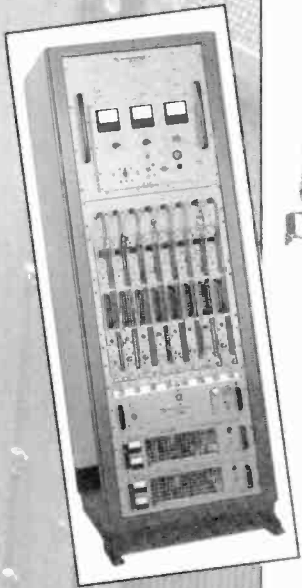
Remove one of the oil pan bolts and manufacture a bracket that will hold the probe to the oil pan. This can be a simple piece of aluminum or thin steel cut in such a way so when the oil pan bolt is inserted through the bracket and into the block, the sensor will be lightly compressed between the bracket and the oil pan. Do not make it too tight, as excessive pressure on the 1N4148 diode will break its glass housing. You may want to hold the sensor by the cable near the diode to be safe. Apply heat sink compound to the sensor and the oil pan where contact is to be made. Be sure the oil pan is free of dirt. Then route the coax cable up through the firewall to the location of the gauge.

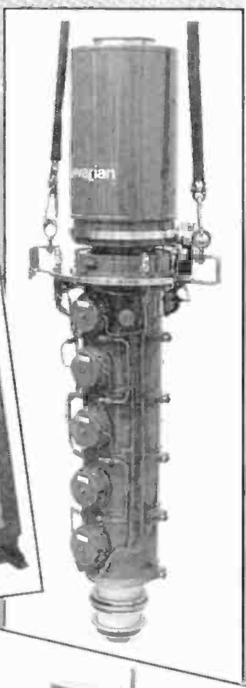
The vacuum gauge is connected to the intake manifold via 7/64-inch vacuum hose. Run the hose through a location in the firewall and to the intake manifold, or vacuum "T" usually located near the rear of the engine compartment. Connect the vacuum hose to P2 (port 2) on the sending unit.

Once a suitable panel or enclosure has been constructed, and the gauges mounted to it, install the assembly into the vehicle and connect the power to a source that is on only when the ignition key is in the "on" position. Be sure to secure any hookup wires so they will not present a hazard to you or your vehicle. Your new digital gauge system is now ready to display important vehicle information and keep you up to date on its condition. **R-E**

INTRODUCTION TO *MICROWAVE* TECHNOLOGY







Learn about early RF oscillators in our continuing series on microwave circuits

JOSEPH J. CARR

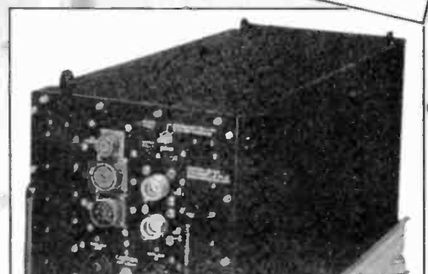
LAST MONTH, WE EXAMINED SOME basic concepts of the electromagnetic spectrum, some basic parameters of electromagnetic waves (such as amplitude, frequency, period, and wavelength), and some early methods of RF generation, including the spark-gap generator, and the *B*arkhausen-*K*urz *O*scillator or BKO. This month, we'll examine some early microwave RF sources in greater depth, to try and appreciate the problems faced by early designers.

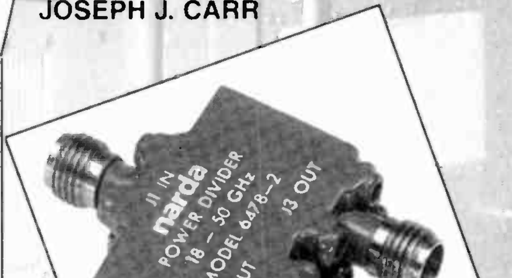
In the early days of radio, the term "microwave" meant anything above about 100 MHz. The region above modern CB was usually called "UHF," which an early textbook referred to jokingly as "unbelievably high frequencies." Many recent European receivers mark the FM band (88–108 MHz) with a "U," after the German "ultra kurz welle" (ultra-short waves). Such early designations were indicative of the problems of generating RF power at such frequencies because of device limitations.

One of the earliest problems inhibiting full use of the RF spectrum was the inability to generate enough RF power at frequencies of value. For many years generating RF signals at useful power levels was limited to the *M*edium-*F*requency (MF) band. Various problems limited devices then in common use. But from 1920–45, advantage was taken of inherent limitations of vacuum tubes to enable the generation of RF power at higher frequencies.

The definition of what constitutes high frequencies has varied according to the difficulty of generating RF power at those ranges. Until the early-1920's, when hams opened the HF shortwave region (3–30 MHz), commercial radio used the MF range with: $\lambda < 200$ m/cyc, or: $f < 1.5$ MHz. The technology of that period worked well at MF, but its effectiveness dropped rapidly with increased frequency.

Even in the early days of radio, higher frequencies were examined. Early radio pioneer Heinrich Hertz, in 1887-88, used 31.3 MHz–1.25 GHz for short range investigations across his lab, and 1.25 GHz is a microwave frequency even now! Guglielmo Marconi used 500 MHz for short-range experiments, but switched to MF when he found that lower frequencies yielded propagation over greater distances.





Besides the fact that RF was easier to generate in this region, the detectors of that period ("Branly coherers," after Prof. Edouard Branly) were far more sensitive in the MF range. In addition, experimenters of the period also ran into some realities of electromagnetic propagation. On December 12, 1901 Marconi and his coworkers achieved the first confirmed transatlantic transmission, of 313 kHz from Poldhu, Great Britain, to Marconi's receiver at St. Johns, Newfoundland, Canada. A transmitter power of 10 kW was used to achieve that feat.

Vacuum tubes made possible operation on yet higher frequencies. Commercial, military and amateur radio moved to the HF shortwave region in the mid-1920's. Difficulties with devices above 25 MHz caused the region above modern CB to be called "ultra-high frequencies" (UHF). Today, "UHF" designates 300–900 MHz. Advances in vacuum tubes during World War II allowed practical use of up to 450 MHz, so the UHF definition was changed.

The three traditional methods for generating RF energy were spark gaps, Alexanderson alternators, and vacuum tubes.

Spark gap generators

An electric arc produces tremendous energy at both harmonic and non-harmonic spurious frequencies. For example, any AM receiver will pick up noise from lightning. Similarly, arcs from motors or ignition systems also produce large amounts of wide-bandwidth RF noise. Figure 1 shows a simple spark-gap RF power generator. Until 1938, when they were declared illegal, circuits like these were used to make crude radio transmitters. Some early experimenters stole Ford Model-A ignition coils from their family car to make spark-gap transmitters. Today, spark-gap RF generators are used for medical electrocautery.

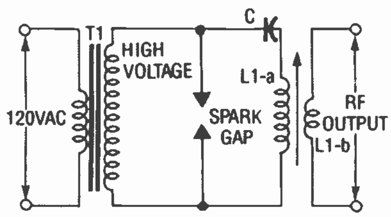


FIG. 1—A SIMPLE SPARK-GAP RF POWER GENERATOR used as a crude transmitter; they were declared illegal in 1938.

The power for a spark-gap generator comes from a high-voltage AC power transformer, T1. The secondary voltage is high enough to ionize the air between the spark gap electrodes. A series-resonant LC tank (L1-a-C1) picks off the RF energy. Unfortunately, a spark gap is very wideband: an 800-kHz spark-gap generator actually produces significant power levels from 10–3000 kHz, and weak harmonics up to the microwave range. A secondary is wound onto L1-a for RF output.

Figure 2 shows a method used in 1930 to generate microwave RF up to 75 GHz. A spark gap goes inside a cavity acting as a resonant tank. A coupling loop picks off the RF output, and delivers it to the load. Unfortunately, spark gaps are very inefficient. Since their RF power has wide bandwidth, only a small amount is available over any narrow band approximating a single frequency. Also, as frequency increases, the power drops dramatically. At 75 GHz, the efficiency is far below 1%, since the majority of the RF power is outside the microwave range.

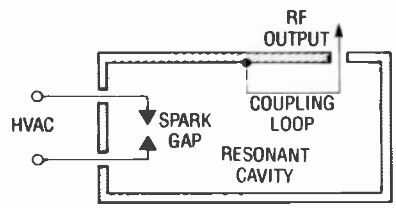


FIG. 2—A SPARK-GAP TRANSMITTER USED IN THE 1930's. The spark gap and cavity are a resonant tank, and the coupling loop picks off the RF. However, bandwidth is very wide, with only a small amount of power per frequency; efficiency is under 1% at 75 GHz.

Alexanderson alternators

The two main problems with spark-gap transmitters are limited efficiency and spectral purity. The Alexanderson alternator attempted to overcome those problems: it was identical, except for the use of rectifiers, to the alternator on modern cars. A magnet would rotate inside a coil. The frequency of the AC generated by the stator is related to the number of poles on the magnet, the number of coil pairs in the stator, and the speed of rotation. If a magnet were spun at 1 rev/s inside a two-pole stator, a 1-Hz signal would be generated. By increasing the number of magnets, the number of stator poles, and the rotation speed, frequencies up to 1 MHz could be generated, although most alternators produced 30–200 kHz.

The alternators in communications use an electromagnet to generate RF. Telegraphy was possible, by interrupting the coil current with a telegraph key. In 1916, engineers from the Naval Research Lab (NRL), Washington, D.C., used the U.S. Navy radio station at Arlington, VA (call sign NAA), to produce the world's first voice transmission over radio. NAA, also known as Radio Arlington, had a 100-kW, 113-kHz alternator, and dominated voice radio before World War I. NAA engineers varied the electromagnet current using a voice signal, to create AM. Because of its low operating frequency, the Alexanderson alternator was of limited microwave value.

Vacuum-tube oscillators

Although this series is about microwave devices, we must take a brief look at vacuum tubes, in order to understand the limitations and problems of microwave oscillators. In 1885, Thomas A. Edison noted the Edison effect, that a positively charged electrode inside an evacuated glass bulb drew current. In 1905, Alexander Fleming of Great Briain used that effect to make the diode rectifier, using a heated cathode to emit electrons, and an anode to collect them. In 1907, Lee De-Forest of the U.S. inserted a grid to modulate the anode current, to make the triode.

Figure 3 shows the basic triode, with cathode, grid, and anode. In some models, the cathode is a direct heater, while here it's a hollow tube with indirect filament. In either case, the object is to heat the cathode until electrons boil off into the surrounding volume; a process called thermionic emission. This electron cloud is called space charge. A positive anode or plate placed nearby attracts these electrons, creating anode current.

The porous grid is between cathode and anode. If the grid is negatively biased, it can control anode current. If negative enough, the anode current goes to zero. When V_i is superposed on V_G, the total grid voltage is $V_i + V_G$. If V_i is negative, the total bias increases, so the anode current decreases. Conversely, when V_i is positive the total bias decreases, so the anode current increases. Thus, V_i modulates the anode current.

Early vacuum tubes were quite limited in bandwidth: devices that operated above 15 MHz were rare. The primary problems were lead inductance, interelectrode

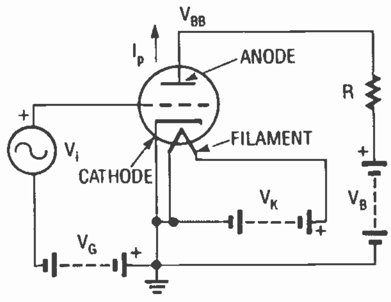


FIG. 3—THE TRIODE, WITH CATHODE, GRID, AND ANODE. The cathode thermionically emits space charge electrons, attracted to the anode as current. Total grid voltage is $V_i + V_G$, and V_i modulates anode current. If V_i is negative, bias increases and anode current decreases, and vice-versa.

capacitance, *Gain-Bandwidth Product* (GBP), transit time/angle, and interelectrode spacing. Making the electrodes smaller decreases capacitance, but severely limits operating power, and was deemed useless. Moving the elements further apart also decreases capacitance, but increases transit time. Transit time/angle problems occur when the time required for electrons to pass from cathode to anode approximates the signal period.

The Barkhausen-Kurz Oscillators

An early solution to the bandwidth problem in vacuum tubes was to exploit transit time, as in the *B*arkhausen-*K*urz *O*scillator or BKO. The BKO in Fig. 4-*a* used a triode with reversed anode bias. The BKO had a cylindrical anode, since flat or rectangular anodes wouldn't work in BKO mode. Both anode and cathode were negative, while the grid was positive.

Figure 4-*b* shows BKO operation. Cathode electrons were attracted by the positive grid toward the anode, but its negative bias repelled them. Since the cathode was negative, a similar effect occurred there. Electrons traveled circularly about the grid, with the operating frequency set by the rotation rate. Output power was taken from the grid, a principal limitation of the BKO. The small grid size limited RF power, so it normally ran white hot.

Other approaches

Later devices used magnetic fields to control current, instead of the electric field of the BKO. These included the magnetron, an "M-type" crossed-field device invented by Hull in 1921, the par-

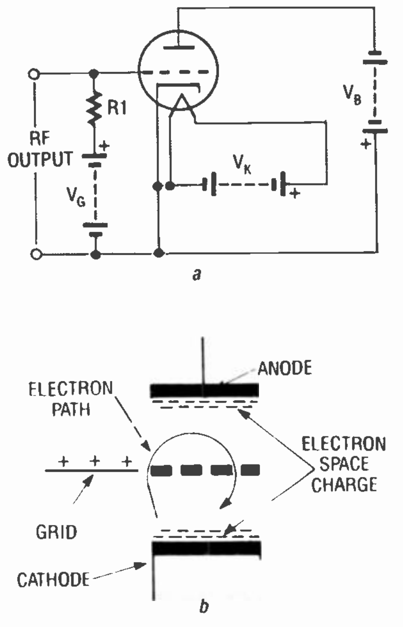


FIG. 4—THE *B*ARKHAUSEN-*K*URZ *O* SCILLATOR (BKO) used transit time to increase bandwidth. In (*a*), both cathode and anode are negative; the grid is positive. In (*b*), cathode electrons are alternately attracted toward and repelled from the anode, traveling circularly about the grid with rotation rate setting operating frequency. The small grid porduced only limited RF output power, so it ran white hot.

allel-field "O-type" device invented by both the Heil's in 1935, and the Varian brothers in 1939. Next month, we'll examine the magnetron in depth. **R-E**

LAWN RANGER

continued from page 58

cutting disks take too long to come up to speed, adjust R38 on the power board. If they take too long to stop, check relay RY2 and resistor R43. Disconnect J11-2.

Automatic guidance test

By blocking grass sensors with your fingers or electrical tape, you can simulate a grass border that the Lawn Ranger can follow. As you block different grass sensors, you can verify that the motor controller is working properly by observing the drive wheels as they change in both speed and direction.

Before turning the Lawn Ranger on, ensure that the cutting blades and disks are disconnected. Place the rear end of the unit up on blocks so the wheels do not touch the ground. Ensure that the grass sensors are not blocked by grass or other objects and that the manual controller is disconnected. Turn the ignition key clockwise and push the START button. The right wheel should spin clockwise and the left wheel should spin counter clockwise. The Lawn Ranger will initiate a left turn because it cannot detect tall grass. If it were allowed to move on the ground, you would see it steer to the left in a counterclockwise circle. It would continue to move in a circle searching for tall grass for approximately 6 seconds and then turn itself off.

Now it is time to test the full range of the steering. Block sensors 1–8 with electrical tape. Adjust potentiometer R203 as described in the July issue. Now, Adjust R201 and R202 until both wheels spin at the same rate. You can calculate wheel speed by counting the number of revolutions that each wheel performs within one minute (rpm's). This test validates that the Lawn Ranger steers straight ahead when the grass border is in the center of the grass-sensor assembly (between sensors 8 and 9).

Clear all the grass sensors so they are free of obstructions; the Lawn Ranger should return to its left turn mode. Now, block sensor 1, then 2, then 3, and so on, until

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WHATEVER HAPPENED TO AM RADIO?

GERRY L. DEXTER

AM radio is seeing hard times.

MOLLY WOULD CRY OUT, "NO, NO, McGee—not the front closet!" But Fibber McGee would open the door anyway, and there'd follow several seconds of crashes, bangs, thumps, and thuds as Fibber's famous overstuffed closet emptied out. The radio audience loved that, as well as the show and its characters.

Fibber McGee and Molly were part of the "Golden Age" of radio in the 1930's, 1940's, and early 1950's, when amplitude modulation (AM) was king, and Jack Armstrong, Gangbusters, Gabreal Heater, the Lux Radio Theater, Edward R. Murrow, and hundreds of other shows and personalities ruled the airways. It was even bigger then than TV is now, because there was really no competition except movies and newspapers. Now, those days are gone and AM is seeing hard times. The present AM is a far cry from a decade ago.

The trouble with AM

Surprisingly, AM's problems are only partially due to TV. When TV skyrocketed in the 1950's, AM radio actually prospered, despite a period when it took some blows. Once the Top 40 arose, with repetitive song cycles, energetic disc jockeys, time, temperature, and contests, AM found its fortunes again. Actually, most of AM's troubles come from frequency modulation (FM) competition. AM and FM may both be radio, but there are some important differences in the way information is transmitted.

Both AM and FM transmitters radiate "carrier" wave RF, modulated to contain transmitted information. In AM, the carrier wave amplitude is proportional to the audio amplitude, but the carrier *frequency* is constant. Figure 1 shows the components of an amplitude modulated waveform; (*a*) is the carrier RF signal, (*b*) is the audio-modulation signal and (*c*) shows the amplitude-modulated carrier signal. In FM, the carrier *amplitude* is constant, while the carrier frequency varies in proportion to the audio signal rate. Figure 2-*a* shows an FM audio signal, and Fig. 2-*b* is the frequency-modulated carrier.

The AM band is much lower in the RF spectrum than FM: AM spans 535–1605 kHz, while FM spans 88–108 MHz. AM channels are 10 kHz wide and FM channels are 200 kHz wide, so you would be able to squeeze only about 5.5 FM channels onto the entire AM band. There are 107 AM channels presently available, and 100 on FM.

FM signals normally don't propagate beyond 75 miles, which is considered the line-of-sight limit and is within the Very-High Frequency (VHF) range. The VHF range used by broadcasters is subject to signal scattering from obstructions such as building edges or hills and is prone to fading in and out under certain conditions. In contrast, AM signals often travel very great distances. The difference between AM and FM signal propagation is due to the great difference in their carrier frequencies, not their modulation differences.

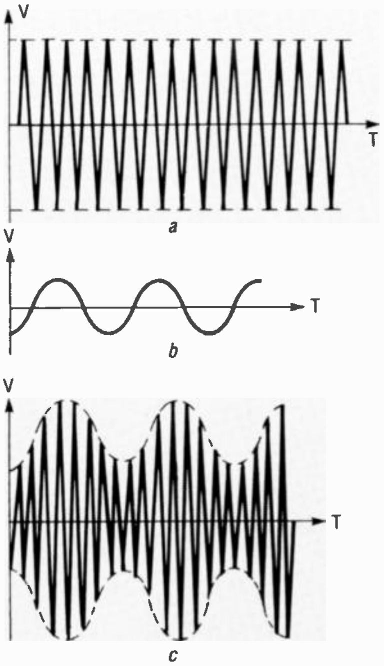


FIG. 1—AM SIGNAL COMPONENTS; (*a*) is the carrier signal, (*b*) is the modulating signal, and (*c*) is the amplitude modulated signal at a constant frequency.

Two characteristics of FM operation are responsible for its high fidelity response: wide bandwidth transmission and constant carrier amplitude. The wide bandwidth allows a wider range of audio frequencies to be processed, up to 15 kHz for FM, compared to only 5 kHz for AM. The source of most noise in AM transmission and reception is from atmospheric or static noise resulting from lightning, fluorescent device radiation, and electronic machinery, especially during hot weather. AM transmission is, therefore, amplitude-sensitive. By maintaining a constant carrier amplitude in FM, static noise can virtually be eliminated. FM was originally used for stereo because of its high fidelity.

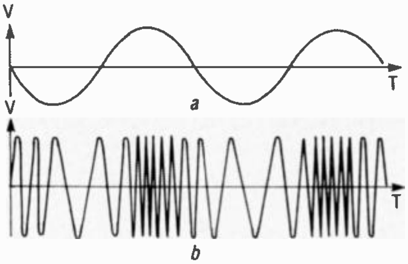


FIG. 2—HERE IS AN FM SIGNAL; (*a*) is the audio modulating signal and (*b*) is the frequency modulated carrier signal at a constant amplitude.

FM popularity

After World War II, AM stations began adding FM. There weren't many FM stations back then, so FM programming consisted primarily of classical music to take advantage of the high fidelity; otherwise they just duplicated AM programming. FM grew slowly, because consumer-electronics manufacturers and the public were mesmerized by TV. Some AM stations gave up on FM, relinquishing their FCC FM station licenses. They regretted it later, when FM became prominent but, by then, most FM frequency allocations were gone.

Several factors contributed to the prominence of FM. Stereo arrived in the early 1960's, becoming the foundation of further success. The availability of FM stereo receivers, component systems, AM/FM portables, and AM/FM car stereos followed. The FCC eventually ruled that most combined AM/FM stations had to program AM and FM broadcasts separately, forcing broadcasters to create competitive FM programming. There then arose a couple of generations of listeners who used radio mainly for music, not comedy, drama, or news.

The growth of FM over AM in the last 16 years has been dramatic. In 1972, AM had 75% of the radio audience; that was reversed by 1988. FM is considered *the* stereo music medium, which is what most listeners want. However, not all AM is in trouble; large markets capable of developing major audience shares command sale prices of tens of millions of dollars. However, the average AM station is far less glamorous.

AM's battle against FM

Most mid-size markets have a couple of AM stations at the bottom of the ratings. The top two or three in a market get by on community service, creative programming, good management, and poor competition. Most AM stations that are considered to be on shaky-grounds are those that broadcast daytime-only stations, especially those that have no FM companion station, and aren't part of a broadcasting group under one owner. They sink or swim on their own and most drown; about 65% lose money.

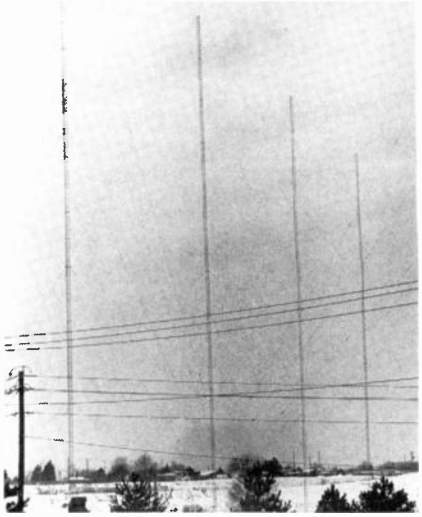


FIG. 3—AM RADIO TRANSMITTING TOWERS aren't the beacons of comedy and drama they were in the good old days.

The FCC helped by giving most daytime stations post-sunset broadcast authorizations, but the rules often dictate transmitter powers as low as 1–50 watts! Even for a small-town station, that's not enough power to provide the needed coverage, especially if there's competition. AM's crowded frequencies are another problem, especially for night listening when signals propagate farther. Interference obviously turns listeners away. Many AM channels are a jumble of noise at night, with half a dozen stations fighting to be heard and none succeeding.

In the 1960's and most of the 1970's, AM rode high, and many broadcasters and investors wanted part of the market. Hundreds of new stations began during that period, crowding the AM dial. Many towns of 20,000 people have two or three AM stations competing for large FM audiences. The economic downturn of the late 1970's and early 80's hurt many AM stations, especially those in rust and farm belts, which suffered most from the sluggish economy.

AM radio generally gets a small slice of local advertising, with the larger chunk going to FM. TV, cable, newspaper, shopping, and billboard competition is very heavy. Falling revenues mean less money for promotional or innovative program changes, or high-quality air personalities that might hold an audience. In 1988, AM and FM each had about 5,000 commercial stations; AM stations did $1.7–$1.9 billion of business, while FM stations did $4.8–$5 billion. FM's early lack of commercial success helped draw listeners because of fewer commercials. And, while FM stations do air more commercials today, they still air about half as many as AM stations—they just charge more.

AM solutions

AM station managers know the problems, and try to find solutions. They know audiences don't see AM as a music medium. A National Association of Broadcasters survey on public attitudes toward AM found that 75% of respondents want good programming with good technical sound. The survey showed both a strong preference for news-talk-information on AM, and an older audience. Some stations try drastic cures. "Narrowcasting" or "niche programming" describes programming aimed at very specific audiences:

- In New York, WFAN (once WNBC, flagship station of the NBC network) runs an all-sports format: play-by-play, sports talk, and news.
- In Los Angeles, with 100 competing stations, KMNY devotes itself to money, and how to have more of it, syndicating some programs to other stations.
- All-kiddie radio by KPAL, Little Rock, Arkansas, includes children's music, stories, and school news reported by children.
- In Florida, WWNN broadcasts self-help and positive-thinking radio programs.
- Several stations now use single-theme approaches to music. There are all-Elvis stations, and at least one playing only Beatles music.

Whether these formats will last is yet to be seen. For example, all-weather and traffic formats have been tried and abandoned in Los Angeles and Minneapolis. AM stations can also inexpensively subscribe to satellite program services. Services with a "big city" feel have proven successful for smaller stations, especially when such services can mean savings through staff cutbacks, or when staff can be freed to develop more local and major news programming. It's easy to insert local news, sports, weather, and other features.

Not long ago, AM operators thought the answer was AM stereo, but it's been a disappointing panacea. Most broadcast experts feel that the FCC ruined things by refusing to pick a specific AM

BETTER RECEIVERS FOR BETTER SOUND

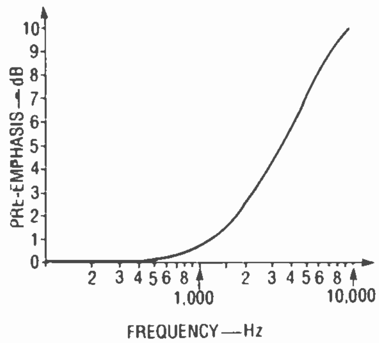
One of the main reasons why AM has taken a back seat to FM is because of AM's inherently poor fidelity. The National Association of Broadcasters (NAB) is trying to do something about that. Specifically, the NAB is trying to convince electronic manufacturers to incorporate three design improvements into their AM receivers. Those improvements, which are in accordance with the National Radio Systems Committee (NRSC) suggested guidelines are: the ability to receive frequencies within the expanded band, AM stereo compatibility and, de-emphasis circuitry.

Manufacturers will be able to make units that receive transmitted signals in the expanded bandwidth fairly easily and inexpensively. However, they are much more reluctant to jump into mass production of AM stereo receivers--adapting current product designs to incorporate stereo reception can be an expensive proposition.

Another stumbling block that manufacturers face is that there are two mutually incompatible systems on the market. Motorola's C-Quam and Kahn Communications are two AM stereo systems that are currently in use by broadcasters today. C-Quam is used by approximately 500 broadcasters, while only about 100 broadcasters use the Kahn System. The only commercially available AM stereo receivers on the market are compatible with Motorola's C-Quam transmitter design. Sony, Sanyo and Sansui previously made IC stereo detectors that were compatible with both the C-Quam and Kahn transmission systems, and about 20 such receiver models were once produced by those companies. However, those chips and receivers are no longer in production because of various legal battles between Kahn and Motorola. We may again see some Kahn-compatible receivers after the legal dispute is over.

There are still many varied opinions in the broadcasting field about which system is better. Broadcast engineers profess the advantages of each system, and may choose one system over another because of their specific transmission needs, or personal preferences. When AM stereo was first introduced years ago, FCC's "let the marketplace decide" attitude sealed the fate of AM stereo by causing a relentless battle between various competing systems. Now, more than eight years after the introduction of AM stereo, the two survivors, Kahn and Motorola, are still battling it out. The FCC's lack of direction during the early stages has hindered the acceptance of AM stereo, and has hurt not only electronic manufacturers, but consumers, too.

Frequency boosting, or pre-emphasis is a design modification that the NRSC is recommending to reduce noise transmission for higher fidelity. Within the time interval that an AM signal carrier is transmitted and received, the carrier signal may be affected by noise. The greatest impact that noise has on the carrier is changing the amplitude. FM is much less subject to that type of noise distortion because it is transmitted at a constant amplitude. The sound volume of an AM detector is proportional to deviation of the carrier amplitude. If the audio signals cause a much larger amplitude change than the unwanted noise amplitude deviations, during transmission and reception, then the noise will not be very noticeable. That relationship is called the signal-to-noise ratio—the higher the value, the better the sound quality.



PRE-EMPHASIS CHARACTERISTIC suggested by the NRSC for AM transmission.

In a pre-emphasis circuit, a portion of the transmitted signal is boosted, or pre-emphasized, causing a larger carrier amplitude deviation. The receiver conversely de-emphasizes, or attenuates that signal. The overall effect is to increase the signal-to noise-ratio. The accompanying figure shows the 75 μs pre-emphasis characteristic suggested for use.

The NAB is working closely with the electronic industry to develop a certification for improved AM receiver designs which follow NRSC guidelines. One idea is to authorize the use of a quality mark that will identify receivers that comply with NRSC standards. Broadcasters are also receptive to the idea of promoting the new design standards in AM receivers. Clearly, AM stereo compatibility and the efforts to improve AM sound quality are complicated issues which are still being worked out. Perhaps with the cooperation of the electronic industry, broadcasters, and the FCC, AM will continue as a viable communications medium.


FIG. 4—TALK SHOWS, OFTEN WITH LIVE GUESTS, are a programming staple of stations of all sizes.


FIG. 5—WELL-RUN SMALL-TOWN STATIONS with a solid history are likely to continue a successful tradition.

stereo approach from the half-dozen stations competing for FCC approval. Instead, the FCC let the market decide, and so far it hasn't. In the last seven years, AM stereo has barely affected the minds of broadcasters or the public.

Two AM stereo systems are still competing: Motorola's C-Quam, and the system developed by Kahn Communications. Broadcasters haven't reached a consensus on which should be standard. Only 10% of AM stations now have stereo. The audience percentage that use AM stereo gear is still low, and there's no real impetus to switch, which can cost up to $100,000—half a year's income or more for some small stations.

AM's expanded band

An important change affecting AM broadcasters as well as radio receiver manufacturers is that of AM frequency band expansion, or "AM improvement." In 1988, the World Administrative Radio Conference agreed to expand the AM radio upper bound from 1600 kHz to 1700 kHz, effective July 1, 1990. Ten additional channel slots will be available as a result of the expansion. With 20 to 30 stations per channel, a total of approximately 200 to 300 new AM stations in the U.S. could conceivably occupy the expanded band.

The primary objective of the FCC in authorizing transmission in the upper range is to unclutter the existing band and reduce the overall levels of broadcast interference. Stations who are considered as causing the most interference will be given highest priority by the FCC for transmission in the upper band. Some night-time broadcasters are considered to be the "worst offenders," and the FCC is hoping that most of those stations will voluntarily migrate into the upper band. The advantage of changing into the upper band is that the adjacent stations will experience less interference, and the listener will receive a much clearer broadcast.

After a transition period, the FCC will make new AM stations available for new licensees, so that broadcasters can make full use of the entire expanded band. Stations who are licensed to broadcast within the new upper range will be able to transmit full-time, with power restrictions of minimum 1 kilowatts after sunset and 10 kilowatts during daylight hours.

Many problems, however, still need to be solved. Existing services, such as the Traveler's Information Stations (TIS) will need to move or—because the TIS are considered by the FCC to be secondary broadcasters—may have to relinquish their transmitting rights.

So, can we see the future of AM? Clearly, it'll hardly vanish from your dial. Most stations will likely solve problems by new programming, promotion, management, and technology. Some may not have their prior success, having to live with less. But those with bleak futures may die out due to survival of the fittest. That sort of periodic adjustment befalls most industries, when change creates a new operating climate, killing off and weeding out the weak, leaving what's left leaner and meaner. Meanwhile, those who live and work in the world of AM radio today can only echo Molly's long ago words: "Taint funny McGee!" **R-E**

HARDWARE HACKER

Perpetual motion, independent research, the magnetocaloric effect, and audio voltmeters.

DON LANCASTER

It's not at all obvious to me why we need all of the foot dragging, infighting, and squabbling going on today over HDTV high-quality video-display standards. It seems that several government agencies are now battling each other to win the coveted role of chief obstructionist.

To me, it is entirely obvious that HDTV *will* use square pixels, *will not* have interlace, *will* use fully programmable, rather than hard-wired (single standard) receivers and displays, *will* be totally digital, *will* use a real-time JPEG compression, and *will* follow Japanese set standards.

It is also totally obvious to me that terrestrial broadcasting will serve a negligible to totally vanishing role in HDTV, while the computing, satellite, VCR, and cable uses will overwhelmingly dominate. And any intermediate or interim "transition" steps will prove to be a monumental waste of time and money, done by the wrong people for the wrong reasons.

So, let's just ban the networks and the feds from *any* HDTV input whatsoever, and then get on with it. They are the enemy, not Japan. Our topics this month seem to range from the ridiculous to the sublime...

Perpetual motion

It may be the New Age nineties, or just a sunspot cycle peak, but a surprisingly large number of all you hardware hackers are busy at work building your own perpetual motion machines. I simply cannot believe the number of helpline calls and visitor drop-ins I am getting on this.

Since perpetual motion is definitely real as far as its history and its ongoing activities are concerned, maybe we should take a brief look here.

I guess I was in the seventh grade when I built my first perpetual motion machine. Figure 1 shows the details. I took a gyroscope and hung several magnets on it so that like poles faced each other. The magnets were at an angle so that the repulsion would have a tangential component. As the poles repelled each other, the gyroscope would accelerate.

Or so I thought at the time. Very strangely, the gyroscope locked up instead of spinning. Seems it latched itself into a minimum reluctance field position and just sat there.

These days, I guess I don't really understand why perpetual motion is desirable. Since unlimited free energy would hasten the entropic heat death of the planet, perpetual motion is both environmentally unconscionable and socially reprehensible. The first thing we should do to a successful perpetual motion machine designer is to just stake him to an anthill, and then leave him out there until the next meeting of the steering committee.

Nonetheless, perpetual motion is a fascinating topic. Some very good books on this subject are available from *Lindsay Publications*, while a few of the more opportune ongoing perpetual-motion scams are available to you through *H&A Industries* or the *Tesla Book Company*.

After working with a bunch of them, the perpetual-motion buildees these days all appear to share several common traits. None of them have ever attended an introductory college physics course, or else they seem to have slept through it.

While all of them claim they "just can't find anything at all" on their idea, they studiously go out of their way to avoid doing any real or honest library research. As we've found out several times in the past, any hardware hacker anywhere can instantly get the very latest scoop on anything by way of the *Dialog Information Service*. More on this shortly.

A disproportionate number of the perpetual-motion buildees seem to belong to one particular religion that happens to be very big on faith and on self-reliance.

There's often a very heavy dose of paranoia, usually aimed at the patent office, a local university, those oil companies, Detroit (who could not possibly suppress anything except quality or profits), an ex-boss, or else "them" in general.

Almost always, the buildees think *linearly* instead of *cyclically*. Thus, while a power stroke of the repelling magnets or their freezing milk bottle makes a lot of sense to them, they usually ignore the inevitable repetitive and cyclic energy supplying steps as needed to get to that stage.

There's also the *Cosmic cupcake* syndrome, the *Few chips shy of a full board* affliction, and the *Boy a whole flock of them flew over that time* concept. But we need not get into any of these here.

Finally, there is the *magic bullet*. Their idea almost but not quite works. So, all we need to fix it is better gears, stronger magnets, a larger milk bottle, or a different rear axle ratio. Or more bucks for research.

Several of us folks around here at **Radio-Electronics** editorial have now somehow gotten some silly ideas into our collective heads. For some unbeknownst reason, many of us presently feel that:

(A) Neither matter nor energy can be created or destroyed, except by an atomic process.

(B) Available energy always seems to convert itself from higher quality forms into lower and less useful ones. Not once have the dishes ever washed themselves. Nor have those pool balls ever re-racked themselves.

(C) Nearly all physical and elec-

NEED HELP?

Phone or write your **Hardware Hacker** questions directly to:
Don Lancaster
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Box 809
Thatcher, AZ 85552
(602) 428-4073

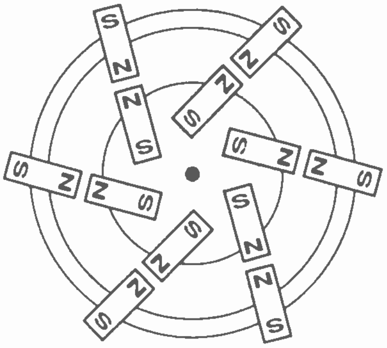


FIG. 1—MY VERY FIRST PERPETUAL MOTION MACHINE. As the like poles of the magnets repel each other, they accelerate the rotor on a gyroscope. Sadly, it latched, rather than speeding up. But maybe if I used stronger magnets...

tronic processes end up producing unrecoverable low-grade heat energy, usually through friction or electrical resistance.

(D) Despite a House-Senate compromise committee, Congress is not expected to repeal the three laws of thermodynamics this session. Paraphrased, these three laws are (1) You can't win; (2) You can't break even; and (3) Yes, the dice are crooked, but it's the only game in town.

I guess one of the reasons some of us around here feel this way is that not once in the entire history of hardware hacking has even one reproducible counter example to these silly ideas of ours ever been successfully and unarguably demonstrated.

Naturally, you are free to agree or disagree with us as you wish. But if you disagree, we do make only one simple request: Provide us with an experiment that can be *independently* duplicated by *disinterested* outsiders which causes your effect to show up at least reasonably well. Then we will all believe.

Doing serious research

So, what is the best way to research any topic? I don't know how many calls and letters I have gotten from people who live in such a "remote" area and will claim that "absolutely nothing" is available locally. Believe it or not, one of these letters was from Cambridge, MA and yet another was from Palo Alto, CA.

Well, I've been sitting right here watching Gila Monsters on this sand dune smack dab in the middle of the Upper Sonoran desert for nearly two decades now. While almost everything I do is local (and much of it done underground or in mountaintop wilderness areas), I've had no problems whatsoever handling top-quality research on all kinds of very rewarding and well-paying topics.

So don't give me any "remote" bull. Admittedly, my tiny and isolated town of 2400 does have its own symphony orchestra, but that's another story.

Figure 2 lists a few of my key secrets to doing independent hacker research. The overwhelming reason you cannot find something is because you are not looking. You are instead going through some inept motions and keeping yourself busy, rather than by taking obvious steps and handling all of them in a logical manner.

Research is not an activity that you turn on or off. Instead, you put yourself in a *continuous* research mode in which you gather and collect *everything*, needed or not, or expected or not. Never mind the topic. The subject does not matter in the least, since chance favors the prepared mind. Thus, your own personal resource file is far and away the most important place to look, should any specific need come up.

Set a minimum goal of eight cubic yards for your personal resource files. At least for a bare bones startup. Then let it grow from there.

Your foremost outside resource should be all of the trade journals. I subscribe to over 400 of them. As we have seen in the past, any and all fields have all their own private technical magazines which are intended for a select group of insiders. Most of these are free, provided you tell them what they want to hear on their qualification cards. Many do include bingo cards, annual directories, and tech info.

Naturally, you'll circle everything even remotely usable on the bingo cards. If in doubt, circle it. If you do not personally rent the largest box in your local post office, you've missed the point here completely.

Electronic trade journal examples include *E.E. Times*, *Electronics*, *EDN*, *Electronic Products*, *Electronic De-*

RARE EARTH RESOURCES

Aesar
Box 8247 Ward Hill
Haverhill, MA 01835
(800) 343-1990
CIRCLE 259 ON FREE INFORMATION CARD

Alfa Products
PO Box 8247
Ward Hill, MA 01835
(800) 343-0660
CIRCLE 260 ON FREE INFORMATION CARD

Cerac
PO Box 1178
Milwaukee, WI 53201
(414) 289-9800
CIRCLE 261 ON FREE INFORMATION CARD

ESPI
5310 Derry
Agoura, CA 91301
(800) 638-2581
CIRCLE 262 ON FREE INFORMATION CARD

Fisher Scientific
711 Forbes Avenue
Pittsburgh, PA 15219
(412) 562-8300
CIRCLE 263 ON FREE INFORMATION CARD

Goodfellow
301 Lindenwood Drive Ste 1
Malvern, PA 19355
(800) 821-2870
CIRCLE 264 ON FREE INFORMATION CARD

(1) - If you can't find it, you ain't lookin.

(2) - Research is a continuous activity done on a total lifestyle basis. You cannot turn it on and off at will.

(3) - Anticipate what you are going to research in the future and get started on it long ahead of any actual or possible need.

(4) - Your own personal resource file should be your first and foremost starting place. Your begining file should fill at least eight cubic yards, and should expand from there.

(5) - The free trade journals are far and away your most important external resource. A complete listing appears in *Uhlricht's Periodicals Dictionary*. Use those bingo cards!

(6) - The *Dialog Information Service* at your local library can instantly find anything for you from anywhere at anytime.

(7) - Other important library resources are the *Science Citations Index*, the *Thomas Registry of Manufacturers*, Interlibrary loan, the *UMI* reprint service, and the *Encyclopedia of Associations*.

(8) - Form an extensive network of contacts outside of your circle of family, friends, or work associates. Clubs, helplines, and BBS systems are ideal for this sort of thing.

(9) - Let your subconscious be your guide, starting from fundamental principles and guidelines. Go with the vibes.

(10) - Quest *tinajas*.

FIG. 2—SEVERAL OF MY INSIDER secrets on independent research.

sign, and dozens more. We'll look at these names and numbers in some future sidebar.

For now, you go to the library and view the Hacker's Holy Grail, that is otherwise known as the *Uhlricht's Periodicals Dictionary*. This one hardware hacking resource is far and away more important than all of the rest put together. Use and enjoy.

The second most important outside Hardware Hacking research resource is the *Dialog Information Service*. It's also at your local library. For a small fee, *Dialog* will instantly research anything, anywhere, anytime. As an example, we'll shortly be looking at magnetic refrigeration. To get from knowing virtually nothing on the topic to having eighteen of the most recent worldwide key abstracts in hand took me a total of seven minutes and cost me a total of $27.57.

There's lots of other goodies in the library, should you snoop around in enough nooks and crannies. In general, the *least* valuable things in any library are its takeout books. There's that free *Interlibrary Loan Service* which lets you get anything from anywhere, and the faster *UMI* service which can get you any reprint of anything provided you know the exact title, journal, and pages. For much less than *Dialog*, as long as you don't mind waiting a few days.

There's also a *Thomas Registry of Manufacturers* that lists who makes everything, but I've found this to be of limited utility. Also, check into the *Encyclopedia of Associations*, and, if you can't locate *Uhlricht's*, then the *International Standard Periodicals Dictionary* is almost as good.

Another library favorite of mine is the virtually unknown *Science Citations Index*. Unlike all the others, this one lets you move *forward* through time, rather than back into older and older material. It works by listing who put whom into their bibliographies.

For instance, any competent new technical paper on active filters *must* reference *Sallen and Key*. Anything new on cold fusion absolutely *must* list *Pons and Fleischman*. Anything new on unfocused solar collectors simply *must* cite *Winston*, and so on. If they don't, then they aren't worth reading anyhow.

Simply shove any of these names through the index, and you'll generate all of the newer papers in the field. After a while, new author names will start cropping up and repeating. You then use the *avalanche effect* to find the latest and the best, just by starting with one or two ancient authors.

And do not ignore the library's kiddie, young adult, or popular press books. Excellent, understandable, and readable backgrounds are easily picked up in the *Doubleday Science Series*, or the *Life Science Library*.

Beyond the library, you'll want to collect the specialty direct-mail books catalogs. We've covered this resource in depth in a previous column and contest. More details appear in my *Hardware Hacker II* reprints.

Let's see. What else is there? You'll definitely want to set up some sort of extensive personal network that involves people strictly *outside* of any friends, family, or work associates. Obviously, my help line works like a champ here. Electronic bulletin board systems are another great route to networking. So are clubs.

Your own personal experiments can very much clarify any topic, as can teaching a class on it. The purpose of research is to get the effect you are after to show up reasonably well in as simple and as cheap a way as possible.

But stay in school forever. While there's lots of possibilities here, the best I've found are local community college courses, and that self-study material from *Heath*.

Finally, simply let things gel. Take Bowseretta up the mountain. Quest a tinaja. Map that terminal crawlway. Any field has an order and a flow to it. Often in directions that "they" don't care to admit. Start with a few fundamentals, think about it for a while, and a pretty fair picture of the rest may fall in place without much in the way of conscious intervention.

Remember that sincerity is everything. Once you've got that faked, all else follows.

This month's contest

Tellyawhat. I am about to reveal here for the first time a stunning new technological breakthrough, one that is eminently hackable, besides being a sure fire winner for a research topic, school paper, or science-fair entry.

Only instead of me doing all the work, let's try doing it together. See how much you can improve your research skills along the way.

Just show me an easily done and **Radio-Electronics**-compatible method to demo the magnetocaloric effect described below, at room or lower temperatures. Or else add in any way (patents, papers, articles, data sheets, etc.) to our ongoing magnetic refrigeration dialog below.

There'll be all the usual *Incredible*

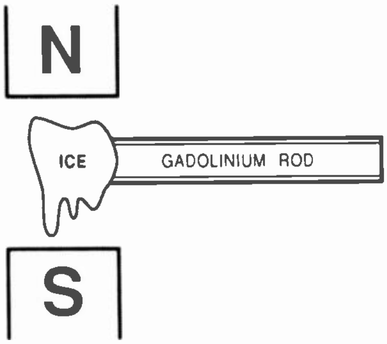


FIG. 3—THE MAGNETOCALORIC EFFECT, very greatly oversimplified. Gadolinium and other rare earth alloys can absorb heat energy in the presence of a magnetic field and release it otherwise. The efficiency can be as much as 40:1 better than mechanical cooling. Magnetic refrigeration is usable over an absolute zero to above room temperature range. Important first uses will be in cryogenics, superconductivity, liquefied gases, and hydrogen fuels.

Magnetocaloric Effect in Strong Magnetic Fields
A.M. Tishin, *Cyrogenics (UK)*, February 1990, v30 #2, pp 127-136.

Magnetocaloric Effects in Rare Earth Magnetic Materials
A.S. Andreenko, et. al., *Soviet Physics (USA)*, August 1989, v32 #8, pp 649-664.

Magnetocaloric Effect in Thulium
C.B. Zimm, et. al., *Cyrogenics (UK)*, September 1989, v29 #9, pp 937-938.

Magnetic Refrigeration
Superconductivity Industries, Spring 1989, v2 #1, pp 32-41.

Magnetocaloric Effect and Refrigerant Capacity of Tb-Dy Alloys
S.A. Nitkin, et.al, *Physics Status Solidi (East Germany)*, May 1989, pp 117-121.

Magnetic Refrigerator for Superconducting Magnets at 1.8K
V.A. Altov, et.al., *ICEC 12 (UK)*, 1988, pp 635-640.

Magneto-thermal Properties of Sintered Gadolinium
E. Gmelin, et. al., *ICEC 12 (UK)*, 1988, pp 432-436.

Determination of the Cooling Capacity of Magnetic Refrigerants
S. Nikitin, et. al., *Soviet Technical Physics Letters*, April 1988, v14 #4, pp 327-328.

Magnetic Refrigerator
T. Hashimoto, *Refrigeration (Japan)*, 1988, v63 #733, pp 1189-1201.

Magnetic Field Changes in the Entropy of Europium Sulphide
P. Bredy, et.al, *Cyrogentic (UK)*, Sept 88, v28 #9, pp 605-606.

Magnetothermal Conductivity of Er-Al for Cyrogenic Applications
C.B. Zimm, et.al., *Journal of Applied Physics*, 15 April 1985, v57 #8, p4294-4296.

Adiabatic Temperature Changes in Ferromagnetic Intermetallic Compounds
C.B. Zimm, et.al., *Journal of Applied Physics*, 15 April 1985, v57 #8, p3829.

Magnetic Refrigeration
T. Hashimoto, et. al., *Solid State Physics (Japan)*, March 1985, v20 #3, p161-175.

Characteristics of Magnetocaloric Refrigerants below 20K
T. Hashimoto, et.al., *ICEC 9 (Japan)*, May 1989, pp 26-29.

A Composite Material for Magnetic Refrigeration Using Internal Heat Transfer.
B. Daudin, et.al, *Cyrogenics (Great Britian)*, September 1982, v22 #9, pp 439-440.

Magnetic Refrigeration from 10K to Room Temperature
T. Hashimoto, et.al., *Cyrogenics (Great Britian)*, November 1981, v21 #11, pp 647-653.

T-S Diagram for Gadolinium Near the Curie Temperature
S. Benford, et.al., *Journal of Applied Physics*, March 1981, v52 #3, pp 2110-2112.

The Magnetocaloric Effect in Dysprosium
S. Benford, et.al, *Journal of Applied Physics*, March 1979, v50 #3, pp 1868-1870.

FIG. 4—A FEW OF THE RECENT PAPERS on magnetic refrigeration and the new magnetocaloric effect.

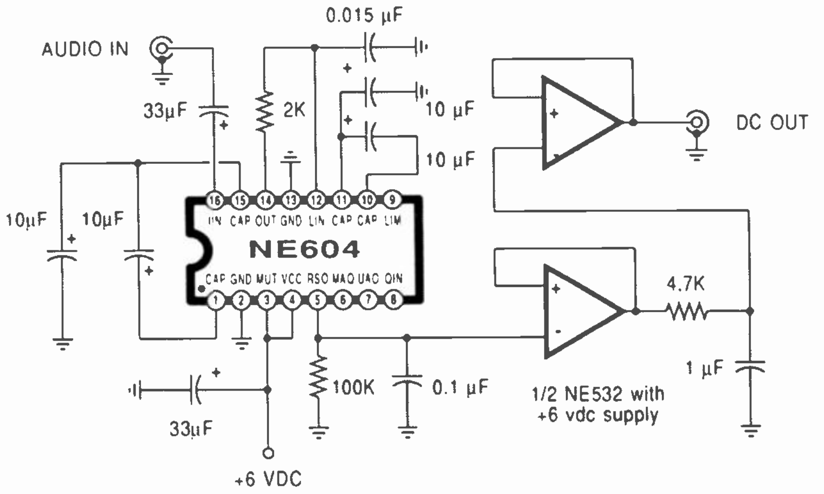


FIG. 5—AN AUDIO VOLTMETER having a range of 0 to −80 dBm. Use this one to calibrate microphones and speakers, or as a receiver "S" meter. Output is 0.5 volts at −80 dBm and 5 volts at 0 dBm. Sensitivity is 10 microvolts.

Secret Money Machine book prizes, along with an all-expense-paid (FOB Thatcher, AZ) *tinaja quest* going to the very best of all. As usual, send your written entries directly to me here at *Synergetics*, rather than directly over to **Radio-Electronics** editorial.

Magnetic refrigeration

There's apparently a brand new way to cool things that is just turning the corner from laboratory to preliminary product development. If what has happened so far is to be believed, it should completely blow away many traditional cooling schemes, particularly at very low temperatures.

This genuine breakthrough is called the *magnetocaloric effect*, and I have grossly oversimplified it in Fig. 3. The latest key papers appear in the listings of Fig. 4.

Basically, if you take critical rare earth elements or their alloys, they will absorb heat when magnetized and release heat otherwise, acting as a heat pump. At least over certain temperature ranges and over specified magnetic field strengths. Gadolinium is one popular material.

Heat transfer operations take place in and around the *Curie Point*. Most magnetic materials lose many of their properties when they exceed their Curie Point temperature.

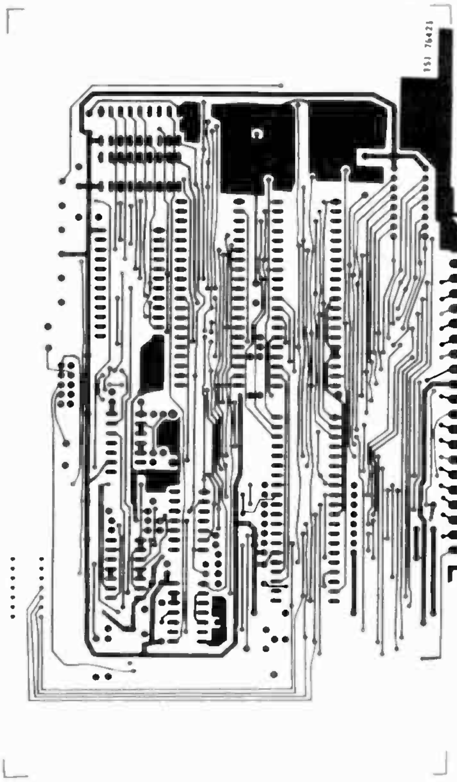
The magnetocaloric effect can be tuned over a range of absolute zero to above room temperature. Efficiencies as much as 40:1 better than mechanical refrigeration have been bandied about. Yes, the effect can be done using no moving parts.

Obvious applications for magnetic refrigeration include cryogenics and superconductivity, the production of liquid gases (especially hydrogen as a fuel), and as Freon replacements for traditional room air conditioners. A few sources of gadolinium and its related rare earths are shown in our

continued on page 90

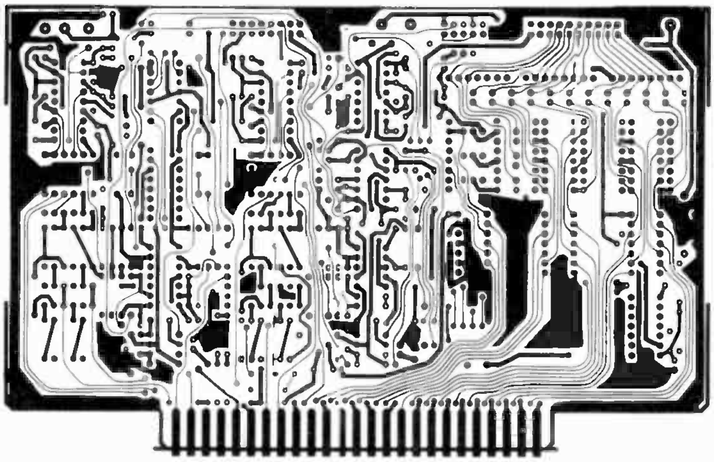
LAWN RANGER

continued from page 70



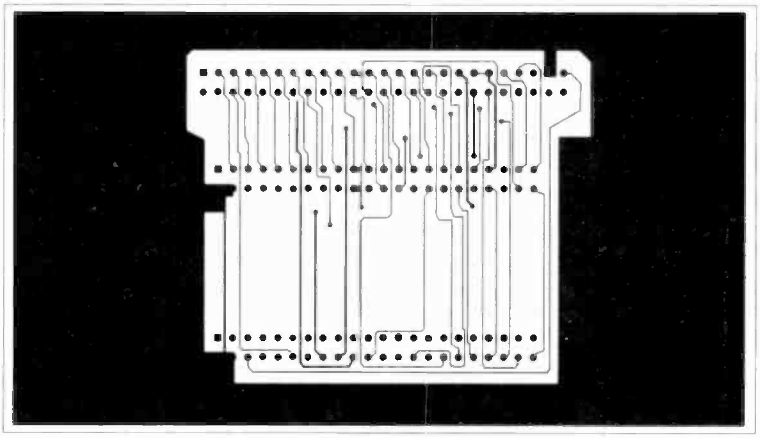
6 INCHES

CPU BOARD SOLDER SIDE AT HALF SIZE.



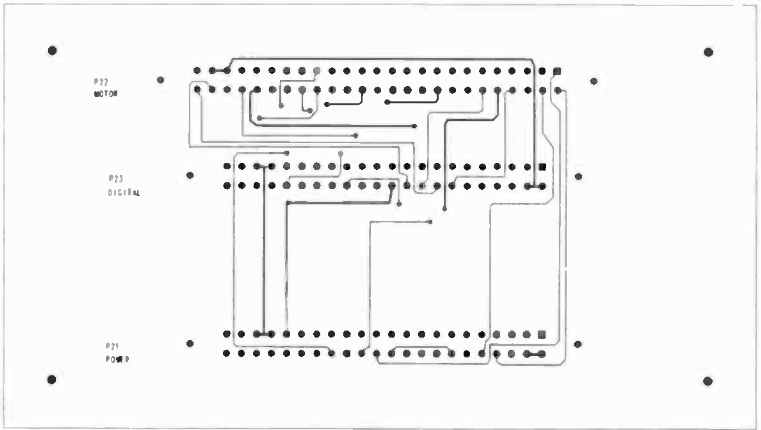
7$^{13}/_{16}$ INCHES

MOTOR CONTROLLER BOARD SOLDER SIDE AT HALF SIZE.



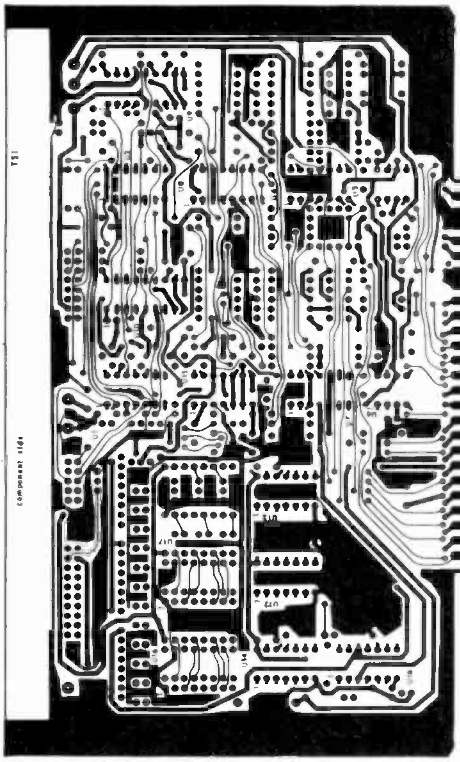
7$^{13}/_{16}$ INCHES

MOTHERBOARD SOLDER SIDE AT HALF SIZE.



7$^{13}/_{16}$ INCHES

MOTHERBOARD COMPONENT SIDE AT HALF SIZE.



7$^{13}/_{16}$ INCHES

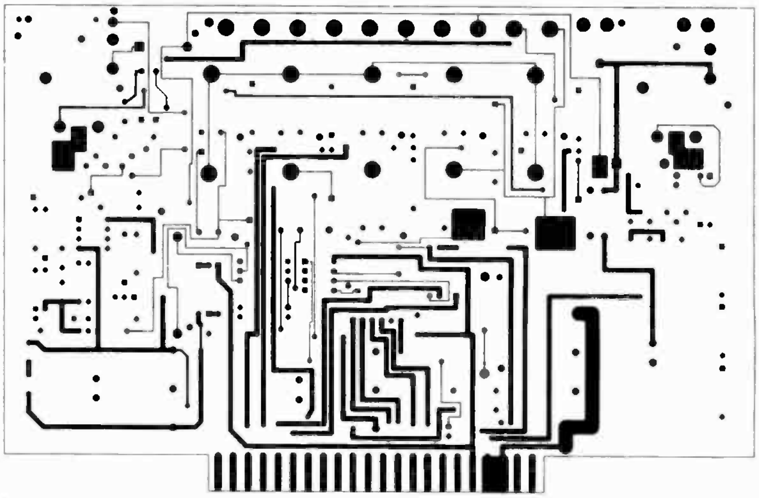
MOTOR CONTROLLER BOARD COMPONENT SIDE AT HALF SIZE.

all the sensors are blocked. You should notice that the left wheel will slowly change from a counter-clockwise to a clockwise direction and the right wheel will change from a clockwise to a counter-clockwise rotation. If the Lawn Ranger has passed all tests so far, it is ready for outdoor testing.

If it did not pass one or more of the tests, double check the operation of the CPU board as described in the June issue.

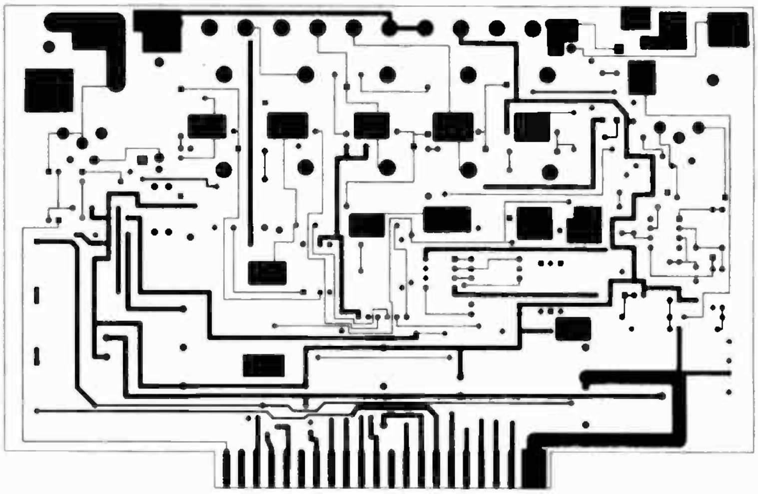
Outdoor guidance testing

Now it is time to have some real fun! Make sure your neighbors or friends are out because they will love to see the capabilities of your new creation. Cut a six-foot thick square border around a small grassy test area with a conventional lawn mower (don't use the Lawn Ranger yet). Connect the manual controller, squeeze the



$7^{13}/_{16}$ INCHES

POWER BOARD COMPONENT SIDE AT HALF SIZE.



$7^{13}/_{16}$ INCHES

POWER BOARD SOLDER SIDE AT HALF SIZE.

hand switch and turn the Lawn Ranger on. "Walk" the unit to the cutting area and place it on the edge of the grass border with the tall grass positioned to the left—see Fig. 1 of the June issue.

Adjust the height of the grass sensors so their tips lie approximately one inch above the cut grass. The uncut grass should be around two inches higher than the cut grass for your first test. Remove the manual controller and push the RUN button. The mower will begin to track along the border you previously cut. It should continue tracking this border until you stop it. If it passes this test, you are ready to connect the cutting blades and really show off.

Final test

Now you are ready to connect the blades as shown in Fig. 3 (make sure the batteries are disconnected before attaching blades). Double check the shields that surround the cutting blades: they should be able to withstand a force as high as 60 pounds upon impact to allow for safe operation.

After the blades are attached, grab yourself a cold drink and "walk" the Lawn Ranger with the manual controller to the test area. Set up the mower as described above and connect the cutting-motor wire to J11-2. Remove the manual controller and turn the Lawn Ranger on.

Push the CUT and RUN button. Now, watch in amazement as the mower automatically cuts the grass contained within the test area. You will love the way it "turns on a dime" when it reaches the end of a row. When it is finished with the job, it will steer in a tight circle searching for tall grass and then turn off. **R-E**

The Sound of Audio: An AES conference report

LARRY KLEIN

Last month I wrote about an audiophile High End Hi-Fi Show. This column is about an altogether different kind of "show" sponsored by the Audio Engineering Society (AES). Properly billed as a conference, rather than a show, "The Sound of Audio" was a wide-ranging exploration of the latest findings on the perception, measurement, recording, and reproduction of sound. A variety of papers were presented along with a special session on the reviewing of audio products featuring reviewers from both "slick" and "underground" publications. Given my 20 years in charge of product reviewing for *Stereo Review*, I heard nothing new—although the session gave me a chance to say hello to a lot of old friends. However, the pertinent and intelligent questions from the audience led me to make a mental note to discuss the somewhat controversial topic of equipment reviews in a future *Audio Update* column. Now, on with the conference.

Pyschoacoustics

Because of my ongoing interest in psychoacoustics, I found the several sessions devoted to audio perception both interesting and enlightening. As you may know, psychoacoustics deals with subjective sonic perceptions, as contrasted to objective sonic measurements. A simple example: For a sound to be heard subjectively as twice as loud, its objective increase in sound-pressure level must be approximately 10 dB.

The three presenters were all university researchers, and their talks included some of their own original research in addition to the very latest findings in the field. Rather than attempting to synthesize three lengthy, and sometimes complex, papers, I'll extract (and paraphrase when necessary) some of the opinions and findings that caught my ear.

- Despite hundreds of years of investigation into human hearing, many mysteries and confusions remain. One author discussing the difficulties of operating in the area of qualitative judgments (Is it twice as loud or 1½ times as loud?) urged that because we are trying to measure the behavior of a very complex biological system that we be skeptical of the derived numbers—they might not mean what we think they do. I got a strong feeling that there is an enormous amount of research that remains to be done, and that digital manipulation of the testing signals is an important new facilitating tool.
- There is more to hearing loss than a simple reduction of sensitivity to various frequency areas. Unfortunately, at the frequencies where there is a hearing loss there are also additional changes that affect perception. Thus, we generally cannot restore normal perception by simply restoring normal sensitivity with a hearing aid or by using equalizers or tone controls in a hi-fi system. The study of the perceptual consequences of hearing loss is an important and very active research area of psychoacoustics and audiology.
- The ear has an incredible absolute sensitivity: At 3 kHz, where the ear is most sensitive, a sound at the threshold of hearing produces a displacement of the eardrum that is about 1/100 of the diameter of a hydrogen molecule! The threshold of pain (ranging from 140 dB at 20 Hz to about 120 dB at 2 kHz) is generally given as the upper intensity limit of hearing. Unlike the eye, whose iris visibly adjusts itself to the ambient illumination, the ear maintains its approximately 120-dB dynamic range by dividing different intensity levels among separate groups of nerve fibers. Each of the fiber groups can handle a range of only 30–40 dB. At levels about 40 dB or so, only about 15–20% of the ear's 30,000 nerve fibers are handling the incoming sounds.
- It is almost always incorrect to refer to the *loudness* of a sound as, say, 90 dB SPL. Sound pressure level is a physical measurement and only indirectly related to loudness, which is a subjective evaluation. A sound measuring 90 dB could be, depending on its frequency spectrum, loud or quite soft.
- There's a new interest in sound-localization research. Some recent findings include: Complex, broadband sounds are localized best, high frequencies must be present for accurate judgment of a sound source's apparent height, and localization is most precise for signals in front and at ear level.

It has been generally accepted that our brain localizes sound sources by using the intensity and timing difference between the sounds reaching each of our ears. Although research has shown that the specific convolutions of our external ears (pinnae) cause reflective cancellations and reinforcements of signals before they reach our ear canals, only recently has it been understood that this direction-dependent spectral filtering plays an important role in our ability to localize sound sources.

Another recent experiment on directional perception sought to determine the relative importance of interaural arrival-time versus sound-intensity differences in determining localization. By digitally manipulating the signal, the experimenters were

WHO IS AES?
The AES is an international organization whose membership includes more than 10,000 persons involved on a professional, semiprofessional, and amateur level in all aspects of audio. For further information on The Sound of Audio conference, on how to become a member of the AES, and/or a catalog of available publications and technical papers, write to: Audio Engineering Society, 60 East 42nd Street, New York, NY 10165-0075.

able to feed the test subjects conflicting intensity and timing information. The expectation was that the subjects would "split the difference," but instead it turns out that the difference in interaural arrival time was the dominant localizing factor—as long as frequencies below 2 kHz were part of the signal.

The authors concluded that this newly discovered time-difference dominance means that "modification of the intensity ratio between the right and left channels of a stereo recording cannot be expected to have any influence on the apparent position of the resultant sound image." I think I missed the author's point, because as far as I can tell my preamplifier's balance control (which operates by adjusting the relative gain levels of the right and left channels) works as well as ever.

The final paper on the localization of sound sources related a series of complex experiments that set up "unnatural" acoustic conditions (such as having one reflecting wall in an otherwise anechoic environment) and used highly controlled, and equally unnatural, special acoustic test signals. It turns out that the subjects *unconsciously* evaluated the plausibility of the test signals against their real-word experience and ignored or re-weighted sounds that made no sense. An example of a nonsensical signal would be one in which the arrival-time differences between the ears exceed the maximum possible (about 765 microseconds) for the human head, or one in which the delayed reflected sound was louder than the direct sound.

The paper didn't cover another related phenomena—the ear/brain's ability to localize sounds where they "should" be rather than at their actual source. For example, when listening to a performer on stage from anywhere in the audience, most people hear the sound coming from the performer rather than from the auditorium's speakers—assuming the sound system isn't grossly misbalanced. And, on a cozier level, most people have no problem when viewing the TV while wearing headphones in placing the dialogue at the actors' mouths rather than at the real source—directly over their own ears.

Next month we will look at some of the other papers dealing mostly with the hardware of audio. **R-E**

TELEPHONE LINE

continued from page 46

PC type bracket, and cut openings for J1 and J2.

Installation

With the modified bracket installed on the card, it is very simple to install in an IBM PC or clone. All you have to do is locate an unused slot in your computer's expansion bus. Make sure the computer is off during the installation. Remove the blank mounting bracket from the back of the computer (if one exists), and insert the new card into the slot. Install the mounting screw, and then plug in the phone line and the AC adapter and battery backup if used, and you're ready to roll.

Software

The software is menu driven and, in most cases, a single key stroke is all it takes to change mode or to perform an operation. Screen colors are used for highlights, and for separation of fields. The only thing you have to remember is to type TLC and hit return (from the DOS prompt). All programming, functions, and mode selections thereafter are done using menus. (See sources box for custom software.)

The software consists of two programs: the operating program and the resident program (which are available on the RE-BBS—516-293-2283). The operating program runs on the host computer and provides the interface with the controller's hardware. The resident program is what the operating program loads into the on-board SRAM. The resident program is the actual program that determines what the controller will perform. But it is the operating program that is used to select, configure, and load the resident program.

User registration cards

Although the software is not copy protected, we strongly recommend users to register their copies; doing so will automatically put you on AC&C's mailing list. AC&C will inform users of new applications software, functions, and updates. **R-E**

DRAWING BOARD

This month begins our discussion on control circuitry.

ROBERT GROSSBLATT

Designing and building electronic controllers used to be a really difficult job if you wanted the circuit to have enough intelligence to do even fairly complex jobs. The reason for that was that there weren't any single-component solutions to electronic intelligence. But when IC's were developed, and affordable microprocessors appeared on the market, things began to change dramatically.

The major change in controllers was the home computer in general and the marketing of cheap motherboards. That's because all the intelligence you'd ever need could be handled by an eighty dollar clone and a bit of software...almost.

The reason for the "almost" is that, even though a cheap PC clone has all the brains and memory needed to control your home's security system or the environmental control system of the space shuttle, there's no convenient way to let the computer talk to the outside world.

All home computers have the capability of talking to an external device since they have to deal with video, keyboards, printers, and so on. How they do that depends on the particular computer since different microprocessors handle I/O in their own unique and often strangely wonderful way. Fortunately for all of us, just about all of the popular clone computers are built around the 80XXX family—from the original 8080, the Z-80, to the 8088 and its more powerful kin, the 80286, 80386, and whatever other surprises Intel comes up with in the future.

All those microprocessors deal with I/O in the same way; through the use of only two instructions IN and OUT. The chip understands that it can be told to address two completely different kinds of locations: memory and ports. If you think of the computer as being an active controller, the former kinds of locations are for thinking and the latter are for doing. It's really that basic.

If you look at the pinouts of any of the 80XXX family, you'll see that there's one pin labelled IO/MEM. On the 8088, for example, you can see that in Fig. 1 on pin 28. That's the control pin that lets external circuitry know whether the microprocessor is doing a memory operation or an I/O (port) operation.

In ordinary use, most people are happily unaware of what kind of instruction is being executed even though both kinds happen all the time. Remember that printers, modems, mice, joysticks, and so on are all treated by the 8088 as I/O devices.

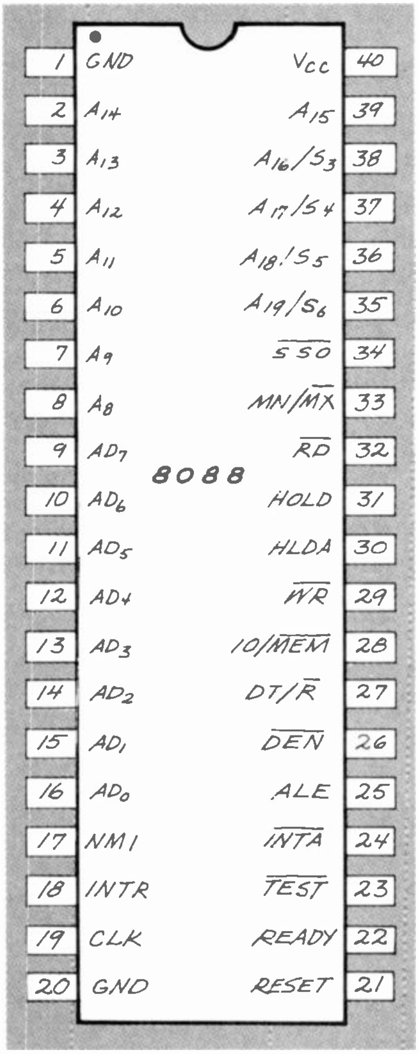


FIG. 1—LOOKING AT THE PINOUTS of the 8088, pin 28 (IO/MEM) is the control pin that lets external circuitry know whether the microprocessor is doing a memory operation or an I/O (port) operation.

Interestingly enough, even though chips like the 8088 make it easy to deal with I/O, designing the circuitry to be controlled is always a pain in the neck, since even the lowly 8088 can handle more than 64,000 different port addresses. That means that anything designed to be driven by the 8088 has to be able to recognize when a particular address shows up on the bus—and that means designing the circuitry necessary to keep an eye on as many as sixteen different address lines to decode the few that you're interested in.

Some months ago I published the details of the Port-A-Matic (**Radio-Electronics**, January and February 1990) which would decode some of the address lines and indicate when the 8088 was talking to particular ports. If you glance through the text of the article, you'll get an idea of just how tedious address decoding can really be.

When you're going to use a store-bought computer as the basis for a controller, it makes a lot of sense to see if you can possibly get away with not having to do address decoding.

You need circuitry to create a working port. This usually takes the form of address decoders, latches, and a wad of logical glue to hold the whole thing together. If the port you're designing has any special needs, that means even more silicon. An example of that would be something like a port aimed specifically at serial stuff where you had to have UART's, line drivers, and so on.

There are several standard port locations in the magical kingdom of cloneland, and I've listed the most popular ones in Table 1. Notice, as we just discussed, that most of the ports actually use several sequential port addresses to handle data, control, and status. That is important to keep in mind because one of the major drawbacks of designing around someone else's hardware is that things aren't set up the way you'd like them to be.

There are actually two problems: The first is that not all the data bits may be used, and the second is that some of the bits may be designed to be either read only or write only. The best way to see that is to look at the port that's available on most clone systems—LPT1, the main printer port.

Just about every clone board I've seen (including the more well-known name brands) that provide an LPT1 port uses the same I/O address space. The three I/O ports that go into making the printer port are 03BCh (the data port), 03BDh (the status port), and 03BE (the control port). The computer uses the data bits at those locations as summarized in Table 2.

The control port at 03BEh is designed to be both written to and read from, although bits 5, 6, and 7 are unused. Bit 4 is used by the port but is designed as a hardware flag to enable the interrupt that the computer uses to find out whether or not the printer can accept data. The bottom line is that bit 4 is only used internally and doesn't show up on the port connector. Keep that in mind because

TABLE 1-COMMON PORT ASSIGNMENTS

PORT	COMMENT
3F8h	FIRST SERIAL PORT (COM1)
2F8h	SECOND SERIAL PORT (COM2)
3BCh	FIRST PARALLEL PORT (LPT1)
3F5h	FLOPPY DISK DATA PORT
201h	FIRST JOYSTICK DATA PORT

there's no hardware available to get the upper four bits out to the external world.

The status port at 03BD is designed so that there are even more restrictions on its use. Not only are the first three bits (0, 1, and 2) not used (and consequently not supported in hardware), but it's only set up as an input port. You can read the state of some of the bits but there's no hardware available to let you write to the port.

The data port at 03BCh, like the status port, has restrictions as well. All eight bits are used, but the port's only configured for output.

Every one of the boards I've seen that has a printer port on it uses some kind of a latch near the end of the hardware chain making up the data port. Usually it's a 74LS373 (boards with discreet components), or a work-alike latch buried in silicon if the board has custom LSI or ASIC chips. Data sent to the port at 03BCh will stay there until it's either changed or cleared by the computer.

It's important to completely understand the parallel-port setup before you start using it as anything other than a printer port since not all the bits are implemented or designed to be both input and output. **R-E**

TABLE 2
BIT ASSIGNMENTS FOR LPT1 WITH A BASE PORT OF 03BCh

DATA PORT – 03BCh – WRITE ONLY

BITS 0-7 - DATA

STATUS PORT - 03BDh - READ ONLY

BITS	0-2	– UNUSED
BIT	3	– ERROR
BIT	4	– SELECT STATUS
BIT	5	– PAPER OUT
BIT	6	– ACK
BIT	7	– BUSY

CONTROL PORT - 03BEh - READ/WRITE

BIT	0	– STROBE
BIT	1	– AUTOFEED
BIT	2	– INIT
BIT	3	– SELECT
BIT	4	– IRQ7 ENABLE
BITS	5-7	– UNUSED

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RICK BRUSH,
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COMPUTER CONNECTIONS

The long-anticipated release of Windows 3.0 and ToolBook, a "software construction set."

JEFF HOLTZMAN

A few days ago Microsoft finally released the long-anticipated and much-hyped new version of Windows. The company spared no expense in the formal product introduction; the initial event cost $3 million, and the company will spend another $7 million between the time when I write this and you read it. According to some reports, Windows 3.0 represents the culmination of a seven-year, $200 million development effort. Clearly, Microsoft means business.

In case you just emerged from detention in Siberia, I'll give a brief rundown of salient new features.

The most conspicuous change is in the user interface. It is simply gorgeous. Mac users will no longer be able to sneer at Windows.

No longer are there separate versions of the product for different CPU's. The same version of Windows 3.0 runs on 8088, 80286, and 80386 processors. However, the program runs in different modes (real, standard, enhanced, respectively) depending on the host processor. Officially, 3.0 will run on an 8088, but a 286 or better is strongly recommended. On a recommended processor, 3.0 breaks the 640K memory limit. Rather, it will when appropriate software is released. For the immediate future, you must run old Windows applications in real mode; however, it appears that most vendors of significant Windows applications are scrambling to convert their products as quickly as possible. The situation will undoubtedly ease considerably by the time you read this.

Another immediate problem that will undoubtedly be fixed quickly is hardware drivers. The program presently comes with precious few. For example, even though 3.0 recognized my Video Seven VRAM VGA card, it provided built-in support only for a 256-color mode at standard resolution (640 × 480), not the 800 × 600 and 1024 × 768 high-res modes. Nor would it recognize the Novell drivers on my office PC. However, updated drivers were available from the vendors almost immediately.

In general, the lack of hardware support is a problem, but not as great a problem as it used to be, because 3.0 lets you alter your hardware configuration on the fly. With previous versions, if you wanted to change *anything*, you had to re-install the whole package, possibly wiping out important setup information in the process. Now hardware and software upgrades will be easy to accommodate.

Most of the applications that come with Windows have been upgraded. For example, the terminal program now does XMODEM and Kermit file transfers, the calculator now has scientific and programmer functions, the clock now has both analog and digital displays, a macro recorder is now included, a solitaire game has been added, etc. In addition, the Windows environment itself is now customizable. You can use one of several predefined background patterns, or create your own, or create (or scan in) an image to use as "wallpaper."

Microsoft has finally disposed of the clunky old MS-DOS Executive; the new Program and Task managers (which bear strong resemblance to the corresponding OS/2 functions) provide a visual approach to running programs. The File Manager (which resembles that in DOS 4.0) provides a much more intuitive means of copying, moving, deleting, and searching for files than the old MS-DOS executive. Windows now also provides a significant interface for network users.

As for hardware, Microsoft has tried to position Windows as needing a 286 + 2MB of RAM versus OS/2's 386 + 4MB. From what I can tell,

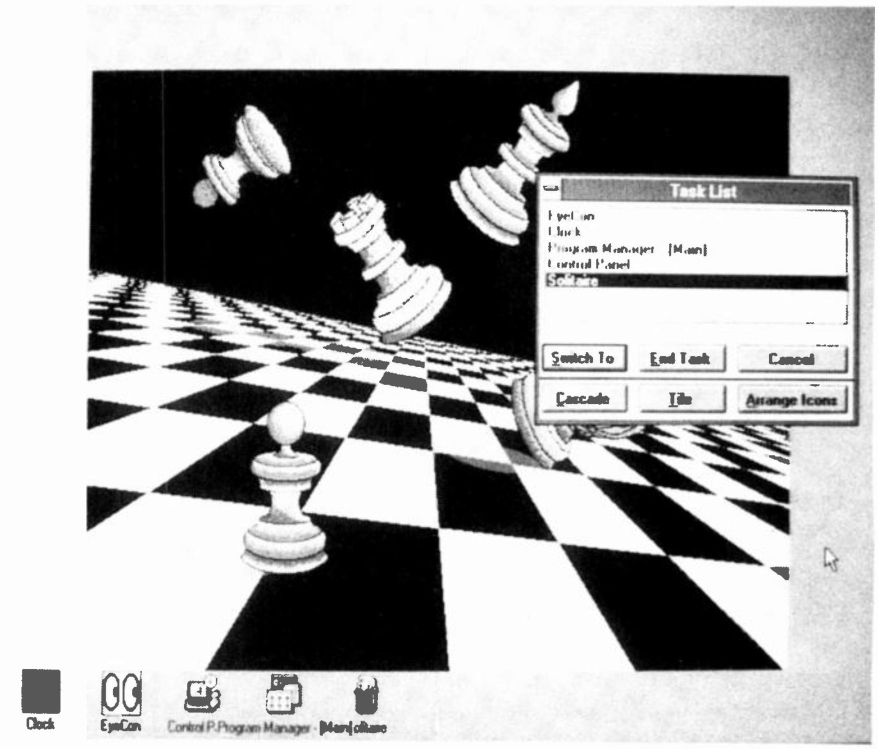

FIG. 1

those distinctions are driven by the marketing folks, not the technical people. A desktop publisher running PageMaker or a heavy-duty financial analyst running Excel simply needs all the memory, hard disk, and CPU speed he or she can possibly obtain. On the other hand, the average user might go a long way using just the built-in applications.

On a 386, Windows now (finally!) lets you run several non-Windows applications simultaneously in an efficient manner.

At long last the documentation includes useful information on setup and configuration. I drastically increased performance of a 3MB Dell System 300 by setting up a dedicated swap area on disk, as described in Chapter 13 of the *User's Guide*.

What's it all mean?

By itself, none of the built-in Windows applications can compete with any serious DOS product. But the Windows apps work together as a group very well. And that's one thing that vaulted the Mac to its place of eminence.

When you stop looking at Windows as a DOS add-on or competitor, but as a product in its own right, it takes on a new glow of its own.

You might compare Windows 3.0 to everything-but-the-kitchen-sink programs like Sidekick Plus and PC Tools. Actually, those are not programs but nearly complete environments that contain most of the tools the average DOS user needs to accomplish daily tasks. Windows 3.0 provides similar functionality, but one that is couched in a sparkling user interface, and is built around an architecture that can accommodate user evolution.

I think 3.0 is going to be a wildly successful product, for several very good reasons:

- Unlike OS/2, Windows has significant applications (Excel, Ami, Word, PageMaker, Corel Draw, Designer, Crosstalk) available now in all application categories except database management.
- The industry hasn't seen such a high level of end-user interest in a product in years.
- The enhanced user interface is going to attract users in a way that previous versions were unable to duplicate (and that DOS never could).
- The ability to write programs that can cleanly access 16MB of memory will attract developers.
- The ease of setup and reconfiguration will attract corporate managers and tech support people.
- And rumors still persist about IBM's pending introduction of a low-cost "multimedia" home PC, for which Windows 3.0 would be the perfect operating environment. Maybe it will turn out to be the elusive PC "for the rest of us" that Apple has promoted but not properly marketed for so long.

By the time you read this, much of the smoke will have cleared. Meanwhile, it's going to be an interesting summer.

ITEMS DISCUSSED

- Windows 3.0 ($149, upgrade $50 + $5.50 S/H), Microsoft Corp., 16011 NE 36th Way, Box 97017, Redmond, WA 98073-9717. (206) 882-8080. Upgrades: (800) 323-3577.

CIRCLE 11 ON FREE INFORMATION CARD

- ToolBook 1.0 ($395), Asymetrix Corp., 110 110th Avenue NE, Suite 717, Bellevue, WA 98004. (206) 462-0501. Orders: (800) 624-8999, ext. 299H.

CIRCLE 12 ON FREE INFORMATION CARD

ToolBook tames Windows

First out of the starting gate is not a revamped version of an old Windows product, but a brand-new one called ToolBook. If the word HyperCard means anything to you, then you'll have some idea of what ToolBook is about.

ToolBook is billed as "a software construction set." It consists of a set of tools that let you build applications by designing screens and linking them to one another. Tools include a graphics editor and a programming language called OpenScript. The editor allows you to create buttons that, when selected on-screen, cause something to happen. What happens depends on scripts you write. The script language provides a rich environment for programming, as it includes full control structures (if/then/else, case, do while, do until, etc.), a single-stepping debugger, a macro recorder, and hundreds of functions.

Writing programs for ToolBook is not like writing BASIC, Pascal, or C programs. Rather, OpenScript is an object-oriented message-passing language, just like the underlying Windows architecture (and OS/2 as well). However, once you start wrapping your mind around that concept, you find that development is no more difficult than in a traditional language—in fact, it's a good deal easier, because many of the grubby, low-level details are hidden from view. ToolBook comes with many sample scripts to help you get started. In addition, at least one company (Heizer Software of Pleasant Hill, CA) has announced a program that will convert HyperCard stacks to ToolBook format.

One extremely powerful facet of OpenScript is that it's extensible. You'll have to understand low-level Windows programming to do so, but the results could well be worth it. Suppose, for example, that you had developed a six-voice stereo music synthesizer and you wanted to build the user interface for it in ToolBook. You would write a dynamic link library (DLL) to control the hardware, link it to ToolBook, and get to work.

Windows 3.0 is currently shipping with a sample ToolBook application called DayBook, which provides a highly intuitive set of daily, weekly, and monthly calendars that provide time- and contact-management functions like some DOS-based desktop organizers.

The only sad thing about ToolBook is its price: about $400. By contrast, Apple includes a copy of HyperCard free with every Mac.

If you're looking for a way to get into Windows programming, but without incurring the extraordinary learning curve involved, ToolBook is the way to go. **R-E**

HARDWARE HACKER

continued from page 78

expensive report on this magnetic refrigeration is now available through *Technical Insights*. Much more on all

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Rare Earth Resources sidebar.

This is all so new and so hot (Uh—better make that so *cold*) that I don't have too much for you beyond these key papers of Fig. 4. One very detailed and thorough but ridiculously expensive report on this magnetic refrigeration is now available through *Technical Insights*. Much more on all this when I actually get the papers and can do some hacking of my own.

An audio voltmeter

Signetics has an intriguing cellular

continued on page 92

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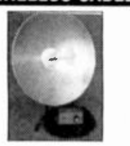

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HARDWARE HACKER

continued from page 90

radio log-amplifier chip in their NE604 and described in their new ap-note AN-1991. Figure 5 shows you how to use this chip to build an audio level meter usable over an incredible 0 to −80 dBm decibel range. It accepts audio levels as low as ten microvolts, and should be useful for speaker and microphone testing, as well as for a receiver "S" meter.

Reasonably priced and wide-range log amps are a rarity, so this is a welcome chip. Be sure to let me know what other uses you can come up with for this gem.

New tech literature

Three free new data books from *SGS* do include their *Power Bipolar Transistors, Zener and Rectifier Diodes*, and their new *1990 Shortform Catalog*. From *Micron*, a *MOS Data Book* mainly on static and dynamic memories. From *Micro Linear*, a *1990 Data Book* has just come out featuring A/D, D/A, telecomm, and power-supply circuits. And, speaking of telecomm, be sure to pick up the new *Telecommunications Data Book* from *National*.

Two hacker surplus sources with ultra-low prices include *Short Circuits* and the *Electronic Goldmine*.

Automotive Electronics is a very interesting new trade journal, while *Electronic Components and Applications* is an outstanding quarterly tech journal from *Philips*. The cost is a tad high at $20 per year for what should be a free house organ. The latest issue includes info on solid-state visible laser diodes, pagers, phase-lock loop circuits, and oscilloscope tubes.

Our free mechanical samples this month include *Alumilite*, an easily castable urethane that sets in three minutes and easily holds small details; and the *Cycle-Flex* mechanical drive cables and fittings from *CMA*.

Turning to my own products, I do have complete autographed sets of book-on-demand published *Hardware Hacker II* reprints for all my **Radio-Electronics** columns here waiting just for you. And, for more information on self-directed research, check into my *Incredible Secret Money Machine*.

Finally, I do have a new and free mailer for you which includes dozens of insider hardware hacking secret sources. Write or call for info.

Our usual reminder here that most of the items mentioned appear either in the *Names and Numbers* or the *Rare Earth Resources* sidebars.

As always, this is your column and you can get technical help and off-the-wall networking per that *Need Help?* box. The best calling times are weekdays 8–5 in *Mountain Standard Time*. Let's hear from you. **R-E**

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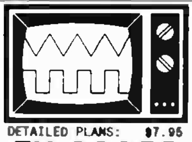
CATALOG: hobby/broadcasting/HAM/CB: Cable TV, transmitters, amplifiers, surveillance devices, computers, **more! PANAXIS,** Box 130-F9, Paradise, CA 95967.



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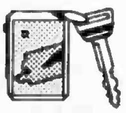

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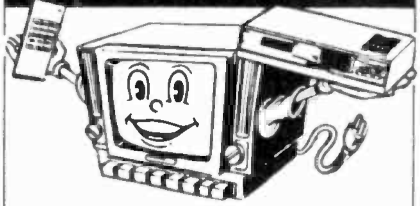

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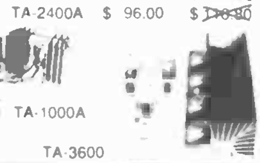

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#002	72VCT 3A	TR-503, TA-323A, TA-400, TA-300	21.00
#003	80VCT 6A	TA-477	27.00
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TTL compatible.
Draws 20 mA @ 6 Vdc. Emits high pitched signal. 0.62 diameter, 0.55" high. PC pins.
CAT# PBZ-06 $1.50 each

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0.182" dia. X .08"high.
0.18" long leads. **CAT# PRE-7** 2 for $1.00
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Hitachi# LM015
16 character dot matrix LCD display with built-in controller/driver. Interfaces with 4 or 8 bit MPU. Displays alphanumerics, kana characters and symbols. CMOS - low power dissipation. Operates on 5 Vdc. Module size: 3.14" X 1.40". Display area: 2.53" X 0.54". Character size: 0.25" high X 0.115" wide. Programming and hook-up instructions included.
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Please specify color.

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PC board with electret mike responds to sounds in immediate vicinity. Originally part of sound activated light organ. Shuts off when sound is not present. Includes hook-up diagram.
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ITT MDPL series. 3/4" X 1/2" grey rectangular key cap. S.P.S.T. N.O. Push to close. RATED: 0.1 amp switching, 0.25 amp carry current. P.C. mount.
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100 for $50.00

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Marquardt# 1843
Rated 6 amps @ 125/250 Vac. Black plastic pushbutton. Switch body: .92" X .94" X .65".
CAT# PB-18 $1.65 ea. • 10 for $15.00

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GC/Thornsen# 35-420
S.P.S.T. normally open momentary pushbutton switch. Red plastic actuator 0.57" diameter. Chrome bezel 0.68" diameter. Threaded bushing mounts in .50" diameter hole. Rated 3 amp @ 250Vac. Solder loop terminals.
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DIFFUSED T 1-3/4 size

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with built in flashing circuit operates on 5 volts.
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Delayed Sweep
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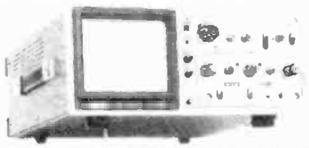

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Dual Channel

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DC to 50MHz, 2-Channel, DC offset function, Alternate magnifier function

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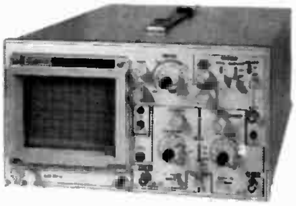

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MO-1251

- Dual Trace
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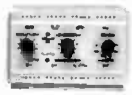

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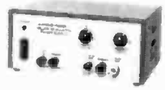

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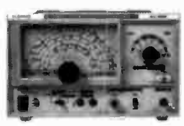

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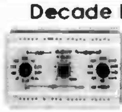

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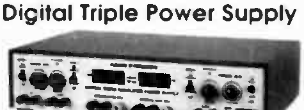

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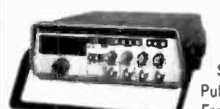

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